PROJECT TO MODEL THE USE OF FISHERIES BY-PRODUCTS IN THE PRODUCTION OF MARINE INGREDIENTS, WITH SPECIAL REFERENCE TO THE OMEGA 3 FATTY ACIDS EPA AND DHA

INSTITUTE OF AQUACULTURE, UNIVERSITY OF STIRLING AND IFFO, THE MARINE INGREDIENTS ORGANISATION

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UNIVERSITY OF STIRLING

INSTITUTE OF AQUACULTURE

IFFO
THE MARINE INGREDIENTS ORGANISATION

EXECUTIVE SUMMARY

- A model was constructed of fisheries and aquaculture production, estimated from FAO databases and including assumptions from IFFO including:
  - Top twenty species by production volume across nine regions
  - Amount of processed product
  - Quantity of by-product available
  - Quantity of whole species directed to fish meal and oil
  - Quantity of by-product directed to fishmeal and oil
  - Amount of by-product raw material that is currently not utilised and potential fishmeal and oil that could be obtained from it
  - Potential extra EPA and DHA that could be obtained
- The model revealed an overall increasing trend in the amount of fishmeal and fish oil being obtained from by-products
- Europe uses proportionately more by-product for fishmeal than other regions with most coming from wild capture
- Asia and China showed most potential for gains in fishmeal and fish oil from underutilised resources from both aquaculture and capture, amounting to some 27 million tonnes of raw material
- The report concluded that whole fish will be increasingly directed to direct human consumption and marine ingredients will need to be sourced more from by-products
- Fishmeal production will grow as more by-product is made available so that in ten years by-product supply will outstrip that from whole fish
- Fish oil production will grow but more slowly as whole pelagic fish are directed more to human consumption and replaced by more low fat aquaculture species
- Overall levels of EPA and DHA may a decline over the long term as a result of changes in species utilisation
- By-products are likely to remain of low value and therefore large quantities would be required to make collection economically attractive
- As most potential for increased raw material will come from Asia, an increasing proportion may be uncertified. More effort is being made to encourage IFFO RS and MSc certification in these regions

INTRODUCTION

A model has been developed that looks at the global production of fishmeal and fish oil, which estimates recent production by geographic area and source raw material by species and whether from whole fish or by-products. Estimates have also been produced going forward for five and ten years (2020 and 2025).

It should be noted that much of the data in the current model has had to be estimated using incomplete data. The hope would be that with time more data will be made available.

The assumptions to produce the model are as follows:

Fisheries: Fisheries data was taken the FAO data set FishStat. Data was collated into 9 different geographical areas, Europe, Middle East (including Turkey), Africa, Russian CIS, Asia (excluding China), China, North America, South America and Oceania. The information collected was split into wild capture derived whether from whole fish or from by-products of processing for direct human consumption and by-products produced from the processing of aquaculture grown fish and crustacean. The database includes fish, crustaceans and cephalopod molluscs but not mammals, other molluscs, reptiles, amphibians or plants as it is assumed that there are no usable by-products, or that they are not readily directed to fishmeal/ fish oil production. All of the usable supply is referred to as seafood henceforth, whether marine or freshwater.

Given the very large number of species involved it was decided to concentrate on the top twenty species caught and farmed by weight in each of the chosen geographical areas. Within the FishStat data by species, there are groupings for Marine and Freshwater species not elsewhere included (nei), these were included as a single entry if these groupings fell within the top ten produced.

Time Series: It was agreed to produce average data for catches and production for the latest available five years (2009-2013). This was given as the current position. Estimates were then made for catches and production in 5 and 10 years' time.

The most up-to-date seafood production volume data for the last 5 years, taken from FAO FishStat, was averaged for each country for all species from capture and aquaculture. This was ranked to find the top twenty production species for each region for each of capture fisheries and aquaculture.

The trade balance for these species was then estimated from the last five years of commodity trade data from FAO Fishstat. Unfortunately the commodities list does not match exactly with the production data in that commodities tend to be grouped into species, and it is also two years behind the production data. Therefore some assumptions needed to be made regarding the commodities to which some species belonged. In each case where there was more than one species per commodity, the allocation between them regarding trade flows was divided proportionately to the production data. This gave the total supply of those species, as whole fish, that was available in each of the regions.

Based on information from IFFO, the amount of supply of each species that was directed either to human consumption or to the reduction industry was estimated. This gave an estimate of total fishmeal and fish oil that was produced from whole fish. Yields of fishmeal, fish oil and EPA/DHA fractions were obtained from IFFO data and literature sources. Estimates were made using IFFO data collected from its members wherever possible. If no data was available estimates were made from related species, data found from other sources or else an industry average for all species.

Assumptions and estimates were then made on the quantity of species which were processed and then how much of the processing by-product was directed to fishmeal and fish oil production. Edible yields for each species were taken from FAO (1989) IFFO and other literature, and the remaining fraction assumed to be the by-product which could be directed to reduction. In some cases, similar species were used to estimate fillet yields where no other information could be found.

There are therefore 4 major assumptions within the database: 1) the amount of raw material that is traded prior to processing; 2) the amount of supply directed to human consumption or reduction; 3) The amount of raw material directed to processing; 4) the amount of resultant by-product which is directed to fishmeal. The majority of this data came from IFFO members and other reports.

This then gives the amount of fishmeal which is produced both from reduction of whole fish and that which is obtained from the reduction of by-products. The database uses these estimates to calculate the potential for additional fishmeal and fish oil production for each region from: 1) the amount of unutilised by-product which could be directed to fishmeal and 2) the total amount of by-product which would be available if all of the initial seafood supply was processed.

In all cases, the EPA and DHA quantities that were available from the fish oil estimates were also obtained, using various IFFO and literature sources. Finally, the quantity of raw material that was certifiable as sustainable by MSC or other accreditation was also estimated.

Although there are several assumptions within the database, there is substantial room to amend and update these. Most of the assumptions are within a defaults input page which contains the 4 major assumptions listed above, as well as the fillet, fishmeal and fish oil yields plus the DHA and EPA content for each species, where available. These can all be updated on the defaults page and (in the case of the 4 major assumptions) for the individual regional sheets.

As well as current production data, the database also includes projections for 5 and 10 years' time. These projected values are calculated in the same way as the current values, except that the total supply is different for each species. The production is calculated on the linear growth increase or the % decrease over the last 5 years. Increases are calculated linearly because % growth rates do not give realistic quantities when projected 10 years hence. Similarly, linear decreases often result in negative values and therefore % decreases are used. Projections of the trade of whole seafood commodities are calculated in the same way and divided proportionately according to production as described above.

KEY OUTCOMES

Current Position

The model shows that a total of nearly 20 million tonnes of raw material is used annually for the production of fishmeal and fish oil, of which around 14 million tonnes comes from whole fish, nearly half of which is in South America. Around 3.7 million tonnes of by product comes from the processing of wild caught fish with Europe producing around 1.2 million tonnes of this total. An estimated 1.9 million tonnes comes from Aquaculture of which 0.8 million is in Asia principally Vietnam and Thailand.

TABLE 1
RAW MATERIAL (TONNES ,000)

Region	Whole fish	By-product from wild capture	By-product from aquaculture	Total Raw Material Used
Europe	1,502	1,165	331	2,998
Asia (exc China)	2,577	827	851	4,255
China	1,251	168	367	1,787
M East	188	32	19	240
CIS	260	103	-	364
Africa	650	222	6	877
S. America	6,810	768	331	7,909
N. America	730	427	31	1,188
Oceania	11	42	13	66
Totals	13,980	3,754	1,949	19,683

This raw material is then used to produce around 4.6 million tonnes of fishmeal. This figure compares to the official IFFO figure of 4.8 million tonnes. The difference of 0.2 is explained by the model only considering most species but not all and the missing species (such as Boar fish in Europe) would make up this missing quantity. From the table below it can be seen that in recent years around 33% of the world's fishmeal production came from by-products with Asia and Europe being the biggest producers of by-product fishmeal.

TABLE 2
FISHMEAL PRODUCTION (TONNES ,000)

Region	From Whole fish	From By-product	Total	% from By Product
Europe	320	381	701	54
Asia (exc China)	580	454	1,034	44
China	281	152	433	35
M East	42	13	55	23
CIS	57	27	84	32
Africa	146	60	206	29
S. America	1,532	289	1,821	16
N. America	170	118	288	41
Oceania	2	14	16	85
Totals	3,131	1,508	4,639	33

A similar pattern is seen with fish oil production although Europe is clearly the largest producer of by-product fish oil. This is principally because Asia processes a large volume of farmed shrimp waste which does not yield any oil. This factor is also a major contributor to the percentage of by-product oil being at 26% globally rather than the 33% for fishmeal.

TABLE 3
FISH OIL PRODUCTION (TONNES ,000)

Region	From Whole fish	From By-product	Total	% from By Product
Europe	101	90	191	47
Asia (exc China)	103	44	146	30
China	48	16	64	25
M East	8	2	10	24
CIS	16	4	20	20
Africa	28	9	37	24
S. America	304	50	353	14
N. America	71	20	91	22
Oceania	0.5	4	4	89
Totals	678	240	918	26

If we look at the estimated volumes of EPA and DHA in the extracted oils we can see that globally there is around 210,000 tonnes of these long chained fatty acids with there being a bit more EPA than DHA extracted. South America, with its anchovy harvests is by far the biggest producer of these fatty acids although Europe is the largest producer of them from by-products with salmon making a considerable contribution (levels of EPA and DHA have been falling in farmed salmon but the model has not tried to factor this in – the default fatty acid profiles by species are assumed to remain constant).

TABLE 4
OMEGA-3 EPA & DHA IN FISH OIL (TONNES ,000)

Region	EPA	DHA	TOTAL EPA +DHA	EPA+DHA FROM BY-PRODUCTS	% FROM BY-PRODUCTS
Europe	16.6	20.4	37.0	19.9	54
Asia (exc China)	12.4	18.6	31.0	7.9	25
China	7.5	7.3	14.8	2.4	16
M East	1.1	1.1	2.1	0.5	21
CIS	1.7	1.6	3.3	0.4	13
Africa	5.2	4.1	9.3	2.2	24
S. America	59.7	34.9	94.6	10.9	12
N. America	9.6	7.3	16.9	2.9	17
Oceania	0.3	0.7	1.1	1.0	90
Totals	114.2	96.0	210.2	48.0	23

It can be seen in Table 1 that it is estimated that around 5.7 million tonnes of by-products are currently processed to produce fishmeal and fish oil. However, it is estimated that globally there are

an additional 11.7 million tonnes produced in processing plants which are currently not collected for marine ingredient production. Asia (ex China), at 4.6 million tonnes, is the area where there is the biggest potential for further production and even in Europe it is estimated that there is an additional 0.6 million tonnes that could be used. If all fish were processed and all the by-product collected it is estimated that globally there would be around 36 million tonnes of raw material available producing about 9.5 million tonnes of fishmeal and 1.5 million tonnes of fish oil.

TABLE 5
POTENTIAL SOURCES OF ADDITIONAL RAW MATERIAL AND PRODUCTION (TONNES ,000)

Region	Unused By-Product potential	Unused By-Product fishmeal potential	Unused By-Product fish oil potential	Full processing by-product potential	Full processing by-product fishmeal potential	Full processing by-product fish oil potential
Europe	585	139	21	667	176	29
Asia (exc China)	4,628	827	110	12,413	3,293	481
China	1,011	221	25	15,231	4,073	653
M East	479	87	16	476	123	21
CIS	1,132	265	44	1,413	365	62
Africa	1,053	233	37	2,758	730	106
S. America	1,330	264	38	1,310	359	54
N. America	1,380	302	57	1,387	363	67
Oceania	109	26	4	181	48	8
Totals	11,707	2,365	352	35,837	9,530	1,481

The additional fish oil that could come from the additional processing and collection would provide additional EPA and DHA. The collection and processing of all by-products not currently used for fish oil extraction would yield around 50,000 tonnes of EPA and DHA with around 80% coming from wild capture fisheries. This additional tonnage of EPA+DHA would increase the global supply by around 25%.

If all fish were processed to produce additional by-product this would yield around 170,000 tonnes of EPA and DHA, nearly doubling the available supply of EPA and DHA. However, around 70% of this would come from Asia, including China, and this is a region where there is still a culture of most fish being sold whole and with few fish processing plants.

TABLE 6
POTENTIAL SOURCES OF ADDITIONAL EPA+DHA (TONNES ,000)

Region	Unused By-Product potential for EPA+DHA from Aquaculture	Unused By-Product potential for EPA+DHA from Capture	Total unused By-Product potential for EPA+DHA	Full processing potential for EPA+DHA from Aquaculture	Full processing potential for EPA+DHA from Capture	Full processing potential for total EPA+DHA
Europe	0.54	3.07	3.60	0.68	4.21	4.89
Asia (exc China)	2.93	12.43	15.36	12.23	44.51	56.74
China	0.24	4.36	4.60	27.18	33.75	60.93
M East	0.94	1.69	2.63	1.00	2.52	3.52
CIS	0.61	5.62	6.22	0.63	8.04	8.67
Africa	0.87	6.00	6.87	2.00	12.32	14.33
S. America	0.89	4.85	5.74	0.89	7.66	8.55
N. America	1.79	5.57	7.36	1.79	6.30	8.09
Oceania	0.15	0.77	0.91	0.15	1.46	1.61
Totals	8.95	44.35	53.29	46.55	120.78	167.33

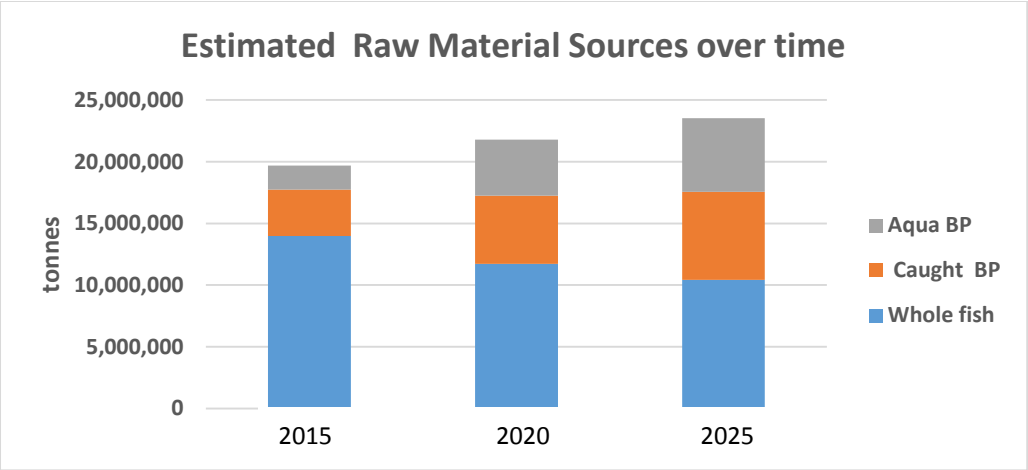
Future prospects

The model assumes that three recent trends will continue, these are:

1. Increasing volumes of pelagic fish will go for direct human consumption.
2. The convenience of processed fish to the consumer and the reduced logistics costs will encourage increasing volumes of captured fish to be processed, creating concentrated areas of by-products for marine ingredient production.
3. The continued growth of aquaculture will produce areas of concentrated by-product production which will drive the growth of marine ingredient production from this source

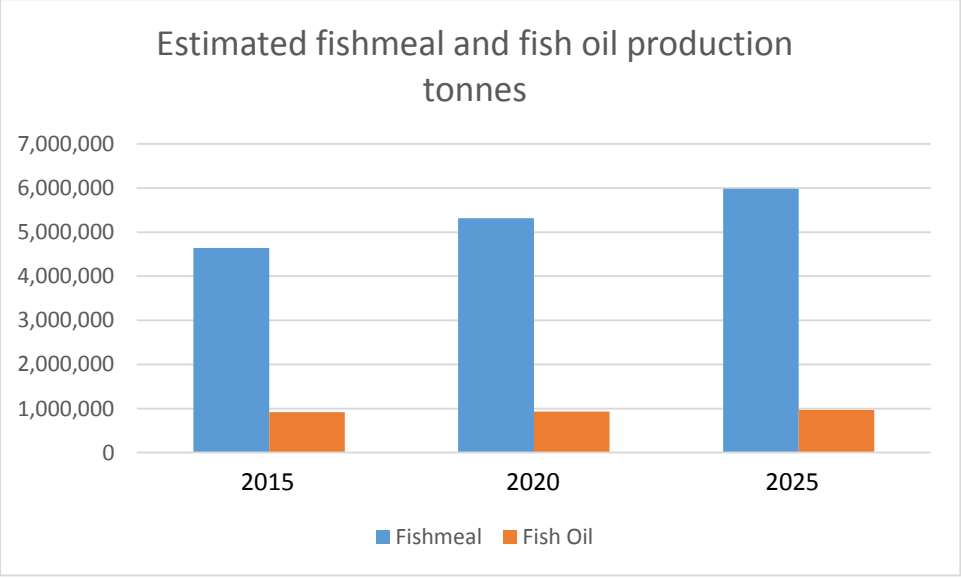
The model therefore predicts that in 10 years the volume of by-product raw material going for reduction will exceed that of whole fish with wild caught and aquaculture by-products making up about 50% each of the supply. This may well occur earlier in years of El Ñino when the harvests of Peruvian anchovy are greatly reduced, but the model does not try to predict El Ñinos.

FIGURE 1



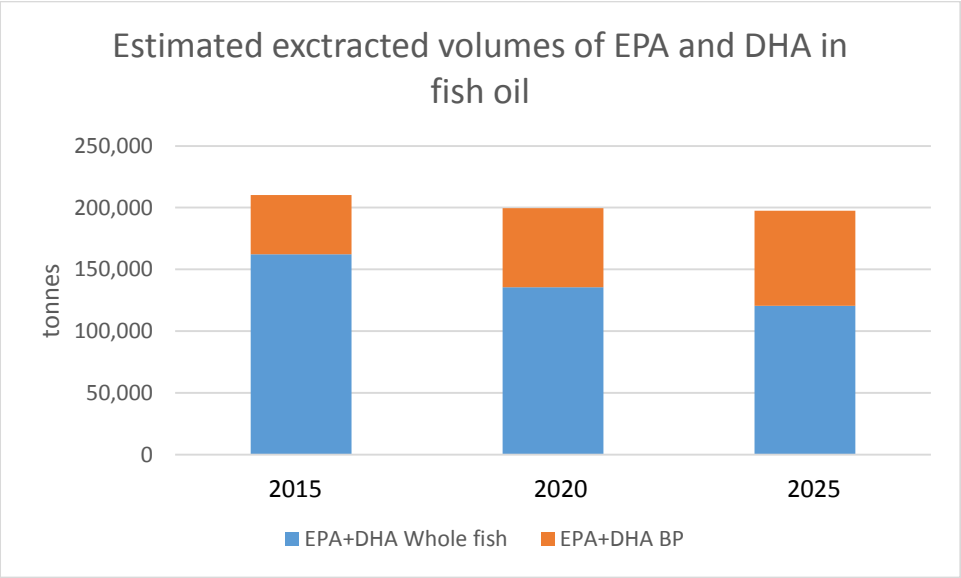
The resulting marine ingredients produced shows that fishmeal production will grow 25-30% over the 10 years as a result of this increased by-product availability. Fish Oil production is estimated to only increase by around 5-10% over the same period. The reasons for this slower growth are twofold. Firstly there is a reduction in whole pelagic fish available as raw material. Whole pelagic fish typically give the highest oil yields. This is being replaced by by-products which are often lower in oil, particularly if coming from white fish such as pollock or from aquaculture species such as tilapia and shrimp.

FIGURE 2



The levels of EPA and DHA available in the extracted fish oil, according to the model, remain constant or indeed fall slightly. This reduction is because the EPA and DHA of the oil from by-products, particularly that from aquaculture, is not as high as that found in whole pelagic fish.

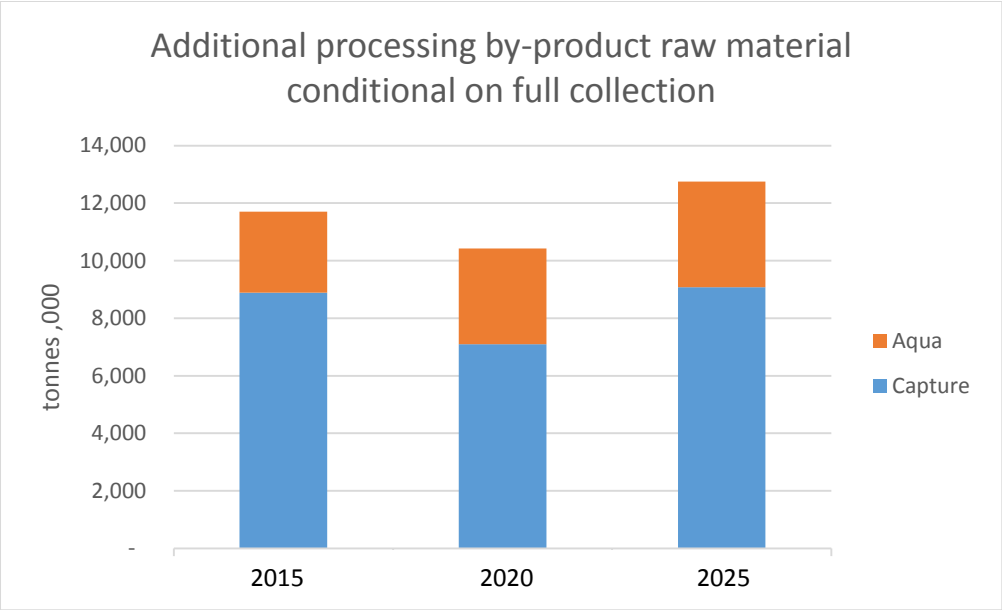
FIGURE 3



The model as reported shows that volumes of by-products used for marine ingredient production are likely to increase from around 6 million tonnes to around 14 million tonnes (Figure 1). However, despite this increase the model still estimates that there are nearly 12 million tonnes that are currently not used and that this will remain at roughly the same level over the next 10 years. The collection of by-products from remote processing plants and the need to have large volumes of raw material to justify the capital investment required for the construction of modern fishmeal plants makes this likely.

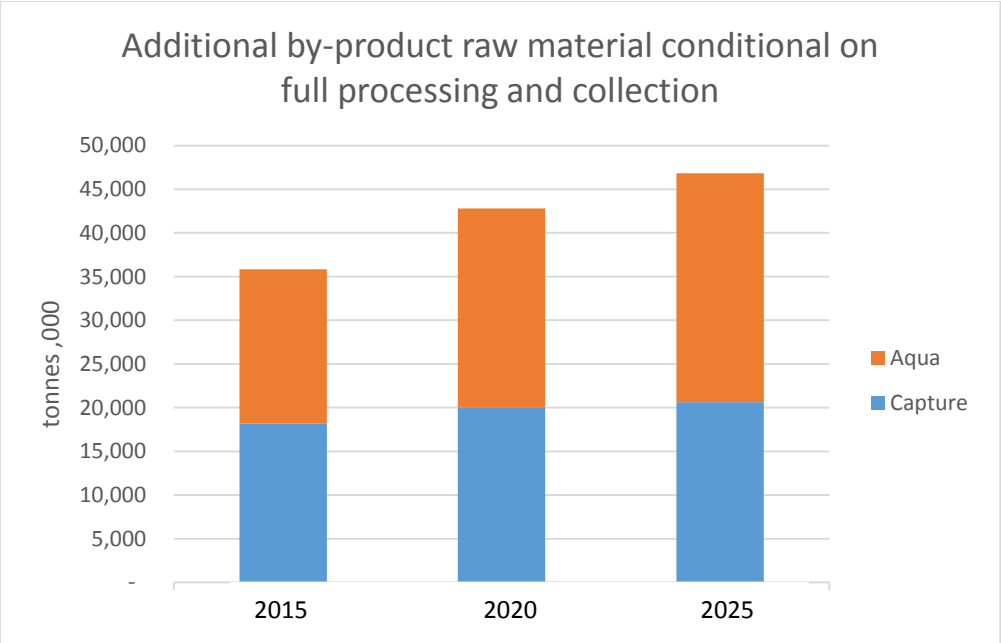
The rising value of the raw materials might change this position as would the development of designs for efficient smaller scale factories. At present these are difficult to justify given the increasing need to treat both effluents and emissions but new technologies are being developed which might change this position.

FIGURE 4



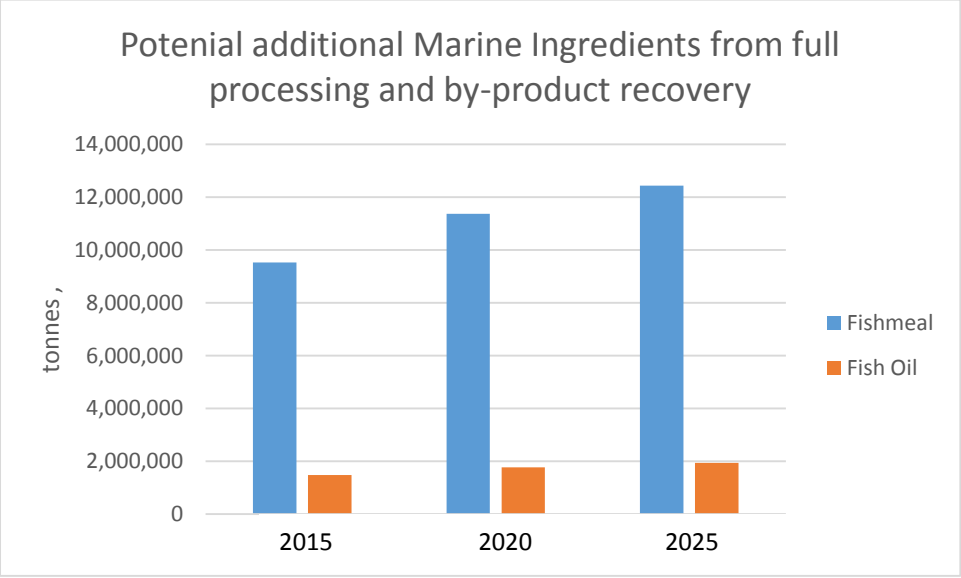
The model also estimates the potential volume of raw material which could be generated if all fish were processed and all the resulting by-products were collected for the production of fishmeal and fish oil. This shows that there are an estimated 35 million tonnes of raw material which could be generated and that despite the increase in by-product rendering predicted in the model this is likely to increase by around 10 million tonnes over the next ten years to reach 45 million tonnes. Most of this potential increase is coming from aquaculture. It should however be remembered that a lot of rural aquaculture in Asia and Africa involves the production of species such as carp and tilapia for the local market and it is assumed that these are unlikely to go to conventional processing plants for filleting etc. in the foreseeable future. Therefore whilst in theory this is a potential raw material source major changes would have to occur quickly to change this position. It should also be remembered that whilst these freshwater aquaculture derived raw materials are a good source of protein they are not a good source of EPA and DHA.

FIGURE 5



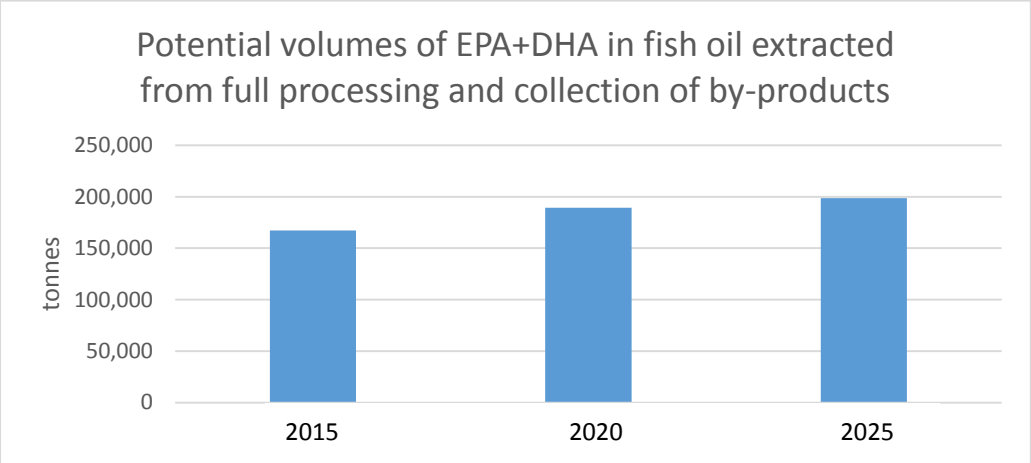
If this were to be achievable it could produce an additional 9 million tonnes of fishmeal increasing to over 12 million tonnes in ten years' time. In addition this would produce an additional 1.5 million tonnes of fish oil increasing to nearly 2 million tonnes in 10 years.

FIGURE 6



This volume of fish oil would yield an estimated 160,000 tonnes of EPA+DHA increasing to around 200,000 tonnes in ten years which is about the same as today's total production (Table 4).

FIGURE 7



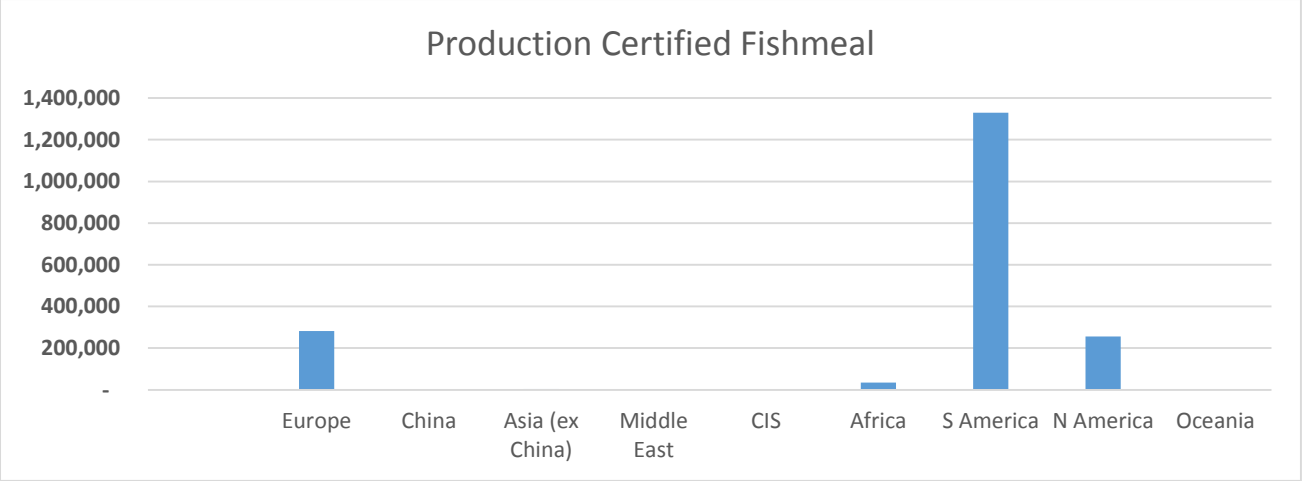
Certification of Marine Ingredients

Currently around 1.9 million tonnes of fishmeal production is certified as either IFFO RS or from MSC certified fisheries, this represents about 40% of global production. South America is the region where most of this comes from with both Europe and North America providing significant volumes (over 200,000 tonnes). Africa, principally South Africa, produces small volumes of certified meal whilst North Africa is a significant fishmeal producing area that currently has now certified production.

Currently there is no certified product produced in China and only very small quantities (<10,000 tonnes) produced in the rest of Asia and this from by-products. Given that Asia as a whole produces around 1.5 million tonnes of fishmeal there is obviously considerable room for improvement, both in the area of fisheries management and in certification uptake. Considerable focus is being paid to this region by both MSC and IFFO RS in the hope of rectifying this disappointing situation.

No estimates were made of future levels of certification as it was considered that there were too many variables (uptake of certification, future fisheries management regimes etc) to produce anything very meaningful.

FIGURE 8


Production Certified Fishmeal
1,400,000
1,200,000
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Europe
China
Asia (ex China)
Middle East
CIS
Africa
S America
N America
Oceania