Chapter 8
The Socio-economic Dimensions of Offshore Aquaculture in a Multi-use Setting

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Abstract Decision-making within the marine realm is a complex process, which endorses ecological, societal and economic needs and they must therefore be managed jointly. Much of the formerly "free oceans" is nowadays subject to intensive uses, thus making the need to optimise the management of the resources within a multifunctional and multi-use(r) context apparent. The high competition for functions and uses of inshore and nearshore waters has given strong incentives to investigate the opportunities of moving industrial activities offshore. The current raise of offshore aquaculture is one prominent example of this. However, our understanding of the social dimensions and effects of offshore aquaculture is yet incomplete. We need to consider also how different multi-use settings for offshore aquaculture affect the socio-economic outcomes on various levels. During the development of offshore aquaculture, this multifunctional perspective has emerged especially for the combination with offshore wind farms. This synergy of two different stakeholders, the so-called multifunctional utilisation of marine areas, can be viewed as a new concept by the implementation of integrated, consensus-based resource planning conditions. We suggest a typology of social dimensions of marine aquaculture, based on the literature of "traditional" nearshore aquaculture. Based on this typology we discuss the current level of knowledge on the socio-economic dimensions of multi-use offshore aquaculture and point to further research needs.

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8.1 Background

Aquaculture has been widely employed for a long time, i.e. traditional fishpond aquaculture in Asia has been a significant landscape element for centuries. The last decades have, however, seen a marine “Neolithic revolution”. About 430 (97%) of the species presently in aquaculture have been domesticated since the start of the twentieth century, and 106 species have been domesticated over the past decade alone (Duarte et al. 2007). Aquaculture is posed to get a prominent role to address one of the major global challenges at the start of the twenty first century, in providing alternative sources for marine food proteins, supply and food-security. Yet, many challenges remain, and not only the numerous technical and biological issues, but also regarding the social, cultural and economic character of future development. Indeed, vis á vis the impressive growth in production volumes over the last decades, with aquaculture expanding from practically being negligible compared to capture fisheries, to constituting over 40% of total global marine production (FAO 2014), this development has had manifold socio-economic repercussions on various levels. This recent rise of aquaculture and accompanying socio-economic relevance has been coined as the so-called “Blue Revolution” (Krause et al. 2015). At the same time the growth in capture fisheries seen over the last 50 years seem to have stagnated (FAO 2014).

Most of this rather recent global growth in aquaculture production has taken place in inland and coastal areas (FAO 2014). However, there are major obstacles to accommodate further growth into existing marine resource use patterns, which would increase conflicts along coastal areas. This is partly due to stakeholder groups growing in numbers or prominence (Buanes et al. 2005), but also due to the risk of spread of diseases and parasites between aquaculture farms, which limits farm densities in coastal areas. Although the typical size of fish farms inshore has grown strongly the last 10–20 years, the potential for creating very large aquaculture production facilities inshore appears limited. In contrast, in the offshore realm, the size of aquaculture plants can be much larger, thus targeting at more cost-efficient scales of production. Hence, moving aquaculture facilities offshore seems a promising way to try to tackle these challenges and limitations, and the technology for offshore aquaculture is emerging now (Buck et al. 2008).

The high and rapidly increasing demand for offshore space for different purposes, such as installations for the production of energy from renewable sources, oil and gas exploration and exploitation, shipping and fishing, nature conservation, the extraction of raw materials such as sand and gravel, aquaculture installations and underwater cultural heritage, as well as the multiple pressures on coastal resources, require an integrated planning and management approach (EU 2014). Indeed, since the offshore move is rather risky and expensive, a multi-use approach is favored, that is the integrated production of marine species with other resource uses, such as offshore wind farms (Buck and Krause 2012). In the case of such multi-use offshore concepts, the typical practical procedure of looking for the most suitable site will be confined to those sites where offshore wind farms are planned or already in place.

This is due to the fact that aquaculture acts as “secondary newcomer”, since the current momentum of moving activities offshore stems from the political will to enforce renewable energy systems in the first place (Buck et al. 2003). Therefore, the typical site-selection criteria catalogue applicable for aquaculture can usually not be implemented. Hence criteria for the selection process must be tailored to capture the relevant local parameters of the conditions around and within an offshore wind farm. Offshore equipment will need to be adapted to co-exist with the other uses to which the platforms may be put. For instance in the case of aquaculture, equipment has been developed for more benign environments and as such is still in the redesign-phase for harsher conditions. It must be noted that several projects are working to realize offshore aquaculture farm designs independent of renewable energy production facilities. In Norway the problems of salmon lice in the fish farms and their transfer to wild salmon populations are also a strong incentive to enable offshore aquaculture. In other parts of the world independent offshore aquaculture farms have been in operation for some time, i.e. in the Caribbean also in real open ocean environments (Ryan et al. 2004).

Additionally, and maybe most importantly, the socio-economic framing conditions must be assessed. They can either promote or hamper such offshore multi-use concepts. While the density and variety of stakeholders and interests affected by inshore aquaculture in general seems much higher than offshore aquaculture could be in the relatively near future, it would be naïve to assume that socio-economic issues can be ignored when going offshore. Inshore as well as offshore aquaculture production activities are subject to dispute and conflict when management regimes have not been established properly, as the participating stakeholder groups have different and sometimes opposing interests (Krause et al. 2011; Wever et al. 2015). Additionally, the flow of costs and benefits and end-consumer preferences vary a lot from place to place (Griffin et al. 2015). This can change an initial local acceptance to strong opposition against the instalment of aquaculture in coastal rural landscapes. Resolving this requires additional input from social, economic and political sciences (Michler-Cieluch and Krause 2008). This has over the years lead to an increasing awareness to the social dimensions of aquaculture production (Krause et al. 2015).

Marine Spatial Planning (MSP), which now has expanded out to offshore areas, as for example in Norway’s Integrated management plans for the Barents Sea, the North Sea, and the Norwegian Sea (Anon 2008–2009; Anon 2010–2011; Anon 2012–2013), attempts to combine governance of stakeholders and their interests with the needs and limitations inherent in ecological sustainability. So far, stakeholder participation in marine spatial planning has been less than in typical integrated coastal zone management (ICZM) processes, but the ecosystem component of MSP management appear to be stronger—the current EU Efforts to define and reach “Good Environmental Status” of Marine Waters by 2020 (Marine Strategy Framework Directive) is a case in point. However, with increasing interest for the use of offshore areas, marine spatial planning must include socio-economic aspects and stakeholder participation to a stronger degree to be successful.

In this chapter we consider the social dimensions of multi-use offshore aquaculture, and the complexities involved in managing the ecological, societal and economic aspects of offshore aquaculture in an integrated and systematic manner. We suggest a first typology of socio-economic dimensions for aquaculture and outline their implications for offshore aquaculture development in multi-use contexts. The chapter closes with a discussion on the current level of knowledge on the socio-economic dimensions of multi-use offshore aquaculture, and point to further research needs.

8.2 Socio-economic Dimensions of Aquaculture—A First Typology

Over the past decades, scientists and policymakers have become increasingly aware of the complex and manifold linkages between ecological and human systems. Social-ecological systems are understood to be complex adaptive systems where social and biophysical agents are interacting at multiple temporal and spatial scales (Janssen and Ostrom 2006). This has stimulated researchers across multiple disciplines to look for new ways of understanding and responding to changes and drivers in both systems and their interactions (Zurek and Henrichs 2007). In this contextual setting, Krause et al. (2015) showed that most socio-economic analysis to date deal mainly with the effects of salmon or shrimp farming, and to a lesser extent with e.g. Pangasius and Tilapia, as well as filter feeders (such as Crassostrea gigas) and seaweeds (such as Kappaphycus alvarezii and K. striatum as well as Eucheuma denticulatum) (see Buanes et al. 2004; Barton and Fløysand 2010; Fröcklin et al. 2012; Stonich and Bailey 2000; Joyce and Satterfield 2010; Sievanen et al. 2005; Buchholz et al. 2012).

In order to promote the sustainable co-existence of uses and, where applicable, the appropriate apportionment of relevant uses in the offshore realm, a framework should be put in place that consists at least of the establishment and implementation by Member States of maritime spatial planning, resulting in plans. Such a planning process should take into account land-sea interactions and promote cooperation among Member States. Its main purpose is to promote sustainable development and to identify and encourage multi-purpose uses, in accordance with the relevant national policies and legislation (EU 2014).

Thus, the management of marine offshore areas is complex and involves different levels of authorities, economic operators and other stakeholders. However, questions pertaining to the inter-relationships between community impacts, right of access, ownership, taxation, liabilities for the negative repercussions from the environmental effects on society, and ethical issues, to name but a few, have remained largely untackled in a comprehensive, integrated manner (Krause et al. 2015). As a result, the socio-economic consequences of aquaculture operations are often poorly understood and repercussions such as poaching not fully anticipated (see examples given in Barrett et al. 2002; Bunting 2004; Fröcklin et al. 2012; Isaksen and Mikkelsen 2012; Jentoft and Chuenpagdee 2013; Sandberg 2003; Sievanen et al. 2005; Varela 2001). In many cases the omission of relevant stakeholders and social concerns in aquaculture development projects has contributed to inequity, social conflicts and violence (Martinez-Alier 2001; Nagarajan and Thiyageasan 2006; Varela 2001). The unavoidability of feedbacks between largely structural and technical interventions and the socio-economic systems within which they are embedded, highlights the need for employing more systematic (or ecosystem) approaches to analyse cause and effect relationships and to explore future sustainable, efficient and equitable development scenarios (Hopkins et al. 2011; Belton and Bush 2014).

This raises the question, what processes are needed to include issues and concerns that are not currently promoted by active and resourceful stakeholders (Buanes et al. 2004). This is especially important in offshore areas under multi-use conditions, since this is a novel line of resource use which lacks yet experiences on which stakeholder group's work well together under which governance and management conditions and what type of socio-economic outcomes can be expected. Indeed, more detailed and context-specific socio-economic dimensions of aquaculture operations include many important factors which need to be understood: gender, employment and income, nutrition, food security, health, insurance, credit availability, human rights, legal security, privatization, culture/identity, global trade and inequalities, as well as policies, laws and regulations, macro-economic context, political context, customary rules and systems, stakeholders, knowledge and attitudes, ethics, power, markets, capital and ownership (Hishamunda et al. 2009). Certainly, the lack of consensus on the social dimension is striking when compared with the universally accepted general definitions that exist for the biological and economic dimensions for sustainable ecosystem management (Krause et al. 2015). This is even more so the case of offshore marine management.

Based on the existing literature from coastal aquaculture (see references below) we identify these major types of socio-economic dimensions of aquaculture which are universally applicable:

(a) Attitudes to and perceptions of aquaculture and its effects
(b) Organization of and participation in planning for aquaculture
(c) Direct benefits of aquaculture and their distribution
(d) Negative effects of aquaculture production activities and conflicts with other interests
(e) Effects on the wider economic and innovation system
(f) Effects on cultural fabric and other social aspects

As the list indicates, the social implications of aquaculture are multi-dimensional and affect multiple levels. As a starting point of this analysis, we capture what we account as social dimension by stating what aspects of aquaculture we have excluded: The internal organization and efficiency of the aquaculture production units, and the ecological effects of aquaculture production (including biological, physical, and chemical). These aspects will, however, affect some of the social dimensions, like the number of jobs provided by aquaculture, the economic benefits to society, and possible conflicts with other stakeholders. Further, the different social dimensions (a)–(f) will typically interact. In the following sub-chapters, we elaborate in more detail on the suggested typology and their implications especially for offshore aquaculture.

8.2.1 Attitudes to and Perceptions of Aquaculture

How attitudes to aquaculture vary and correspond between social groups must be taken into account by planning authorities. However, capturing these varying stakeholder attitudes are also of relevance for businesses, NGOs and other stakeholders (Mazur and Curtis 2008; Freeman et al. 2012; Ladenburg and Krause 2011). Studies from different countries have explored groups' views on how aquaculture impacts, i.e. on the environment (e.g. by chemical pollution, effecting local fish stocks and wildlife, visual pollution of coastal landscape), on possible job-creation and economic benefits of mostly rural marginal areas, how it interferes with tourism, fishing or recreation, how it contributes to food security, and how the regulation of aquaculture should be.

This has been done for a number of countries, including Australia (Mazur and Curtis 2006, 2008), Spain (Bacher et al. 2014), Thailand (Schmitt and Brugere 2013), US and Norway (Chu et al. 2010), Greece (Katranidis et al. 2003), New Zealand (Shafer et al. 2010), Germany (Krause et al. 2011; Wever et al. 2015), Israel (Freeman et al. 2012), and Scotland (Whitmarsh and Palmieri 2009). Many of the studies concentrate on local stakeholder groups related to aquaculture (e.g. Bacher et al. 2014), several include tourists (e.g. Katranidis et al. 2003), some consider the general public (e.g. Mazur and Curtis 2008), and some also try to consider how the attitudes and risk perceptions expressed correlate with personal characteristics (e.g. lifestyle behaviour, Freeman et al. 2012), or even with community situation (e.g. employment or income deprivation, Whitmarsh and Palmieri 2009).

Bergfjord (2009) asked fish farmers in Norway what they see as the greatest risks to their business. The majority of respondents raised biggest concerns pertaining to market conditions for their product and towards the outbreak of diseases. Socially related dimensions do, however, also appear on their list, including sea area access, changes to the license system and of environmental regulations, which are all relatively high up on the list, while public repugnance to fish farms (aesthetics, environment) is ranked lower.

Slater et al. (2013), investigate how personal characteristics correlate with willingness towards choosing aquaculture as a livelihood in a developing country setting. Their model allows policy makers to consider the influence of socio-economic factors on the success of introducing aquaculture in different local contexts.

There is a need for further research on attitudes towards aquaculture and their formation, both for inshore and offshore aquaculture. The central theme to date on attitudes is how aquaculture under different settings and circumstances leads to conflicts. Questions that remain to be covered are whether the large increase in aquaculture production will reduce social acceptance, and if attitudes depend on the degree of exposure to prior experience of inshore aquaculture, as a study by Ladenburg and Krause (2011) has indicated for the expansion of wind turbines. They could show that prior experience plays an important role in affecting positive or negative perceptions of renewable energy systems. It can be assumed that this effect may also be relevant for offshore aquaculture development.

8.2.2 Organization of and Participation in Planning for Aquaculture

The omission of relevant stakeholders and social concerns in aquaculture development projects has, more often than not, contributed to inequity, social conflicts and violence (Krause et al. 2015). Therefore, the analysis and documentation of who the relevant stakeholder groups are is important for achieving a good planning process. This may include assessment of their legitimacy and power (Buanes et al. 2004). The design and execution of the planning process for aquaculture, or for the broader MSP process, is important both for the efficiency of the process and for the social sustainability of the outcomes. Qualities like transparency, representativeness and fairness matter for i.e. the legitimacy and support for the outcome (Buanes et al. 2004), for the wider trust in authorities, for development/maintenance of democracy, and for sustainable development (Krause et al. 2015).

Who to include in the planning process, and how, can be difficult to decide upon, balancing the ideals above with the ambition for an effective planning process, which typically also is embedded in a larger governance system. Whilst addressing the interactions and feedbacks between issues (e.g. economic, social and environmental consequences) in a MSP context, it becomes evident that many of these play out over time (i.e. in past, present and future contexts) and space (i.e. at local, regional and ecosystem/global scale)—these are referred to as ‘cross-scale’ or ‘multi-scale’ processes (Krause et al. 2015). What time-scale to consider in the planning process, and thus also what geographical scale, is also something that must be decided.

Discussions of the availability, usefulness and ease of use of knowledge is also important, e.g. on aquaculture’s value creation and its distribution (Isaksen and Mikkelsen 2012). For example, with the development of feed-aquaculture turning to more land-based production of feeds, agriculture can also be seen as a new emerging stakeholder in aquaculture production (Costa-Pierce 2010). Indeed, when new groups of stakeholders are included in planning processes they may often bring about new knowledge to the process. However, the authorities managing the planning process are likely to influence specific knowledge realms that will be used with MSP.

The relative position of different stakeholder groups in MSP, either as holding perceived historical rights by decision-makers or de facto allocated property rights, also shapes future planning. Being a relatively new activity, aquaculture has often had a weaker position than traditional activities, according to some authors (Burbridge et al. 2001; Wever et al. 2015). On the other hand, the lack of appropriate governance systems in some developing countries, and specifically the presence of corruption, can lead to unwanted privatization by aquaculture entrepreneurs (Cabral and Aliño 2011).

8.2.3 Direct Benefits of Aquaculture, and Their Distribution

The provision of food and nutrition security, jobs and income are the main reasons for promoting and employing aquaculture. In addition to these rather straightforward benefits, aquaculture makes a further contribution as the consumption of animal source food facilitates uptake of nutrients from dietary components of vegetable origin (Leroy and Frongillo 2007). This role of addressing the hidden hunger problem, that is the lack of certain nutrients in everyday accessible foodstuff, is particularly important in countries such as i.e. Bangladesh, Cambodia, Ghana, Nigeria, and the Pacific Islands, where many people are impoverished and fish is by far the most frequently consumed animal-source food (Belton et al. 2011; Hortle 2007; Biederlack and Rivers 2009).

The documentation of the economic and employment benefits of aquaculture is often done in either official statistics (like for Norway: http://ssb.no/en/fiskeoppdrett) (Goulding et al. 2000), or in reports from aquaculture industry associations to strengthen support for the industry (e.g. see Sandberg et al. 2014), or as commissions from regional authorities who want to understand how different industries contribute to regional development (e.g. see for Troms county in Norway Robertsen et al. 2012).

In contrast to these Western country examples, cases from Thailand and Bangladesh suggest that, whilst the financial and employment gains generated by this sort of activity may appear substantial on paper (incomes from fish more than doubled, etc.), when placed in the context of the overall livelihood portfolio of practicing households, they are generally fairly modest. Thus, whilst economic gains in aquaculture production achieved in Thailand were superficially impressive, the already relatively affluent households involved subsequently abandoned techniques required to sustain them, because they could not compete with alternatives such as selling labor in a buoyant non-farm economy (Belton and Little 2011). The retention by project participants in rural Bangladesh of similar techniques capable of generating similar production increases may be indicative of the generally more severe nature of rural poverty there, which is itself linked to more limited opportunities for well-remunerated diversification of economic activities beyond the farm (Belton et al. 2011).

Assessing the benefits of aquaculture can be difficult, even focusing solely on financial and economic aspects, as exemplified by Burbridge et al. (2001) and Isaksen and Mikkelsen (2012). While aquaculture is seen as important for alleviating protein deficiency in diets in developing countries (FAO 2014), some have questioned the total effect of fish protein supply if aquaculture does not manage to reduce wild fish inputs in feed and adopt more ecologically sound management practices (Naylor et al. 2000). Belton et al. (2011) point out that global fish supply is undergoing a fundamental transition as capture fisheries is succeeded by aquaculture. This transition is however far from uniform. Even among major aquaculture producing nations, capture fisheries is yet crucial to food and nutrition security. For numerous countries outside this 'elite' group, wild capture fisheries remain the dominant supplier (Hall et al. 2011). Thus, who will benefit from aquaculture in what ways and on what level remains yet unresolved. These issues are even more difficult to assess in offshore aquaculture conditions, by which the initial monetary input is much higher and thus the benefits play out on much different levels and dimension than small-scale subsistence farming.

8.2.4 Negative Effects of Aquaculture Production Activities and Conflicts with Other Interests

The literature on attitudes and perceptions about aquaculture referred earlier can well be used as documentation of actual external effects and conflicts. Indeed, the conflicts between aquaculture and other interests are typically due to negative environmental effects from aquaculture, or competition over marine areas (Primavera 2006). Changes in environmental conditions due to aquaculture can be measured technically (Grigorakis and Rigos 2011) and thus rather objectively.

Assessing the impact or severity of a change in the natural environment due to aquaculture, and even more so in offshore environments, is however more difficult. It will vary with the local environment, and the local use of the area by humans, as shown by for example Primavera (2006) and Paul and Vogl (2011). Asking stakeholders or the general public to give their input for this has its challenges. However, instead of asking end-consumers to what degree aquaculture is or creates problems, one should rather investigate their use of and valuation of ecosystem services (Millenium Ecosystem Assessment 2005) affected by aquaculture, as well as the impact of aquaculture on these services. Media analyses as a source of information on negative effects of aquaculture and conflicts associated with it also has its problems (Tiller et al. 2012). This difficulty in assessing negative effects was reflected in a recent end-consumer study in Germany by Feucht and Zander (2014). Their focus group outcomes revealed an obvious lack of knowledge among the participants concerning aquaculture in general. It was found that consumers are mostly unfamiliar with aquaculture (Aarset et al. 2004). The image of aquaculture seems to be created by comparing it to agricultural systems and by contrasting it with fishing, whilst, at the same time the image of aquaculture being an unsustainable, antibiotic-driven production activity prevailed. Further negative conflicts of aquaculture pertain to the rights to utilize certain marine areas, more often than not having roots in legal, ethical, economic, historical and social aspects of marine use (Joyce and Satterfield 2010).

8.2.5 Effects on the Wider Economic and Innovation System

The establishment of aquaculture businesses in a region can influence the availability of input factors like skilled labor, specialized suppliers, education programs, and other infrastructure. Competition for input factors in limited supply may hamper the development of other industries, particularly if they are not as profitable as aquaculture. Over time, the development and growth of the aquaculture sector can however stimulate other more or less related industries to grow in the area (Ørstavik 2004), i.e. through the contribution to the development of regional innovation systems (Asheim and Coenen 2005), including developing knowledge intensive service activities (Aslesen and Isaksen 2007).

However, some countries governments have reacted to this situation and placed demands on large producers (Huemer 2010). In the case of Scotland, this has led to significant investment in infrastructures like improved roads, schools and other facilities (Georgakopoulos and Thomson 2008).

In Norway, there has been frustration in many coastal communities in the latter years, as increased ownership concentration and centralization of production have excluded many of them from the benefits generated by the aquaculture activities and production chain (Huemer 2010; Sandberg 2003; Isaksen and Mikkelsen 2012).

Thus, the rules of aquaculture that evolved over the past decades, based on notions of 'managing' marine resources for aquaculture practices, were almost all oriented toward determining who could gain access to a certain marine area and how much they would be taxed (see e.g. salmon aquaculture tax practices in Norway, Isaksen and Mikkelsen 2012).

8.2.6 Effects on Cultural Fabric and Other Social Aspects

Socially-sound aquaculture development relies on the understanding of two fundamental aspects: (A) the conditions that aquaculture operates under and (B) the mechanisms and channels by which aquaculture affects the social fabric. The latter term encapsulates the social context-specific setting in a particular ecosystem with its respective people and their attributes, e.g. knowledge holders, right holders, access to power holders, gender and institutions, among others (Krause et al. 2015). Indeed, all across human history and geography, people have perceived, lived, used and explored marine resources in coastal lagoons and bays, estuaries and shores, which conducted to changes in those habitats and their natural populations. Consequently, coastal communities changed their values and perceptions of the sea, as well as their way of living and of using natural resources. Thus, advancing change within any civilization does not occur in a vacuum, but rather must evolve out of the given circumstances and discourses that prevail. For instance in western civilization, we cannot think of culture without considering the context in which products and goods are produced, mediated, and consumed over time. Thus, aquaculture as culture exists in relationship to broader societal discourses that evolve across different scales, from interpersonal and group relationships to mainstream media discourses (Bell-Jordan 2008; Fiske 1987; Rosteck and Frentz 2009).

New aquaculture industries, especially in rural areas, should strive to integrate into the cultural fabric of the local community (Burbridge et al. 2001). This is paramount consideration, i.e. if an aquaculture industry develops successfully in a region or community that has previously been dominated by other types of industries, it can alter the very image of what the region, community and its inhabitants “is”. This can be because the base economic activity has been a fundamental factor for the identity of the community and its inhabitants, be it fisheries, tourism, agriculture or something else. It can be because aquaculture introduces new and very visible landscape elements, and a third possibility is that in-migration substantially alters the cultural mix in the community population. Furthermore, gender issues, like the opportunities for increased women participation and responsibility in the labor market through aquaculture development may gain more prominence. However, this seems to primarily have been an issue for developing countries (Veliu et al. 2009; Ndanga et al. 2013).

How aquaculture development and planning processes are organized may also affect learning among and between stakeholder groups. Leach et al. (2013) examine qualities in aquaculture partnerships in the US that enhance knowledge acquisition and belief change, and these include procedural fairness, trustworthiness among participants, diverse participation and the level of scientific certainty. Their work also indicate that knowledge acquired through collaborative partnerships make the participants primed to change their opinions on science or policy issues. Stepanova (2015) find that knowledge integration and joint learning are crucial for conflict resolution over coastal resource use.

8.3 Current Knowledge on Socio-economic Effects of Offshore Aquaculture

Having briefly presented the general types of socio-economic effects of aquaculture, we will review the current knowledge of the socio-economic effects of offshore aquaculture. Hereby we specifically review existing, rather limited, knowledge on the socio-economic dimensions of offshore multi-use. However, we believe that it is likely not be a very large difference of the socio-economic categories mentioned above pertaining to the relevant aspects for offshore aquaculture in a multi-use setting.

For instance, summarizing several stakeholder analyses for offshore aquaculture, Krause et al. (2003, 2011) and Wever et al. (2015) showed that there are different types of actors involved in the offshore realm than in near-shore areas. Due to this, different types of conflicts, limitations and potential alliances surface. These root in the essential differences in the origin, context and dynamics of near-shore—versus offshore resource uses. For instance, the near-shore areas in Germany have been subject to a long history of traditional uses through heterogeneous stakeholder groups from the local to national level (e.g. local fisheries communities, tourism industry, port developers, military, etc.), in which traditional user patterns emerged over a long time frame. In contrast, the offshore areas have only recently experienced conflict. This can be attributed to the relatively recent technological advancements in shipping and platform technology, both of which have been driven by capital-strong stakeholders that operate internationally. Whereas there is a well-established organizational structure present among the stakeholders in the near-shore areas in terms of social capital and trust, as well as tested modes of conduct and social networks, these are lacking in the offshore area. Indeed, for the latter, a high political representation by stakeholders is observed, that possess some degree of "client" mentality towards decision-makers in the offshore realm. It implies in this context that financial powerful and political influential «newcomers», such as offshore wind farm operators, effect the political and economic environment in providing favorable operation conditions (Krause et al. 2011; Griffin et al. 2015).

These fundamental differences between the different stakeholders in near-shore and offshore waters make a streamlined approach to multiple use or conflict management difficult. The results of the survey of stakeholders in Krause et al. (2011) indicate the importance of the social context for how various mariculture-wind farm integration processes go forward, specifically regarding the various forms of ownership and management such a venture might take.

Thus, the effects covered in the offshore aquaculture studies mentioned above pertain mainly to the socio-economic typology realms of *Attitudes to and perceptions of aquaculture and its effects*, the *Effects on the wider economic and innovation system* as well as on the *Organization of and participation in planning for aquaculture* and, closely related to these, the *Effects on cultural fabric and other social aspects.*

A number of studies have considered the economic performance of various types of offshore aquaculture primarily from the farm or business side. Some also provide more general frameworks or analyses to the profitability of offshore aquaculture. All these contributions fits into the social typology category of *Direct benefits of aquaculture and their distribution*. Jin et al. (2005) provides a risk-assessment model of open-ocean aquaculture, and present a case study of farming of Atlantic cod farming in New England, USA. Knapp (2008a) provides an analytical approach to the economic potential of offshore aquaculture in the United States of America, while Knapp (2008b) consider the potential employment and income which might be created, directly and indirectly, from U.S. offshore aquaculture. Kim et al. (2008) investigate the investment decision of offshore aquaculture under risk, for Rock Bream aquaculture in Korea.[1] Kam et al. (2003) gave an early case study of offshore Pacific Threadfin aquaculture in Hawaii. Kim et al. (2008) considered the economic viability of offshore Rock Bream aquaculture in Korea, and later (Kim and Lipton 2011) provided a comparative economic analysis of inshore and offshore Rock Bream aquaculture in Korea. Kim (2012) provides an economic feasibility study of mackerel offshore aquaculture production in Korea (see footnote 1).

A recent study of the economic performance of Italian offshore mariculture by Di Trapani et al. (2014) evaluated the economic performance of an offshore production system for sea bass compared to an inshore one, based on interviews with actual, "representative" farmers. They compared the net present value, discounted payback time, and the internal rate of return. They found better economic profitability of offshore farming than inshore, even if sensitivity analysis revealed that financial indicators of both aquaculture production systems have been very sensitive to market condition changes. They also ran Monte Carlo simulations to test the robustness of their analysis. They concluded that an "offshore production system could represent an opportunity for fish farmers to increase their profitability, obtaining a more sustainable production and avoiding possible conflicts with other human activities in coastal areas." The authors have, however, not specifically investigated possible conflicts with other activities, only the financial performance.

A few scientific contributions have considered the legislative side required for offshore aquaculture in various countries, fitting into the social dimensions type *Organization of and participation in planning for aquaculture*. Stickney et al. (2006) considered the interest in open ocean aquaculture in the USA, the regulatory environment, and the potential for sustainable development. They concluded that in the time of their study there was little interest in commercial offshore aquaculture, largely because of the lack of a formal regulatory structure. Cicin-Sain et al. (2005) in a technical report considered requirements and proposed a legislative framework for offshore aquaculture in the USA, including planning and site assessment, leasing and permitting for sites, and monitoring and compliance and enforcement. They briefly also considered the economic potential and possible environmental effects. Forster (2008) tried to answer the question "What new law, if any, is needed

[1]Paper in Korean, abstract in English.

to enable private farming in marine public lands?" with the USA as the empirical reference. Cha et al. (2009) studied legislation and planning for offshore aquaculture in Korea (see footnote 1).

It seems common to assume that moving aquaculture further offshore will reduce the conflicts with other users. Some papers have tried to investigate this, in particular to fisheries. These papers consider many more interactions than just competition over ocean space. Knapp (2008b) considers, for the USA only, potential impacts of market-driven changes from offshore aquaculture prices and production volumes of wild and farmed fish, and the subsequent changes in net economic benefits to fishermen, and also fish farmers and consumers.

Valderrama and Anderson (2008) include several other mechanisms for interaction, and point to a number of ways that modern coastal aquaculture has affected fisheries, and through which also offshore aquaculture could make an impact. They believe that the largest influence of aquaculture on wild fisheries has probably occurred through international trade and the market, having: "(a) influenced prices negatively through increased supply and positively through the development of new markets; (b) changed consumer behavior; (c) accelerated globalization of the industry; (d) increased concentration and vertical integration in the seafood sector; (e) resulted in the introduction of new product forms; and (f) significantly changed the way seafood providers conduct business." They find that the growth of aquaculture has stimulated the traditional wild fisheries sector to improve product quality, and in some cases also wild fisheries management to improve. But the success of the aquaculture sector has also lead to attacks from the fisheries sector—and environmental organizations—which Valderrama and Anderson (2008) link to the establishment of international trade restrictions, for example for salmon, shrimp and catfish. While some of the interactions and effects fit into the social typology category of *Negative effects of aquaculture production activities and conflicts with other interests*, some also relate to *Effects on the wider economic and innovation system.*

Valderrama and Anderson (2008) also consider environmental interactions. They sum up that "aquaculture has: (a) directly influenced fish stocks through its use of wild fish stocks for inputs, such as feed and juveniles; (b) influenced fish stocks through intentional releases (salmon stock enhancement) or through unintentional escapes; (c) displaced wild fish through its use of habitat and, in some cases, enhanced fisheries habitat (e.g., some oyster operations); and (d) influenced and been influenced by wild fish stocks through transmission of diseases and parasites." This mainly fits into the social typology categories of *Negative effects of aquaculture production activities and conflicts with other interests.*

In a recent study, Tiller et al. (2013) used systems thinking and Bayesian-belief networks approach to investigate how offshore aquaculture developments in California can impact commercial fishermen. The scientists arranged a workshop with 10 commercial fishermen where they presented 7 pre-selected drivers for how offshore aquaculture could affect the fishermen. These drivers, e.g. such as "the quantity of farmed seafood released to the market", were defined as "variables that influence other variables, but are typically not affected themselves, within the stakeholder's sector" (Tiller et al. 2013). During the workshop the participants nominated Marine Spatial Planning (MSP) as an additional driver. They even coined it a "super" driver, and felt it necessary as a pre-condition for the discussion as a whole. The exercise Tiller et al. (2013) conducted was thus to explicitly identify what attitudes and risk perceptions stakeholders have for offshore aquaculture. The concrete risks or effects they identified were, among others, related to loss of income, to extra costs incurring due to loss of gear, and to being excluded from the fishing grounds. All the effects they considered fit in the social typology category of *Negative effects of aquaculture production activities and conflicts with other interests*.

Forster (2008) sets out to tackle some broader issues related to offshore aquaculture, including how the potential of offshore aquaculture fit into the bigger picture of global food supply, how the assessed long term potential of offshore aquaculture may be important in evaluating current efforts to get it developed, and how offshore aquaculture should be judged in comparison to other methods of food production.[2] He looked into the anticipated future need and demand for food and hence seafood, but also into other ways of making more productive use of the sea, including for energy production and animal feed. He further discussed some of the criteria to assess the sustainability of offshore aquaculture, as well as some of the major substantial issues. Thus, his deliberations point out to the typology item *Effects on the wider economic and innovation system.*

Lastly, a recent study by Ferreira et al. (2014) in southern Portugal investigated interactions between inshore and offshore clam aquaculture through a modelling framework. This enabled them to consider production volumes in the two contrasting aquaculture settings, as well as the environmental effects and disease interactions between them. They could show that whilst the inshore aquaculture activity targets clams of high value, a substantial part of the primary production which is food for the clams originates from the offshore. The offshore area has one of the world's first offshore aquaculture parks, 3.6 nm from the coast. The park has 60 leases for aquaculture production, 70% for finfish cage culture and 30% for bivalve longline culture, covers 15 km^2 and is at 30–60 m depth. Ferreira et al. (2014) found that the bivalve offshore production has caused a decrease of clam yields inshore. While this is replaced by the yields offshore, it is a source of stakeholder conflict. The authors' modelling of potential disease spread between the offshore and inshore systems made it possible to develop a risk exposure map. The authors argue that such quantitative models of interactions, including reduced yields for inshore stakeholder, demonstrate a need for "strong governance to offset disease risks", and they stress "the need to go beyond the conventional spatial planning toolset in order to ensure an ecosystem approach to aquaculture." These findings fit into the social typology categories of *Direct benefits of aquaculture and their distribution*; *Negative effects of aquaculture production activities and conflicts with other interests.*

[2]He also considered legislative issues, as noted earlier.

8.4 Implications for Assessing the Socio-economic Effects of Offshore Aquaculture in a Multi-use Setting

Combining offshore aquaculture with other activities, such as offshore wind farming, is an opportunity to share stakeholder resources and can lead to greater spatial efficiency in the offshore environment. However, next to the apparent questions on the biological and technical nature of how to link these activities, these prospected challenges endorse that the participating social actors will have to negotiate agreements and management regulations for elaborating and coordinating their individual tasks (Michler-Cieluch and Krause 2008).

So far, the main motivation to undertake this multi-use efforts in the offshore aquaculture sector can be attributed to the assumed positive socio-economic effects that such an approach, in which resources and activities are shared and managed jointly, may hold. Indeed, the decision to partner with mariculture firms may be primarily motivated by cost considerations for wind energy firms (Reith et al. 2005; Griffin and Krause 2010). Thus, in an offshore setting where many users are competing for space, allowing the concurrent use of a wind farm for mariculture may provide a dual benefit to wind energy producers and aquaculture (Krause et al. 2011). The benefits can be large when firms coordinate core skills to form an alliance with unique capabilities that neither partner could efficiently provide alone. For instance, Michler-Cieluch and Krause (2008) showed that there is scope for such wind farm-mariculture cooperation in terms of operation and maintenance activities (Table 8.1).

This assessment points out to the strong role of attitudes towards offshore aquaculture that act as building blocks to engage and act in a multi-use context. These relate directly to the question of acceptance, the prevailing mental-mind models of stakeholders and the probability of joint action. Indeed, pre-existing

Table 8.1 SWOT-Matrix on potentials and constraints factors of multi-use approaches in offshore aquaculture and wind farms (modified from Michler-Cieluch and Krause 2008)

	Potential	Constraint
	Strengths	Weaknesses
Internal	Development of a flexible, collective transportation scheme Sharing of high-priced facilities Shortening of adaptive learning process by making use of available experiences and knowledge	Little to no interest in joint planning process Little willingness to engage into new fields of activity Ambiguous assignment of rights and duties
	Opportunities	Threats
External	Available working days coincide Availability of a wide range of expertise Lack of legislation in EEZ favors implementation of innovative concepts	Lack of regulatory framework supporting co-management arrangements No access rights within wind farm area for second party Unsolved problems of liability

social networks can provide significant political leverage for governance transformations as required for the move offshore. Moving beyond sole offshore operation and maintenance aspects of multi-use offshore aquaculture, our proposed first typology of socio-economic effects of aquaculture points to this aspect.

This typology aims to capture the socio-economic consequences and effects of aquaculture, and more specifically offshore aquaculture. We have analyzed the current knowledge of such effects for offshore aquaculture, including in a multi-use setting. The socio-economic dimensions of offshore aquaculture in the existing literature relate primarily to *Attitudes and perceptions of stakeholders*, *Organization of and participation in planning for aquaculture*, *Direct benefits of aquaculture*, and *Negative effects of aquaculture production activities and conflicts with other interests*.

In regard to our proposed typology, we can detect considerable knowledge gaps in all the different socio-economic dimensions. Most noteworthy are the gaps to the specific multi-use issues of offshore aquaculture. Questions on who will benefit on which level to which degree, who takes the burden of the associated risk, and who can be made liable if a multi-use concept affects others in the offshore realm remain to be addressed in more detail. Next to the yet emerging body of literature on the multi-use of offshore waters for aquaculture, the current situation demonstrates clearly that within the vast variety of regulations inside the EU, the EU Member States as well as in North America, their implementation is as yet incipient and examples of best practice in multi-use settings are needed (Krause et al. 2011). These need to combine different knowledge systems (e.g. authorities, decision-makers, local communities, science, etc.) to generate novel insights into the management of multiple uses of ocean space and to complement risk-justified decision-making.

Hence, social and regulatory issues will play a significant role in fostering or hindering collaboration (Christie et al. 2014) for offshore aquaculture in both single and multi-use settings. Given the significant volume of subsidies already used to promote wind energy and smarter use of offshore resources, relatively modest technical or financial support for co-production could provide the catalyst to more fully scope this idea and hopefully move the focus of marine spatial planning a little closer to collaborative solutions (Griffin et al. 2015). In this regard, building partnerships amongst actors and increasing 'social capital' can be a way forward in multi-use offshore aquaculture. Localizing activities in marine spatial planning involves organizing a knowledge base of particular social, cultural, ecological and economic values related to the context of each marine activity. As most offshore aquaculture in a multi-use setting will take place beyond national jurisdictions (although still in the EEZ), a debate on who decides on the future of the sea and what criteria are used to take such decisions remains to be worked out. Indeed, unresolved issues of ownership of the process, i.e. which stakeholders are involved in the consent procedure and their relative influence appear to be crucial (Krause et al. 2015). Furthermore, socio-economic dimensions in aquaculture operation, e.g. emotional ownership of the sea/coastal area by the local residents/stakeholders and the social values that drive this ownership are difficult to capture in such remote offshore settings.

In addition to the issues of how to undertake a streamlined socio-economic assessment based on the suggested typology, scale issues of the effects of multiple-use activities need to be addressed. Indeed, the appropriate scales to analyses the effects and interactions of offshore aquaculture naturally depends on how far different effects extend and how they interact in a multi-use setting. Engaging in offshore aquaculture production, larger scales are required to understand the *context* in which the activity works and the smaller scales support our understanding of the underlying *mechanisms* of the respective aquaculture operation. The necessary interconnectedness of the different scales and time frames needs therefore to be captured by a multi-layered approach (Krause et al. 2015).

8.5 Outlook

Especially for offshore aquaculture in a multi-use setting, we need to be more specific to identify and to articulate societal choices and their related values that build the foundation of the decision to move offshore in a sustainable manner in the first place. This directly frames the socio-economic effects of such activity. The typology of socio-economic dimensions of aquaculture presented in this chapter can be regarded as a first step to capture these societal values and thus remains to be worked out in more detail for their implications for offshore aquaculture. It must be verified with the emerging body of insights and growing experience on how this new form of marine resource may develop in the future.

The present practice involves the political allocation of ocean space for specific purposes only, which leads to a complex mix of ownership, associated commons and private property. Depending on the activity, these contain very different customary and statutory rules and regulations, in which we can detect a "failure of understanding" the socio-economic effects on offshore marine resource use by and large. Indeed, questions as "how *should* the socio-economic dimensions of offshore aquaculture be captured and interpreted?", and How *can* it be managed, and what are the major challenges for efficient sustainable management?" point to existing knowledge gaps and opens up the arena for discussion on what is required to address the socio-economic dimensions of offshore aquaculture.

This current gap between oceans as common and oceans as private property as well as diverging views and pictures leads to a contested sea space. In multi-use settings, these are especially important to address at the interface of policy, research and practice. There is a high risk of failing in integrating offshore aquaculture within the emerging marine management regime. What is at odds is the balanced management of the politically powerful vs. newcomers. Critical for dealing with the whole breadth of socio-economic issues in offshore aquaculture are the further development of suitable and robust methods. These are necessary for analyzing and assessing the cultural fabric and other social aspects that may be impacted through offshore production systems, as well as generating insight on what effects we can expect on the wider economic and innovation systems involved therein.

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