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Too important to fail? Evaluating legal adaptive capacity for increasing coastal and marine aquaculture production in EU-Finland

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ABSTRACT

This article analyses the legal adaptive capacity for increasing sustainable fish aquaculture production in EU-Finland. Currently, fish aquaculture is driven by increasing global demand of fish, declining natural fisheries, food security and blue growth policies. At the same time, environmental policies such as the EU Water Framework Directive and the Marine Strategy Framework Directive set tightening legal-ecological requirements for the industry's nutrient emissions. Against this background, the success of blue growth policies related to aquaculture – and the hope of reconciling competing interests at sea – boil down to measures available for dealing with excess nutrients. In line with the mitigation hierarchy, the article establishes four alternative pathways for the fish aquaculture industry to grow without increasing its environmental nutrient footprint significantly, and evaluates the legal adaptive capacity and the legal risks attached to these pathways.

1. Introduction

In 2017, fish accounted for roughly 17% of global animal protein intake [1]. In 2014, for the first time in history, the aquaculture sector produced more fish for human consumption globally than wild-caught fisheries [1]. The relative rise of aquaculture in fish production is the result of several factors. The global per capita consumption of fish and the global human population have both more than doubled between 1965 and 2015 [1,2]. Simultaneously, fish stocks have in many parts of the world reached the limits of sustainability [1]. The role of aquaculture in global fish production is likely to increase in the future as recent estimates show that increases in the global mean temperatures and overharvesting will likely result in diminishing wild fisheries (e.g. Ref. [3].

Also food security and blue growth policies are driving aquaculture. In the EU, there is an eight million tonne gap between the consumption and production of fish [4]. This has resulted in major imports of cultivated fish originating outside of EU [4]. With increasing demand on global fisheries and the need to support food security and blue economy in the EU member states, the EU Commission has set a goal for increasing aquaculture production significantly (Blue Growth Agenda, [5]. The Finnish Bioeconomy Strategy shares these goals by aiming at a substantial increase in domestic fish aquaculture production in the near future [6]. At the moment, the Finnish aquaculture sector produces annually 14.6 million kilograms of food fish, of which some 85% is produced in the Baltic Sea [7]. Against this background it is justified to ask whether the development of aquaculture industry is too important policy goal to fail on environmental grounds?

Pressures to increase aquaculture production significantly in the Baltic Sea pose a significant environmental problem: many coastal waters most favourable to aquaculture are in ecologically poor or moderate condition, and the most commonly used open-net rearing units cannot escape significant nutrient discharges to the sea [8,9]. The Baltic Sea's eutrophication status is already at a critical level, and one can argue that the ecological resilience of this brackish, semi-closed sea cannot withstand an industrial scale increase in nutrients without transforming into eutrophic state even further [10,11].

The argument for managing the ecological resilience of the Baltic Sea from crossing unwanted thresholds is backed by heavy legal artillery, too. At present, the EU Water Framework Directive (WFD, 2000/60/EC) sets a binding legal obligation for the member states not to authorise projects that may deteriorate the ecological status of coastal

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waters or jeopardise the achievement of Good Water Status in waters up to 1 nautical mile from the baseline as set by the UN Law of the Sea Convention.[1] Similarly, the Marine Strategy Framework Directive (MSFD, 2008/56/EC) aims at Good Environmental Status of marine waters beyond the one nautical mile mark. Moreover, and implementing the goal set in the MSFD, the Baltic Sea Action Plan (BSAP) devised under the Helsinki Convention[2] aims at Good Ecological Status of the Baltic marine environment by 2021. In the aggregate, these ecological goals present significant legal challenges for increasing nutrient loads in the EU member states around the Baltic Sea generally, and in Finland specifically. There is a need to decouple the growth and nutrient emissions of aquaculture operations.

This article analyses the adaptive capacity of the multi-level legal framework for increasing sustainable aquaculture production in EU-Finland. The guiding question is whether the current legal framework allows reconciling two competing policy goals, namely growing the aquaculture sector and reaching the good ecological status of coastal and marine waters.

The structure of the article is as follows. Section 2 lays out the theoretical framework for evaluating legal adaptive capacity. Section 3 analyses the adaptive capacity of the current multilevel regulatory framework applicable to coastal and marine aquaculture. As unfettered Blue Growth in the aquaculture sector faces significant legal obstacles, section 4 analyses the possibilities for avoiding, minimising, remediating and offsetting fish aquaculture sector's nutrient emissions. We conclude that growth needs to be reconciled with legal-ecological requirements but there are some technological and social innovations developing within the industry that hold a promise for realising this.

2. Adaptive law as a theoretical framework

Resilience is often defined as a characteristic of a system that can respond and has the capacity to adapt to changing circumstances without losing its core functions [12,13]. The Baltic Sea is a dynamic social-ecological system that is due to human impact (mainly agriculture and forestry) transforming to a eutrophic state which would disturb the sea's core functions and drastically decrease the amount of ecosystem services provided by the sea [14]. Even though resilience is at its core a descriptive concept (a characteristic of systems) – and not all resilience in all the systems is desirable – the concept often has normative implications in legal contexts [15,16].

One – although incomplete – answer to the question of why the regulation and management of social ecological systems needs to be adaptive is that the systems are constantly changing, and there are considerable gaps and uncertainties in the human understanding of these systems [17,18,19]. These uncertainties may be caused by the lack of scientific data, economic and social risks, and the dynamic and complex nature of social-ecological systems [16,19]. The constant changes and uncertainty need to be taken seriously, and regulated accordingly [20,21]. Governance in general and law in particular must be on one hand strict enough to protect desired ecosystems functions, and at the same time loose enough to allow social adaptation to constant changes in social-ecological circumstances in which legal rules are applied. Law needs adaptive capacity for managing the ecological resilience of the Baltic Sea effectively [22].

In the context of complex and ever-changing social-ecological systems, such as the Baltic Sea, actions impacting the ecological resilience of the sea must be steered with an ecosystem approach in mind and considering the legal-ecological objectives set in international and EU law. First, this merits a precautionary approach to management and governance of nutrient pollution [23–25]. As changes in ecosystem functions can be abrupt and hard to reverse, it makes sense to create buffers in support of the Baltic Sea's ecological resilience. Second, the dynamic nature of the Baltic Sea ecosystem merits adaptive management which requires, among others, setting goals for ecosystem status, constant monitoring of the sea's ecosystems, setting measures to support and improve ecosystems functions, and iterative revision of the above process [23–26].

The EU Water Framework Directive and the Marine Strategy Framework Directive are based on the adaptive law theory [22]. They establish an ecosystem approach with precautionary principle and adaptive management at the core of their operation. After the Court of Justice of the European Union (CJEU) issued its Weser ruling in 2015, the adaptivity of the framework has been questioned [27]. In the ruling, the Court established Good Ecological Status and non-deterioration as legally binding goals of the directive in permitting new operations. This formalisation of the WFD's objectives may cause significant side-effects in the Baltic Sea context, if too much weight is given to individual projects, individual water bodies and individual ecological quality elements instead of taking a systems perspective, i.e. evaluating the overall ecological resilience of the Baltic Sea [28]. The formalisation of WFD's ecological objectives poses several tricky questions for reconciling conflicting policies, such as water and marine policy, blue growth, food security and the vitality of European fish stocks.

Next, the article analyses the formalisation of EU's water, coastal and marine policy in more detail, after which section 4 delves into the tools with which the conflict between the effective management of ecological resilience of the Baltic Sea and the EU Blue Growth policy could be untangled at the national level in Finland.

3. Legal frameworks for regulating aquaculture in EU-Finland – the end of industry growth scenarios?

3.1. Water Framework directive

The EU Water Framework Directive requires all the EU member states to reach Good Ecological Status of inland surface waters, transitional waters, and coastal waters by 2015, or if postponed, by 2021, or 2027 the latest (WFD art. 4.1; [29]. Simultaneously, these waters are regulated by the non-deterioration clause, which requires EU member states to implement all necessary measures to prevent further deterioration of water bodies in their territory (WFD Article 4.1(a) (i); 4.1(b) (i)).

The assessment of ecological status is primarily based on three or four Biological Quality Elements, depending on the water body in question. In coastal waters, the evaluation is based on the following criteria: 1) Composition, abundance and biomass of phytoplankton; 2) Composition and abundance of macroalgae and angiosperms; and 3) Composition and abundance of benthic invertebrate fauna. Good Ecological Status requires, on a general level, that the Biological Quality Elements show only a low level of distortion resulting from human activity (WFD Annex V).

Also, physico-chemical and hydro-morphological quality elements must be considered in the assessment of ecological status. This assessment must include the following elements: 1) evaluation of the tidal regime; 2) morphological conditions; 3) temperature, oxygenation conditions and transparency; 4) nutrient conditions; and 5) specific synthetic and non-synthetic pollutants. All the physico-chemical and hydro-morphological quality elements must be at a level required to “ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements” (WFD Annex V).

According to the 2015 Weser ruling (C-461/13) of the European Court of Justice, the member states are required – unless a derogation is granted – to refuse authorisation for any project that may cause

[1] United Nations Convention on the Law of the Sea, Montego Bay, 10 December 1982, in force 16 November 1994, 21 International Legal Materials (1982) 1261.

[2] Convention on the Protection of the Marine Environment of the Baltic Sea, in force 17 January 2000.

deterioration of the status of a water body or jeopardise the attainment its status objectives. Perhaps surprisingly, the Court also linked this deterioration to individual quality elements instead of the overall water quality status by stating that deterioration occurs as soon as the status of at least one quality element falls by one class. In other words, the Court clarified that the environmental objectives of the WFD are legally binding on the member states when permitting new developments and a drop in any Biological Quality Element is considered an infringement of the Directive (see also [27]. Overall, the WFD's environmental objectives have become more binding than originally expected [30]; [26,31,32]. Since the Weser ruling, for example the Swedish courts have set strict limitations for fish farming and denied permits for open-net fish aquaculture operations [33].

In the Weser-ruling, the Court also hinted at a possibility to deploy project-specific exemptions ("unless a derogation is granted") as stated in Article 4 (7) of the WFD. The use of exemptions was further clarified in the 2016 Schwarze Sulm case (C-346/14, paras 69–73) in which the Court stated that the construction of a rather small hydropower operation could be granted a water permit and an exemption under WFD Article 4 (7). The Court referred to the EU renewable energy policy and stated that the member states must be allowed a certain margin of discretion in evaluating project-specific exemptions as stipulated by the WFD.

At a first glance, it seems that the Schwarze Sulm case left a wide margin of discretion for the member states to use exemptions to permit individual projects that are in the public interest. Similarly to the renewable energy policy referred to in the ruling, growth in blue bioeconomy could also be considered a public interest promoted by the EU and Finnish maritime policies, as explained in the introduction.[3] The big difference between the two policy umbrellas, however, is that in the aquaculture sector the possibilities to utilise the WFD exemption regime are, due to the scope of application of Article 4 (7), far more limited than in permitting hydropower.

The use of exemptions to permit fish farming in EU member states' coastal waters is challenging, first of all, because Article 4 (7) does not allow an exemption for polluting activities that would lower the ecological quality of a water body (or, in light of the Weser ruling, any of its quality elements) in less than good status [34]. Only 25% of the Finnish coastal waters are in good status and none are in high status [10]. Secondly, while the Court stated in the Schwarze Sulm case that member states have a certain margin of discretion in evaluating exemptions, the conditions for exemptions are still rather demanding. Article 4 (7) requires that 1) all steps are taken to mitigate the adverse impact of a project; 2) there are reasons of overriding public interest and/or the benefits to the environment and to society of achieving the environmental objectives are outweighed by the benefits to human health, human safety or sustainable development; and that 3) there are no other means, which are significantly better for the environment, to achieve the beneficial objectives of a project. At the very least, all options such as (re)locating aquaculture facilities inland (closed loop technology), further offshore as well as nutrient remediation and offsetting should be fully considered before an exemption may be granted.

3.2. Marine Strategy Framework Directive and the Baltic Sea Action Plan

The legal framework applicable beyond coastal waters (here: the one nautical mile mark from the baseline) sets somewhat similar obligations to the Water Framework Directive discussed above. The Marine Strategy Framework Directive requires member states to achieve Good Environmental Status of their marine waters by 2020 (MSFD Article 1 (1)). The ultimate goal of the directive is to maintain biodiversity of the seas that are clean, healthy and productive, and to secure sustainable use of the European seas (MSFD Preamble 3 and 4). The main driver for adopting the directive was to prevent a significant deterioration of the marine environment [35], which, in turn, would jeopardise the very basis on which a large part of the European blue economy stands. The Commission has emphasised that in all community and state actions, priority should be given to achieving or maintaining the Good Environmental Status (MSFD Preamble 8).

The Good Environmental Status is defined by the following factors: 1) biological diversity; 2) the level of non-indigenous species; 3) populations of commercial fish and shellfish; 4) elements of marine food webs; 5) eutrophication; 6) sea floor integrity; 7) alteration of hydrographical conditions; 8) contaminants; 9) contaminants in fish and seafood for human consumption; 10) marine litter; 11) introduction of energy, including underwater noise (MSFD Annex I).

MSFD seeks on one hand to fulfil its obligations under general international law. On the other hand, it relies on the regional seas conventions to implement the Directive's ecological goals [35]. In the Baltic Sea, the relevant regional seas convention is the Helsinki Convention on the Protection of the Baltic Sea. The convention establishes in Article 3 that "the Contracting Parties shall individually or jointly take all appropriate legislative, administrative or other relevant measures to prevent and eliminate pollution in order to promote the ecological restoration of the Baltic Sea Area and the preservation of its ecological balance". This legal goal is further clarified in the Baltic Sea Action Plan which states as its goal, among others, that the Baltic Sea should be unaffected by eutrophication meaning a return to "natural" levels of oxygen and algae [36]. The Helsinki Commission is developing basin specific maximum allowable input (MAI) levels and country-allocated reduction targets (CART) [37]. Although these mechanisms do not have clear legal implications, they pinpoint the importance and help quantify the need for reducing the overall levels of nutrients in the Baltic Sea. This target does not mesh well with policy goals seeking to increase traditional open-net aquaculture.

Although the goals of the WFD and the MSFD sound quite similar, there are significant differences between the two directives [22]. First, the WFD is much more precise and leaves less discretion for the member states to define what good ecological/environmental status means. Second, the WFD contains a precise exemption regime discussed above, while the exemptions in Article 14 of the MSFD are more vaguely worded. This may be taken to imply that the ecological goals of the MSFD are not considered as binding as those set in the WFD. Finally, and in contrast to the WFD-system, the CJEU is yet to rule on the legal nature of MSFD's goals. Arguably, the goals have some legal-normative effect but, while writing this, it is anyone's guess what kind and how much. In conclusion, the ecological goals applicable to the coastal waters enjoy strict legal protection whereas the ecological goals applicable to marine waters are on a significantly weaker standing.

3.3. Regulation of aquaculture in Finland

The effectiveness of Good Ecological/Environmental Status depends heavily on national implementation and enforcement. In Finland, aquaculture operations need two main permits, one for controlling environmental pollution and another for controlling hydro-morphological changes to the water body in question. According to section 27 of the Environmental Protection Act of Finland (EPAF, 527/2014), operations causing risk of environmental pollution need a permit from a Regional Administrative Authority (state authority). This permit obligation applies to all fish farms that utilise at least two tonnes of fish fodder or equivalent annually, and operations in which the annual growth of reared fish is more than two tonnes (EPAF Annex I). In addition, according to chapter 3, section 2 of the Water Act of Finland (WAF, 587/2011), fish farms require a water management permit from the Regional Administrative Authority for locating the rearing units in coastal and marine waters. Both legal regimes, which are procedurally combined, apply to all inland, coastal and marine waters alike.

[3] On the close relationship between article 4(7) derogations and the EU sector policies see Ref. [34].

As a general rule, an environmental protection permit is granted provided that the operation does not cause a health hazard, or significant pollution of the environment (EPAF section 49). According to the Water Act, a water management permit is granted provided that the benefits to public and private interests outweigh the harm to these interests (WAF chapter 3, section 4). The significance of pollution under the Environmental Protection Act and the weight of harm and benefit under the Water Act are partly evaluated against the Water and Marine Management Plans as established by the Water Framework Directive and the Marine Strategy Framework Directive [31,38]. When interpreted in light of the CJEU Weser ruling, this means that an environmental protection permit or water management permit should be denied if the proposed project risks deteriorating ecological quality elements in the Finnish coastal waters (Weser C-461/13; Finnish Supreme Administrative Court 14.2.2018 t. 608; [39]. In marine waters, legal prerequisites for permitting are more uncertain since the environmental targets of the MSFD are not as specific as the environmental objectives of the WFD, and the CJEU is yet to rule on their bindingness.

Overall, there is a broad consensus that environmental and water management permits should be denied if the planned operations are not in compliance with EU law. The environmental objectives of WFD Article 4 (1) are legally binding and may significantly restrict aquaculture permitting in the Finnish coastal waters. Moreover, exemption from the non-deterioration clause established in WFD Article 4 (7) can hardly be used to allow aquaculture due to the provision's limited scope of application. Therefore, in the current legal framework, quite often the only possibility for growing the aquaculture industry in coastal waters is to consider harm mitigation, minimisation, remediation and offsetting mechanisms that would neutralise the aquatic impact of fish farming. Although open net operations are still considered best available fish farming technology in Finland (Supreme Administrative Court 26.4.2018 t. 1953; Supreme Administrative Court 26.4.2018 t. 1948, 1949 ja 1950), this situation is unlikely to continue for long in light of the current EU and international legal frameworks.

There are four possible options for increasing aquaculture production sustainably in EU-Finland within the current legal-ecological requirements: 1) increasing aquaculture operations in closed systems and controlling the vast majority of nutrient output of these activities (avoiding nutrient pollution); 2) effective utilisation of fish feed and effective waste management combined with moving present open net aquaculture operations further offshore (minimising and relocating nutrient pollution); 3) remediating nutrient pollution caused by coastal aquaculture operations *in situ*; and 4) and offsetting nutrient pollution *ex situ*. Each of these alternatives, and their respective legal risks, will be discussed in the following section.

4. Four pathways of increasing legal adaptive capacity for sustainable aquaculture

4.1. Setting the scene: mitigation hierarchy in nutrient pollution

Fish farms have long been considered as harmful point sources of phosphorus and nitrogen, especially in the shallow coastal waters of the Baltic Sea (e.g. Refs. [40,41]. Nutrient rich waste consists of uneaten feed particles, faeces and metabolic waste products of the reared fish. As scientific and public understanding of these environmental impacts increased, an urgent call for novel solutions to mitigate the aquatic impacts of the industry was voiced [42]. Currently, such solutions can be categorized in several non-exclusive groups that include at least the sustainability of fish feed, efficient use of feeds, effective waste management, recirculation aquaculture systems (RASs), Integrated Multitrophic Platforms (i.e. aquaculture products and e.g. edible plants are produced in the same system) and flexible farming strategies, in which juvenile fish are reared inland in recirculation systems and then moved to pelagically floating sea cages offshore to be farmed into commercially utilisable size.

The above solutions for mitigating the environmental impacts of aquaculture vary along the mitigation hierarchy which consists of four sequential stages: 1) avoidance; 2) minimisation; 3) remediation and 4) offsetting (see e.g. Ref. [43]. The sequence of mitigation measures is hierarchical in the sense that harm avoidance and minimisation are primary to remediation and offsetting. This principle is well established in literature (e.g. Refs. [43–45], and also an established part of some branches of environmental law, such as EU nature conservation law (Habitats Directive Article 6 [46]; CJEU Briels C-521/12; Opinion of Advocate General Sharpston in C-521/12; [47].

Some elements of a mitigation hierarchy are also visible in the Finnish law regulating aquaculture. The Finnish Environmental Protection Act and the Water Act set general obligations for aquaculture operators to avoid and minimise environmental harm, but the law does not contain general obligations for remediation or offsetting (FEPA, Section 7; FWA, Section 2.7). With the technological developments and the increasingly intensifying legal-ecological requirements for achieving good ecological/environmental status of coastal and marine waters, the pressure for harm avoidance and minimisation on one hand, and remediation and offsetting on the other have increased. One may even argue, as is the case in Sweden, that traditional open net rearing units can no longer satisfy the EU and national legal requirements for aquaculture operations in coastal waters [33]. The Finnish courts will likely face similar questions in the not too distant future. In the current regulatory environment, the legal acceptability of aquaculture depends on how effectively it can avoid and minimise, or if these fail, remediate and offset the release of nutrients into coastal and marine waters. So far, the Finnish permit authorities and courts have been more liberal towards aquaculture than their Swedish counterparts [48].

4.2. Avoiding nutrient pollution: the promise of recirculation and closed-loop technologies

In an aquaculture context, the first stage of the hierarchy requires locating aquaculture operations inland and/or utilising technology capable of mitigating nutrient emissions close to zero. Recirculation aquaculture systems in general and closed loop systems specifically are currently the most realistic technologies capable of mitigating nutrient pollution at this level [49].

The recirculation systems operate by re-using waters several times and circulating it via mechanical filtration and cleaning tanks [49,50]. In theory, an optimal recirculating aquaculture facility would require minimal amounts of energy and clean water and would produce no nutrient discharge. As recirculating aquaculture tanks are often placed indoors, they have an advantage of producing fish throughout the year in controlled favourable conditions. Despite the promise of this technology, absolute closed circulation is not yet available but the need for new clean process water is often only one to two percent of the whole circulating water volume. Technologies are available for phosphorus and nitrogen removal but resolving full cost-effectiveness is still challenging [50,51]. The RASs need efficient oxygenation and are still associated with fairly high maintenance costs and energy consumption [49]. Closed systems may also suffer from aquatic pathogens and diseases and can thus lead to higher mortality losses [52]. Water quality can, however, be improved by adding UV-disinfection or peracetic acid treatment in the process.

So far, the recirculation technology has been generally too costly for mass production of standard food fish like rainbow trout in Finland. The cost efficiency of RAS-facilities may be improved by focusing on juvenile fish production or production of expensive delicacy fish products that have a high market demand. Despite challenges related to cost-effectiveness, Finland has witnessed some major investments in large scale recirculation units, a recent example being Finnforel Ltd's rearing unit in south-eastern Finland. This recently established unit takes advantage of a nearby Stora Enso company's pulp mill that produces warm water, inexpensive energy and provides access to associated large-scale wastewater treatment units for nutrients [53].

From a legal perspective (and with a focus on nutrients), advanced RASs are rather unproblematic as the technology allows for controlling and avoiding nutrient pollution very efficiently and effectively [49]. The biggest obstacle for a large-scale adoption of this technology are fairly high investment and energetic running costs of such operations [49]. Without a focus on high-priced species and access to inexpensive energy and waste-water treatment services, the operations would not be profitable in the current economy. For this reason, it is likely that open-net rearing units will maintain their role as the most commonly used fish farming technology in the near future. With this technology, the legal-ecological framework will, however, require harm minimisation, remediation and offsetting.

4.3. Minimising nutrient pollution

The second step of the mitigation hierarchy is harm minimisation. If nutrient pollution cannot be entirely avoided, spatial flexibility, technological innovations and other measures must be taken so as to minimise the release of nutrients to the aquatic environment [39,54]. Open net rearing units cannot by design prevent all nutrient slippage to the adjacent water body. With this technology, the source and efficient use of fish feed as well as effective waste-water management in rearing units can be used to minimise some environmental impacts of fish farming [54]. The source of the fish feed will likely play an increasingly important role in the future as collection of solid waste materials in net pen finfish farming is, at present, unpractical and expensive [55].

The above measures may also be combined with a flexible farming strategy, in which different life stages of fish are farmed in different locations. Flexible farming strategy is already commonly applied, and it often means that juvenile fish are first reared in inland hatcheries and then moved close to the shore or preferably offshore into deeper water [55]. This provides an effective way to decrease and cope with some of the local nutrient loads associated with aquaculture. The main idea in offshore fish farming is to dilute the nutrient discharge to a large body of water by placing the farming units away from the coast, and thus minimising the local impact and avoiding possible conflicts with the other coastal users (e.g. Ref. [55]. In contrast to oceans where immense water volume dilutes the nutrient discharges from aquaculture, the smaller and more shallow, semi-closed brackish bodies of water, like the Baltic Sea, often suffer from critical levels of eutrophication, and in these water-bodies point sources of nutrients can have a notable negative local impact [40]. This notwithstanding, nutrient discharge-related issues have been also reported in industrial scale salmon farming in oceanic coastal areas of Chile [56].

There are some drawbacks in offshore rearing as well. Offshore net pen aquaculture occurs often in deeper waters, which requires, for example, stronger anchorage, sturdier cage frames, as well as larger vessels, and incurs increased transportation costs for the operator (e.g. Ref. [55]. As a consequence, the size of economically viable fish farms increases in comparison to traditional operations. This is clearly visible with Laitakarin Kala company's fish farm in western Finland, which is projected to be the largest fish farm operation in Finland, if the operator is successful in securing environmental and water permits for the operation.

In Nordic countries, the winter conditions and pack ice pose additional challenges for the offshore farms. Moreover, species-dependent characteristics may affect the chosen farming strategy as some species, like the whitefish, may potentially be more sensitive to handling and are thus negatively affected by rough offshore caging conditions and transportation. Moreover, we note that offshore location of the farming activities does not *per se* affect the total nutrient loads imposed to the water body (if everything else stays equal), but it rather masks and dilutes the nutrient load and cuts down the local intensity of negative impacts caused by nutrients.

At present, the legal framework seems to provide flexibility in locating aquaculture operations outside the 1 nautical mile coastal margin, as long as the negative impacts of nutrients do not lower the coastal water quality elements discussed in section 3. In Finland, the harm minimisation measures discussed in this section have been considered as meeting the requirements of the Environmental Protection Act, the Water Act, and by implication the requirements of the Water Framework and Marine Strategy Directives [48]. If the scale of aquaculture grows, however, from the current situation by roughly 40% as is the current policy goal (from 14.2 million tonnes to 20 million tonnes by 2022 [57], harm minimisation measures discussed in this section will likely prove legally problematic.

The legal problems with relying on the current methods of harm minimisation stem from two directions. First, a substantial increase in fish aquaculture along the Finnish coast has potential to deteriorate the local coastal waters to such an extent that environmental permits must be denied in line with the WFD and the CJEU Weser ruling, even if sustainable fish feeds and advanced sludge removal and other waste-water treatment technologies are used. Second, locating the rearing units offshore cannot escape increasing the nutrient load of the Baltic Sea as a whole, although the local and more direct impacts are mostly mitigated with this approach. This is problematic within the framework of the Helsinki Convention and the Marine Strategy Framework Directive. Major investments in offshore aquaculture may prove a misguided step, if the marine ecological goals are deemed binding similar to the goals applicable to coastal waters, or if consumers start avoiding unsustainably reared fish. In the end, remediation and offsetting may be required even when locating the rearing units offshore, and certainly for rearing units operating on the coast.

4.4. Remediating nutrient pollution: Integrated Multitrophic Aquaculture

To the extent that the release of nutrients cannot be avoided or minimised, the nutrient footprint of aquaculture operations may be remediated within the project impact area. Integrated Multitrophic Aquaculture (IMA) is a good example of this approach [58,59].

Integrated Multitrophic Aquaculture is a potential way to limit nutrient and organic matter outputs through biomitigation. In IMA, different aquatic species are co-cultured in the same system and used as biofilters, and similarly to the aquaponic farming approach, the co-cultured species provide additional commercial value [58,60]. The main difference between the IMA and the traditional aquatic polyculture is the incorporation of species from different trophic or nutritional levels in the same system. Experiences from the marine environments from the last two decades clearly indicate that salmonid farming can be combined with the farming of filter-feeding mollusks (e.g. mussels and oysters) and seaweed, that act as extractors of inorganic and organic nutrients [60]. Suitable species for IMA in the Baltic Sea include blue mussel (*Mytilus edulis*) and zebra mussel (*Dreisena polymorpha*) as filter feeders and sea beech (*Delesseria sanguinea*) and sugar kelp (*Saccharina latissima*) as macroalgae components [61]. The promise of IMA notwithstanding, the efficiency and effectiveness of this approach is uncertain in the Baltic Sea's brackish water conditions.

From a legal perspective, remediation is a feasible approach in offshore areas as the objectives of the Marine Strategy Framework Directive are currently looser than those of the Water Framework Directive. In coastal areas, the legality of open net rearing and remediation depend on whether the nutrient loads impact the individual water quality elements of coastal water bodies. If the scale of the rearing unit is demonstrated to match with sufficient water circulation in the rearing area and remediation through the use of mussels or similar water filtering species, this approach constitutes a relatively safe alternative for the industry to deal with the current legal-ecological requirements. Scientific uncertainty regarding the remediation capacity of nutrient extracting species as well as the economic viability of matching the levels of nutrient emissions and remediation do, however, pose significant practical challenges to this approach.

4.5. Offsetting nutrient pollution outside the project area

Nutrient offsetting aims to neutralise the net environmental impact of aquaculture operation's nutrient loads by measures taken outside the immediate project area. Offsetting measures include using preferably local feedstuff (that is based on local aquatic organisms like Baltic herring-based feeds for salmonids) for fish farming, restoring and building wetlands to catch nutrients from other sources, such as agriculture, or reducing agriculture close to the coast [62].

Recently introduced commercial Baltic Blend innovation by Raisioagro company has taken an offsetting approach in the production of sustainable fish feeds. In this particular fish feed type, the nutrients come fully from fish oils and fish powders that originate in wild herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) that have been harvested from the Baltic Sea. In principle, use of this feed supports nutrient offsetting of the local aquaculture operations relying on such feed. A recent study demonstrates that a sustainable feed that is based on a protein mixture from the Baltic Sea sprat and herring, blue mussels (*Mytilus edulis*) and baker's yeast (*Saccharomyces cerevisiae*) could provide reasonable results in offsetting the nutrient impact of salmonid aquaculture [63]. Nutrient offsetting could include also compensatory payments from aquaculture operators to projects aiming to reduce the nutrient output stemming from agriculture close to the shoreline of the Baltic Sea, or even at a river basin scale. Also, restoration of nutrient-load-buffering wetlands provides one possible mechanistic way for nutrient offsetting [64].

From a legal perspective offsetting holds a lot of promise but some possible pitfalls as well. First, the current EU and Finnish legislation applicable to aquaculture does not recognise offsetting measures. Without an explicit reference in the law, it is uncertain how permit authorities will react to offsetting as a mechanism to reduce the overall nutrient impact of aquaculture operations [64]. Offsetting taking place outside the immediate project area faces additional legal challenges. The Finnish environmental permit system is based on an evaluation of local environmental impacts of aquaculture. Operations exceeding pollution control limits locally cannot obtain a permit regardless of their total net impact on the Baltic Sea. This limits the deployment of offsetting measures *ex situ*. Also the Water Framework Directive requires the Member States to prevent the deterioration of the ecological status of *each* coastal water body (WFD Article 4 (1)). Measures offsetting nutrient loading of an aquaculture operation in an *ex situ* water body (with no offsetting impacts in the water body where the impacts of aquaculture occur) does not meet the legal requirements set by the directive. In marine areas, these spatial requirements for possible offsetting measures are looser since the MSFD's environmental targets cover significantly larger geographical areas (whole marine regions or sub-regions, MSFD Article 10).

Second, a more principled problem with offsetting revolves around the legal-ecological goal to achieve Good Ecological/Environmental Status of the Baltic Sea as a whole. Although offsetting can go a long way in mitigating a major *increase* in nutrient levels, the bottom line is that the overall nutrient levels would need to follow a *declining* trend meaning that all new nutrient loading stemming from aquaculture would need to be offset in full, or even beyond this level. This in turn evokes a plethora of other legal questions, such as who should pay for reconciling food security and ecological water quality. If according to the latest science, the agriculture industry is the biggest emitter of nutrients to the Baltic Sea, is it in line with the EU treaties (TFEU art. 191 (2)) that aquaculture operators are required to *pay* agriculture operators to cut their emissions to make room for new aquaculture development? It seems that the multi-level legal framework would need re-designing in allocating mitigation, minimisation and offsetting measures within and between different nutrient-intensive sectors.

5. Conclusions and a way forward

Adaptive governance contains a conception of the law that is capable of dealing with changing social-ecological circumstances and facilitates the adoption of a systems perspective to environmental management. This article has sought to analyse the mechanisms with which the conflict between growing aquaculture and the ecological condition of the Baltic Sea could be unravelled in EU-Finland. After discussing adaptive law as a theoretical framework and the main international, EU and Finnish legal frameworks for regulating aquaculture, the article analysed four alternative strategies for solving the problem. Located along the mitigation hierarchy, these strategies contained closed-loop technologies, efficient use of fish feed and effective waste-water management, flexible farming strategies as well as several remediation and offsetting measures.

Each strategy has its own challenges. From an environmental perspective closed-loop technology is by far the most attractive alternative. Despite this, the technology is likely to become economically viable solution only if operated in tandem with other industrial operations producing inexpensive energy and access to waste-water treatment services. This is not currently realistic in all aquaculture production, but the situation can change rapidly in the future as we are already witnessing some promising examples of this technology.

Problems abound with the harm-minimisation route as well. The assumed environmental benefit of minimising nutrient pollution by locating open net aquaculture operations offshore is based on the idea that dilution of nutrients to a large body of water reduces the adverse environmental impacts to a minimal level. Environmental research challenges this view and, furthermore, the investment costs of offshore aquaculture are also high, which tends to increase the size (and the related nutrient impact) of fish farms.

Nutrient remediation and offsetting could provide the EU member states such as Finland the adaptive capacity needed to aspire towards increased aquaculture production without impairing the legal-ecological goals of the Baltic Sea's coastal and marine waters. An effective remediation and offsetting regime could potentially ensure the ecological quality of waters and still allow a substantial increase in aquaculture production. The problem with this approach, however, is that the current Environmental Protection Act of Finland only pays attention to the local impacts of aquaculture and does not allow taking a systemic perspective looking at cross-sectoral benefits, or benefits to the Baltic Sea as a whole. Similarly, the formalisation of the WFD's ecological goals and the limitation to consider offsetting only within the same water body in which the environmental impact occurs may prove a considerable limitation to increasing sustainable aquaculture production. This being said, the current legal-ecological framework does open a very promising window of opportunity for plant-based aquaculture that would absorb nutrients instead of emitting them.

All in all, the current legal framework contains promise for shifting the aquaculture industry onto a more ecologically sustainable path. Especially the goals of the Water Framework Directive are driving a societal change towards more ecologically sustainable production of fish. At the same time, the legal framework contains several more detailed obstacles for reconciling food security, blue growth and sustainability. The pressures on the overexploited fisheries as well as food security and blue growth considerations would merit a more adaptive and systemic approach to the governance of aquaculture. There is a need to consider nutrient emissions from all sectors as a whole. Regulatory day-dreaming aside, an integrated systems perspective to the regulation of coastal and marine resources is still many nautical miles away.

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Appendix A. Supplementary data

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