Faculty of Science

Co-products in the Swedish Seafood Processing Industry

Quantification and present uses

Kristina Bergman

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Department of Biological and Environmental Sciences
University of Gothenburg

Examiner: Susanne Eriksson
Department of Biological and Environmental Sciences
University of Gothenburg

Supervisor: Friederike Ziegler
SP Food and Bioscience

UNIVERSITY OF GOTHENBURG

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1. Abstract

With a growing global human population and increasing human impact on ecosystems and climate it is crucial to increase the production of food and to do so in the most resource effective way possible. A way of increasing the supply of fish for food without increasing its environmental impacts is to use landings and subsequent seafood products more efficiently. The processing of seafood, such as filleting of fish, generates large amounts of co-products not currently used in an optimal way. Therefore, this study, being part of the Vinnova-funded project MareValue, aimed to quantify the amounts and types of seafood co-products generated in the Swedish fish processing industry. A second aim was to investigate how they were currently used, as a first step towards a more resource effective use. Two approaches were used to quantify the amounts of seafood co-products generated: one based on official statistics and one based on interviews with seafood processors. This study showed that around 30,000 tons of seafood co-products are generated each year in the Swedish seafood processing industry based on interviews with processors. Pelagic fish like herring accounted for the largest quantity of co-products, followed by whitefish like gadoids. The main utilization was as feed for minks and production of fish meal and oil for animal feeds. The interviews revealed that an increased economic value of the co-products is needed for any changes in present practices. The potential to increase the value to enable better utilization of the co-products is large. The results of the present study provide a starting point for continued research on how to make better use of seafood co-products generated in Sweden in the future.

2. Sammanfattning

Eftersom världens befolkning ökar och likaså människans påverkan på jordens ekosystem och klimat är det avgörande att öka matproduktionen, och att göra det på ett så resurseffektivt sätt som möjligt. Ett sätt att öka tillgången på fisk som matkälla, utan att öka fiskets miljöpåverkan, är att använda landningar och fisk-och skaldjursprodukter mer effektivt. Beredning av fisk och skaldjur genererar stora mängder av biprodukter som inte används på ett optimalt sätt idag. Den här studien, vilken ingår som en del i det Vinnova-finansierade projektet MareValue, syftade därför till att kvantifiera mängderna av de biprodukter från fisk och skaldjur som uppkommer i svensk beredningsindustri. Den syftade även till att ta reda på vilka typer av biprodukter som uppkommer och deras användningsområden idag, som ett första steg för att förbättra användningen. Två strategier användes för kvantifieringen av biprodukter: en baserad på offentlig statistik och en på intervjuer med fiskberedningsföretag. Studien visade att det genereras ca 30,000 ton fisk-och skaldjursbiprodukter i Sverige per år, baserat på intervjuerna med fiskberedningsföretagen. Pelagisk fisk som sill stod för den största volymen av biprodukter, följt av vitfisk som torsk. De huvudsakliga användningsområdena för produkterna var minkmat och produktion av fiskmjöl och fiskolja till djurfoder. Under intervjuerna framgick det att ett ökat värde på biprodukter krävs för att en förändring av användningen av dem ska vara möjlig. Möjligheterna för att höja värdet så att biprodukterna som uppkommer i svensk fiskberedningsindustri kan användas bättre är goda. Studiens resultat utgör en utgångspunkt för vidare forskning om hur sjömatsbiprodukter kan användas bättre i framtiden.

3. Introduction

Fish is an important source of food for people worldwide. It makes up 17 % of the intake of animal proteins globally (FAO, 2014), in some countries more than 50 % (FAO, 2014). However, the fishing industry, besides producing valuable food products, also has environmental impacts. Among the consequences of the fishing industry are depletion of fish stocks, consumption of fossil fuels and damage of benthic communities (Dayton et al. 1995, Tyedmers et al. 2005, Ye et al. 2013). With a growing global human population and increasing human impact on ecosystems and climate (DESA 2013, IPCC 2014), it is crucial to increase the production of food, and to do so in the most resource effective way possible.

One way of increasing the supply of fish without increasing its environmental impacts is to use landings and subsequent seafood products more efficiently. On a global scale, only 86 % of the fish landed is used for human consumption (FAO, 2014). The remaining 14 % are used for other purposes, most commonly for production of fish meal and fish oil for feeds (FAO, 2014). Fish and fish parts that are not used directly for human consumption include feed fish, discarded fish and by-catches. However, the 86 % landed for human consumption also include fish and fish parts that are not used for human consumption in many parts of the world, for example co-products from processing and retail waste.

Fish and invertebrates which are being discarded are often fish of other species than the target species or fish in other sizes than desired (Catchpole et al. 2005, Kelleher 2005). When landed, the same types of catches are often referred to as by-catches. As an effect of the reform of the EU common fisheries policy (Regulation (EU) No 1380/2013 of the European Parliament and of the Council) the amounts of by-catches landed will initially increase as the new regulations currently being implemented aims at reducing discards through a landing obligation.

Co-products generated in the seafood processing industry are another type of fish resource not used in an optimal way. The co-products from the seafood processing industry include heads, backbones, skins and guts. For some fish species, processing like gutting is performed on the fishing vessel and the guts are discarded at sea (WRAP 2011). The amounts of co-products generated in seafood processing are large (Ghaly et al. 2013). For some of the most commonly consumed fish species in Sweden, like cod, salmon, herring and saithe, the fillet yield is only 33-50 percent of the whole weight of the fish (FAO 1989).

A part of the seafood co-products could be used directly for human consumption or for other valuable purposes instead of being used as feed or burnt for energy production as is often the case today (FAO 2014). An example of a seafood co-product that could be used in a more resource effective and profitable way is the rest raw material from backbones of fish. It is possible to extract 10-50 % of clean meat parts and minced meat of the weight of the backbones of salmon that remain after filleting (Bekkevold & Olafsen 2007). The minced meat can be used to make fish burgers, a refined and valuable product. There is also a large potential for products that are regarded as inedible in Sweden, but viewed as common food ingredients and even delicacies in other parts of the world, like heads of cod and salmon (Rustad et al. 2011).

Precise data on the amounts and types of seafood co-products that arise in the Swedish processing industry is lacking today. A complete picture of the present utilization of co-products is unknown as well. However, more and more countries are starting to realize the value of seafood co-products (WRAP 2011, Olafsen et al. 2012). The constantly growing production of farmed fish will also encourage a more sensible utilization of seafood co-products as aquaculture relies on them for feed (Thurstan & Roberts 2014).

Blanco et al. (2007) state that marine co-products which are not adequately used represent one of the largest wastes of fish. As a first step towards a more resource effective and profitable use of seafood co-products, this study aimed to quantify the amounts of co-products generated in the Swedish seafood processing industry. The present study also aimed to investigate how these co-products are currently used.

These investigations are part of the recently started Vinnova-funded MareValue project; a collaboration between SP Technical Research Institute of Sweden, Chalmers University of Technology-Food and Nutrition Science, SLU-Institute of Marine Research and several companies (Rena Hav AB, Fiskberedning Paul Mattsson AB, Skillinge Fisk Imp-Ex AB, Leröy Sverige AB, Bröderna Hansson AB) aiming at estimating the amounts and types of underutilized resources from the seafood processing industry and the fishing industry. Furthermore the project aims to identify and isolate valuable biomolecules, to find the most suitable type of fish resource and technique for large scale isolation of biomolecules and to analyze the environmental potential of the identified solutions.

4. Methods

Two approaches were used to quantify the amounts of seafood co-products generated in Sweden; one based on official statistics and one based on interviews with seafood processors. Answers from interviews with seafood processors and feed producers were used to investigate how the co-products were currently used. This study focused on seafood co-products generated in Sweden between the years 2011 and 2014. The types of co-products included in the study were rest raw materials that arise in the seafood processing industry, and only co-products that did not go to human consumption. Sludge generated in the waste water of the processing facilities, feed fish and damaged mussels from farming or harvesting that did not reach consumers were excluded. Feed fish was excluded as it is not fished with the purpose to go to human consumption and therefore does not generate the type of co-products focused on in this study. Furthermore the quantity of feed fish caught and proportion of mussels farmed not reaching consumers is already known (Kollberg & Lindahl 2004, Ericson 2014a).

4.1. Quantification of co-products generated in Sweden using official data

One method used to calculate how much seafood co-products that were generated during a year in Sweden was to use official statistical data. Suitable data for the calculation was searched for on websites of several Swedish authorities and in the databases of Statistics Sweden, who gather large amounts of statistics used by decision makers, researchers and the public. Data gathered on both the Swedish production of processed fish products and on Swedish fish supply (the sum of all whole fish available in Sweden) was used to calculate the amounts of co-products generated in Sweden.

4.1.1. Quantification of seafood co-products using statistics on production of processed fish products

The quantities of processed fish products produced in Sweden were divided into the groups: whitefish, salmonid fish, pelagic fish and other fish. Whitefish included gadoids (for example cod and saithe) and flatfish. Salmonid fish included salmon, trout and other fish in the Salmonidae family. Pelagic fish included herring, sprat and mackerel. In the group “other fish” both unspecified fish and fish that did not belong to any of the other groups were included. By using conversion factors that convert the weight of a fish product (for example a fillet) to the corresponding weight of the whole fish it was possible to estimate the amount of whole fish and co-products that the quantity of processed fish products were equivalent to.

The quantity of processed fish products within each fish group was multiplied with the conversion factor for the most common product of each fish group. The conversion factors were obtained from the website of the European Commission (European Commission, 2015). The data on production of invertebrate products did not specify if shells had been removed or not. Therefore processed invertebrate products were excluded.

4.1.2. Quantification of seafood co-products using statistics on fish supply

Data on fish supply was also gathered to calculate which amounts of co-products that were generated in the Swedish seafood processing industry. To quantify fish supplies, data on landings, aquaculture production and import and export of whole fish were gathered. The quantity of whole fish available for processing was calculated by adding the import of whole and live fish, landings of marine and freshwater fish and production of fish and then subtracting the export of whole fish and the landings of feed fish. The landings of feed fish by Swedish fishers abroad seemed to be included in the data on exports, and were therefore excluded from the figure on export of whole fish. The figure on fish supply was multiplied first with an assumed proportion of whole fish going to processing and then divided by a conversion factor, as follows

$$((a - b) \cdot x)/y$$

where a = sum of landings, production and imports of whole fish, b = sum of exports of whole fish and feed fish landed, x =proportion of whole fish processed and y = conversion factor converting the weight of a fillet to live weight. The conversion factor used was a mean of the conversion factors for some of the most common fish processed by filleting in Sweden.

All figures used were obtained from Statistics Sweden except for the data on aquaculture production which was obtained from the Swedish Board of Agriculture (Table 1). Since the amounts of landed and produced fish vary between years, a mean of the years 2011, 2012 and 2013 was used for calculations when possible. Data from 2013 was the most recent available data. For the amount of processed seafood produced, a mean of 2011 and 2012 was used since statistics from the year 2013 was not yet available. The statistics on landings of marine fish during 2012 was not included since the figures on feed fish were inaccurate.

Table 1. Swedish fish supply and processing data sources.

Data	**Years**	**Source**
Import of whole and living fish	2011-2013	Statistics Sweden (2015a)
Export of whole fish	2011-2013	Statistics Sweden (2015a)
Landed fish from sea	2011, 2013	Statistics Sweden (Ericson 2014a)
Landed fish from freshwater	2011-2013	Statistics Sweden (Ericson 2014b)
Aquaculture production	2011-2013	The Swedish Board of Agriculture (2014b)
Production of processed seafood products	2011, 2012	Statistics Sweden (2015b)

4.2. Interviews with seafood processors

Since no data is available on the amount of seafood co-products produced in Sweden, interviews with seafood processors were conducted to obtain an estimate of the total quantity. Fourteen seafood processors were interviewed between November 2014 and February 2015. The majority of the processors interviewed were among the 20 largest seafood processors that generate co-products in their production in Sweden, based on income. The interviews took place either at the processing factory or were conducted by telephone.

Of the 223 enterprises that process fish in Sweden as their main activity (Swedish Board of Agriculture 2014a) the ones interviewed for the present study made up around 45 % in terms of income (Largest Companies, 2015). However, these 223 include processors where co-products are not generated. Therefore the 45% that the interviewed companies make up based on income might be underestimated in terms representing volume produced. For the two groups “pelagic fish” and “invertebrates”, the interviewed processors were estimated to cover all processing in Sweden (of companies that produce co-products).

The questions posed to the seafood processors were:

- What amounts of seafood co-products are generated in your production?
- What species of fish and invertebrates are processed?
- How are the co-products currently used?
- What would it take to use the co-products differently?

The processors interviewed gave information that applied for the most recent year, which was 2014.

4.2.1. Quantification of seafood co-products generated

The amounts of co-products that the interviewed processors generated were divided into the same fish groups as described above: whitefish, salmonid fish, pelagic fish and other fish (see previous chapter for details on fish included in each group). The group “invertebrates” which included shrimps was added to the other fish groups. The quantity of seafood co-products in each fish group was multiplied with the proportion that the interviewed companies made up of all companies that processed that group of fish (based on income) so that a total for all of Sweden could be calculated. For pelagic fish and invertebrates the proportion used was 100% and for the other fish groups it was 45 % based on income.

4.2.2. Present and future uses for seafood co-products

The uses of seafood co-products that did not go to human consumption reported by the interviewed processors were divided into: fishmeal production, mink feed production, pet food production and destruction. The percentage that each of the uses made up for the three largest fish groups: whitefish, salmonid and pelagic fish and the total use was calculated.

The processors were also asked about what it would take to make better use of the co-products (no answers were provided by the interviewer). The processers often gave several answers and all answers were counted and listed, starting with the most common answer.

5. Results

5.1. Quantification of co-products generated in Sweden using official data

5.1.1. Quantification of seafood co-products using statistics on production of processed fish products

The quantity of seafood co-products generated in the Swedish processing industry was on average 20,467 tons per year 2011-2012, based on the statistics of the Swedish production of seafood products (Fig.1). The fish group that generated most co-products was whitefish, generating around 13,000 tons of co-products per year, 65 % of the total production.

The most common fish products produced within the fish groups were cod fillets for whitefish, salmon fillets for salmonid fish and herring fillets for pelagic fish. The conversion factors, converting fillet weight to live weight obtained for the products were 3.25, 2.8 and 2 respectively for each product. The three conversion factors used are equivalent to fillet yields of 31 %, 35 % and 50 %. For the group other fish, 2.68 (fillet yield=39 %), a mean of the three conversion factors was used.

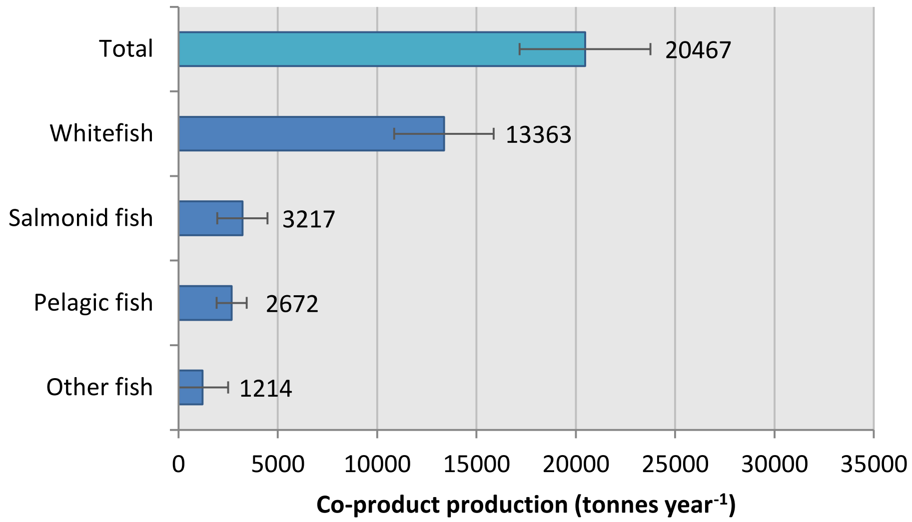

Fig.1. Mean production of seafood co-products (tons year^{-1}) generated in the seafood processing industry in Sweden 2011 and 2012 based on statistics over the production of seafood products in Sweden. Error bars show standard deviation.

5.1.2. Quantification of seafood co-products using statistics on fish supply

The supply of whole fish available for processing per year was calculated to be around 115,000 tons using data on landings, aquaculture production and import and export of whole fish from 2011-2013. Based on my assumption that 90 % of the whole fish supply is processed and that the conversion factor was 2.68 (fillet yield= 39 %), the quantity of fish co-products generated in processing was 63,000 tons (Fig. 2). The conversion factor of 2.68 used was the same as used for the group other fish in the calculation of the quantity of co-products based on the production of processed fish products (see above). The 63,000 tons include co-products used for human consumption in Sweden and co-products exported for human consumption in other countries.

The statistics on landings also showed that the amount of co-products discarded at sea from fish landed in Sweden 2013 was 1,535 tons (Ericson 2014). The majority of the co-products discarded were guts from cod and saithe, which are landed with their guts removed.

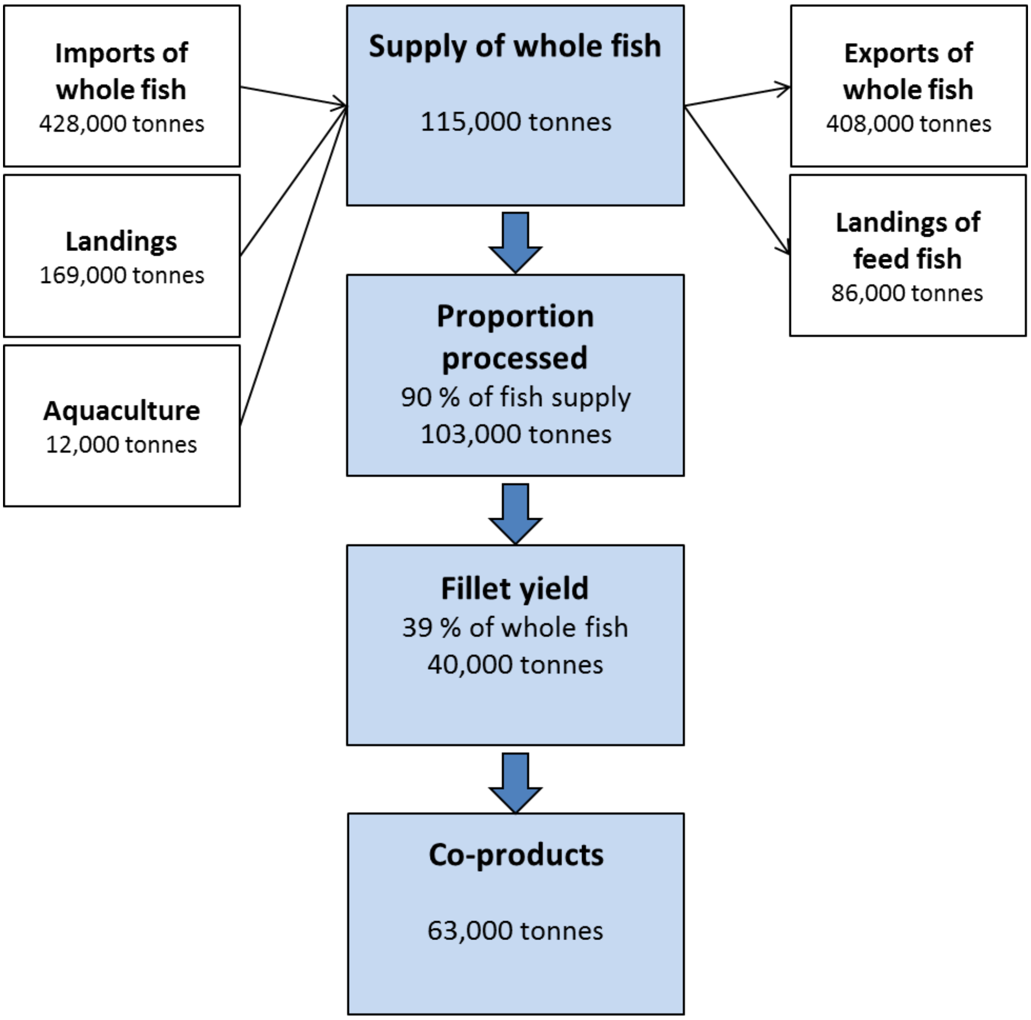

Fig. 2. Resource map using data on landings, aquaculture production and import and export of fish from 2011-2013.

5.2. Interviews with seafood processors

5.2.1. Quantification of seafood co-products generated

Based on the production of seafood co-products by interviewed processors, the total quantity of seafood co-products produced in all of Sweden was around 30,000 tons during 2014 (Fig 3). Pelagic fish accounted for the largest quantity of co-products, making up around 50 % of the generated seafood co-products. Whitefish represented the second largest source of co-products with around 10,000 tons generated a year. The 14 processors interviewed generated around 23,000 tons of seafood co-products. The composition of these co-products was backbones, heads, guts skins and shells.

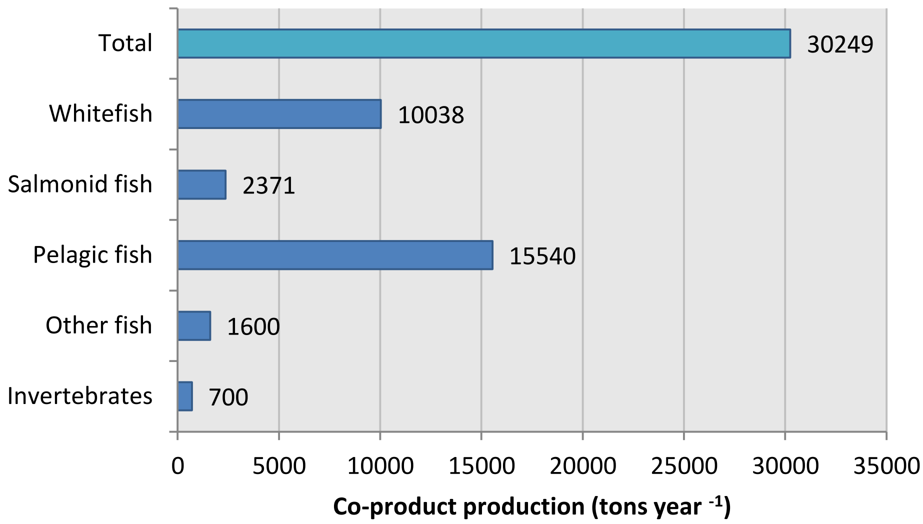

Fig. 3. Production of seafood co-products in Sweden 2014 (tons year^{-1}) based on interviews with seafood processors.

5.2.2. Present and future uses for seafood co-products

The current uses of the seafood co-products produced by the 14 interviewed processors were feed for minks, fish meal, destruction and food for pets (Fig.4). The most common uses of fish co-products were feed for minks in the fur animal industry and fish meal production for feed for aquaculture, fur animals and pets (Fig.3a). The quantity of co-products used for mink feed was 12,400 tons which accounted for 55 % of all co-products produced. The quantity of co-products used for fish meal production was 8,800 tons which accounted for 39%. The use of seafood co-products for pet food and destruction both accounted for 3 % (600-700 tons each) of all co-products produced. For whitefish, almost all of the co-products were used for mink feed (Fig.3b). For both salmonid fish and pelagic fish, the proportion of co-products going to mink feed was 43 % (Fig. 3c-d). The rest of the co-products from salmonid fish were used for pet food or were destroyed and the remaining co-products from pelagic fish were used for fish meal and fish oil production.

The two most common answers to why the processors would not use the co-products differently were that the profitability was too low and that it would require more staff (Table 2). However, three processors answered that the reason for not using the co-products differently was that they were satisfied with the way that they currently used the co-products and one processor mentioned the lack of knowledge about using co-products for food as a difficulty.

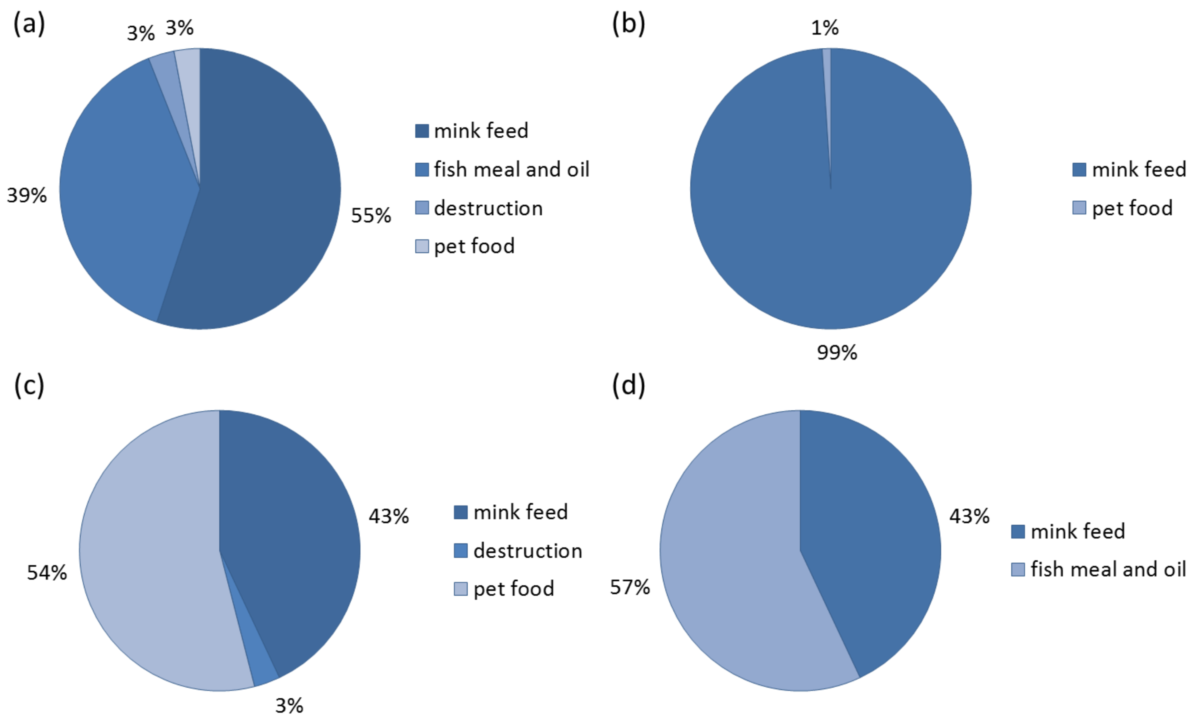

Fig. 4. Present uses of seafood co-products (proportion in %) generated in Sweden 2014 by 14 interviewed seafood processors (a) for all fish groups, (b) for whitefish, (c) for salmonid fish and (d) for pelagic fish. The total amount of seafood co-products was 22,500 tons.

Table 2. Reasons stated by seafood processors for not using seafood co-products more efficiently.

Reasons stated for not using co-products differently	**Number of answers**
The profitability is too low	4
It would require more working staff	4
It would require more space	3
It would require more time	3
It would require transportation	3
Satisfied with the present utilization of co-products	3
It would require refrigeration/freezing	2
Knowledge is lacking about co-products as a food source	1

6. Discussion

6.1. The quantities of seafood co-products produced in Sweden

The estimations of the yearly production of co-products in the Swedish seafood processing industry ranged between 20,000 and 60,000 tons depending on the calculation method. The fourteen interviewed processors generated 23,000 tons of seafood co-products which exceeds both the annual production of fish in aquaculture (12,000 tons) and the total catch of cod (11,600 tons) in Sweden.

That the three methods used to estimate the quantity of seafood co-products gave different figures was not unexpected since they were based on different data. The estimation based on the interviews with seafood processors of a production of 30,000 tons of co-products per year is most likely closest to the real quantity, since it was based on actual quantities produced by the largest processors. During interviews we learned that the official data on the production of processed seafood products did not include the production from all processors and not all kinds of processed seafood products that generates co-products. Therefore, the calculation using data on production of processed seafood products underestimates the real quantity. The reason why the estimation using official data on fish supply differed from the others could also be explained by that the datasets used were unsuitable for the kind of calculation performed, but also that assumptions were used and that no specific conversion factors were used.

The lack of data on the amounts of co-products that arises in Swedish seafood processing suggests that this resource is considered to be a product of low importance and economic value. However, this view on seafood co-products is aged.

In comparison to major seafood producing and processing countries and states like Norway and Alaska, the Swedish production of seafood co-products is small, up to 30 times less (Sathivel et al. 2005, Olafsen et al. 2012). The large amounts of co-products that are generated there have encouraged a more profitable use of co-products which could be adopted by Sweden. Actions taken in Norway to assure better use of co-products include collection of data on the quantities of co-products produced and their uses as well as extensive research on techniques to separate meat and bone (Bekkevold & Olafsen 2007).

6.2. Present and future uses for seafood co-products

The co-products generated in Sweden were mainly used for feed for minks in the fur animal industry and for the production of fishmeal and oil for aquaculture and other animal feed. Mink feed was the most or second most common use of co-products within all fish groups. With the rapid expansion of aquaculture (Troell et al. 2014), the demand for co-products for the production of carnivorous fish will increase. A conflict between aquaculture and the fur animal industry might therefore arise in the future. With feeding the growing human population being one of the largest global problems to solve, the use of potential food sources in a responsible way is becoming more and more important. In terms of increased food production, it would be better to use co-products from the seafood processing industry for aquaculture rather than for production of mink furs, but also to use the co-products directly for human consumption when possible rather than for aquaculture. For farmed carnivorous fish like rainbow trout, which is the most commonly farmed fish in Sweden (Swedish Board of Agriculture, 2014b), between 1.4 and 1.5 kg of feed fish can be needed to produce 1 kg of farmed fish (Tacon & Metian 2008, Jackson 2009). Therefore, the farming of carnivorous fish results in energy losses and remained pressure on wild fish stocks.

The main reason stated by Swedish seafood processors for not using the co-products differently was that it was not seen as profitable. The ways that the different processors handled their co-products could be very different from processor to processor. Some processors paid for both transportation and for destruction of the co-products whereas other processors had the buyers of their co-products paying for the transportation as well as for the co-product. Several of the interviewed processors said that they were interested in letting biogas facilities use their co-products to produce biogas. However since the biogas facilities would not pay enough for the co-products or the transportation, this option was not seen as economically interesting. The interviews with the processors showed that for a change in utilization to be possible, the value of products from co-products needs to increase considerably and the attitude towards using them in new ways must change. There is a large potential for using these high protein products more intelligently and profitable. Some of the co-products that are used for purposes like feed production in Sweden, for example cod heads and cod roe are in Norway and Iceland exported for human consumption (Rustad et al. 2011, Statistics Norway 2015).

One way of increasing the profitability of using seafood co-products more responsibly than today is to produce and handle co-products in a way so that they maintain their good quality. Aksnes and Mundheim (1997) showed that the use of spoiled fish (as measured by the level of biogenic amines e.g. cadaverine) for fish meal production results in a lower quality product which influences the growth and feed efficiency ratios of animals fed with the fish meal. A higher quality of the co-products should therefore result in a higher price which could motivate an investment in freezing or refrigeration equipment to keep the co-products from becoming spoiled. Likewise, production of co-products for human consumption could result in higher profit and motivate better handling of co-products than the production of fish meal which requires less careful handling.

Another way of increasing the value of the co-products is to make the extraction of muscle from the rest raw material more cost effective. Many processors interviewed for the present study stated that it was possible to cut out relatively large amounts of meat from backbones of salmon by hand, but that it was not performed in large extent since it was too time-consuming. By using machines to separate remaining muscle from bones and skin the process can be made faster and at lower cost. There are machines available that can mechanically separate bone and meat today by pressing the raw material through a perforated rotating drum (Bekkevold & Olafsen 2007). Other, more novel ways of isolating muscle from bones and skin are by acidic/alkaline solubilization processes (Nolsøe & Undeland, 2009) or by enzymatic hydrolysis, the latter generating peptides with other functionalities as compared to the intact proteins (Nilsang et al. 2005). These techniques open up for possibilities for production of foods for human consumption using rest raw materials. For example the mince produced by the techniques mentioned can be added to fish products or used to produce surimi. Additional advantages of separating muscle via acid/alkaline solubilization or hydrolysis is that such fractionation could facilitate the extraction of valuable compounds. Compounds derived from seafood co-products used in cosmetics or for industrial and pharmaceutical appliances can generate high prices (Olafsen et al. 2012). An example of a pharmaceutical product produced from seafood co-products is a cold-preventing mouth spray using the enzyme trypsin extracted from cod co-products (ColdZyme®). Additional uses, although of lower value than the ones mentioned above, is to use e.g. guts to produce silage which can provide pets and aquaculture fish with nitrogen (Blanco et al. 2007).

6.3. Other underutilized seafood resources

Large sources of fish not used for human consumption that were excluded from this study are feed fish and discards. The quantity of feed fish landed by Swedish fishers was 79,000 tons in 2013, 47 % of the total marine catch (Ericson 2014a). The species were mainly herring, sprat and sand eel. The feed fish is presently used to produce fish meal and fish oil.

Discard of fish at sea is another source of fish that could be used for human consumption or for other purposes. Guts that are discarded could potentially be used more. Akse et al. (2002) found that cod, which have their guts removed and discarded at sea in the Swedish fishery, could be landed ungutted without decreasing the quality of the fish or the co-products as long as it was gutted within 12 hours after the catch. Fish and crustaceans smaller than the minimum allowable size that are mandatory to land should however not be included in the efforts to find valuable uses, but should instead not be caught at all if not intended to be landed. The aim of the landing obligation (Regulation (EU) No 1380/2013 of the European Parliament and of the Council) is to encourage the utilization of more selective fishing gear that catches only the target species of allowable size, and therefore it should not be profitable to land fish of unallowable sizes. Other sources of fish not included in this study are seafood co-products currently being processed for Swedish companies abroad and co-products from blue mussels produced in Sweden. The amount of blue mussels not reaching human consumption because of damage during harvesting is 500 tons per year.

6.4. Conclusion

This study showed that around 30,000 tons of seafood co-products were generated each year in Swedish seafood processing based on interviews with the largest processors of seafood in Sweden. Pelagic fish accounted for the largest quantity of co-products followed by whitefish making up around 50 and 33 % of the generated seafood co-products respectively. The main uses were feed for minks and production of fish meal for animal feeds.

The main obstacle to overcome to gain a more effective usage of this resource was to increase the profitability.

The results of the present study provide important information that enable further research on how to make better use of Swedish seafood co-products.

7. Acknowledgements

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