Closing the aquaculture nutrient loop: Roundtable discussion summary

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Baltic Sea Region
Programme 2007–2013

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

AQUABEST

AQUABEST

Finnish Game and Fisheries Research Institute, Helsinki
2013

ISBN 978-952-303-057-2

Reports of Aquabest project 7 / 2013

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Description

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Title
Roundtable discussions to consult stakeholders on the possibilities of closing the nutrient loop in the Baltic Sea

Year	Pages	ISBN
2013	18	978-952-303-057-2

Abstract
Aquaculture in the Baltic Sea is currently importing nutrients through the raw ingredients in fish feed. To increase the sustainability of the industry the nutrient inflow needs to be balanced. One of the aims of the Aquabest project is to close the nutrient loop in the Baltic Sea aquaculture. During three organized roundtable discussions stakeholders were gathered to discuss the obstacles and opportunities of doing so. The discussions gathered representatives from fish farmers, feed industry, authorities and academia. Roundtable discussions served as a networking platform, to improve exchange of information, as well as allowing all parties to express their individual concerns. Implementing incitements which encourage fish farmers to chose feeds which contain more locally sourced marine nutrients was identified as crucial for closing the nutrient loop. All stakeholders also agreed that the inclusion must be based on a mass balance definition for Baltic Sea fish feed, which should be based on a three year span. The feed industry confirmed that increasing the content of nutrients from Baltic Sea marine ingredients, mainly Baltic Sea fish meal, is possible, but will come at an increased price. The increase in cost which can be expected is not possible to estimate at this time, since the feed industry has no experience of buying fish meal with specific geographic criteria. Other alternative marine ingredients from the Baltic Sea, such as mussel meal and microbial protein, is yet not developed enough to be implemented on a larger industrial scale. In the future, if fish meal prices continue to increase and production methods develop, these alternative options might become appealing. The roundtable discussions helped gain an understanding of the complexity in decision making. Further, giving voice to all stakeholders leads to better cooperation and increased possibility of finding solutions which can be implemented successfully.

Keywords
Stakeholder discussions, roundtable, aquaculture, Baltic Sea

Publications internet address
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Contents

1. Introduction

Almost the entire Baltic Sea is eutrofied and stringent measures are required to reduce nutrient load of various human activities (HELCOM, 2012). Aquaculture contributes to the Baltic Sea eutrofication so that its share of the total waterborne nutrient load is appr. 0.12 % nitrogen (N) and 0.35 % phosphorus (P). This contribution originates to 99.9% from open cage farms, but the respective parts of costal versus inland farms is at present unknown and require further research to be clarified. Although open cage aquaculture production has become more resource efficient and reduced the nutrient load per production, continuous development in sustainability issues has become vital for the industry to gain acceptability in the society. This report does not deal with different types of systems and the possibility of reducing the net outflow of nutrients per production unit by e.g. more closed systems allowing water treatment or recapture of nutrients before the water is released to the recipient. This report deals only with the nutrient budget of the effluent as such and the recipient.

The nutrient load of aquaculture originates totally from the feeds that are used in the fish production. Feeds are composed of feed ingredients purchased from the global commodity markets. Traditionally, the most important ingredients are fish meal and fish oil. These ingredients are made from various marine fish stocks, mainly from the Atlantic and the Pacific ocean. Fish meal has long been the main source of nitrogen and phosphorus in aquafeeds, but fish meal is increasingly replaced with plant sources such as soybean products. Nevertheless phosphorus and nitrogen are mainly sourced from outside the Baltic Sea. Thus, aquaculture is a net nutrient importer from the Baltic Sea nutrient balance point of view.

The Aquabest project attempts to bring new solutions for closing the nutrient loop of the Baltic Sea - in other words; turn aquaculture from net ocean nutrient importer to a nutrient-neutral system. This is accomplished by creating incentives and technologies for using locally and regionally produced feed ingredients. Detoxified Baltic Sea fish meal and oil, farmed mussel, microbial meal and by-products from crops, are potential regional feed ingredients. Together with stakeholders an assessment on the feasibility of closing the nutrient loop has been investigated.

1.1. Roundtable discussion series

Within Aquabest three roundtable discussions have been organized. The first meeting was held during the Åland Aquaculture Week on 9th – 12th of October 2012, the second one took place in Stockholm on 7th of March 2013, and the third one was also organized in Stockholm on 19th of June 2013. Discussions of these meetings, presented below, have been summarized and circulated among participating stakeholders for comments and amendments.

The roundtable discussions offered a platform for cooperation and networking among different stakeholders in the Baltic Sea Region's aquaculture sector, such as policy makers, academia, feed manufacturers, fish and mussel farmers. NGOs were invited but did not actively participate in the workshops. During the discussions different stakeholders were allowed to express their concerns about, and ideas on how to close the nutrient loop in the Baltic Sea. Further the discussions served as effective exchange of information, teaching participants about different aspects of aquaculture. The discussions were a good platform to scope the complexity of decision making in aquaculture. Moreover it was also a chance for different actors to network, improving further communication and cooperation within the project.

2. First roundtable in Marieham, October 2012

The Åland Aquaculture Week took place in Mariehamn, Åland and hosted over 60 participants from all over the Baltic Sea region. The event was organized in cooperation between the two Baltic Sea Region Programme projects Aquabest and SUBMARINER.

The first two days were dedicated to the challenges and opportunities for "closing the nutrient loop" of aquaculture in the Baltic Sea. Multiple perspectives were contrasted during presentations and roundtable discussions during group work sessions. The presentations can be found at Aquabest-project web pages.

For roundtable discussions, participants were divided in three groups: feed industry, fish farmers, authorities as well as academia. To summarize the active and versatile discussion, the following conclusions could be drawn:

- The feed industry is interested in continuing the discussion on regional ingredients but emphasizes that in global competition, there is a high risk that increasing production costs will lead to market share losses and thus decreased production without some counter mechanisms. Feed companies have sustainability strategies, and diets are formulated taking into account numerous targets and constrains. Raw materials are selected based on their nutrient contents, cost, secure availability, eco indexes, suitability to processing etc. During the roundtable, especially logistics, availability and costs of Baltic Sea-sourced fish meal and mussel meal were discussed.

- Mussel farming projects have gained useful information to stimulate production in the Baltic Sea. Also downstream processing technologies have been developed. However, it appears that incentives or direct financial support will be needed. Also farming technologies better suitable for stormy winter conditions should be developed.

- Continuously decreasing environmental permits (=nutrient space within the society) is the biggest obstacle to expand open fish farming. The entrepreneurs are afraid that new initiatives such as incentives by using recirculated nutrients will be too slowly if managed through the permitting system. Faster concrete actions are needed to maintain the sector's competitiveness. From the fish farmers' point of view, increased production licenses would be by far the best incentive to start using diets with sustainable Baltic Sea region feed ingredients.

- Both the feed industry and the fish farmers raised the concern over uncertainties in future herring and sprat quotas. If a system is established assuming availability to Baltic Sea fish meal, but the availability turns out to be poor due to lower quotas or some other reason, problems will arise for both farmers and feed industry. A longer perspective, several years, is therefore needed when use of recycled nutrients is assessed.

- The starting point for authorities is that societies must follow the EU's Marine Strategy Framework Directive and Water Framework Directive as well as HELCOM's Baltic Sea Action Plan (BSAP).

- Despite a common legislative framework Member States are free to implement them differently.

- At the same time, authorities voice that "closing the loop" is extremely important and a common objective. When talking about closing the loop during the roundtable authorities meant that the "box" is the Baltic Sea, including the drainage area.
- Authorities also stated that it is important for different BSR states work together in order to accomplice the goal of a sustainable use of the resources of the Baltic. Also indicated was that it is important not to focus on already utilized species, but in trying to find new sources for feed ingredients. Furthermore it was admitted, that not all regions within the BSR would benefit from nutrient recirculation concept. For those areas, e.g., recirculation farming technologies are more important to develop the support sector sustainably.

3. Second roundtable in Stockholm, March 2013

The main topic of the 7.3.2013 Stockholm roundtable meeting was to continue the discussion initiated at the first roundtable discussion in Åland October 2012, and further address whether preconditions for nutrient circulation exist. In addition, the meeting also addressed concerns regarding the environmental and economic benefits and drawbacks of a closed nutrient loop.

3.1. Framing the scope of recirculation in the Baltic Sea

As of today, at least four potential ingredients exist for making circulatory-based fish feed: fish meal based on Baltic Sea fish, purged of dioxins and other toxins; farmed mussels; microbial protein from microbes grown on organic waste of human food quality; and protein from the leftovers of biodiesel manufacturing from rapeseed. Also other local plant ingredients, like field beans etc. are being evaluated. Some are still in the early stages of their development and might not be economically feasible just yet.

The question is: within which frames is the process of recirculation defined? Should recirculation be defined as: the recirculation of material within the immediate vicinity of the fish farm; within the specific geographical part of the Baltic Sea where the fish farm is situated (e.g. the Baltic Proper, the Gulf of Bothnia, etc.); the Baltic Sea in itself; or even the drainage basin of the Baltic Sea?

If considering the whole drainage basin of the Baltic Sea, parts of countries like Belarus and Ukraine which de facto have no coastal lines to the Baltic Sea, would have to be included. Considering fish from these regions rapeseed could potentially also be included from them as a substitute to soybeans from regions outside of the Baltic Sea drainage basins. Plant sources constitutes roughly 60-70% (oil and protein combined) of the present fish feed. Soybean alone makes up approximately 30% of dietary nitrogen content.

During the discussions, the present market economic feasibility and availability of Baltic Sea-based fish meal was questioned, partly due to the present use of herring in the fur industry. Also it is questionable if fish meal of Baltic origin will be available in sufficient quantities due to increase in natural predators (see below).

Protein concentrate from rapeseed bio-diesel production is of high nutritional quality. It could be economically feasible in large scale production, but its availability will depend future agriculture and bio fuel policies. Mussel meal production is feasible if the current system for terrestrial catch crops financial support policy is implemented, again depending on policy decisions. Also ecological egg production is a possible large scale buyer of this product, making future availability uncertain at present. A very promising nitrogen (protein) source within BSR is microbial protein (and possible also HUFA of n-3 origin) produced from organic side streams of human food quality. However, even though an increasing number of studies indicate that both bacteria and yeast strains may partly and even fully substitute other feed protein sources, a lot of unknowns remain. This concerns especially production procedures in order to optimize protein and economic yield and to combine utilization of nitrogen rich organic waste in a serial manner to other bio-reactor based commodities, as e.g. biogas, biochemicals, human grade food etc. Therefore it can be concluded that even if a number of promising nitrogen based feed commodities of BSR origin exist, no one is at present economically feasible or available in sufficient quantities.

Current EU-rules make it difficult to give economic incentives to fish farmers, or fish feed producers, who choose feed purely made out of Baltic Sea ingredients before imported ones. A possibility would be to brand fish and fish feed in relation to how much of their nitrogen and phosphorus originates from the Baltic Sea. According to the representatives from the fish feed industries it is feasible to keep track of how much Baltic fish meal comes into the factory. The problem and extra costs lays in keeping that specific source separated through the whole process and guarantee delivery of raw material on time to secure delivery to the customers. This is where the “green electricity argument” comes into play: the argument that consumers are willing to pay more for food which has been manufactured with a transparent balance, but without an exact traceability of each molecule.

3.2. Fish stocks in the Baltic Sea

The fish meal part of the fish feed stands for the biggest portion of the fish feeds phosphorus content. If striving towards closing the nutrient loop via using fish caught in the Baltic Sea, it is feasible to believe that an outtake of appr. 100 000 tons of sprat and herring per year is sustainable. Professor Sture Hansson, Stockholm University, underlined the fact that care has to be taken when predicting future fish stocks: as it is neither know what has caused the current increase in them, nor how long stocks will stay this high. Regarding underutilized species like stickleback, common roach, common bream and white bream, the difficulty to catch these species in large amounts may make their part in the fish feed production insignificant. In addition, the seal population is steadily increasing, and according to HELCOM the population should be allowed to keep increasing until it has reached its own carrying capacity: this would result in a seal population which is five times that of today which will have impact on the availability of sprat and herring. The same argument is applicable for the increase in predator fish populations like cod and salmon.

The present situation is that Baltic sprat and herring are already utilized for fish meal production, some of which is exported globally. At the same time, fish meal produced from fish caught in the Atlantic and Pacific Ocean is imported to the Baltic Sea region. To conclude whether or not nutrients are exported or imported, better models of nutrient flows are needed. Such calculations will be of value both for internal planning and also to convince decision makers that aquaculture is on the way towards being sustainable. The general conclusion amongst the participants was that the decrease of released phosphorus should be the first main target, followed by nitrogen in next generation aquafeeds including substantial amounts of BSR nitrogen sources. A first outline of a model, aimed at BSR nutrient budget evaluation, was constructed during the meeting (see Figure 1 below).

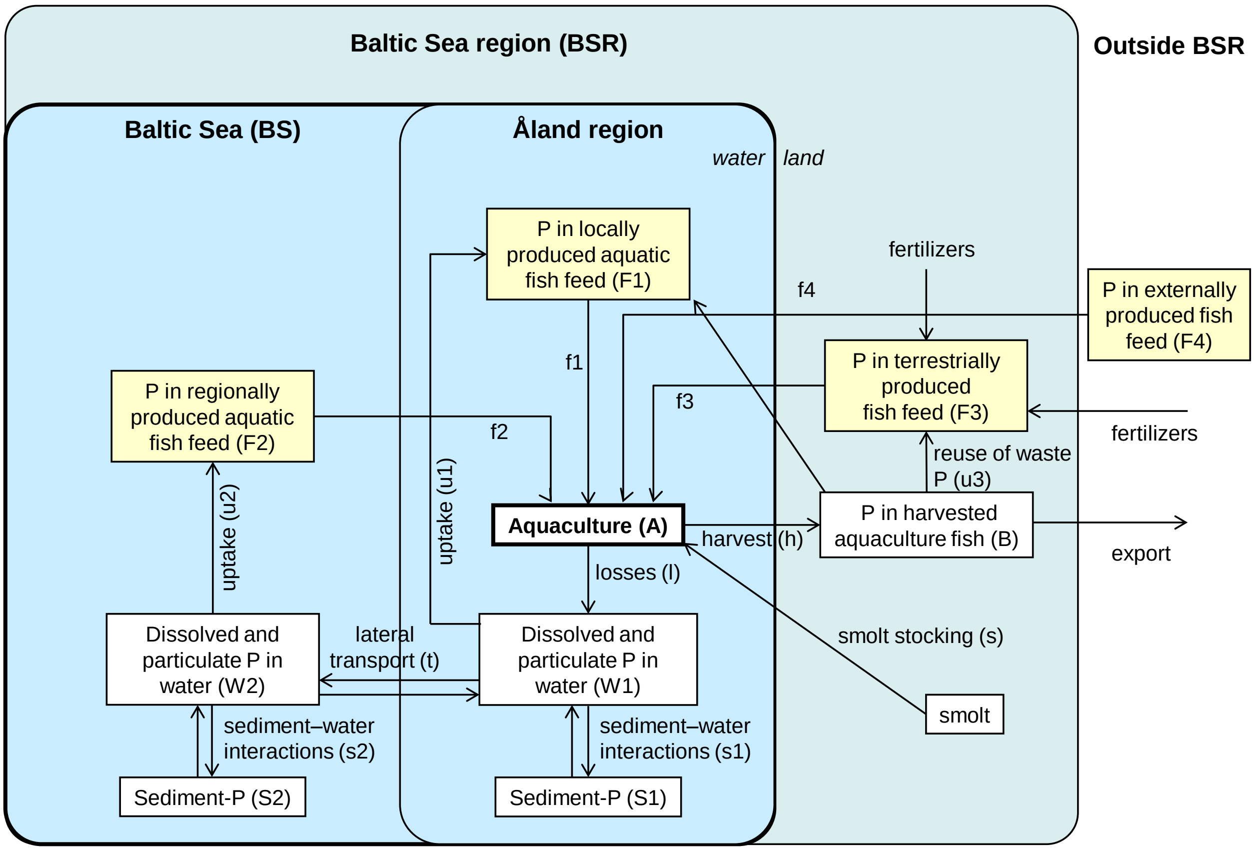

Figure 1. Developed model during the roundtable discussion.

3.3. Mussel meal

Regarding feed made out of Baltic mussels (*Mytilus trossulus*), the mussels should be seen as a blue catch crop, and mussel farming should be seen as a way of recirculating nutrients, especially nitrogen, within the Baltic Sea. Using lysis in a newly Swedish patented industrial process, the mussel meat is liquefied then dried in a drum dryer. The price for mussel meal in comparison to fish meal is likely to drop in coming years because of a constant increase in price of fish meal. In comparison to mussels farmed off of the west coast of Sweden, the Baltic Sea mussels from the farm in Kumlinge, Åland, are smaller (15 – 25 mm) and have lower muscle content (17.3% instead of 25 – 30%). The comparatively small muscle content might be a result of them having been harvested in December December as analysis of Kalmar mussels harvested while still feeding showed a higher content. The final mussel meal has a protein content of 65% and a lower fat content than fish meal, the composition of fatty acids is however similar to fish meal with a high content of omega 3 long chained and highly unsaturated fatty acids of marine type. Mussel meal also contains natural pigment as astaxanthine, making it highly desirable as feed ingredient for laying hens. If the content of this pigment is sufficient to also result in the for salmonids so typical red meat is under evaluation by Aquabest Arctic charr experiment. Representatives of the fish feed industry said that it could be possible to pay more but the increased cost will be brought upon customers. No evidence of accumulation of environmental toxins have been found, as long as the mussel farms aren't located in heavily polluted areas, e.g. harbors or zones with industrial effluence. Neither is there any indication of accumulation of cyanobacterial hepatotoxins. Mussels are pelagic feeders with phytoplankton as base in the food web. Lipid soluble pollutants as PCB, Dioxins and PCB-like dioxins tend to be very low, independent of levels in sediment based food webs, where most fish feed. It is therefore possible to have high levels of these xenobiotics in fish, but low in mussel from the same area.

Some quick calculations showed that 30.000 tons of fish would require 10.000 tons of mussel meal (if targeted level is as high as 30% of diet), which would require 200.000 tons of Baltic farmed fresh mussels (5% of whole mussel becomes meal with TS 90%), demanding an farming surface of 4.000 hectare (50-150 ton / hectare every second year). This means that mussels cannot be seen as an exclusive way to make fish feed. The main working point should therefore be to see if the mussel farmers could get compensation per kg of recovered nitrogen and phosphorus, something which is similar to that which the farmers receive for planting catch crops and the use of the meal as a valuable feed ingredient must be seen as an extra bonus.

4. Third roundtable discussion in Stockholm, June 2013

4.1. Session 1

The SLU modelling team, consisting of Tobias Vrede, Martyn Futter and Hampus Marksten, with input from David Abrahamsson and Teresa Lindholm, drafted a model of phosphorous fluxes in aquaculture in the Baltic Sea Region (Figure 2). This model was based on the suggested model from the previous roundtable discussion, but further developed to provide some calculated scenarios. The focus of the model is on the Åland region, but it can also be applied to other regions. The model is based on a scenario where a phosphorus net nutrient load means the import into the sea of nutrients from feed minus the harvest of the fish. The loss (gross nutrient load) combines both dissolved and particulate nutrients and the model assumes conservatively that no phosphorus will end up in the sediment. There is also a lateral transportation to other parts of the Baltic Sea (not shown in the box).

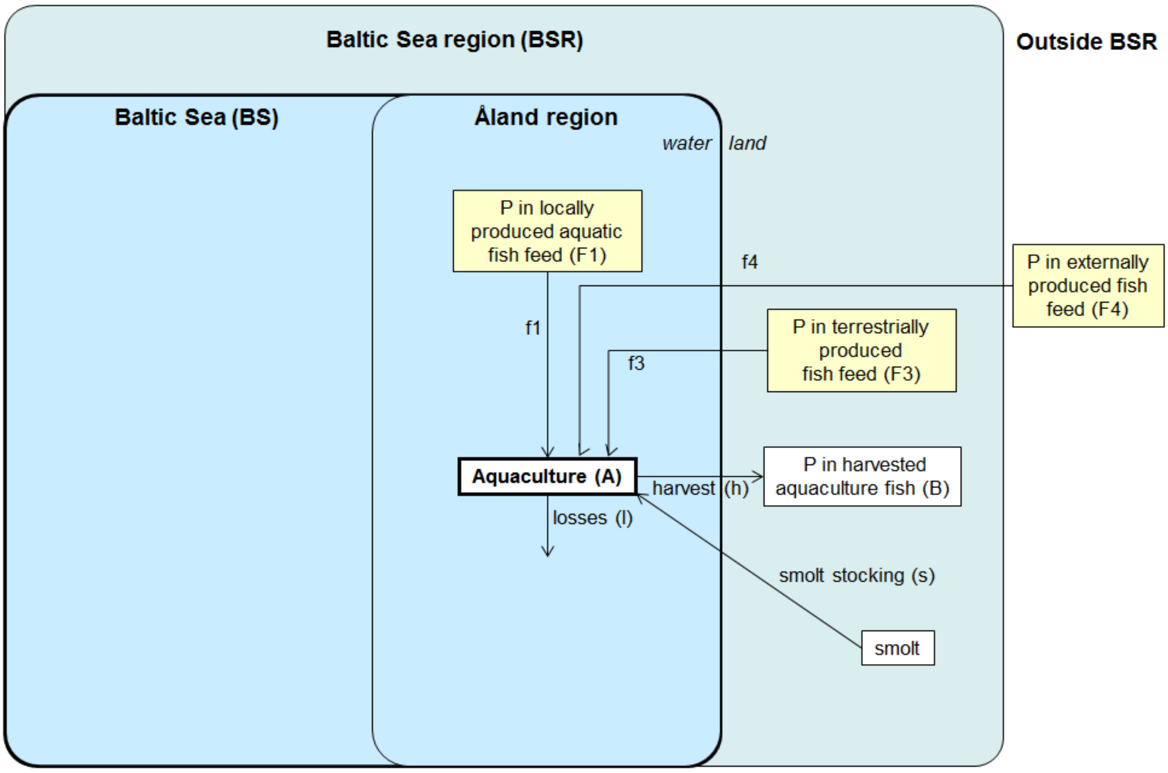

Figure 2. The schematic of the model.

The basic assumptions of the model are:

- To focus on fluxes of phosphorus because of the large losses of phosphorus from aquaculture
- The model represents a steady state, i.e. it is a static model where flow will not change over time
- Sedimentation is absent, which makes the model represent a "worst-case scenario"
- The content of phosphorus, protein, and fat are kept constant at the same levels as those of commercial diets
- The content of phosphorus in fish is fixed at 0.4%
- Local effects are not considered as these are site and case specific
- It is assumed that smolt is imported from outside the Baltic Sea

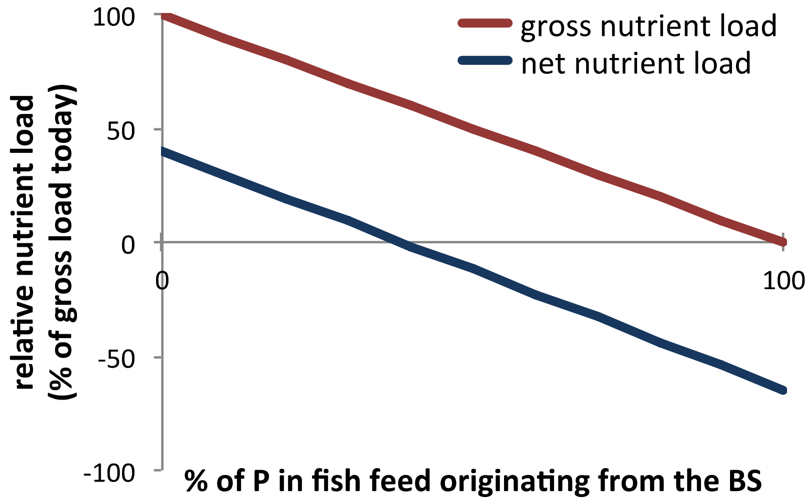

Figure 3. The connection between gross- and net nutrient load.

Figure 3 describes the basic idea behind the model. The x-axis marks the percentage of phosphorus in fish feed with origin in the Baltic Sea. At the intersection of the y-axis, no use of phosphorus sourced from the Baltic Sea is assumed, i.e. the situation of today.

The y-axis shows the gross nutrient input into the aquaculture today, but some of it is harvested. About 55 % of the phosphorus given to fish is incorporated in the biomass of the fish, the rest is released into the water.

If the fish is still fed with the same amount of feed with the same nutrient content, but of100% BS origin, the gross nutrient load reaches zero. At the intersection of the x-axis, the input and outtake of phosphorus balances each other out, i.e. it theoretically does not matter how much you cultivate. As the value for line representing the net nutrient load increases on the x-axis and decreases on the y-axis, there is a removal of nutrients from the system.

The model scenarios presented were the following:

0	Current situation
-1	A 50% increase of aquaculture using current practice
1	Zero net load of phosphorus
2	Maximally negative net phosphorus load
3	Marine aquaculture is moved to inland freshwater lakes and current feed is used, retention in the freshwater system of 50% is assumed.

Scenario 0 is simply the base for the model and represents the current situation in the Baltic Sea.

Scenario -1 answers the question of how much extra phosphorus in the Baltic Sea a 50% increase of the fish farming will lead to if we do not change the feed formulas.

Scenario 1 answers the question of how much fish feed from the Baltic Sea is needed to maintain current aquaculture production, but with a zero net phosphorus load.

With a phosphorus content of 0.6 % in the feed (this was changed to 0.7 %, the minimum for maintained fish health and growth), 45 % of P in the feed would have to originate in the BS. This is the equivalent of 5 900 ton/y sprat (for producing 4 500 ton/y fish).

Scenario 2 answers the question: Is there a potential for cleaning the Baltic Sea using open cage aquaculture? The model proposes 'yes' as the answer, but the assumptions for the scenario will probably have to be revised. The hypothetical maximum 'cleaning effect' would require that 96 % of the phosphorus in feed originates from the Baltic Sea. This would require using 50 000 ton/y mussels (1 000 ha à 50 ton/y) and 250 000 ton/y sprat (the fishing quota for 2013 set by the European Commission), which is probably unrealistic. The result would be a production of 73 000 tons of farmed fish, which would remove also 340 tons of phosphorus from the Baltic Sea yearly.

Scenario 3 maximizes the negative net nutrient load by using the best case scenario for using open cage farming, also cultivating fish in freshwater systems with an assumed retention of 50 %. When 45% of the phosphorus in the diet is sourced from Baltic Sea sprat and mussels, the net load to the Baltic Sea becomes 0. Fresh water farming is included in this scenario based on the interest to use fish farming as artificial fertilization of unnatural oligotrophic hydropower dams.

The following conclusions could be drawn from the model:

- An increased aquaculture using current practice is questionable as the import of phosphorus to the Baltic Sea will increase.
- Using resources from the Baltic Sea makes it possible to increase aquaculture substantially and still have a zero net phosphorus load to the Baltic Sea.
- The theoretical maximum open cage fish production, based on present fisheries estimates, is 73 000 tons, removing 340 tons of phosphorus per year from the Baltic Sea.
- Sourcing raw materials from the Baltic Sea and having aquaculture in freshwater decreases the net phosphorus load even further. However, the retention of phosphorus in the freshwater system may be a lot higher than the assumed 50% as there is a lack of research data.
- The case with Baltic Sea recapture of phosphorus and fresh water farming is also representative of a situation where a Baltic nutrient balanced feed in a more closed systems allows for purification of effluent and/or recapture of nutrients by e.g. horticulture or other bio-reactors with algae, yeast or bacteria

Following the presentation, a number of issues were discussed. The modelers pointed out that the scenarios are just basis for dialogue and needs to be developed further in order to give realistic results. There is a big potential for improving it in various ways, for example integrating dietary efficiency factors into the model.

The significance of the Åland aquaculture load depends on which geographical scale is chosen. It is hard to see differences on a Baltic Sea scale, while local effects are easier to measure. However, improving the recirculation of nutrients has gains for the sea as a whole and will thus eventually also improve the water status locally. Decision-makers need to take into consideration both the local and regional effects. On The Åland Islands, this has already been discussed for 20 years. If you take away aquaculture, you take away 60-70 % of The Åland Islands phosphorus load into the Baltic Sea, as the Åland Islands does not have any large industries or agriculture activity, but at national level Åland aquaculture represents 0.6 % of the total Finnish load (2006).

The second part of the first session also concerned modeling. This ‘model’ however, was designed to be used as a tool for the authorities on the Åland Islands who hand out the permits for the fish farms. The underlying idea is that fish feed made from ingredients sourced from the Baltic Sea will give increased allowances. This will work as an incentive for the farmers to use more Baltic Sea sourced ingredients at locations with deep water and rapid water exchange, as such hydrological factors minimizes local effects. According to the calculations, a fish feed in which 100% of the fish meal is made out of Baltic Sea fish would allow an increased feed usage corresponding to 25.6% if the proposed idea of a 20% improvement regarding net input of nutrients into the Baltic Sea is realized. If this is not implemented, a fish farmer could increase his feeding, i.e. production, with roughly 33%.

Table 1. Amount of fish meal sourced from the Baltic Sea (BSFM) in the fish feed (FF) and the increment.

	g BS fish meal / kg feed	**% BS fish meal of total dietary fish meal**	**% of dietary total nutrients**	**Nutrients released into the water (total, g/kg growth)**	**Released from BS fish meal into the water (g/kg growth)**	**% Increased feed allowance**	**% theoretical allowed increased production, (FCR: 1.18)**
Phosphorus	0	0	0.00	4.00	0.00	0	0.00
	10	5	2.93	4.00	0.12	1.16	0.98
	25	13	7.34	4.00	0.30	2.92	2.47
	50	25	14.78	4.00	0.59	5.92	5.02
	100	50	29.92	4.00	1.18	12.14	10.29
	200	100	61.39	4.00	2.36	25.55	21.65
Nitrogen	0	0	0.00	27.50	0.00	0	0.00
	10	5	1.81	27.50	0.50	0.58	0.49
	25	13	4.51	27.50	1.24	1.46	1.24
	50	25	9.03	27.50	2.48	2.09	1.77
	100	50	18.06	27.50	4.95	5.84	4,95
	200	100	36.11	27.50	9.91	11.69	9,91

These two presentations prompted a lengthy discussion considering the possibility to create recirculation based fish feed. The main problem with manufacturing such a feed is the constantly fluctuating prices of the raw materials used in the fish feed (Figure 4). This results in the fact that becoming dependent on a single raw material (in this case, fish meal from The Baltic Sea) will make one vulnerable economically. Especially since Baltic Sea fish is not readily available all year around.

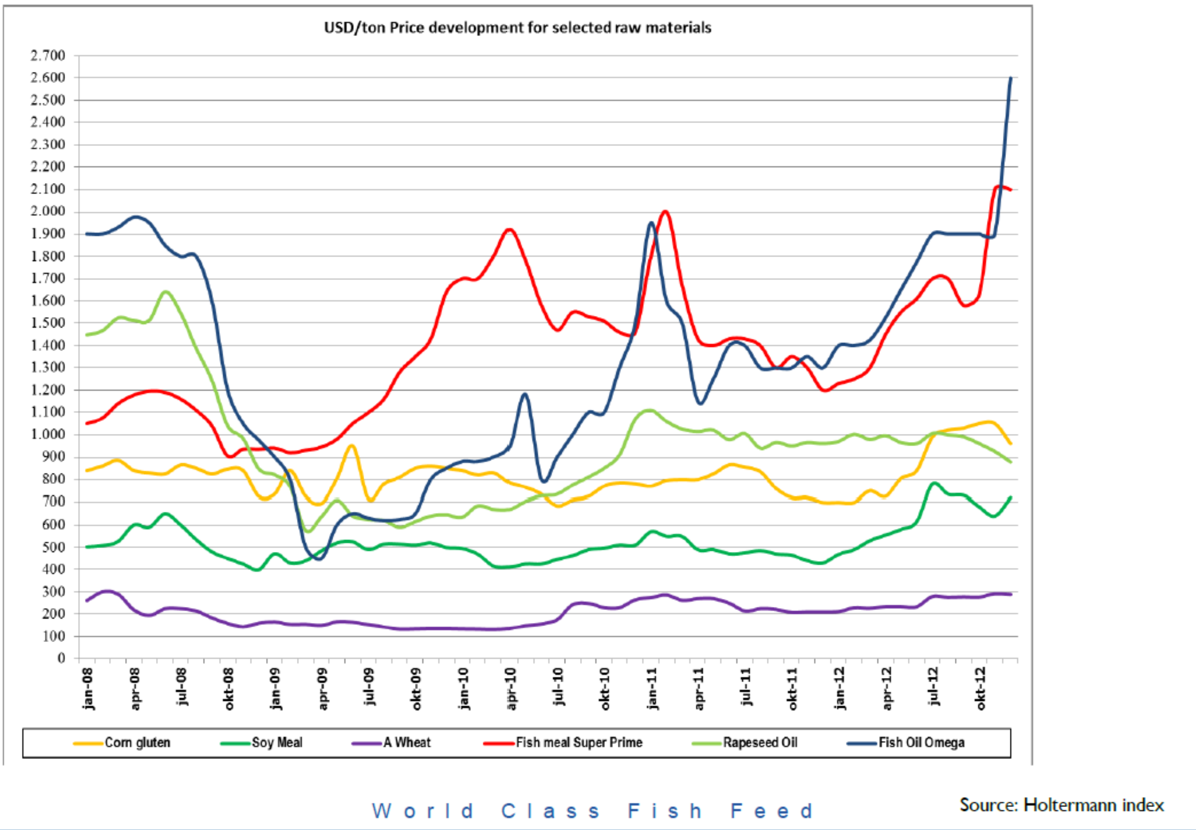

Figure 4. The development of raw material prices.

The fish feed manufacturers also expressed concern regarding the fact that fish sourced from the Baltic Sea needs to be cleaned of dioxins and PCB before it can be used as fish meal. Consumers are concerned about the POP content of Baltic Sea fish, thus the negative image might have an unfavorable effect on sales. At the very least, it is unlikely that claiming that the fish is from the Baltic Sea will add to the price the customer is willing to pay.

It is also theoretically possible to farm fish by using entirely plant based diets. In Norway, the content of fish meal is thought to go down to approximately 10-12% in the next few years, in the Baltic Sea it is at the moment around 20%, but shrinking. If less of the content of the fish feed comes from fish, theoretically: less incitement can be given to the fish farmers.

4.2. Session 2

The second session was centered on two presentations about new types of fish feed. Both were held by Anders Kiessling, SLU. The first trial is being carried out on turbot at Gesellschaft für Marine Aquakultur mbH, Germany. In the trial, fish meal is gradually replaced by rapeseed protein, a concentrated protein byproduct of rapeseed oil production. In a sub-trial, effects of supplemental phytase are also being tested.

The second feed presented was a Swedish formula called ‘Baltic Blend’ which is undergoing trials on Arctic char at Vattenrukscentrum Norr, Kälarne. Baltic Blend consists of mussel meal, detoxified fish meal/oil from the Baltic Sea and yeast protein. Mussel meal is a good raw material that is too expensive at present to consider for the fish feed manufacturers. Political incentives to support the farmed mussels as aquatic catch crop are crucial in order to make mussel meal a feasible source.

Both diets have shown good results so far and the Arctic char actually preferred the taste of Baltic Blend to that of conventional fish feed. This might be because of the yeast, as brewers yeast is already used as a taste enhancer in some conventional fish feeds. Microbial protein in general is an interesting raw material for fish feed and has been used before, but was phased out earlier because of too large variations in quality and the price. It is possible to grow on several industrial and household organic side streams as food waste. Microbial protein production does not cause a nutrient load itself, but could actually diminish the nutrient load of industries and municipalities. Microbial protein like that from yeast or the bacteria *Methanococcus* has a higher biological value, i.e. more appropriate amino acid profile, than plant proteins. Despite that microbial proteins are likely to have low impact values in a life cycle assessment, microbial protein would still result in a net input of nutrients into the Baltic Sea. If reduced leakage of organic waste, which would otherwise end up in the Baltic Sea, would be included in the model it could be possible to count microbial sources as contributing to lowering the inflow of nutrients. Such inclusion would require an expansion of the present model.

It was also discussed whether or not incitements could be given if fish feeds contain other Baltic Sea region-sourced ingredients such as plant proteins. It was concluded that these should also count as a net import of nutrients to the Baltic Sea if not a similar approach as suggested for microbial sources above is employed.

4.3. Session 3

The third session concerned legislation and was focused on defining what a recirculation based feed is. The participants agreed that the working definition for recirculation based feed declaration should be “A three year average proportion and content for phosphorus originating in the same marine region that the farm is located”. This will be based on a mass balance calculation, meaning that the fish feed cannot be counted on containing a specific percentage of e.g. Baltic fish, or any other Baltic source, in the feed at any given time, but over a longer time span. It was agreed that three years would be the time period which should be used for determining the content of Baltic Sea products. Gathering the information needed to make this mass balance will not increase the price of the fish feed. This fact differs a lot from making a fish feed in which a certain percentage must always be from the Baltic Sea as that would incur increased storage costs on the fish feed producers which are deemed unacceptable. The increased prices would be passed on to the fish farmers and in turn to the consumers.

5. Conclusions

During the roundtable discussions it was agreed that the efforts should now be put on creating interest among stakeholders for the final conference, which will be held in Mariehamn on 5th – 6th of February 2014 jointly with another Baltic Sea Region Programme project AQUAFIMA. The following are some conclusions from the three roundtable discussions:

- Stakeholder discussions provide valuable information which helps understand the complexity of the issues. Stakeholder discussion further aids communication between partners, and allows for better collaboration also outside the roundtable discussions.

- The participants of the roundtable discussions agreed on a mass balance definition for the Baltic Sea fish feed: “A three year average proportion and content for phosphorus originating in the same marine region that the farm is located”.

- Production increments are presently the only way to give out incitement to fish farmers, a Baltic Sea fish feed will further not be developed unless there are clear incitaments in place for farmers to use such a feed. Regulation needs to be in place before fish farmers can adopt a Baltic Sea fish feed.

- Mussel meal is an ideal sustainable ingredient in the Baltic Sea fish feed, but it is currently too costly to produce and logistic issues need to be sorted out. Once production methods and logistics are improven, along with fish meal prices rising, mussel meal might become a competitive ingredient in Baltic Sea fish feeds.

- Alternative BS feed sources, such as field beans, rapeseed protein and microbial protein, are investigated, but these require political incentives and/or more research to make them commercially viable.

- At present only fish meal and oil have the volumes and competitive qualities to be a commercially viable alternative for nutrient recirculating fish feeds in the Baltic Sea.

- It is not technically difficult to store Baltic Sea fish meal separately, but demanding a certain type of fish meal, in this case fish meal sourced mainly from the Baltic Sea, will cause added cost. The cost of fish feed may also increase if manufacturers become too dependent on Baltic Sea fish meal.

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