

Fishmeal and fish oil facts and figures

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Compiled by Seafish (with thanks to the Marine Ingredients Organisation (IFFO) for permission to use its data).

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1. Fishmeal and fish oil - summary

MANUFACTURE

Fishmeal is the crude flour obtained after milling and drying fish or fish parts, while fish oil is usually a clear brown/yellow liquid obtained through the pressing of the cooked fish. Many different species are used for fishmeal and fish oil production, with oily fish, especially anchoveta, the main groups of species utilised. A significant, but declining, proportion of world fisheries production is processed into fishmeal and fish oil thereby contributing indirectly to human consumption when they are used as feed in aquaculture and livestock raising.

Fishmeal (FM) and fish oil (FO) are produced mainly from sustainably managed stocks of fish for which there is little or no demand for human consumption. Non official estimates of the contribution of fish by-products and processing waste, rather than whole fish, to the total volume of FM and FO produced indicate it is now about 25-35% and this figure is expected to grow.

These two fish products are manufactured in EU approved dedicated manufacturing plant and through a safety monitored supply chain. FM is never produced in the same factories as meat and bone meal. There are three different products sold as meal:

- High quality - usually for small-scale aquaculture units (trout farms) or marine species.
- LT (low temperature) meal - is highly digestible and used in salmon and piglet production.
- Prime FAQ (fair average quality) - lower protein content feed ingredient for pigs and poultry.

PRODUCTION AND CONSUMPTION

World-wide annual production of FM has been between Mt since 2006. The main producing countries are: Peru, Thailand, China PR, Chile, Vietnam, USA and Denmark. The main species used are:

	Species	Marketability as food
Industrial grade forage fish	Gulf menhaden, sandeel, Atlantic menhaden, Norway pout	No market at all as food. Fishery would cease if no fishmeal plants.
Food grade forage fish	Peruvian, Japanese, European and other anchovy. Capelin, blue whiting and European sprat.	Demand often small, localised or niche. Fishmeal plants take what food fish markets cannot absorb.
Food fish rejected by the market	Chilean Jack mackerel, chub mackerel and other species of sardine, mackerel and herring.	Well established food markets. Landings not in demand for food go for fishmeal and fish oil.

USE

Virtually all FM is used as a high protein (60 to 72%) ingredient in feed for farmed land animals and farmed fish. FO is used mainly in the feed of farmed fish and in very small quantities in land animal feed. FM is not fed straight (undiluted) and typical inclusion rates for fishmeal vary.

2. WORLD food and feed fisheries and aquaculture – key figures and trends

World Fishing	2014	2015	2016	2017
Global capture production	93.4 Mt	92.6 Mt	90.1 Mt	90.4 Mt
Total aquaculture production	73.8 Mt	76.6 Mt	80.0 Mt	83.6 Mt
Total capture and aquaculture production	167.2 Mt	169.2 Mt	170.1 Mt	174.0 Mt
Of which, caught to produce fishmeal and fish oil*	15.8 Mt	15.1 Mt	14.3 Mt	15.6 Mt

*Down from 16.3 Mt in 2012 and 17.9 Mt in 2009. This is a declining trend and well below peak levels of more than 30 Mt in 1994.

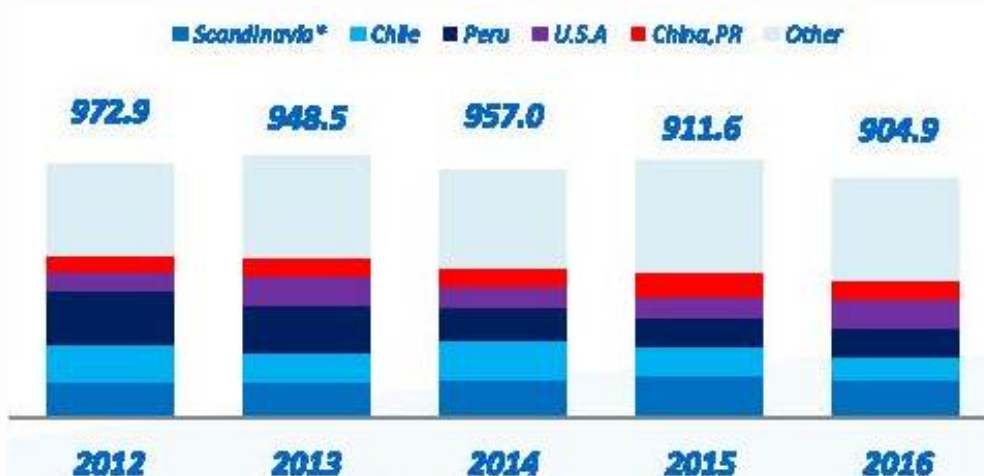
Source: FAO SOFIA Report 2016 and Globefish Highlights October 2017

FISHMEAL WORLD PRODUCTION

Scandinavia = Denmark, Norway, Iceland



FISH OIL WORLD PRODUCTION



Source: Fishmeal and fish oil. A summary of global trends. IFFO October 2017.

3. WORLD production, supply and consumption of fishmeal

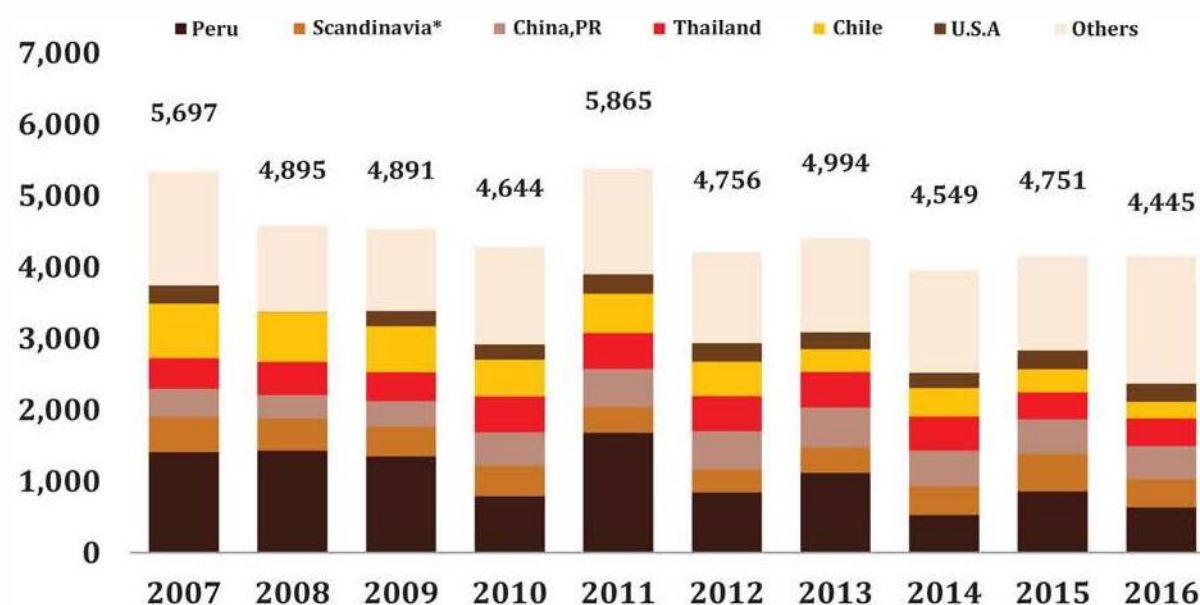
The **FAO State of World Fisheries and Aquaculture (SOFIA 2016)** (we are awaiting the 2018 version) states that global total fisheries production (excluding aquatic plants) reached 167.2 million tonnes (Mt) in 2014, with 93.4 Mt from capture and 73.8 Mt from aquaculture. Global total capture fishery production in 2014 was 93.4 Mt, of which 81.5 Mt was from marine waters (a slight increase on the previous years) and 11.9 Mt from inland waters. World aquaculture production continues to grow and now provides half of all fish for human consumption. Excluding fish destined for non-food uses, a milestone was reached in 2014 when, for the first time ever, the world's population consumed more farmed fish than wild-caught fish.

Fishmeal and fish oil trends

- 21 Mt (22.4% of total catches) was destined for non-food products. Of this 21 Mt 76% (15.8 Mt) was reduced to fishmeal (FM) and fish oil (FO) in 2014, the rest being largely utilised for a variety of purposes including fish for ornamental purposes, culture (fingerlings, fry, etc.), bait, pharmaceutical uses, and as raw material for direct feeding in aquaculture, for livestock and for fur animals.
- This figure of 21 Mt has fallen from 34.2 Mt in 1994. The reasons for this drop range from the increased use for human consumption and a decrease in dedicated fishing for feed production (due to tighter quota setting and additional controls on unregulated fishing). Another factor is the increased use of fish residues and by-products, increasingly replacing whole fish for FM and FO production.
- FM and FO are still considered the most nutritious and digestible ingredients for farmed fish feeds. To offset their high prices, as feed demand increases, the amount of FM and FO used in compound feeds for aquaculture has shown a clear downward trend, with their being more selectively used as strategic ingredients at lower concentrations and for specific stages of production, particularly hatchery, broodstock and finishing diets.
- Owing to the growing demand for FM and FO, in particular from the aquaculture industry, and coupled with high prices, a growing share of FM is being produced from fish byproducts, which previously were often discarded. In industrial fish processing, 30–70% of the fish ends up as by-products, e.g. heads, viscera and backbones. These by-products are usually further processed into FM and FO, and are primarily used for feed purposes.
- Non official estimates of the contribution of by-products and waste, rather than whole fish, to the total volume of FM and FO produced indicate it is now about 25-35% and this figure is expected to grow.
- The amount of FM and FO used in compound feeds for aquaculture has shown a clear downward trend, with their being more selectively used as strategic ingredients at lower levels and for specific stages of production, particularly hatchery, broodstock and finishing diets.

WORLD FM cont'd – total production

3.1 World fishmeal production 2007 - 2016 ('000Mt)



*Includes Denmark, Norway and Iceland
 source: IFFO, FAO and ISTA Mielke GmbH, OIL WORLD

Source – IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.

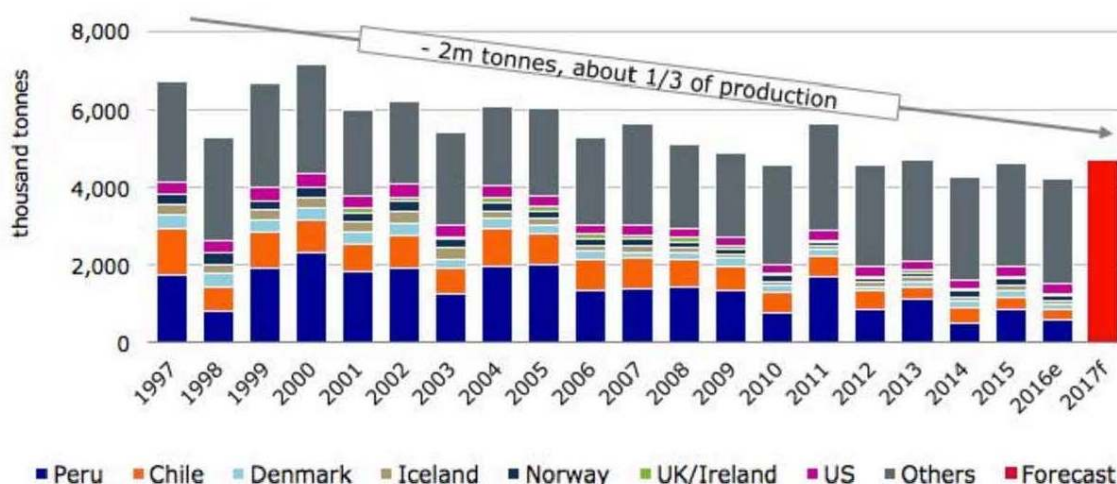
3.2 Total world production of fishmeal 1998 to 2016
 Tonnes

1988	6,837,000	2002	6,201,700
1989	6,875,000	2003	5,401,600
1990	6,380,000	2004	6,274,500
1991	6,448,000	2005	6,022,700
1992	6,263,000	2006	5,286,000
1993	6,514,000	2007	5,698,000
1994	7,441,000	2008	5,161,000
1995	6,833,000	2009	4,894,000
1996	6,912,000	2010	4,645,000
1997	6,617,000	2011	5,861,000
1998	5,208,000	2012	4,755,000
1999	6,670,000	2013	4,993,000
2000	7,125,000	2014	4,549,000
2001	5,997,400	2015	4,751,000
		2016	4,445,000

Source – IFFO Fishmeal and Fish Oil Statistical Yearbooks.

WORLD FM cont'd – total production

3.3 Global supply of fishmeal 1997 to 2016 ('000Mt)



Source: *Factors of Change in the Global Aquaculture Industry*. Gorjan Nikolik, Rabobank, GOAL 2017.

3.4 Fishmeal production by top 15 countries 2008 to 2016 (ranked according to 2016 figures) (000Mt)

'000 tonnes	2008	2009	2010	2011	2012	2013	2014	2015	2016	Ave 2012 - 2015
Peru	1,430	1,347	789	1679	841	1,115	524	852	633	835
China PR	141	160	465	530	535	560	450	400	460	519
Thailand	468	408	500	495	487	450	460	420	386	462
Vietnam	46	56	70	195	245	275	310	285	288	279
USA	216	214	217	274	259	235	223	263	252	244
Chile	692	639	509	549	483	320	397	322	234	381
Japan	204	205	202	183	186	183	186	184	177	185
Denmark	163	180	191	163	89	139	165	206	166	150
India	63	52	53	68	67	76	120	103	153	92
Norway	142	137	153	107	98	96	144	167	143	127
Ecuador	100	98	109	109	116	128	103	125	135	118
Morocco	77	100	113	99	77	90	135	116	106	94
Russia	75	75	80	77	82	85	84	93	95	83
Iceland	140	103	84	91	133	121	92	153	91	125
Malaysia	44	45	46	109	25	102	109	90	86	82

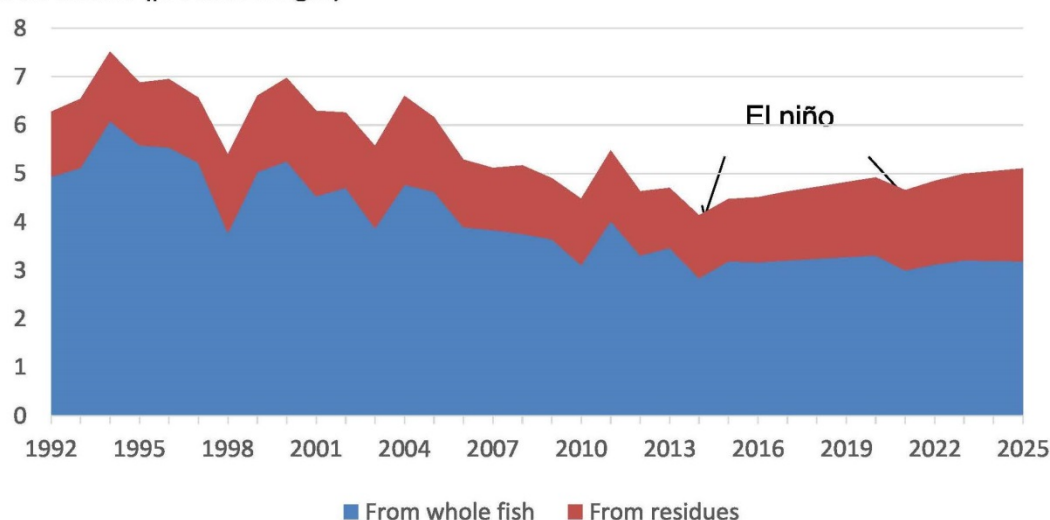
Source: 2016 figures from IFFO *Fishmeal and Fish Oil Statistical Yearbook 2017*.
 2011 – 2015 figures from IFFO *Fishmeal and Fish Oil Statistical Yearbook 2016*.
 2008 – 2010 figures from IFFO *Fishmeal and Fish Oil Statistical Yearbook 2013*.

WORLD FM cont'd – raw material used

Nearly 20 Mt of raw material is used annually for the production of FM and FO, of which around 14 Mt comes from the whole fish, nearly half of which is in South America. Around 3.7 Mt of by-product comes from the processing of wild caught fish from Europe producing around 1.2 Mt of this total. An estimated 1.9 Mt comes from aquaculture, of which 0.8 Mt is in Asia, principally Vietnam and Thailand.

3.5 Fishmeal production – overview of raw material used

Million tonnes (product weight)



Source:

FAO presentation, EUfishmeal Symposium on future perspectives of fishmeal and fish oil. August 2016.

3.6 Fishmeal production – Typical model of raw material used

Region '000 tonnes	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

Source: Institute of Aquaculture, University of Sterling and IFFO, July 2016.

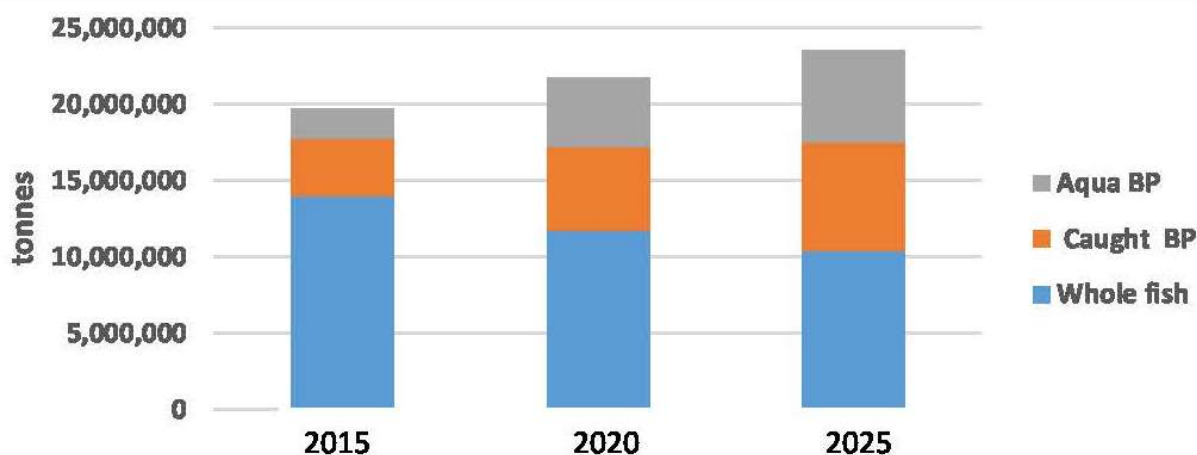
WORLD FM cont'd – raw material used

3.7 Fishmeal production – typical model of raw material from by-product (000t)

Region '000 tonnes	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	11	288	41
Oceania	2	14	16	85
Totals	3,131	1,508	4,639	33

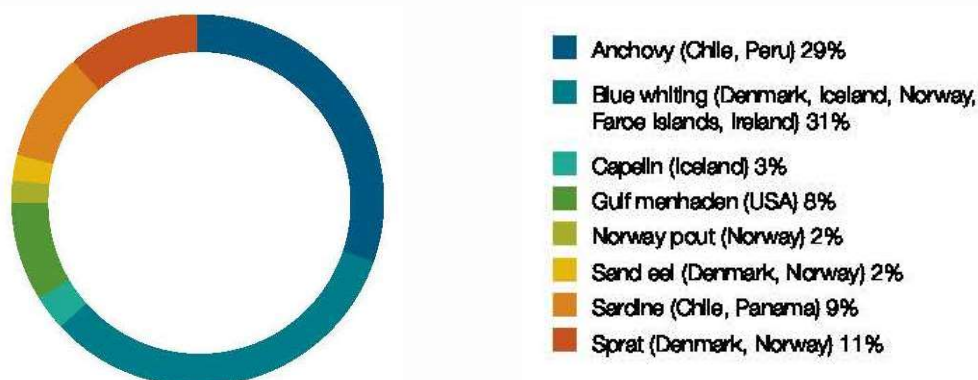
Source: Institute of Aquaculture, University of Sterling and IFFO, July 2016.

3.8 Fishmeal estimated raw material sources over time



Source: Institute of Aquaculture, University of Sterling and IFFO, July 2016.

3.9 Fishmeal and fish oil by forage fish species in 2016



Source: Cargill Aqua Nutrition Sustainability Report 2016

WORLD FM cont'd – raw material used

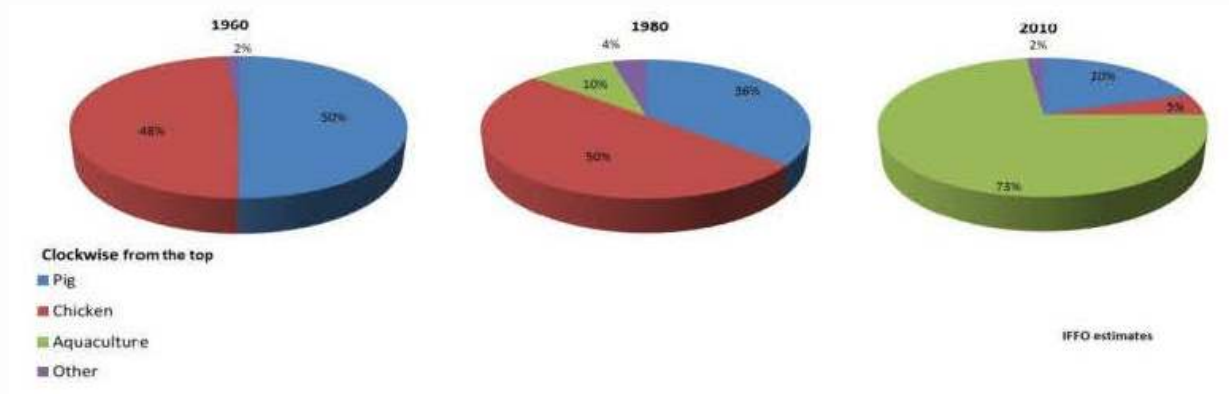
3.10 Key feed manufacturers – species used in fishmeal production – Biomar (2016), Skretting (2015) and EWOS (2016)

Species	Biomar (2016)		Nutreco/Skretting (2015)	Cargill/EWOS (FM and FO) (2016)
	Volume MT	Share %	Share %	Share %
Whole forage fish				
Blue whiting	25,486	16	33	31
Anchoveta	45,861	29	14	29
Sardine	26,597	17		9
Capelin	2,512	2	Icelandic 8 Barents Sea 3	3
Krill	15,948	10		
Lesser sand eel	2,953	2	7	2
Sprat	6,527	4	European 11 Baltic 3	11
Herring – Icelandic summer spawning				
Herring – Norwegian spring spawning				
Menhaden	3,303	2		8
Other	719	0		5
Anchovy	2,225	1		
Norway pout	2,181	1	2	2
Jack mackerel		1		
Other marine - krill				
Total marine			83%	67%
Trimmings				
Herring - Norwegian spring spawning			7	49
Herring - Icelandic summer spawning			1	
Capelin			Barents Sea 1	2
Unidentified/various			8	7
White fish				24
Hake				2
Atlantic mackerel				10
Brazilian sardinella				1
Jack mackerel				3
Sardine				2
Total Trimmings	23,011	15%	17%	33%
Total overall marine	157,323	100%		100%
Certification				
IFFO RS approved fisheries	128,090	81%	96%	93%
ASC compliant	97,715	62%		

Sources: BioMar Annual Sustainability Report 2016, Cargill Aqua Nutrition Sustainability Report 2016, Nutreco/Skretting Norway Annual Sustainability Report 2015.

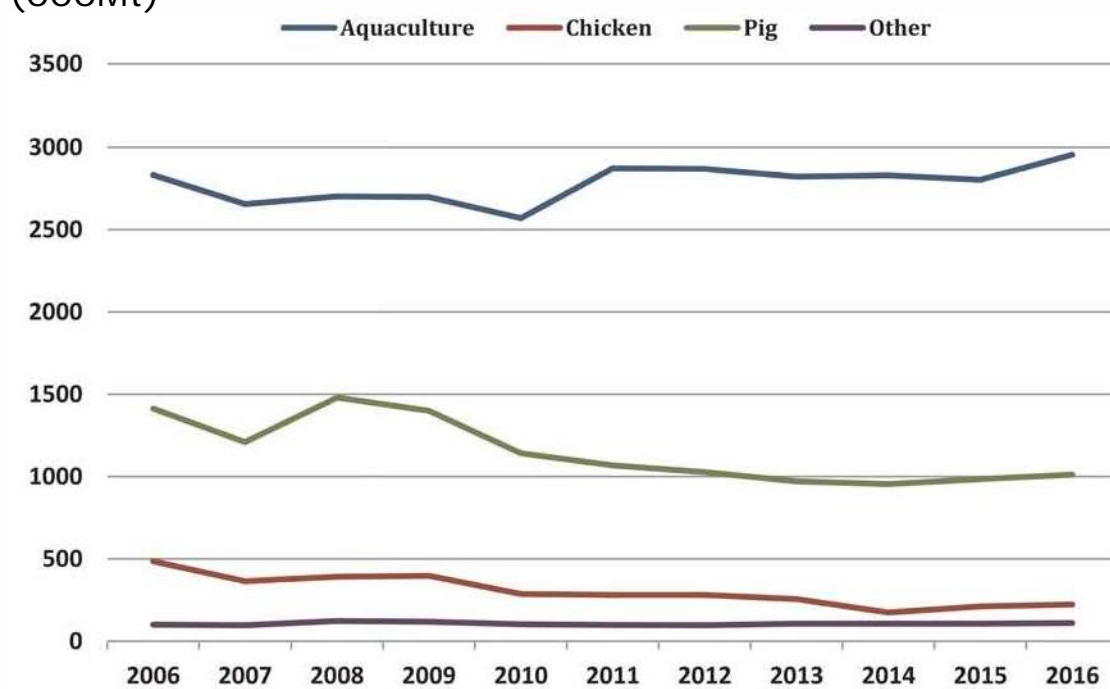
WORLD fishmeal use by sector

3.10 Changing uses of fishmeal from land animal feed to fish feed 1960 to 2010



Source: www.ifo.net

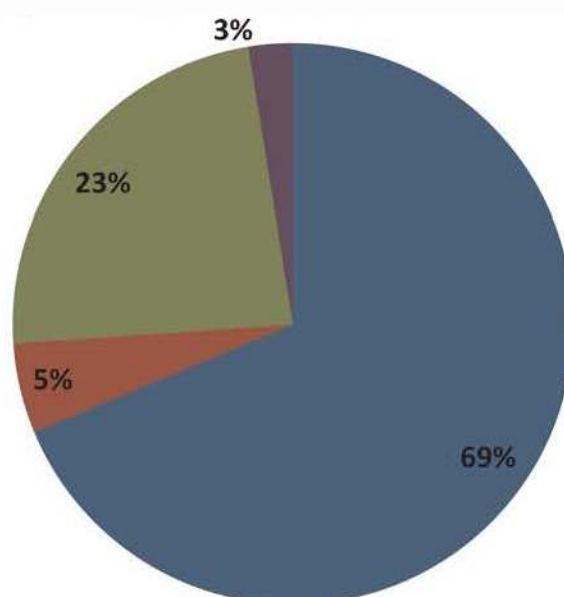
3.11 World fishmeal market use by sector 2006 – 2016 (000Mt)



Source – IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.

WORLD FM cont'd – use by sector

3.12 World fishmeal market use by sector in 2016 (000Mt)



Source – IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.

WORLD FM – imports and exports

3.13 Fishmeal exports by top 15 countries 2008 to 2016 (ranked according to 2016 figures) (000Mt)

'000 tonnes	2008	2009	2010	2011	2012	2013	2014	2015	2016	Ave 2012 - 2015
Peru	1,560	1,538	1,084	1,281	1,328	849	850	705	631	927
Vietnam					97	111	157	150	202	129
Chile	521	609	316	331	306	236	255	192	190	248
Denmark	209	207	208	211	185	197	177	203	169	191
Germany	20	20	30	197	232	168	203	144	168	187
Thailand	21	26	110	73	63	126	172	155	154	129
USA	89	79	77	183	188	149	160	148	124	162
Morocco	76	92	89	67	72	84	134	110	118	100
Ecuador	81	91	81	89	93	99	79	70	111	83
S Africa Rep				39	59	18	52	57	76	47
Iceland	158	94	70	90	120	121	80	144	70	117
Russia	46	33	47	51	46	47	50	62	66	52
Mauritania	11	24	33	32	32	29	66	56	51	46
Norway	64	27	22	25	18	21	35	64	46	35
Malaysia					28	22	56	34	43	35

Source: 2016 figures from IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.
2011 - 2015 figures from IFFO Fishmeal and Fish Oil Statistical Yearbook 2016.
2008 – 2010 figures from IFFO Fishmeal and Fish Oil Statistical Yearbook 2013.

WORLD FM cont'd – imports and exports

3.14 Fishmeal imports by top 15 countries 2008 to 2016 (ranked according to 2016 figures) (000t)

'000 tonnes	2008	2009	2010	2011	2012	2013	2014	2015	2016	Ave 2012 - 2015
China PR	1,349	1,308	1,038	1,212	1,249	980	1,041	1,030	1,042	1,069
Norway	242	328	206	230	249	214	225	182	176	210
Japan	310	282	324	236	257	199	253	230	157	220
Germany	20	20	30	166	228	167	215	143	149	181
Taiwan	148	180	156	154	183	138	165	143	127	151
Vietnam	125	118	93	84	91	81	105	96	115	101
Turkey	55	52	50	44	65	73	81	79	108	81
Denmark	115	95	122	119	153	107	89	87	83	104
Thailand					18	8	21	31	72	30
Greece	96	93	70	54	66	65	72	63	71	68
UK	92	114	101	83	74	65	62	57	71	66
Canada	46	45	61	52	51	43	59	63	70	57
Indonesia	68	67	61	100	94	99	79	64	65	81
USA	38	34	39	34	43	47	53	49	52	49
South Korea	43	48	47	36	44	35	53	49	51	47

Source: 2016 figures from IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.
2011 – 2015 figures from IFFO Fishmeal and Fish Oil Statistical Yearbook 2016.
2008 – 2010 figures from IFFO Fishmeal and Fish Oil Statistical Yearbook 2013.

WORLD FM – fishmeal composition

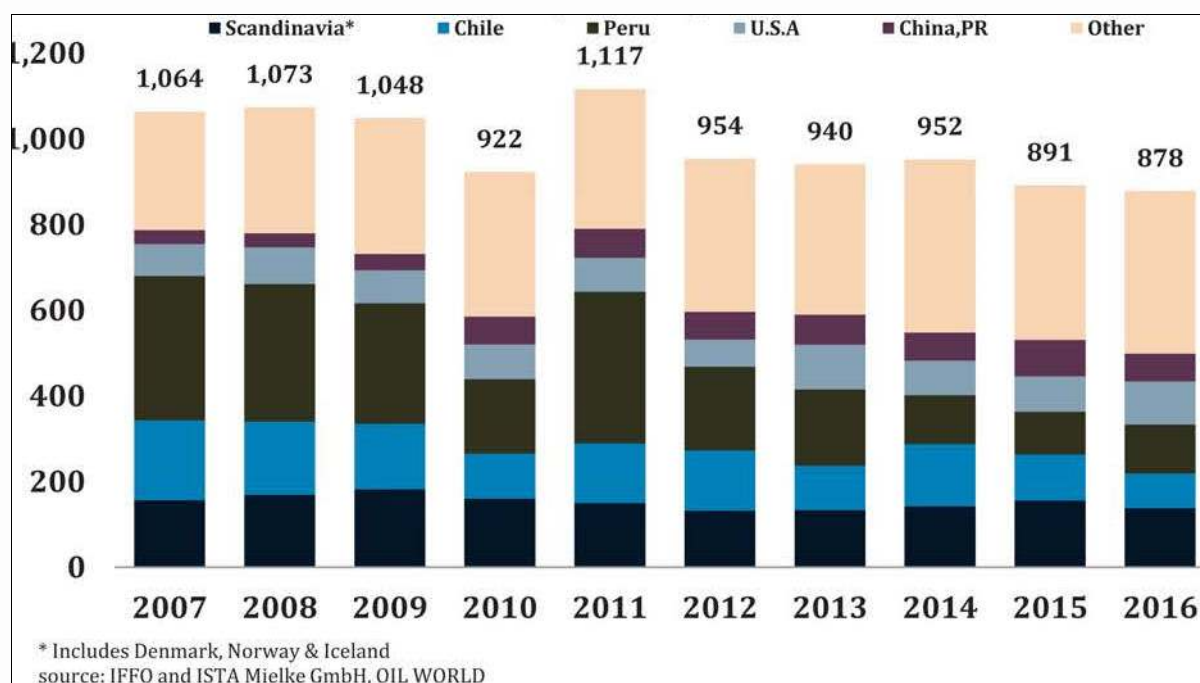
3.15 Composition of 1st, 2nd and 3rd grade fishmeal

Fishmeal	1 st Grade	2 nd Grade	3 rd Grade
Protein (not less than)	60%	55%	50%
Ash (not more than)	26%	28%	30%
Salt (not more than)	3%	3%	3%
Humidity (not more than)	10%	10%	10%
Remaining (not less than)	2%	2%	2%

Source – Oxfam. Mapping shrimp feed supply chain. March 2014.

4. WORLD production, supply and consumption of fish oil

4.1 World fish oil production 2006 - 2016 ('000Mt)



Source – IFFO Fishmeal and Fish Oil Statistical Yearbook 2017

4.2 Fish oil production by top 15 countries 2008 to 2016 (ranked according to 2016 figures) (000Mt)

'000 tonnes	2008	2009	2010	2011	2012	2013	2014	2015	2016	Ave 2012 - 2015
Peru	320	282	173	354	195	178	115	94	114	140
USA	86	76	61	79	63	104	80	83	101	86
Chile	171	152	105	139	140	103	144	107	81	115
China PR	32	38	44	47	45	50	45	40	65	70
Japan	62	64	60	55	55	54	62	60	62	59
Norway	39	42	40	45	41	42	58	51	61	51
Vietnam	26	20	49	28	30	40	53	48	49	44
Denmark	56	72	67	54	33	43	51	55	48	46
Iceland	72	62	43	49	56	46	32	48	28	42
India	4	5	12	17	23	21	37	20	27	26
Morocco	25	40	43	22	29	20	35	28	22	27
Ecuador	13	10	13	16	17	19	12	16	16	16
Mauritania				4	12	8	16	14	15	13
Germany	5	6	6	10	11	12	16	12	14	13

Source: 2016 figures from IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.
2011 – 2015 figures from IFFO Fishmeal and Fish Oil Statistical Yearbook 2016.
2008 – 2010 figures from IFFO Fishmeal and Fish Oil Statistical Yearbook 2013.

WORLD FO contd – production

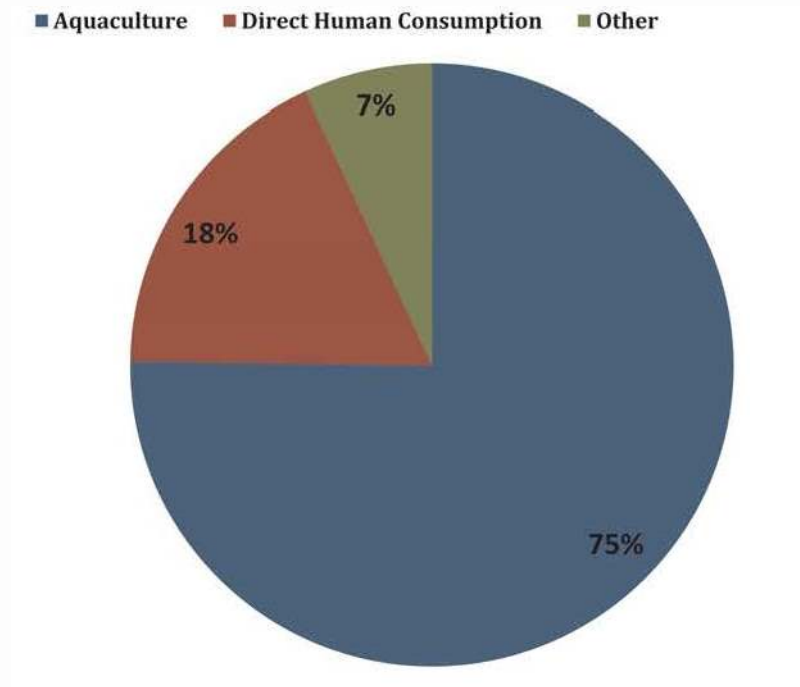
4.3 Key feed manufacturers – species used in fish oil production – Biomar (2016) and Skretting (2015)

Volume MT	Biomar		Skretting (2015)
Species	(2016)	Share %	Share %
Whole forage fish			
Anchoveta	10,333	12	19
Sardine	11,291	13	
Capelin	3,576	4	Icelandic 6 Barents Sea 1
Menhaden	2,116	2	10
Alaska pollock			
Lesser sand eel	2,997	4	10
Blue whiting	4,497	5	9
Sprat	9,209	11	North Sea 5 Baltic 4
Herring	2,141	3	Norwegian spring spawning 2
Anchovy	1,279	1	
Other	1,501	2	
Norway pout			1
Total marine	84,728		67
Trimmings			
Herring - Norwegian spring spawning			9
Herring – Icelandic summer spawning			2
Capelin			Icelandic 1
Unidentified/various			12
Total Trimmings	37,068	44%	33
Total overall marine	84,728	100%	
Certification			
IFFO RS approved fisheries	58,955	70%	94%
ASC compliant	66,405	78%	

Sources: BioMar Annual Sustainability Report 2016, Nutreco/Skretting Norway Annual Sustainability Report 2015.

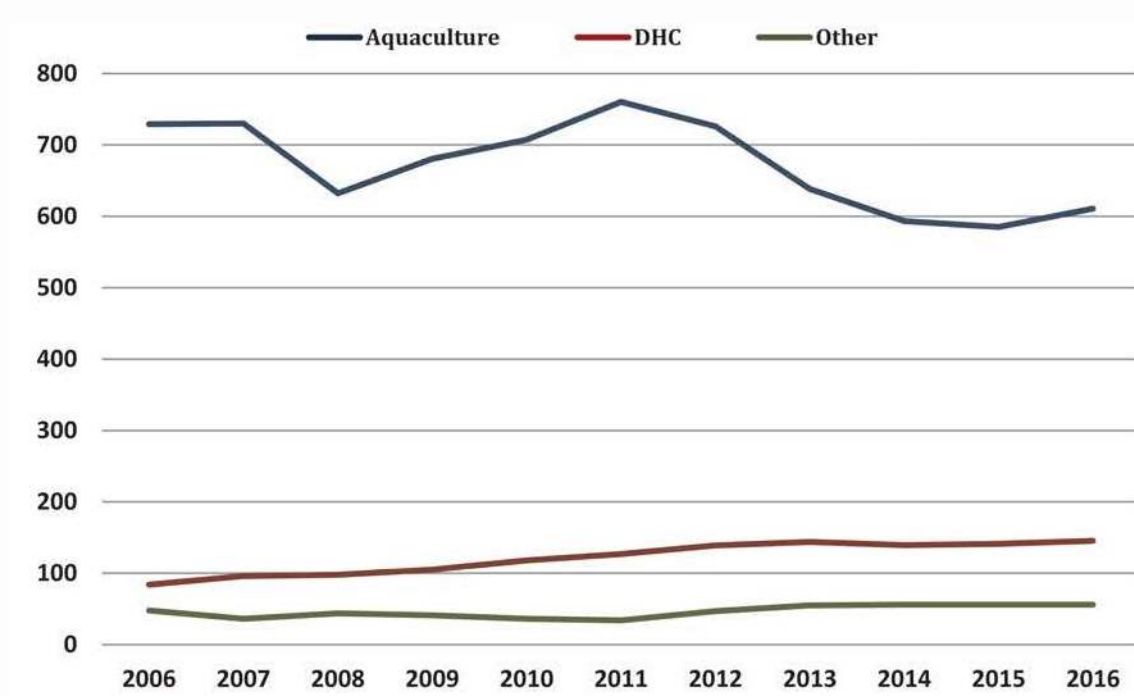
WORLD fish oil – use by sector

4.4 World fish oil market use by sector in 2016 (000Mt)



Source – IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.

4.5 World fish oil market use by sector 2006 – 2016 (000Mt)



Source – IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.

5. European production, supply and consumption of fishmeal and fish oil

The total European production of fishmeal and fish oil is approximately 500,000 metric tonnes of fishmeal and 190,000 tonnes of fish oil a year and the total value of production is approximately 1,000 million €/year. Exports go to a large variety of countries.

Production is based on landings of small, oily, short-lived species such as blue whiting, capelin, sand eel, Norway pout and sprat as well as by-products (trimmings) from the consumption fish processing sector. Production varies according to the access of raw material but the overall trend over the last 5-10 years has been a fall in production.

Source: *EUfishmeal*.

European fishmeal and fish oil factories (20)



Source: *EUfishmeal Symposium on future perspectives of fishmeal and fish oil. August 2016.*

European FM cont'd - production

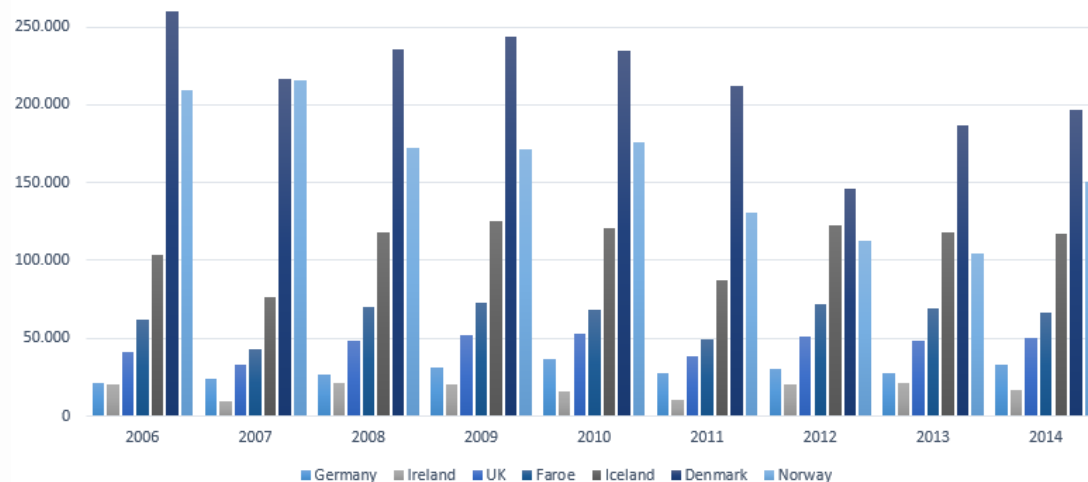
5.1 European fishmeal production 2016 and 2017

'000 m tonnes	2016	2017
Denmark	166	215
Norway	143	169
Iceland	91	110
Spain	55	50
Faroe Islands	44	71
UK	30	34
Poland	24	24
Germany	23	21
Ireland	15	18
France	15	15
Lithuania	14	12
Latvia	11	9
Total	631	748

Source: Fishmeal and fish oil. A summary of global trends. IFFO October 2017.

5.2 European fishmeal production 2006 to 2014

EUfishmeal member countries production of fishmeal and oil
Tonnes/year

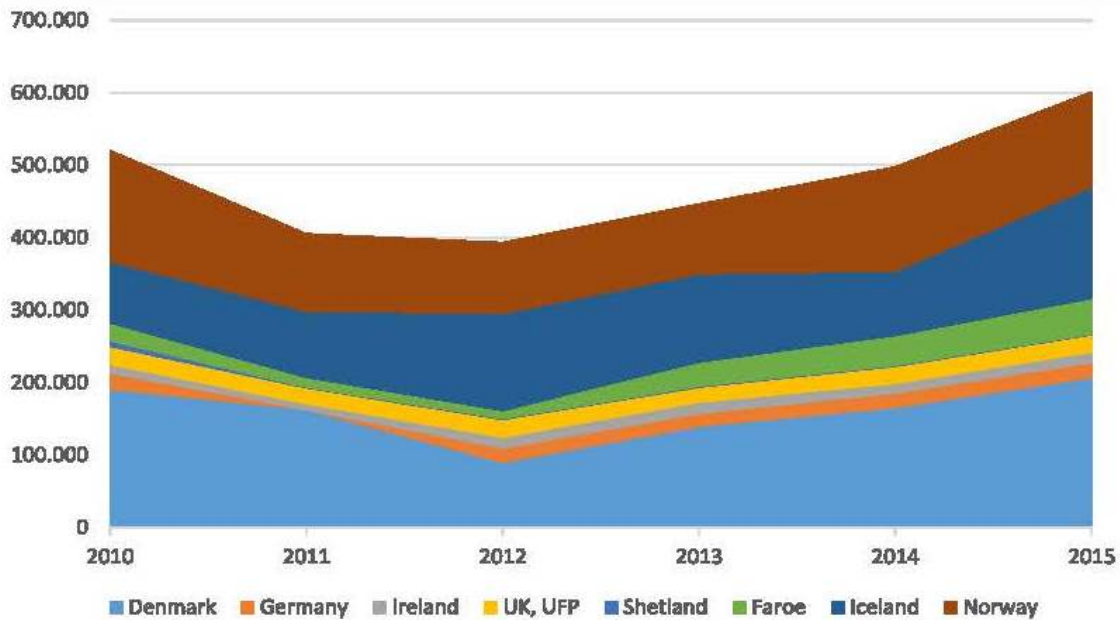


Source: EUfishmeal.

European FM cont'd – use by country

5.3 European fishmeal production 2010 to 2015

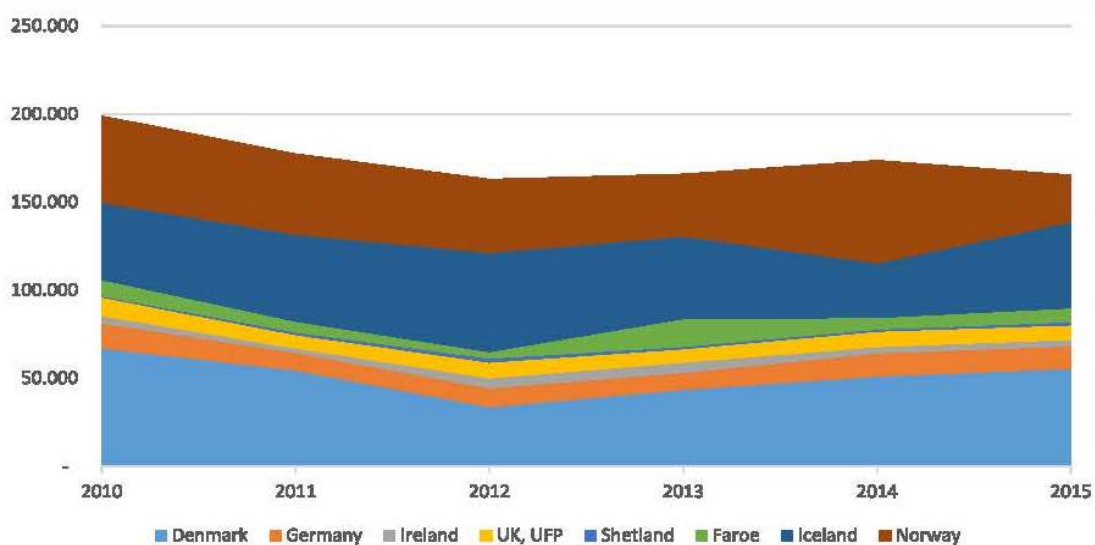
Tonnes



Source: EUfishmeal, EUfishmeal Symposium on future perspectives of fishmeal and fish oil. August 2016.

European fish oil – production

5.4 European fish oil production 2010 to 2015 (Tonnes)

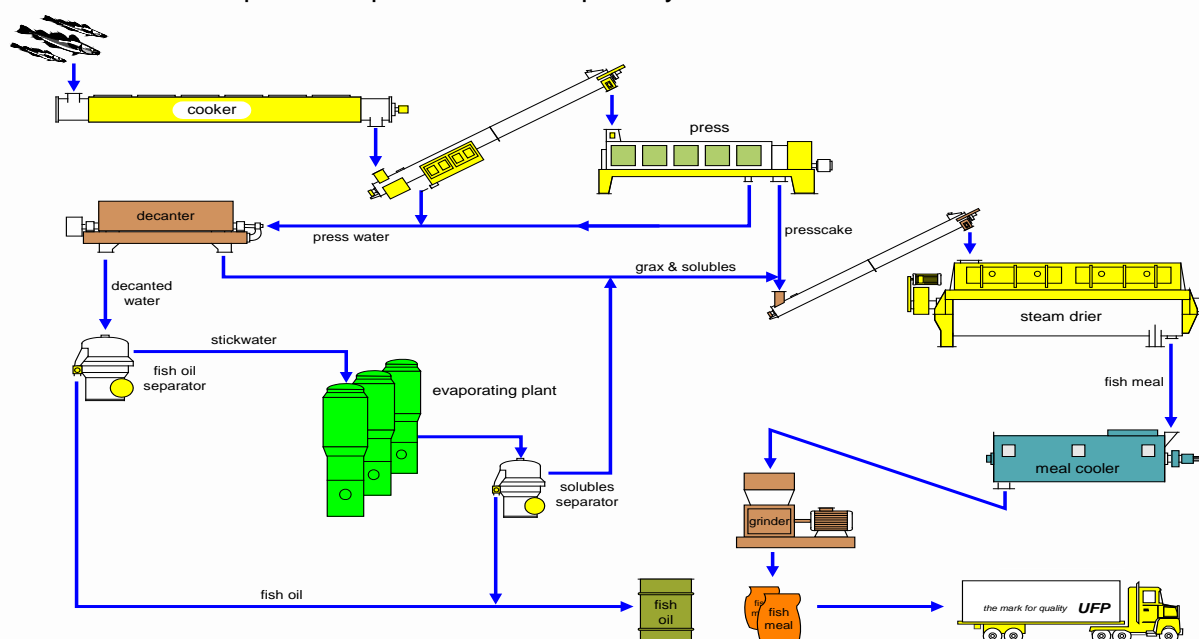


Source: EUfishmeal, EUfishmeal Symposium on future perspectives of fishmeal and fish oil. August 2016.

6. UK production, supply and use of fishmeal and fish oil

UFI Grimsby – production process

UFI is part of Pelagia AS, a leading producer of pelagic fish products for human consumption, and an important supplier of essential ingredients in all kinds of fish and animal feed including protein concentrate, fishmeal, and fish oil. The company operates 26 factories in Norway, Denmark, the UK and Ireland. There are UFI facilities in Aberdeen, Killybegs and Grimsby. UFI Grimsby predominantly processes trimmings from cod, haddock and salmon and can process up to 300 tonnes per day.



6.1 Summary of UK fishmeal imports – 2009 to 2016

'000 tonnes	2009	2010	2011	2012	2013	2014	2015	2016
Norway	2.6	3.7	3.1	0.1	5.6	11.6	12.7	14.2
Ireland	22.1	11.2	2.6	9.7	12.5	9.9	10.6	13.2
Peru	53.1	33.3	28.6	24.2	11.9	14.6	2.3	1.4
Germany	2.5	14.9	14.9	10.4	7.3	1.2	5.5	9.3
Denmark	19.1	29.7	23.7	10.3	11.2	11.4	11.6	11.3
Chile	4.7	1.2	1.5	1.9	2.9	2.0	0.3	0.0
Spain	0.0	0.0	0.1	0.4	1.4	9.7	2.4	2.6
Iceland	1.6	2.8	3.5	7.3	5.7	2.3		
France	1.2	1.1	1.8	1.4	1.8	1.1		
Netherlands			0.3	0.1	0.5	1.4	0.1	3.1
Sub total			74.8	57.1	53.4	61.9	45.4	55.2
Others	7.6	3.5	9.2	16.9	11.7	1.8	12.5	16.1
Total	114.5	101.4	83.9	74.0	65.1	63.7	57.9	71.3

Source: 2009 and 2010 Globefish; 2011 – 2015 IFFO Fishmeal and Fish Oil Statistical Yearbook 2016; 2016 IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.

UK FM cont'd – production and imports

6.2 Historical - summary of UK fishmeal supply – 2002 to 2008

000 tonnes	2002	2003	2004	2005	2006	2007	2008
UK Consumption	c237.8	c231.2	184.2	187.6	168.8	122.5	115.1
Imports from EU	33.3	30.5	48.8	57.1	62.2	39.8	40.5
Imports from non-EU	154.5	150.7	91.1	87.8	74.4	45.3	46.8
UK production	50	50	50	53	44	44	42
UK exports			5.7	10.3	11.8	6.6	14.2

Source – Trade sources.

6.3 Historical - sources of UK fishmeal imports 2000 to 2008

000 t	2000	2001	2002	2003	2004	2005	2006	2007	2008
Imports from non EU									
Peru	70.1	54.7	28.9	47.0	19.4	23.2	37.6	21.2	24.6
Iceland	57.5	52.5	64.2	49.1	42.5	34.6	13.6	3.8	10.3
Norway	32.1	28.0	35.6	16.5	9.5	3.7	7.9	9.9	3.8
Chile	13.6	18.9	11.6	21.4	6.5	12.6	10.9	5.1	0.2
Faroe Is	8.7	11.7	14.2	9.7	11.5	10.9	2.3	3.4	7.9
M'rocco	4.5	4.8	0	7.0	1.7	2.8	2.1	1.9	0
Sub tot	186.5	172.6	154.5	150.7	91.1	87.8	74.4	45.3	46.8
Imports from EU									
Denm'k	6.1	9.6	17.8	14.3	24.7	16.1	25.2	12.9	22.0
G'many	33.8	26.0	9.6	8.6	8.2	25.4	30.8	13.5	8.3
Eire	14.2	19.9	5.9	6.0	15.1	11.7	6.1	11.6	9.2
N'Lnds	0	1.7	0	1.6	0.8	3.9	0.1	1.8	1.0
Sub tot	14.1	57.2	33.3	30.5	48.8	57.1	62.2	39.8	40.5
Others	2.1	3.2	4.5	2.2	2.5	3.0	2.9	2.6	3.6
Total	242.7	233.0	192.3	183.4	142.5	148.0	139.4	87.7	91.0

Trade sources.

6.4 Historical - Fishmeal consumption and imports - UK 1996 to 2008

000' tonnes	UK consumption	UK imports	From EU	From non EU
1996	272,000	241,995	Na	Na
1997	330,000	284,788	34,289	250,499
1998	260,000	238,602	34,968	203,634
1999	270,000	221,056	41,260	19,796
2000	290,000	240,951	50,226	190,725
2001	280,000	232,765	60,183	172,582
2002	240,000	191,990	36,473	155,517
2003	233,000	183,442	31,486	151,956
2004	192,000	142,492	51,227	91,265
2005	187,000	136,892	48,770	88,122
2006	189,000	138,973	62,634	76,339
2007	134,800	90,800	44,500	46,300
2008	134,100	92,100	40,200	51,900

Source: Trade sources.

UK FM cont'd – use and stock status

6.5 Feed grade fish stocks used to produce fishmeal and fish oil

Trade Sources:	% of FM used in UK			How stock is used	Estimated status of fish stocks in 2017
	2007	2011	2013		
EUROPE AND THE ANTARTIC – Source ICES and FishSource					
Sandeel <i>Ammodytidae</i>	Less than 3%	8%	2.2%	Not used for human consumption (HC)	Main North Sea: Adult stock is large enough for optimal use in the long term. Improvement in Spawning Stock Biomass (SSB) in 2015, 2016 and 2017. Uncertain recruitment in 2016.
Sprat <i>Sprattus Sprattus</i>	3%	8%	1.1%	Potential uses for HC but mainly used for fishmeal (FM).	North Sea: Adult stock size is large enough and fishing pressure is low enough to ensure a sufficient amount of offspring can be produced. Recruitment increased in 2016.
Capelin <i>Mallotus villosus</i>	Less than 1%	2%	5.3%	Roe used for HC. Frozen capelin for specific limited markets. Mainly used for FM.	Barents Sea: Estimated that 2016 year class at age 1 is below long-term average but above 2014 and 2015. Icelandic: Likelihood that SSB is above the precautionary limits of 150,000 t.
Norway pout	Less than 1%	2%	2.0%	Not used for HC.	SSB is above precautionary levels in 2017. Recruitment is variable (high in 2014 and 2016) and below average in 2015 and 2017.
Blue Whiting <i>Micromesistius Poutassou</i>	21%	1%	3.6%	Mainly used for FM. Limited use for HC due to processing difficulties.	SSB has increased from 2010 and is above the MSY biomass trigger. Recruitment in 2017 is estimated to be low, following a period of high recruitments.
Herring <i>Clupea harengus</i>	3%	1%	0.2%	Primarily HC, but non-food grade fish and trimmings may be used for FM.	Icelandic: Indications of poor recruitment and fishing pressure has been increasing. Norwegian: Stock is declining and estimated below MSY biomass trigger in 2017.
Mackerel <i>Scomber scombrus</i>	n/a	n/a	4.1%	Primarily HC, but non-food grade fish and trimmings may be used for FM.	NEA: Various surveys give contradictory evidence. SSB is estimated to have decreased from 2016 to 2017.
Boar fish <i>Capros aper</i>	n/a	n/a	5.9%	Currently for FM but HC market underway.	Stock status is currently unknown. Stock has declined sharply since the peak in 2010–2013 and is currently at a historic low.
Krill	n/a	n/a	1.1%	Mostly used for FM.	No recent stock assessment for <i>Euphausia superba</i> .
Trimmings	38%	35%	50%	Generally small pelagic species (e.g mackerel, capelin, herring) and trimmings from the white fish processing sector (e.g. cod).	
SOUTH AMERICA/GULF – Source FishSource					
Anchovy <i>Engraulis ringens</i>	28%	38%	19.6 %	Very small amount used for HC. Majority used for FM.	2017 estimates show SSB to be above the limit biomass reference point but below the optimal biomass level. Surveys show the ability of this stock to recover rapidly.
Jack mackerel <i>Trachurus murphyi</i>	1%	3%		50% of Chilean jack mackerel used for HC and 50% for FM.	The stock shows a continued recovery since the time-series low in 2010. Recruitment in the most recent years shows signs of stronger incoming year-classes but the information is uncertain.
Sardine <i>Strangomera bentincki</i>	Less than 1%	1%	4.2%	Used for HC and FM	Recruitment has been low in the 2015-2016 biological year, but it is estimated above historical levels in 2017. Fishing mortality is showing a decreasing trend since 2005.
Gulf Menhaden <i>Brevoortia patronus</i>	n/a	1%	0.6%	Mostly used for FM and FO.	The stock is not overfished and overfishing is not occurring. Population fecundity well above benchmarks/fishing mortality well below benchmarks. Stock appears in very good shape.

UK fish oil production and imports

6.6 Summary of UK fish oil imports – 2011 to 2016

'000 tonnes	2011	2012	2013	2014	2015	2016
Peru	2.4	8.0	1.5	2.3	12.3	1.9
France	1.9	1.3	1.8	3.1	3.6	1.5
Belgium	0.0	4.3	1.2	2.4	1.2	0.0
Ireland	1.2	2.1	0.8	1.2	1.0	1.1
Thailand	0.9	1.6	0.6	0.5	0.5	0.5
Iceland	3.9	2.2	0.7	0.5	0.5	0.3
Netherlands	0.2	2.8	0.1	0.1	0.3	1.5
China	0.0	0.0	0.0	0.1	0.2	0.1
Sweden	0.0	0.0	0.0	0.1	0.0	0.0
Sub Total	10.5	22.5	6.8	10.3	19.7	6.8
Other	9.2	1.3	5.1	0.1	6.1	11.9
Total	19.7	23.8	11.8	10.4	25.8	18.7

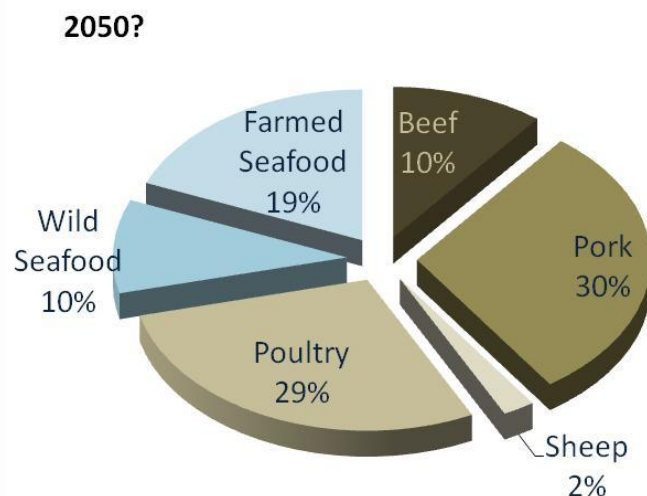
Source: IFFO Fishmeal and Fish Oil Statistical Yearbooks 2016 and 2017.

7a. Feeding fishmeal and oil to farmed land animals

Fishmeal as an ingredient is particularly suited to meet the demands of the contemporary food chain.

Fishmeal is primarily used in aquaculture feed, but is also used in used in poultry and pig diets and other markets (mainly pet food). Use in ruminant feed, which had been about 5-10% of the EU market, is zero, due to the precautionary EU ban on its use in ruminant feed as part of BSE controls.

- Fishmeal is fed to farm animals, not only to improve productivity, but also to protect health and welfare and reduce dependence on antibiotics and other drugs.
- Fishmeal has low antigenicity, making it easy for young animals to digest.
- Fishmeal has anti-inflammatory properties which improve animal's disease resistance.
- Fishmeal and fish oil are “functional feeds” – offering, through their high omega-3 content, specific health and welfare benefits to both farmed livestock and to the human population eating the animal products.



- Assumes no growth in wild caught seafood
- Assumes similar relative seafood demand (29%)
- Assumes meat and seafood demand of 600 million tonnes
- Farmed seafood is roughly double 2006 production.

Source: WWF presentation at Humber Seafood Institute Summit. September 2011.

Feeding FM and FO to farmed land animals cont'd

7a.1 Comparison of basic nutritive characteristics of various protein concentrates

	Crude Protein g/kg	Crude fat g/kg	Energy MJ DE/kg	Calcium g/kg	Phosphorus g/kg
Fishmeal (herring)	720	100	11.0	55	33
White fishmeal	620	40	10.8	75	36
Skimmed milk	330	5	11.3	12.5	10.1
Low lactose whey	170	10	12.1	15	12
Whey	120	7	14.0	8.7	7
Dried blood	800	10	8.49	2.8	2.2

Source: IFFO 2002.

7a.2 Recommended rates of inclusion in diets for optimum benefit (pig and poultry feed)

Pig	% inclusion
Creep	5-10
Weaner	5-10
Grower	3-5
Finisher	3
Sow	3
Poultry	% inclusion
Chick rearing	Up to 3
Broiler	2-5
Layer	2
Breeder	1-5
Turkey	3-10
Pheasant/game	3-7
Dairy Cattle	
Late pregnancy	2.5-10
Lactating	5-10
Calves	2.5-10
Sheep	
Breeding ewes	
Pregnant	2-7.5
Lactating	5-10
Growing lambs	
Early weaned/ Intensively reared	2.5-7.5
Finishing lambs/ On forage diets	2.5-7.5
Reduce body fat/ On overfat lambs	5-10

Source: Nutritional advice in 2002.

Feeding FM and FO to farmed land animals cont'd

7a.3 Amino acid composition fishmeal/other protein sources

g/kg	Fishmeal	Soya bean	Barley (42)
Lysine	48	27	5
Methionine	16	6	2
Cystine	5	6	3
Threonine	25	17	4
Tryptophan	6	7	2
Leucine	43	38	8
Iso-leucine	25	28	4
Valine	28	22	6
Phenylalanine	23	21	6
Arginine	35	32	5
Histidine	17	11	2

Source: IFFO 2002.

7a.4 A comparison of fishmeal with other protein sources

Feed Ingredient As received %	Fishmeal Chilean	Fishmeal Herring	<i>Fishmeal</i> White	Soyabean Meal – hipro	Milk Pwd – skimmed
Crude protein	66	71	66	48	34
Digestible CP	63	66	63	46	31
Essential amino acids:					
Total lysine	5.0	5.6	4.4	2.7	2.3
Available lysine	4.8	5.4	4.2	2.5	2.2
Methionine + cysteine	2.5	2.6	2.4	1.3	1.2
Tryptophan	0.8	0.8	0.6	0.8	0.4

Source: Reprinted in *Fishmeal for Pigs* from *The Feeds Directory*.

7a.5 Protein retention – how much animal food protein is produced per unit feed protein fed to the animal

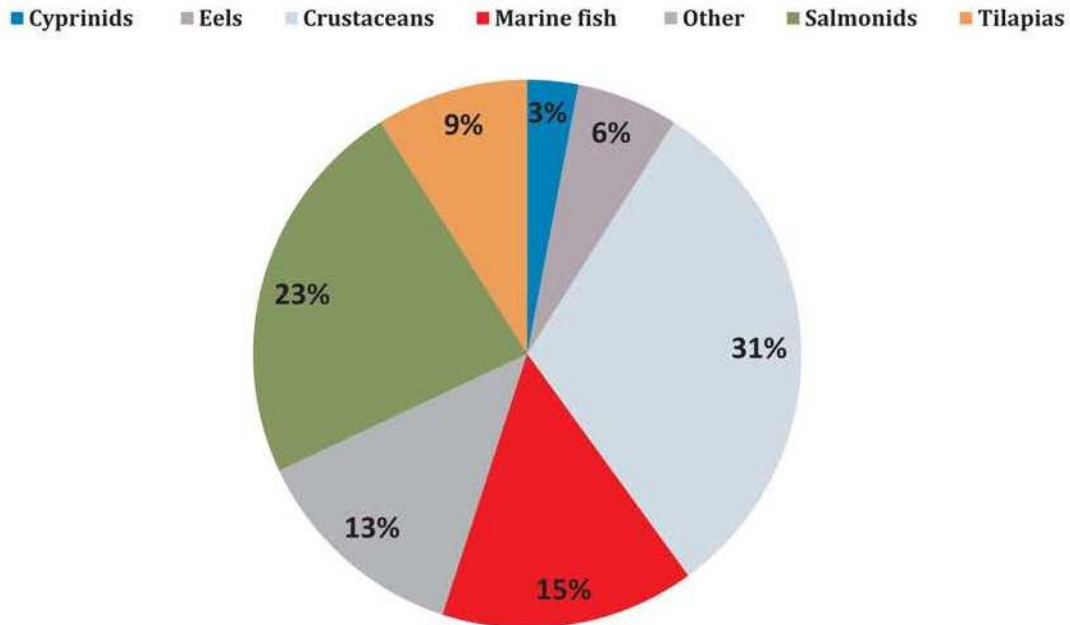


Protein Retention	31 %	21 %	18 %	15 %
Energy Retention	23 %	10 %	14 %	27 %
Edible Yield	68 %	46 %	52 %	41 %
Feed Conversion Ratio (FCR)	1.1	2.2	3.0	4-10
Edible Meat pr 100 kg fed	61 kg	21 kg	17 kg	4-10 kg

Source: *Marine Harvest Salmon Farming Industry Handbook 2017*.

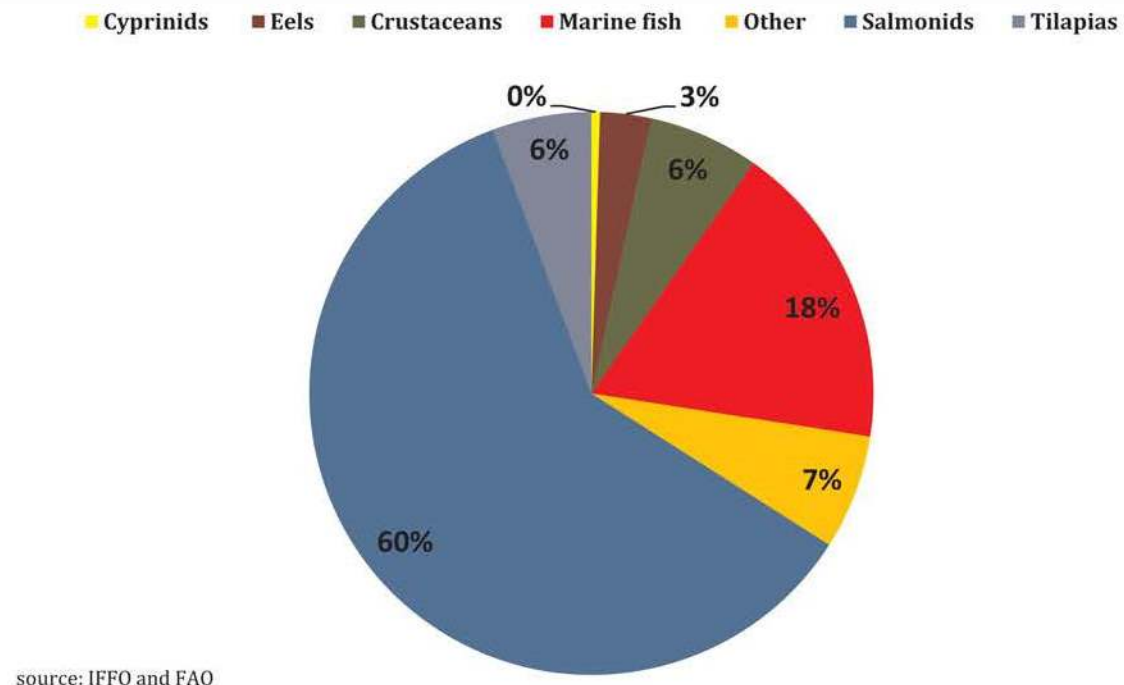
7b. Feeding fishmeal and fish oil to farmed fish

7b.1 Use of fishmeal in aquaculture in 2016



Source: IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.

7b.2 Use of fish oil in aquaculture in 2016

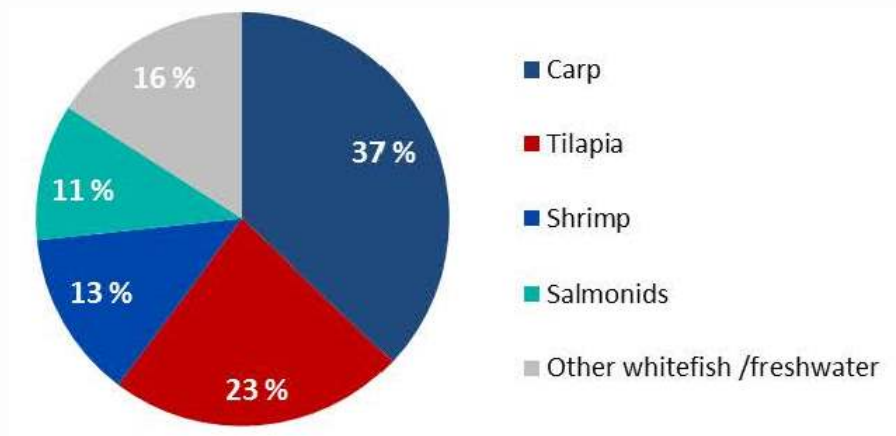


source: IFFO and FAO

Source: IFFO Fishmeal and Fish Oil Statistical Yearbook 2017.

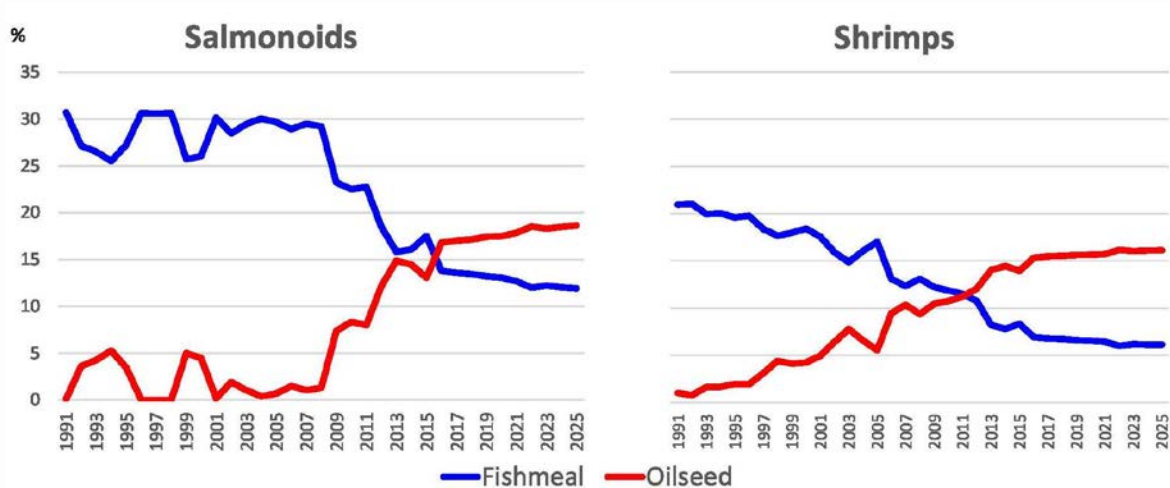
Feeding FM and FO to farmed fish contd

7b.3 Global production of aquatic feed in 2016



Source: Marine Harvest Salmon Farming Industry Handbook 2017.

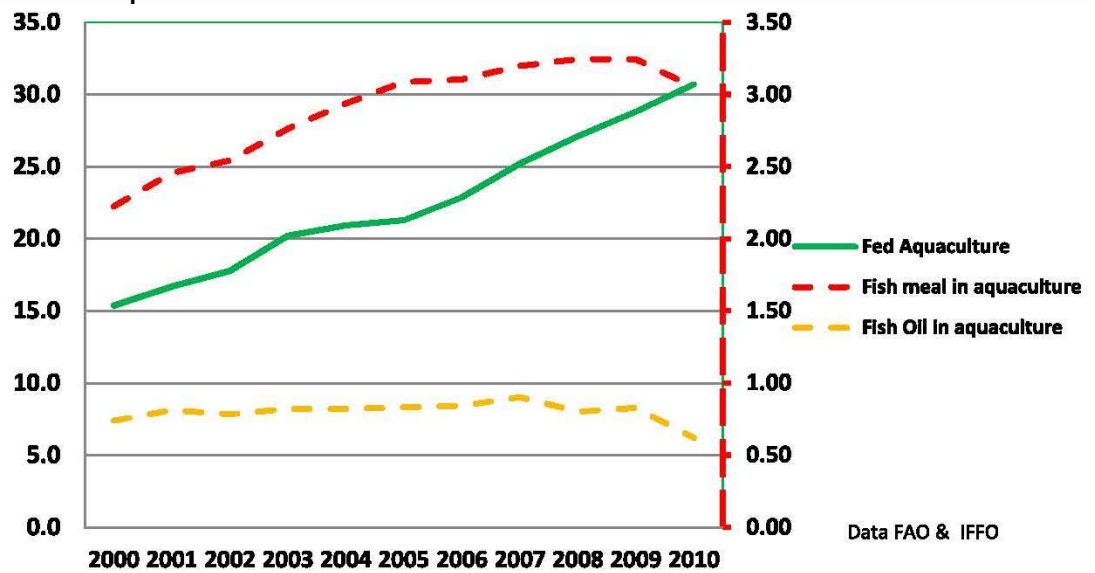
7b.4 Share of fishmeal in feed ratio- world average 1991-2025



Source: FAO presentation, Eufishmeal Symposium on future perspectives of fishmeal and fish oil. August 2016.

Feeding FM and FO to farmed fish contd

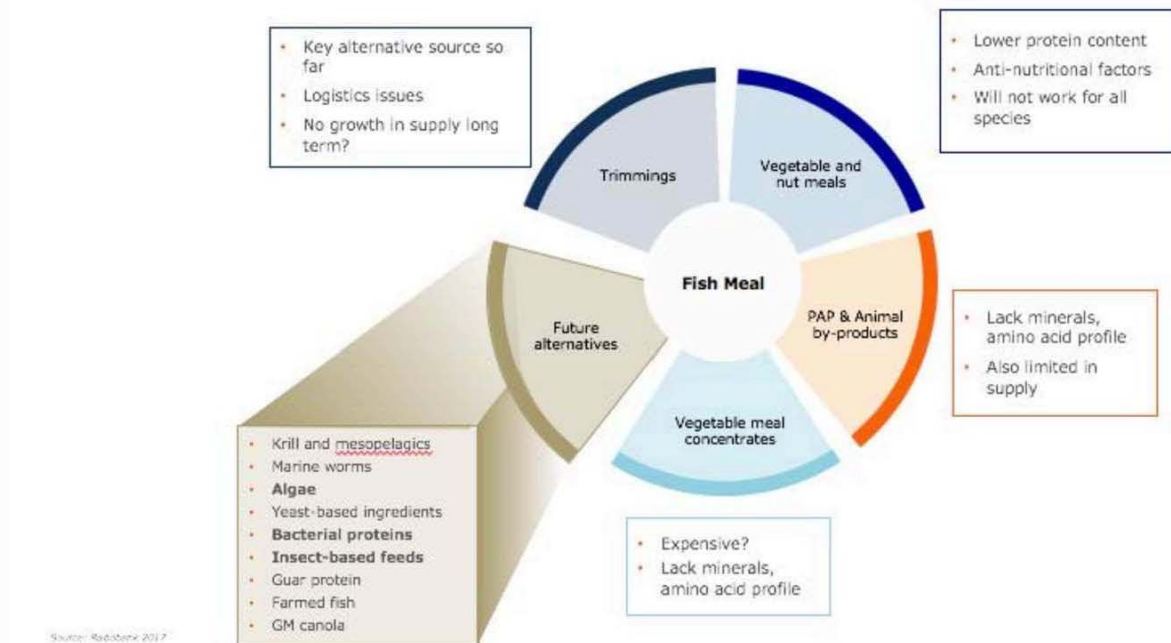
7b.5 Fishmeal and fish oil consumption relative to growth of 'fed' aquaculture 2000 - 2010



Source: IFFO Positional Paper. February 2013. *Is aquaculture growth putting pressure on feed fish stocks? And is the growth of aquaculture being restricted by finite supplies of fishmeal and fish?*

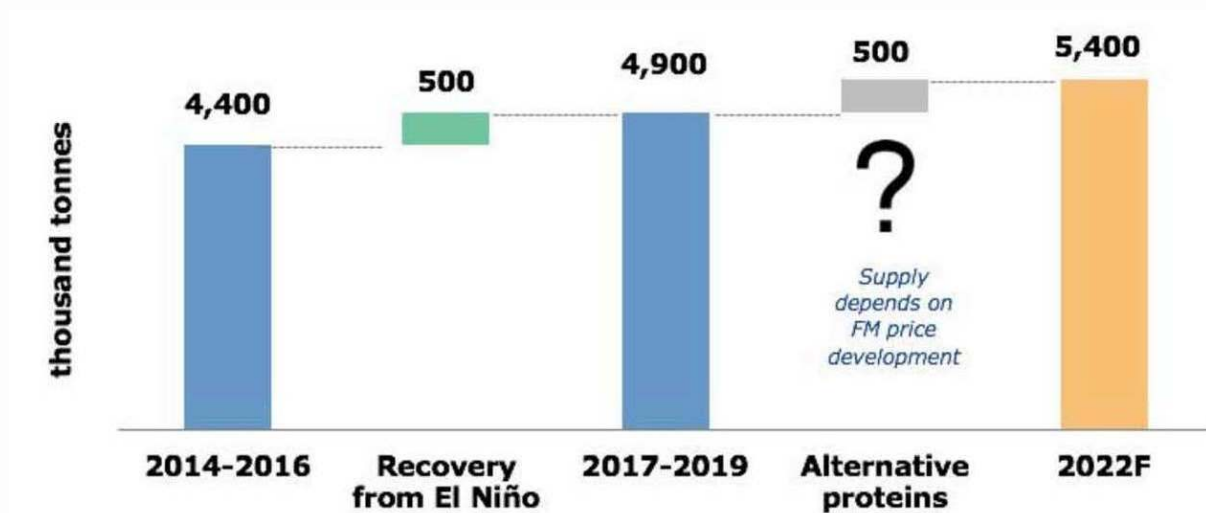
Feeding fishmeal and fish oil to farmed fish – alternative protein sources

7b.6 Alternative protein sources



Source: Factors of Change in the Global Aquaculture Industry. Gorjan Nikolik, Rabobank, GOAL 2017.

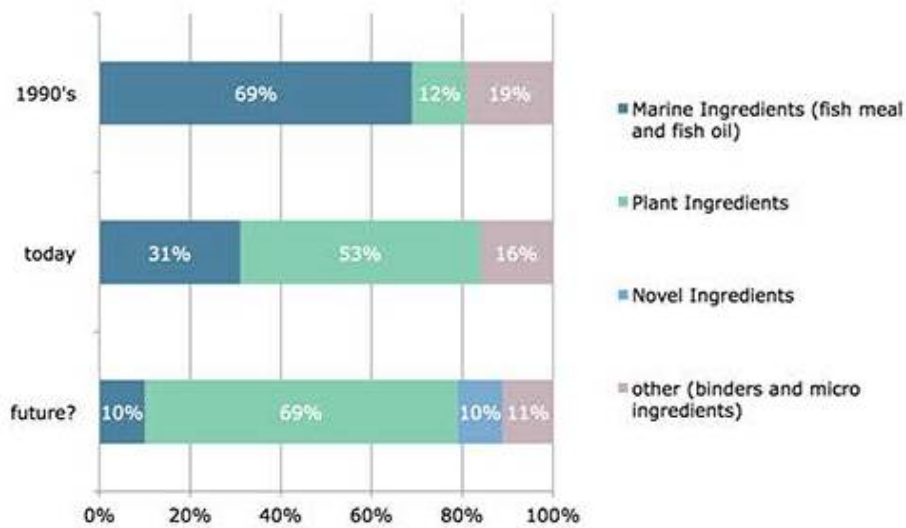
7b.7 Rough estimate of total FM supply and alternative proteins



Source: Factors of Change in the Global Aquaculture Industry. Gorjan Nikolik, Rabobank, GOAL 2017.

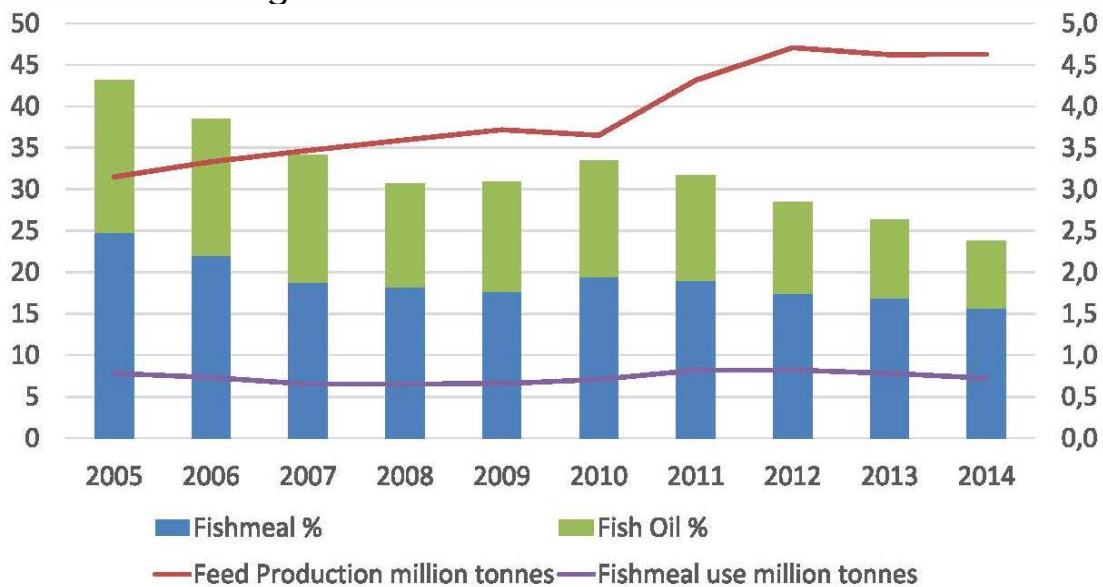
Feeding fishmeal and fish oil to farmed salmon

7c.1 Declining fishmeal inclusion rates in salmon diets



Source: *The Appeal of Fishmeal: Fishmeal's Transformation from a Commodity to a High-Priced, Strategic Protein.* Gorjan Nikolik, Rabobank, GOAL 2015.

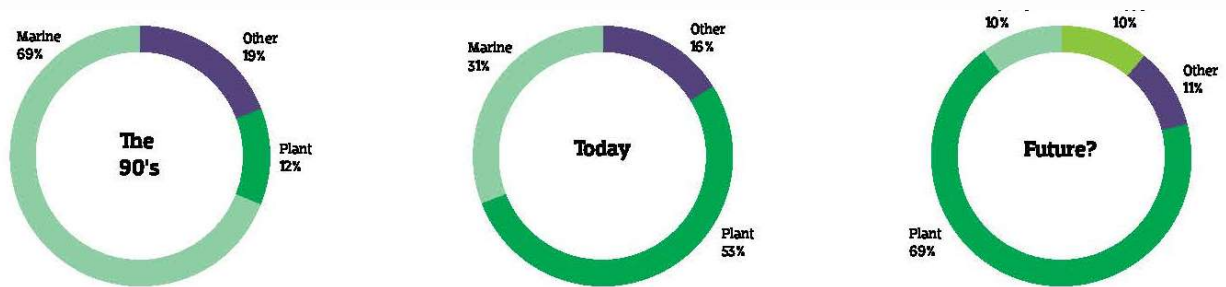
7c.2 Marine ingredient inclusion in salmonid diets



Source: IFFO presentation, *EUfishmeal Symposium on future perspectives of fishmeal and fish oil.* August 2016.

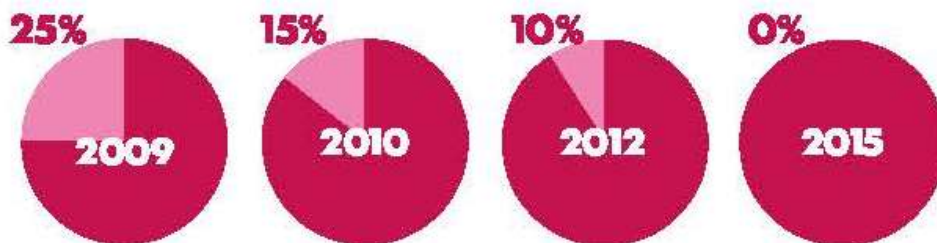
Feeding FM and FO to farmed salmon contd

7c.3 Salmonid feed moving forward - EWOS



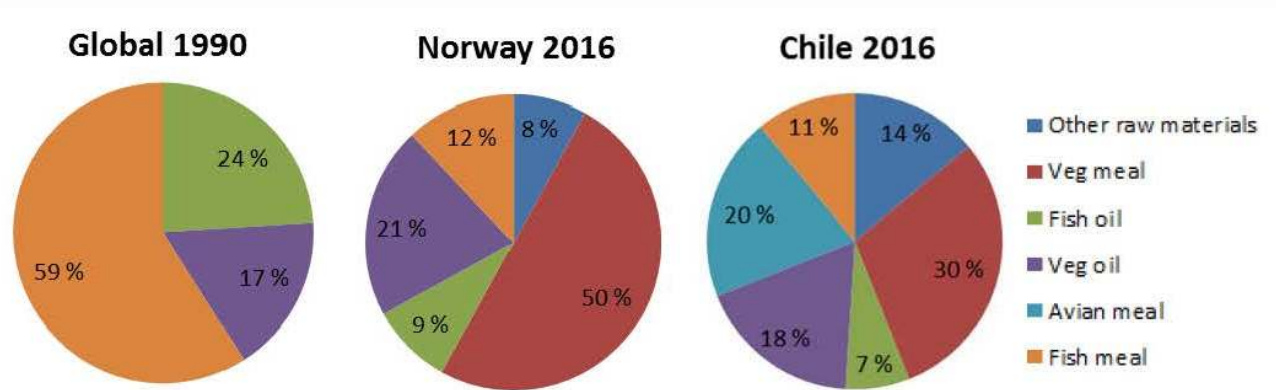
Source: EWOS Annual Sustainability Report 2015.

7c.4 Trends in fishmeal content of Skretting feeds



Source: Nutreco Sustainability Report 2016.

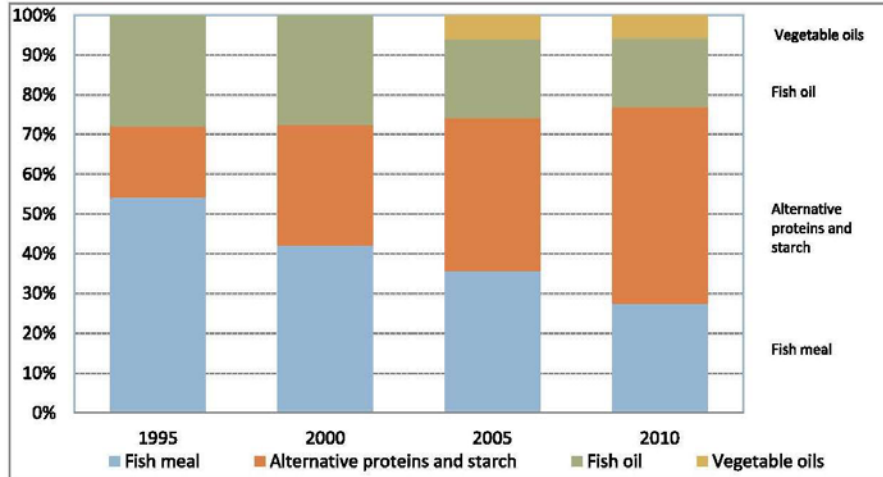
7c.5 Trends in fishmeal content of Marine Harvest feeds



Source: Marine Harvest Salmon Farming Industry Handbook 2017.

Feeding FM and FO to farmed salmon contd

7c.6 Changing composition of salmon feeds – fishmeal and fish oil substitution



(UPDATE: For 2013 inclusion is 15 % fishmeal and the oil content is 1/3 fish oil and 2/3 vegetable oil .
Some major producer grower diets are down to 10 % fishmeal.)

Source: IFFO Positional Paper. February 2013. *Is aquaculture growth putting pressure on feed fish stocks? And is the growth of aquaculture being restricted by finite supplies of fishmeal and fish?*

Feeding fishmeal and fish oil to farmed fish – conversion efficiency in terms of FIFO and FFDR – what do these terms mean?

Fish in: fish out (FIFO)

The fish in:fish out ratio (FIFO) indicates the overall quantity of wild caught fish used per quantity of cultured fish produced. The fish in/fish out ratio (FIFO) measures the amount of fishmeal and fish oil that is used to produce one weight equivalent of farmed fish back to wild fish weight equivalents.

FIFOs have been examined over time as a way to look at the performance of aquaculture in relation to the wild fish that are utilised in feed. Although there are some issues with the applicability of the concept, FIFO is still regarded by some as a benchmark of progress by the sector in relation to its environmental performance.

Forage Fish Dependency Ratio (FFDR)

The forage fish dependency ratio (FFDR) is the amount of wild caught fish used to produce the amount of fish meal and fish oil required to produce 1 kg of salmon. According to the Aquaculture Stewardship Council standards, this measure is referred to as the feeder (forage) fish dependency ratio (FFDR), and should be calculated for both fishmeal and fish oil, using the inclusion levels of marine meals and marine oils in the feed recipe, multiplied by the feed conversion ratio and divided by their corresponding contribution factors.

Feeding fishmeal and fish oil to farmed fish – conversion efficiency in terms of FIFO

7d.1 Fish in: Fish Out (FIFO) ratios for the conversion of wild feed to farmed fish. 2017.

In the table below IFFO has calculated the total amounts of fishmeal and fish oil based on the required feed volumes, in turn based on FCR estimates. These figures are extrapolated to whole fish equivalents for raw material, based on the yield figures. A conversion factor is then applied to the raw material figures to account for the byproduct volume used in production, reflecting the reality in the sector.

	2000	2010	2015
Crustaceans	0.91	0.45	0.46
Marine Fish	1.48	0.88	0.53
Salmon & Trout	2.57	1.38	0.82
Eels	2.98	1.81	1.75
Cyprinids	0.07	0.03	0.02
Tilapias	0.27	0.18	0.15
Other Freshwater	0.60	0.15	0.13
Aquaculture total	0.63	0.33	0.22

Source: IFFO position paper. Fish in: Fish Out (FIFO) ratios for the conversion of wild feed to farmed fish, including salmon. 2017.

Feeding fishmeal and fish oil to farmed fish – conversion efficiency in terms of FFDR

7d.2 Forage Fish Dependency Ratio (FFDR) for fishmeal and fish oil. 2017.

The formula used by the Aquaculture Stewardship Council (ASC) salmon standard for calculating the FFDR for fishmeal and fish oil is as follows:

$$\text{FFDR}_M = \frac{(\% \text{ fishmeal in feed from forage fisheries}) \times (\text{eFCR})}{24}$$

$$\text{FFDR}_O = \frac{(\% \text{ fish oil in feed from forage fisheries}) \times (\text{eFCR})}{5.0 \text{ or } 7.0^3}$$

As an option to the use of FFDR_O , the ASC standard also permits for a calculation that accounts for marine-derived EPA and DHA, in the feed set at a limit of 30g kg⁻¹ feed, and presented:

$$\text{EPA\&DHA in feed (g)} = \frac{(\text{fish oil in feed (g)}) \times (\% \text{ EPA \& DHA in fish oil})}{100}$$

The permitted level for the FFDR_M in the ASC standards ≤ 1.35 and for FFDR_O is 2.95. With current levels of marine ingredient inclusion in aquafeeds and eFCRs seen in the salmon farming industry, these figures readily achievable.

Source: IFFO paper. Why is the application of the term FFDR debatable? January 2017.

7d.3 BioMar, Skretting and EWOS FFDR

	BioMar (2016)	Skretting (2015)	EWOS (2016)
FFDR fishmeal	0.58	0.6	0.73
FFDR fish oil	0.93	1.7	1.97

The Aquaculture Stewardship Council criteria for the FFDR for fishmeal is < 1.35 and the FFDR for fish oil is < 2.95 . Forage fish dependency ratios vary between countries due to customer preferences regarding marine ingredient composition of the feed, and also the sourcing capabilities for byproducts and trimmings.

Sources: BioMar Annual Sustainability Report 2016, Nutreco/Skretting Norway Annual Sustainability Report 2015, EWOS Annual Sustainability Report 2016