Marine Policy 43 (2014) 254–261 http://dx.doi.org/10.1016/j.marpol.2013.06.002

Co-location of activities and designations: A means of solving or creating problems in marine spatial planning?

Christie, N.[a,*], Smyth, K.[b], Barnes[a], R., Elliott, M.[b]
[a] The Law School, The University of Hull, Hull HU6 7RX, UK
[b] Institute of Estuarine & Coastal Studies (IECS), University of Hull, Hull HU6 7RX, UK
* Corresponding author. Tel. +44 1482 466055. E-mail address: cnikki986@gmail.com (N. Christie).

Suggested citation: *Christie, N,. Smyth, K,. Barnes, RA,. and Elliott, M. (2014). Co-location of activities and designations: a means of solving or creating problems in marine spatial planning? Marine Policy 43: 254-261* http://dx.doi.org/10.1016/j.marpol.2013.06.002

Abstract
Worldwide demand for energy is growing and predicted to increase by up to three times by 2050. Renewable energy will play a vital role in meeting this demand whilst maintaining global climate change targets. Around the British Isles, development of wind farms has entered Round three, with large, high capacity wind parks being planned to enhance energy security and achieve 2020 renewable energy targets. Such developments place additional pressure on existing sea space and may result in conflicts with other marine activities and users. Co-location of certain activities, marine protected areas, aquaculture and commercial fishing in particular, has therefore been proposed as an option to ease demands on space. Using the UK guided by EU and regional policy, as a case study, following the criteria-based planning system, co-location is legally feasible. Crucially, co-location options will depend on site specific characteristics and site management plans. The biology, ecology and hydrology of the site as well as consideration of important commercial and economic factors will be determining factors of success. For marine protected areas compatibility with conservation objectives for the site will be fundamental. Where possible, it is suggested that activities suitable for co-location will develop in tandem with renewable energy projects. The importance of developing joint projects in this manner is particularly true for aquaculture projects to ensure tenure security and commercial viability. Adaptive management will be a basis for evolution of the concept and practice of co-location. Pilot projects and continued monitoring will be essential in shaping the future of co-location of activities. As the Marine Management Organisation continues the development of marine plans for the English inshore and offshore waters, a study into potential solutions for resolving sea use conflicts is timely. This paper therefore provides a concise overview of the current regulation affecting co-location of key marine activities within wind farm zones and provides suggestions on how co-location projects can be adopted and taken forward, using the UK as a case study.

1. Introduction
As new marine activities are realised and existing ones developed and expanded there will be increased competition for marine space resulting in further pressure upon traditional users such as fishing and navigation. In the past, minor use conflicts were handled in a discretionary manner. Now due to the scale of the issue, a systematic approach is required to avoid conflicts and resolve competing demands. This systematic approach will require a coordinated, integrated and complementary planning and management system [1] to prevent spatial or temporal conflicts in marine space use. Marine spatial planning will therefore have to consider concurrent activities in time or space, hereafter defined as co-location.

One of the key drivers for marine spatial planning in Europe is regional conservation legislation [2]. There has been a focus atboth the international level and within the EU on better environmental management of the oceans and protection of marine species which, in turn, has determined the direction of domestic environmental law and policy. The introduction of the EU Marine Strategy Framework Directive [3] and the aim of 'good environmental status' for all Member State coastal seas by 2020 provides legally binding targets for Member States [4]. This also requires increased attention on the development of a network of marine protected areas in inshore and offshore waters. Recent legislative developments have established a framework for action through marine planning. As countries begin the process of preparing marine plans, guided by the Marine Management Organisation (MMO) for English inshore and offshore waters, co-location is emerging as a preferred means of tackling spatial conflicts [5].

Worldwide demand for energy is expected to increase by up to three times by 2050 [6] and the worldwide energy-related carbon dioxide emissions are predicted to increase from 30.2 bn metric tonnes in 2008 to 43.2 bn mt by 2035 [7]. For example, in 2009 only 3% of the UK energy was from renewable sources and the European Union (EU) 2009 Renewable Energy Directive set a target for the EU to achieve 20% of its overall share of energy from renewable sources by 2020 [8]. Across Europe, member states have set targets in National Action Plans in support of the EU goals; Denmark and Germany have targets of 20% of energy consumption from renewable sources and Finland has a target of 38% [19]. In July 2011, the UK Government increased its target for the deployment of offshore wind generation by 2020 from 13 GW to 18 GW as part of the plan to generate 15% of energy from renewables by 2020 [10]. Scotland has more ambitious targets, with aims to source 50% of its energy demand by 2015 and the equivalent of 100% of the country's energy demand by 2020 [11]. It is clear that offshore wind energy generation will play a significant role in EU and UK Government strategy, with strong commitments to development of wind energy in the Renewable Energy Strategy [12] and the Renewables Roadmap 2011 [13]. The UK Government has, in its recent Energy Bill, reinforced its focus on renewables, through increased incentives and financial stability within the Levy Control Framework [14].

Offshore renewable energy is expanding together with a growth in marine activities. Potential new initiatives in aquaculture represent further demands on marine space. In order to enhance food security and assist in production of raw non-food materials for biofuel production, offshore aquaculture is becoming increasingly attractive [15]. This is particularly the case for macro-algae cultivation for sustainable biofuels where offshore production negates the potentially damaging effects of converting agricultural land from food to fuel production [16].

This will increase pressure on a finite sea space and thus requires marine spatial planning to manage activities in an efficient and sustainable manner. As well as legal recognition at the national level, this is recognised at European level through the Commission proposal for legislation on Maritime Spatial Planning and Integrated Coastal Management [17]. Although proposed and established offshore wind farm zones occupy a significant proportion of the marine landscape in countries such as the UK, Denmark, The Netherlands and Germany, it is suggested that a mere 3% of the total area leased for an offshore wind farm is occupied by the piles and foundations in place to support the turbines [18]. Proposed co-location of marine activities is therefore an attractive option for marine planners and stakeholders seeking to reduce the conflicts in use of the sea.

In general, stakeholders seem to be amenable to co-locating activities within and around wind farms [19], although displacement of fishing by wind farms is of concern. Stakeholder consultations indicate that within the UK, for example, Round 3 developers are keen to consider co-location of activities within offshore wind farms [19]. The frequency with which an individual visits or uses the coastal zone has an influence on how much discomfort they experience from wind farms within sight. In general, a greater frequency of coastal use (e.g. recreation, fishing, etc.) results in more discomfort [20]. Anticipated visual distance to proposed wind farms also affects the level of opposition by local residents, with developments that are expected to be "out of sight" being considered in more general terms and therefore more acceptable [21]. A choice experiment performed on tourists to the region of Languedoc Rousillon in France showed two acceptable 1to the tourists] policy options in terms of the siting of wind farms: (1) irrespective of other factors, wind farms should be >12 km from shore to avoid loss of tourism revenues and (2) a minimum distance of 5 km from the shore can be achieved without loss of tourism revenues if the farm is associated with recreational activities and is accompanied with a coherent environmental policy [22]. Therefore developers may need to consider the amount a particular area of coast is used for industrial, residential and recreational purposes when planning the location of wind farms, and hence co-locating recreational or fishing activity, for example, may assist in making renewable projects more acceptable to the public.

Using UK implementation of EU law and policy as a case study, this paper seeks to assess the compatibility and legal and environmental constraints of co-locating three key marine activities with wind farm developments: marine protected areas, offshore aquaculture, and fishing. This allows us to conclude whether co-location is a feasible option for addressing competing marine demands.

2. Marine protected areas (MPAs)

Marine protected areas are promoted and governed under the EU Birds, Habitats and Marine Strategy Framework Directives, the Convention on Biological Diversity 1992 (CBD) and, in the UK, the Marine and Coastal Access Act 2009. An increase in such areas puts additional pressure on an already heavily populated sea space. Within UK territorial and offshore waters there are 102 SACs for marine habitats or species and 107 SPAs for birds that have a marine component [22]. Nearly a quarter of English inshore waters[1] are now under European site protection [23].

In the UK, the main types of MPA are:

- Marine Conservation Zones (MCZs) for nationally important habitats and species, [1]Marine and Coastal Access Act].
- European Marine Sites (EMS); as Special Areas of Conservation (SACs) for habitats of European importance, 1Habitats Directive].
- European Marine Sites (EMS); as Special Protection Areas (SPAs) for birds (also known as *Natura 2000* sites), 1Birds Directive].
- Sites of Special Scientific Interest (SSSI) and RAMSAR sites are mostly terrestrial or intertidal areas but some extend into the marine environment below the low water mark.

The Marine Strategy Framework Directive (MSFD) aims to achieve Good Environmental Status (GES) in EU waters by 2020 [14]. The MSFD supports the creation of Natura 2000 sites, implemented through the Habitats Directive, in order to support the conservation objectives necessary for the achievement of GES [24]. The Marine and Coastal Access Act introduces specific provision at domestic level to support the creation of such a network within UK waters, covering an area of the sea bed or subsoil within the limits of the UK sector of the continental shelf, EEZ and territorial sea[2] in what will be known as Marine Conservation Zones [25]. The creation of these zones will contribute to fulfilling UK obligations under the CBD as well as other regional non binding instruments such as the recommended coherent network of MPAs under the OSPAR Recommendation 2003/3 126]. Implementation is similar across Europe, for example, in the Netherlands this is done under the 1998 Nature Conservation Act.

The operational phase of an offshore wind farm development is thought to have minimal environmental impacts 127] and scour protection may lead to habitat enhancement and therefore be actively beneficial. In addition to officially designated MPAs, wind farm sites can create an informal MPA as they often become an effective no-take-zone for fish. These MPAs occur, because the nature of the licensing and operational legislation for the wind farrm means that certain fishing gear cannot be used within the area, such as trawls and other towed gears. Co-locating wind farms and marine protected areas could therefore be a feasible option for reducing pressure of conflicts on other marine activities [28].
There is a substantial overlap between possible Marine Conservation Zones (MCZs) and offshore renewables, with up to 30% of existing and 13% of future offshore wind farm arrays potentially being affected, and up to 30% of the power export cabling [29]. In line with legislation and Government policy, MCZs aim to contribute to the achievement of a coherent network of protected areas. This may be done with regard to consideration of adverse socio-economic impacts [30]. It is suggested that wind farm development is an important socio-economic interest and as such can be taken into consideration in the selection process for MCZs [31]. The presence of socio-economic considerations will not necessarily be determinative but rather are a factor in the consideration process.

Co-location will however, not be possible in all MCZ circumstances. In line with the objectives of the Marine and Coastal Access Act, Natural England and JNCC in their Ecological Network Guidance have set out a framework to establish 'reference areas' which will act as highly protected MCZs, excluding all damaging activities [32]. The joint guidance on activities permitted within reference area MCZs suggests that offshore wind farms are incompatible with reference sites since mitigation of potentially damaging effects, such as seabird mortality and disturbance from electromagnetic fields is unlikely

[1] The English inshore areas means the area of sea within the seaward limits of the territorial sea (12 nm limit) adjacent to England, Marine and Coastal Access Act 2009, s 322(1).
[2] NB. As a devolved matter, MCZs will not apply to the Scottish or Northern Irish Inshore region—Marine and Coastal Access Act 2009 s. 116(3)

[32]. As none of the 65 recommended reference areas within the English inshore and English and Welsh offshore region have been adopted for consultation, the interaction between these areas will not be of a practical concern in the foreseeable future [33].

The EU Birds and Habitats Directives [34] have been transposed into domestic law through a number of instruments [35]. The Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2007, as amended [36], apply the Habitats Directives to offshore areas, and so impact upon the development of offshore wind farms. Through the Offshore Regulations, the UK is in the process of creating a network of protected areas within its marine area. Together SACs and SPAs form Natura 2000 sites. The Habitats Directive does not prohibit the development of renewable energy installations within Natura 2000 sites. In practice, as the designation of European Marine Sites is well underway, these sites will precede wind farm developments and therefore the pertinent question is whether development activities can take place within an already designated EMS. The impact of the Habitats Directive on wind farm development will depend upon the application of the Directives under domestic law. Following the criteria-based planning system used by the UK, it is possible for wind farms to operate in harmony with protected areas.

Although the UK does allow wind farm development within Natura 2000 sites, it is still required to ensure a certain level of environmental protection to these protected areas. When projects are deemed to have a likely or significant effect on the environmental integrity of a Natura 2000 site especially on the conservation objective for which the site was designated, an Appropriate Assessment is required [37]. The Secretary of State is only permitted to grant a Development Consent Order (DCO) for an offshore wind project on the basis of a positive outcome of the assessment, if the adverse effects can be mitigated, if an alternative solution to the adverse impacts can be found, or if the development is required for imperative reasons of overriding public interest (IROPI). The purpose of an Appropriate Assessment is to identify negative effects on a SPA or SAC. If negative impacts are found, the assessment must respond with appropriate mitigation measures. A DCO will be refused if it is found that the plan will have an adverse effect on the overall integrity of the site.

As an example, in July 2012 the Department of Energy and Climate Change (DECC) refused a DCO for a wind farm development based on negative impact on a designated bird species within the North Norfolk Coast SPA. The site qualifies for special protection status as it supports populations of European importance of a number of bird species contained within Annex 1 of the Birds Directive. The Sandwich tern, *Sterna sandvicensis*, is one species upon which site designation is based [38]. Appropriate Assessment of the Docking Shoal wind farm development in combination with two additional wind farm developments in the Greater Wash area concluded that the impacts on foraging Sandwich terns particularly would be significant. Due to its location closest to the North Norfolk SPA and the foraging areas used by the Sandwich terns, the Docking Shoal wind farm was predicted to produce a higher annual mortality rate for breeding Sandwich tern that the other two sites, and as such the application was refused [39].

In theory, co-locating wind farms with marine protected areas in the UK is legally feasible, provided adequate assessment and monitoring take place. In fact the findings of the most recent offshore energy Strategic Environmental Assessment encourage such practice, concluding that

> '*Where the objectives of the conservation sites and renewable energy development are coincident, preference should be given to locating windfarms in such areas to reduce the potential spatial conflict with other users.*'[40]

In practice, the success of co-location will depend on stakeholder attitudes and developer co-operation and several advantages and disadvantages of co-locating wind farms and MPAs are noted (Table 1) [41].

A study of developer attitudes to co-location suggests that they would not be prepared to commit to development within an MCZ or MPA unless assured that there would not be a significant increase in associated monitoring, mitigation or maintenance costs [42]. This is mirrored in concerns from the UK Crown Estate that developers will be required to conduct additional surveys of MCZ features of conservation importance, which would not normally be required and thus add further cost to developers involved in co-located sites [42]. However, as indicated above, there is a statutory requirement to conduct Appropriate Assessments in conservation designated areas.

Table 1
Stakeholder consultation: advantages and disadvantages of co-location of fishing, wind farms and MCZs [41].

Advantages	Disadvantages
Co-location may minimise social and economic impacts on the fishing industry	Turbines and windfarm infrastructure may prevent the attainment of MCZ conservation objectives
Co-location discussions may support windfarm developers' efforts to engage with local fishing communities	Co-location may increase responsibilities and costs for windfarm developers
Co-location discussions may support windfarm developers' efforts to engage with local fishing communities	Co-location may make gaining consent for developments more difficult, putting investment potential at risk
Restrictions on fishing activities within windfarms may support MCZ conservation objectives	Co-location may limit access to fishing grounds inside windfarms that would otherwise be targeted
Routine operations in co-located windfarms may support MCZ management efforts	Co-location may require a compromise on where MCZs are located resulting in sub-optimal performance of the network
Co-location may support the attainment of MCZ habitat protection targets	Concern that fishermen will not receive compensation for lost fishing opportunities of co-location occurs

Successful co-location between wind farms and marine protected areas will therefore largely depend on an effective pre- and post-construction monitoring regime. This would ensure that, in line with the enacting legislation, any development within the MCZ does not hinder or cause significant risk to achieving the conservation objectives of the MCZ [43]. Specific conservation objectives will be detailed for each MCZ once the site has been designated in a statement produced by JNCC and Natural England. The objectives will establish whether the feature of a site meets the desired state and protection is afforded in order for it to be maintained or if protection acts as a means of enhancing the feature which should be recovered to favourable condition [44]. Siting offshore wind farms within MCZs will ultimately depend on the conservation objectives set for each site.

3. Aquaculture

Aquaculture is becoming an increasingly significant sector worldwide. The Food and Agricultural Organisation (FAO) predicts that world seafood consumption will continue to rise [45] and demand cannot be met only from wild species. In 2011 aqua-culture accounted for 40% of the world's fish production at around 63.6 million tonnes (the other 60% is capture fisheries) and is an industry that is currently expanding in most regions due to traditional capture fisheries reaching critical stock levels or their maximum potential yields [45].

Farmed food fish include finfishes, crustaceans, molluscs, amphibians (frogs), aquatic reptiles (except crocodiles) and other aquatic animals (such as sea cucumbers, sea urchins, seasquirts and jellyfishes). In 2010 ca.75% of marine aquaculture comprised mollusc shellfish beds although this percentage is less than the 1990s due to increasing finfish and crustacean culture over the last two decades [45].

According to the 2012 assessment of fisheries and aquaculture by the FAO, the amount of capture fish stocks in the world that are now threatened is ca.88% (based on 2009 figures): 58% fully exploited, 30% over exploited [45] and projections suggest that by 2030, in order to maintain current per-capita consumption levels, an additional 40 million tonnes of food from capture or aquaculture fisheries will be required [46]. Therefore offshore aquaculture may be a way of meeting this demand. Additionally, locating an aquaculture farm away from the nearshore area reduces the amount of anthropogenic factors that can influence the quality of the produce, e.g. pollution, runoff, sewage etc [47]. In trials, oysters (*Crassostrea gigas* and *Ostrea edulis*) cultured in an offshore installation showed comparable growth rates to those reared in traditional nearshore culture [48], indicating that offshore areas can indeed function acceptably as a site for aquaculture for some commercial species.

Europe is one of the largest aquatic-food markets in the world and is increasingly relying on imports in order to meet consumer demand [49]. It is anticipated that marine aquaculture, specifically offshore aquaculture, will form a key element of future strategies in meeting this demand and decreasing dependence on imports [50]. Where sensitive areas occur, only indigenous species should be considered for the purposes of aquaculture so as to avoid the disruption of local flora and fauna. This is potentially very limiting to profitable economic opportunities, as only a small number of indigenous species are regarded as high-value. Additionally, as offshore aquaculture systems cannot be attended to on a daily basis, species which can be cultured extensively rather than intensively, and therefore with modest needs for service, are the best candidates, e.g. *Laminaria saccharina* (sugar kelp) and *Mytilus edulis* (blue mussel) [47].

The benefit of an increase in aquaculture production is twofold: food security and contribution to biofuel technologies [16]. The importance of sustainable aquaculture is recognised at EU and national level [15] although it increases marine anthropogenic pressures. As a result there is growing recognition within Europe of the potential to integrate offshore renewable energy structures with certain types of mariculture [51]. This is supported, for example, in the on-going Defra consultation on the future of aquaculture in England, which has highlighted in particular the opportunity for offshore energy infrastructure to support production of non-food raw materials, to be used in biofuel production [52]. Growing macro-algae for renewable energy production focuses on growing species that can attach to underwater ropes or similar support structures [53]. These could be sited within the wind farm area and wind turbine foundations used as anchor points [27]. Offshore aquaculture of this kind directly supports implementation of the EU Commission Proposal to amend the current legal framework on biofuels within the EU [54]. The Proposal includes amendments to the Renewable Energy [55] and Fuel Quality [56] Directives to provide market incentives for biofuels, particularly algae, which do not create an additional demand for land and avoids damaging effects of conversion of agricultural land into fuel production.

Buck et al. (2004) [57] noted that wind farm sites can provide a potential location for aquaculture as their solid foundations provide a base for culturing species such as blue mussels (*Mytilus edulis*), oysters (*Ostrea edulis, Crassostrea gigas*) and seaweed (*Laminaria saccharina, Palmaria palmata*). However, despite increasing interest from both the aquaculture industry and the renewable energy industry, there are few existing examples of where wind farms and aquaculture have been co-located. This is partly due to the lack of regulatory framework for such ventures and the need for both offshore wind and offshore aquaculture industries to prove commercial viability in a standalone sense. A trial co-locating aquaculture and offshore renewable occurred in Denmark at the Middlegrunden wind farm in 2001 using caged trout and *M. edulis* [58], however the results were never made publicly available so it is unknown whether the trial was a success. A subsequent study in Germany cultured *L. saccharina* and *M. edulis* within wind farms and showed that *L. saccharina* grew well in offshore locations, although *M. edulis* experienced a lower settlement success, but lacked the parasites found with nearshore cultivation, making it a good candidate if settlement rates can be increased [47].

Although aquaculture projects in association with wind farms are still in the planning or trial stages, similar schemes do exist. For example in several locations worldwide, "rigs to reefs" and "rigs to riches" programmes exist whereby disused oil platforms are used for the creation of artificial reefs, or as a basis for aquaculture. One such example is in the Gulf of Mexico, where many local and state laws were consolidated to develop the National Artificial Reef Plan to avoid the damaging effects decommissioning can have on the artificial reef habitat and associated biological community [59].

Co-locating aquaculture with wind farms is potentially of high benefit to aquaculture in that it may reduce the high start-up costs associated with building an offshore facility [60] as well as providing some shelter in a high energy environment. Options for aquaculture generally come in three categories: culture on simple structures such as ropes or frames (for example with seaweeds [47,61,62] and molluscs [47,63,64]), ranching/stock enhancement on the seabed involving wild release or simple cages (e.g. lobsters [65–67]), or culture in intricate structures such as large cages or pens (for example fin fish [68]). Due to the complex nature of cage/ pen based culture (feeding regimes, water quality controls, mooring and support structures etc.) and therefore the more complex nature of co-locating wind power and cage/pen aquaculture, this paper mainly concerns the simpler aquaculture on ropes and ranching. However, depending on an appropriate assessment, fin fish culture in cages attached to turbine monopoles and foundations is physically possible as demonstrated in the trial by Buck (2007) [47].

The idea of offshore installations and aquaculture sites co-locating seems like a practical option to counteract spatial concerns and one which could be technically and scientifically feasible. In practice, for the idea to become reality there must be benefits for both parties involved. The key advantage for the aquaculture industry is clear; without the turbine foundations to act as anchor points, due to the high energy environment of much of the North Sea, installation of mariculture equipment would not be economically feasible [58]. More challenging is establishing strong incentives for offshore wind developers. Macroalgae cultivation which will be harvested and used as a source for biofuels could be a means of mitigating or offsetting environmental impacts of wind farm developments.

For multifunctional use of a site to operate effectively, it is essential that both parties have secure and clear legal rights in tenure in order to increase investor confidence and promote long term investment opportunities. At present the framework for leasing of the seabed for aquaculture purposes beyond 12 nautical miles is not clear. Ownership of the seabed out to the 12 nm territorial sea limit is vested in the Crown Estate under the Crown Estate Act 1961. On this basis, the Crown Estate is responsible for the lease of areas seabed for aquaculture installations within the territorial sea. Outside the 12 nm limit the Crown Estate has no ownership rights. The legal rights conferred to the Crown Estate under the Energy Act 2004 relate solely to the Renewable Energy Zone and development of renewable energy therein. At present therefore, the Crown Estate lacks an adequate legal basis for providing aquaculture developers security over an offshore site.

Extension of Crown Estate rights comparable to those enjoyed for the leasing of renewable energy installations beyond 12 nm would provide aquaculture developers the desired tenure security required for development.

Lease agreements from the Crown Estate for use of the seabed are however, site and activity specific to the exclusion of others. As a result, developers of current wind farm projects are not permitted to make profit from any activity other than the production of wind energy and so sub-leasing options are not currently feasible. If offshore aquaculture and offshore renewables are to function concurrently, an entirely new lease and the assessment process would be required. This would likely be the granting of a joint seabed lease for the co-location venture to provide security for both parties. Co-location projects should therefore, ideally be developed in the initial planning stages.

The Crown Estate involvement in both offshore renewable energy and offshore aquaculture begins and ends in the leasing of the seabed for development. The Crown is in no way involved in the statutory regulation of activities within leased areas. Like offshore wind the development process for aquaculture involves two stages; a lease from Crown Estate and separate statutory planning permission. For offshore aquaculture projects, a marine licence is required in Scotland. Prior to the establishment of the Marine and Coastal Access Act 2009, offshore aquaculture projects such as the Lyme Bay Mussel farm, required a permit under s34 Coast Protection Act. Moving forward, under Marine Management Organisation (MMO) rules, the deposit of any shellfish trestle, raft, cage, pole, rope or line in the course of propagation or cultivation of shellfish is exempt from requiring a marine licence [69]. A licence is however required for the construction works associated with the shellfish operation. On this basis, if the wind farm installation is used as anchoring points for the shellfish ropes a licence would not be required. If however, a new fixed structure is required to support the ropes sited within the wind farm zone a marine licence will be required. It should be noted that the suggestion is that future co-location ventures will develop as an entirely new venture and not the addition of one activity to the other. One option therefore is for the licence for construction works to be incorporated into the deemed marine licence for the offshore renewable energy installation acquired as part of the development consent order.

In the face of scientific uncertainty adaptive management plays a vital role in progressing projects which may have a detrimental effect on the environment. The development of offshore renewable energy has progressed on the basis of adaptive management from small scale demonstration projects to small arrays and eventually extension to large-scale wind farms. This is a process whereby flexible decision making is adjusted as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process [70]. Offshore aquaculture too is developing in the same manner, using 'deploy and monitor' techniques as a means of assessing the effects and controlling development. Offshore wind and aquaculture co-location pilot projects are likely to play a key role in associated challenges of co-locating activities, both in terms of environmental impact and business related activities. Lessons learned from activities such as the EFF funded project in Wales [51] can feed into the development of policy and regulation for co-location.

4. Fishing

The impact of offshore wind on fishing is likely to be substantial. Not only can the construction, operation and ultimate decommissioning of wind installations have an adverse effect on fish populations themselves, resulting in a potential depletion of stocks around individual sites, there are also likely to be access issues for fishing vessels once safety zones are established. Concerns within the fishing community heighten as offshore wind development plans intensify. There are a number of uncertainties surrounding fishing rights in areas where wind farms are being constructed. The key question from the fishing industry is 'which, if any, fishing activities will be permitted inside these sites' [41]. To assess the legality of fishing and offshore wind farm interaction and establish possible options for co-location it is necessary to look to both common law and statutory legislation.

Public rights to fish and public rights of navigation are enshrined in English common law. These rights are valid irrespective of Crown Estate ownership of the sea bed. Both the Crown and developers who derive ownership rights from the Crown must respect public rights. Some have argued on this basis that limiting the public right to fish in a wind farm zone in English waters may be regarded as an act of public nuisance under common law [71]. As the right to fish is not an absolute right, an action of public nuisance is subject to the extent to which the public right has been curtailed by statutory means. There are two key provisions in the Energy Act which successfully limit these rights; the so-called s36A declaration and the establishment of safety zones. By introducing an amendment to the Electricity Act 1989, section 99 of the Energy Act specifically extinguishes public rights of navigation in the area where the wind turbine is sited. The declaration applies only to the area where the physical structure is placed on the sea bed and not the intervening waters. Thus common law public rights to fish within a wind farm site in English waters apply, notwithstanding the establishment of safety zones.

Under the Energy Act, and in line with international regulation, a safety zone is permitted around an offshore installation

[72]. The extent to which access for fishing vessels will be allowed is determined by the permissible size of safety zone, details of which can be found in the implementing regulations [73]. Under international law safety zones of up to 500 m are allowed within a coastal state Exclusive Economic Zone (EEZ) [74]. With average spacing between wind turbines likely to be between 500–700 m if the maximum entitled safety zones under international law were commonplace the effect would be to close off significant portions of the sea to navigation and fishing. The Safety Zone Regulations specify the dimensions of 'standard safety zones' in two instances [75];

1. in the case of the proposed or ongoing construction, extension or decommissioning of a wind turbine, or of major maintenance works in respect of such an installation, a safety zone with a radius of 500 m measured from the outer edge at sea level of the proposed or existing wind turbine tower; or
2. in the case of the proposed or ongoing operation of a wind turbine, a safety zone with a radius of 50 m measured from the outer edge at sea level of the proposed or existing wind turbine tower.

On this basis while there is likely to be significant disruption to fishing in the construction, maintenance and decommissioning phases of a wind farm, legally, fishing vessels will be entitled to access the intervening waters to fish during the operational life of a wind farm. Studies have shown that while legally permitted, a considerable proportion of representatives from the fishing industry have indicated that they would be inclined to avoid fishing within a wind farm area [41]. Health and safety and issues regarding insurance are in top of the list of concerns. If co-location of fishing activities and wind farms is to function effectively, clarity is required on these points.

The artificial reef effect of wind farms, especially those where scour protection is used, can be beneficial to some species, creating new habitats and over time, increasing both species diversity and abundance. Where existing crab/lobster fisheries already exist in an area, after the initial potentially destructive nature of the construction phase, there may be potential to enhance the habitat for these species. With careful construction of the scour protection, it may be possible to increase the yield of both crab and lobster—species which both thrive in a rocky environment. Following on from this stock enhancement, commercial fishing activity may then benefit from the wind farm as long as they are allowed access to fish within the area. This will most likely be agreeable for those fishers using traditional methods such as pots/creels rather than destructive methods such as trawling which could pose a danger to the wind farm infrastructure such as the buried cabling in the seabed.

5. Conclusions

This paper concludes that co-location of marine activities is feasible in UK waters from an environmental and legal perspective but that the success and extent are site-specific. Potential for co-use of the site depends on the biology, ecology and hydrology of the site as well as consideration of important commercial and legal factors. Some sites may be suitable for aquaculture, some for stock enhancement of crab/lobster, some may even be of use for eco-tourism and recreation in the form of diving if a great enough artificial reef effect is produced.

The scope and likelihood of co-location should be assessed at the planning stage for all future projects. For MPA sites, governing legislation, both at national and European level does permit the development of wind farms within the conservation areas. This is not however without important constraints. Since siting offshore wind farms within MPAs will ultimately depend on the conservation objectives set for each site it is impossible to provide a firm answer as to whether co-location will work. For aquaculture, it is likely that successful business ventures between the two industries may be possible, again this would have to be managed on a case by case basis, with joint projects developing in tandem, rather than separate entities joining up once operational.

As with the development of offshore renewable energy, co-location, particularly within MPAs and with aquaculture projects, should progress on the basis of adaptive management. Pilot projects and continued monitoring will be essential in determining the future of co-location of activities. Given scientific and commercial uncertainty, a 'deploy and monitor' process will be required to determine whether co-location is practicable.

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