Report

Krill Meal and Krill Oil

How price and tonnage competitive are they to other fishmeals and oils

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Take Away:

- South Antarctic Krill meal (and oil) production (*Euphausia superba,* Dana) started mid/late 70s when the Soviet Union led fishing and production, alongside Japanese and Koreans.
- Although dried meal was manufactured at the very inception of the fishery, fresh whole frozen krill and human-grade meats were primary targets, meal tonnage capping around 25 000 tons (2014).
- Krill oil grew from 5 to 1.450 tons/yr. in 3 decades (2013). Since late 90s, human applications triggered new processing layouts sourcing pricy phospholipids-enriched krill oils away from feed applications.
- Krill meal quality specifications focus in protein and pigment content. Late 90s to early 2000s aminoacids and palatability components reinforced demand for meal with new feed applications in aqua-farmed species.
- As krill meal is also used to extract oil since mid 2000s, these meals compete with feed-grade applications, the latter impossible to compete in price, sometimes doubling the price of the former.
- Krill oil quality became of market interest since late 90s when the first phospholipids-enriched krill oils hit the market; from oxidized triglycerides-enriched to phospholipids-enriched supplement/pharma quality oils being human applications current market focus.
- Krill meal and oil uniqueness rely on:
    - Natural antioxidant as astaxanthin
    - Omega-3's mainly bound to phospholipids
    - Unsurpassed freshness when the meal is manufactured onboard (at-sea)
- High quality protein, aminoacid profile and low molecular weight compounds that confer krill meal its unique palatability enhancing properties.
- Meal prices from USD475-775 per ton late 80s/early 90s to current USD2.75-3.45 per kilo FOB, the latter mostly for oil extraction applications. Krill oils from USD475-575 late 90s to current USD125-175 per kilo FOB (bulk, not blended, high quality, human applications).
- Krill meal price will stay anchored around USD2.5 per kilo FOB while oils will face pressure from new extraction technologies and expanded processing capabilities pushing prices bellow the USD100 per kilo FOB mark within the coming 2 to 3 years.
- Strict environmental and fishing regulations (current TAC 8MM tons/yr., precautionary limit 620.000 tons/yr.) applied by CCAMLR, limits krill end-products supply to a minor fraction compared the Peruvian anchovy, West Africa and North European fisheries.
- Krill meals and oils will remain a niche ingredient.

Krill are swarming pelagic euphausiids similar in appearance to shrimp, being an important member of the food chain and polar waters. They are relatively low in the trophic food web and form an essential part of the diet of diverse species such as fish, seabirds and whales. There are currently six krill species that are fished (*Nicol and Endo 1997*) particularly Antarctic krill *Euphausia suberba.*

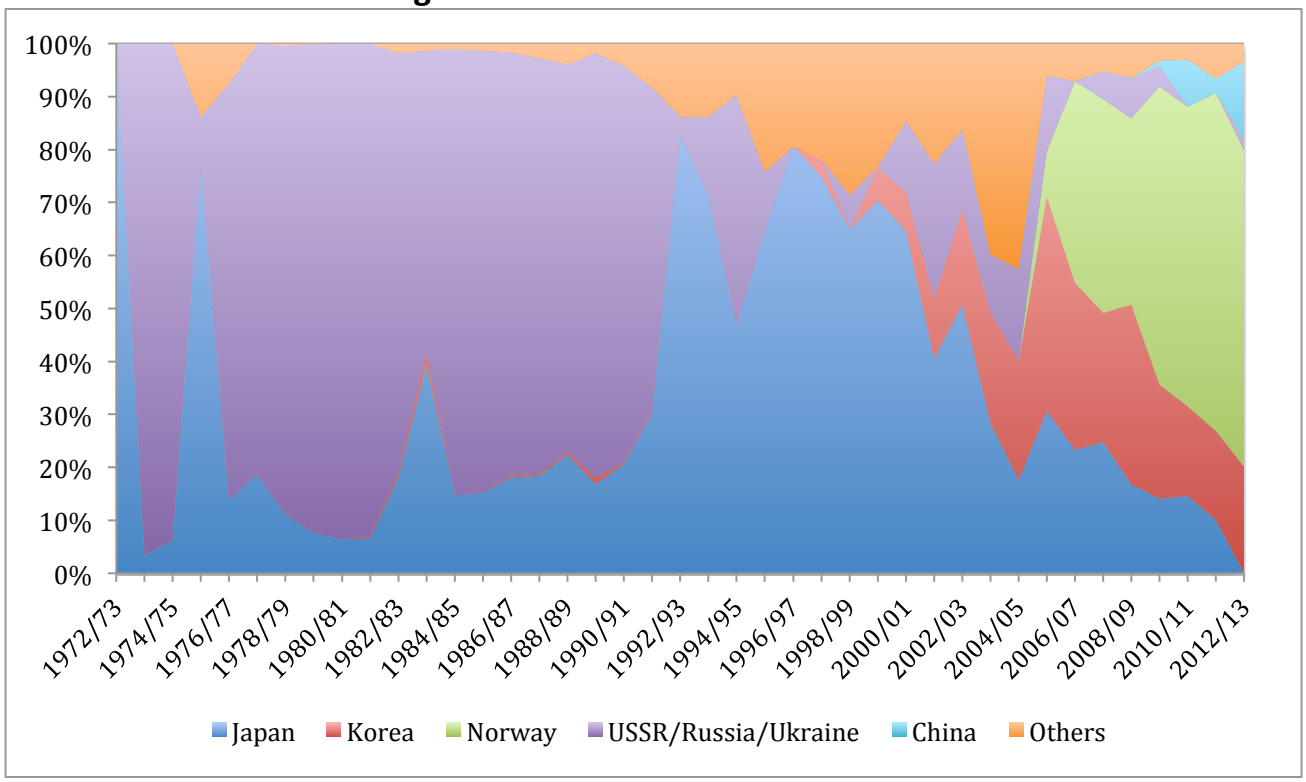
The Antarctic krill fishery is the largest extending to annual 10-year avg. of 145,000 tons. This catch represents only 1/50th of the total allowable catch where the standing stock is estimated between 55 and 160 million tons (*Nicol and Foster, 2003*).

The development of the market for krill meal and oil as an aquaculture ingredient is limited by technical difficulties, associated with catching and processing, and issues pertaining to its suitability of inclusion in the human food chain. Astaxanthin (*Storebakken 1988*), proteins and lipids that are present in high concentrations in krill, degrade rapidly once captured meaning that krill must be immediately processed once on board. The extreme environment characteristics of a majority of oceans where krill are found increase the cost of exploiting this resource limiting future growth.

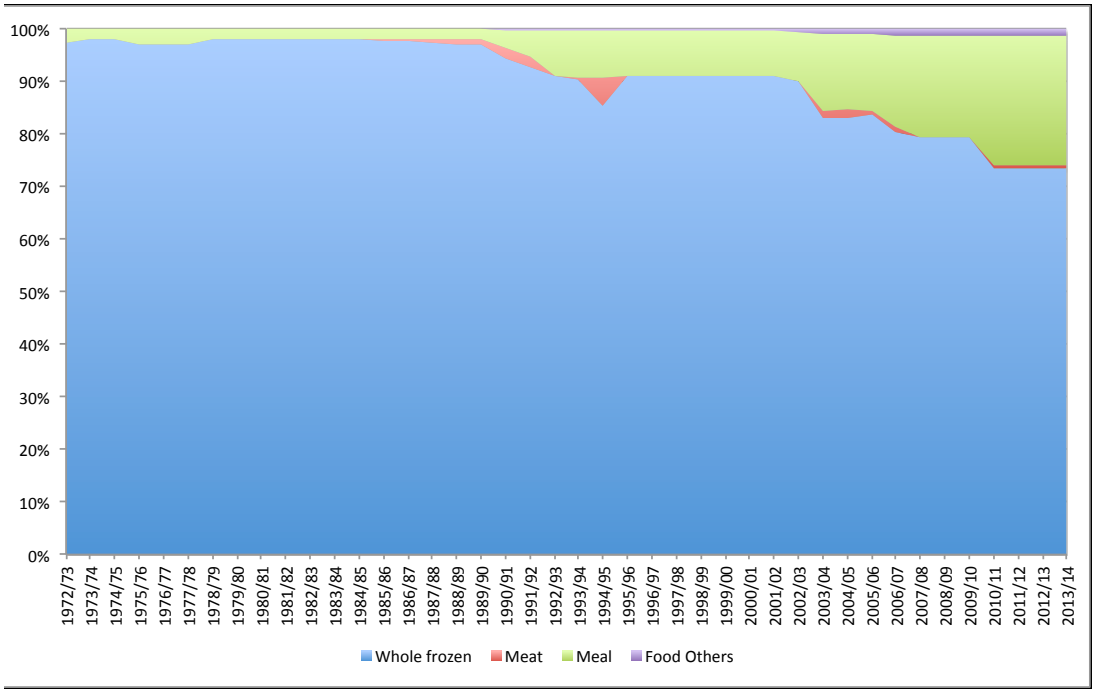
Although krill has been successfully cultured in extensive ponds (*Hirano et al. 2003*) there is currently no research suggesting that intensive culturing methods may serve as a potential source of protein and-or oil for aquaculture feeds.

Krill meal, and krill oil more specifically, are considered a rather new ingredient, although in the 70s the former Soviet Union krill fishing fleet was manufacturing both.

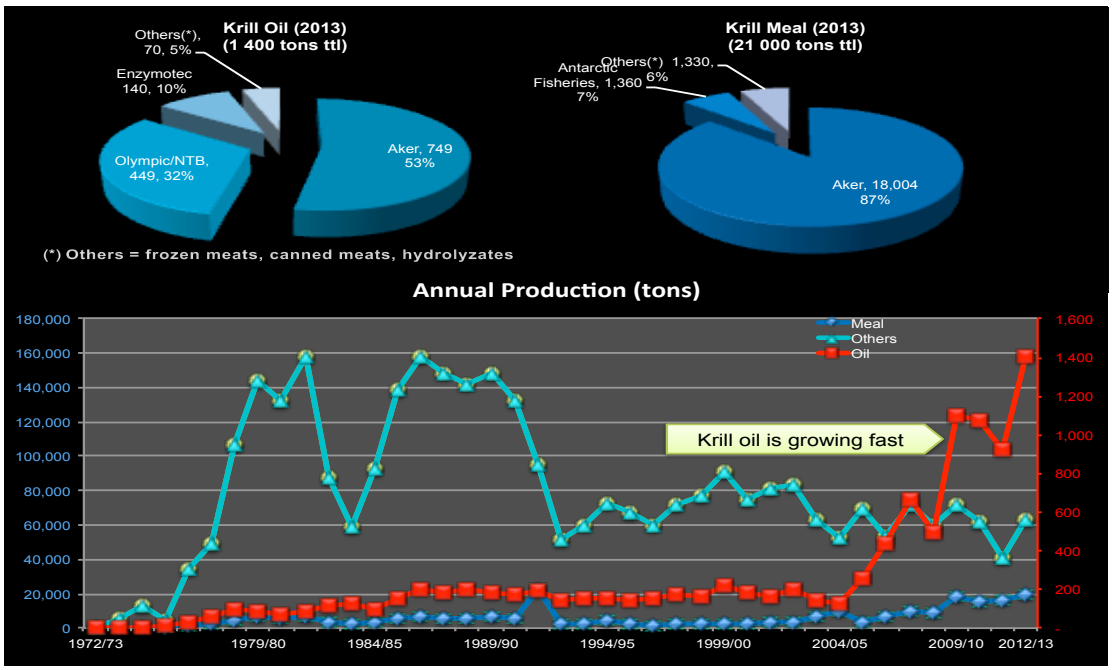
South Antarctic Krill Fishing Effort



Whole fresh frozen, meats and feed-grade meals are major krill products with an annual 10-yr avg. of 70 000, 750 and 9 750 tons, respectively. In the same period, krill oil was close to 450 tons per/yr., triglycerides (TG) and phospholipids (PL) enriched oils.



If current world production plans are fully accomplished, will increase dried meal tonnage twofold and krill oils three times as much in the coming 3 to 4 years, a tonnage that will not ease shortages of other marine-origin meals and oils, less for oils as its primary target is pricy human-grade applications, predominantly the human health and supplement category.



Whole Frozen – Dried Krill Meal (all qualities) – Krill Oil

Feed-grade TG-enriched krill oil is neither a target unless blended with phospholipids-enriched krill oils to help improve viscosity, hence, encapsulation easiness.

Krill Meal as a Feed Ingredient

Various Aquafeeds.com publications and articles address krill meal protein, palatability, pigment, heavy metals, dioxins and other important krill meal compounds and its impact in aqua feeds.

Krill meal is a specialty feed ingredient. Although there are more than 80 different krill species around the globe, resource abundance and high-quality dried krill meals are entirely manufactured from South Antarctic Krill [***Euphausia superba***, Dana].

South Antarctic krill meal nutritional attributes makes it a unique feed ingredient for aqua-feeds due to krill meal's unique protein quality, strong palatability, natural beta-carotene (in the form of astaxanthin), excellent lipids and minerals profile and its chitin & chitosan constituency.

Although pelagic meals and oils are getting scarcer, hence, expensive, krill meal is not call to become main not relevant protein source, rather one that allow vegetable proteins take a leading share in the feed. Krill meals' negligible amount of dioxins, PCB's and heavy metals help this goal.

Krill meal is an excellent source of **protein** (avg. 60% dry basis] with the highest biological value with the following typical average amino acid profile *(Mr. Raul Toro, Mr. Dimitri Sclabos, independent report 1994)*;

- Alanine 5.8% [percent of protein]
- Arginine 6.7%
- Aspartic Acid 9.5%
- Cysteine 1.2%
- Glutamic Acid 12.6%
- Glycine 4.8%
- Histidine 2.5%
- Isoleucine 5.0%
- Leucine 7.8%
- Lysine 8.2%
- Methionine 4.0%
- Phenylalanine 5.2%
- Proline 4.0%
- Serine 4.5%
- Threonine 4.7%
- Tyrosine 4.5%
- Valine 5.3%
- Taurine 2.9%.

Regarding **palatability**, krill meal has a low molecular weight of soluble compounds such as nucleotides, amino acids in the form of proline and glycine, glucosamine, and high levels of trimethyl amine oxide, TMAO (190 MgN/100 g sample). All these act together as an effective attractant and flavoring agent. *(Allahpichay and Shimizu 1984; Storbakken, 1988; Shimizu, et al., 1990; Ogle and Beaugz, 1991).* Krill meal high TMAO content has an extra osmoregulatory contribution, useful to reduce salmon's physiological stress when they are transferred from fresh to seawater *(Finne, G., 1992)* and has been successfully used in low palatability diets containing vegetable proteins and/or antibiotics.

Arnd et al. (1999) show that a 5% inclusion increased palatability of highly fish oil/meal substituted feeds to levels comparable with traditional diets while *Suontama et al. (2005)* demonstrated excellent performance of both salmon and halibut fed diets based on krill protein and copepod oil.

The inclusion in feed formulations of ingredients that act as attractants has been proposed as a means of increasing feed consumption, hence, growth of farmed shrimp. Squid, crustacean and krill meals have been examined to assess their effectiveness in increasing feed intake of black tiger shrimp *Penaeus monodom*. Given a choice between the base feed and one containing krill meal for example, *P. monodom* shows a significantly greater preference for the feeds containing crustacean or krill meal. (*The efficacy of ingredients included in shrimp feeds to stimulate intake. D.M. SMITH, S.J. TABRETT, M.C. BARCLAY & S.J. IRVIN. CSIRO Marine Research, Cleveland, Queensland, Australia. November 10th 2010*

Research made by the Institute of Marine Research and the National Institute of Nutrition and Seafood Research (NIFES) in Bergen, Norway, using proteins from Northern krill (*Thysanoessa inermis*), Antarctic krill and Arctic amphipod (*Themisto libellula*), concluded that krill meal can partially replace fish meal in diets for Atlantic salmon (*Salmo salar*) without affecting product quality and can successfully replace fishmeal up to 60%. (*Institute of Marine Research, Bergen, Norway; Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, Ås, Norway; Aquaculture Protein Centre, Ås, Norway; National Institute of Nutrition and Seafood Research (NIFES), Bergen, Norway*.

South Antarctic krill meal natural **pigment** (in the form of Astaxanthin) has a typical range of 115-175ppm dry basis, depending in processing, resource and fishing conditions, used to increase flesh pigmentation in salmon, trout, yellow tail, shrimp and other farmed species. *(Storebakken 1988; Storebakken et al. 1987; Torrissen et al., 1989).* The end product contains the same type and coloring agent as naturally fed wild caught salmon. This characteristic adds a strong selling argument for feed manufacturers focused on natural or organic conscious buyers.

Beta-carotene astaxanthin found in krill meal has an important role in the regulation of fish immune system, enhancing disease resistance, boost survival rates and an essential fish growth regulator. *(Christiansen et al., 1994; J. Torrissen, 1984).*

When Tharos Ltd introduced in the market, early 90s, krill meal sales separated by pigment content, it was a time when Japanese krill meals prevailed in the market sold primarily by protein content.

Tharos' pigment segmentation lapses each 50ppm, 100ppm onwards for feed-grade meals. Less than 100ppm pigment meals are currently sourced off processes that extract oils from the meal, oils used in human health applications. Tharos' selling principle stands for krill meal prices varying in a ratio of USD50 per ton for every 50ppm pigment difference.

Krill meal **steroidal** component located in krill's cephalotorax has proved an efficient promoting agent in the use of the protein found in feed diets. It acts as a good growth promoting agent, increasing weight gain and feed conversion rates *(Allahpichay and Shimizu, 1985)*

Krill meal **chitin** content found in raw krill shell at an average content of 2-4% of chitin, the resulting krill meal is used as an immune system stimulant in some fish species. *(Siwicki et al., 1994).*

Krill meal is a good source of bio-available **minerals**; Copper 101ppm (dried meal), Selenium 12ppm, Calcium 1.7%, Phosphorous 1.3%. *(Raul Toro, Dimitri Sclabos, independent report 1994).* Copper plays an important role in fin and skin integrity, while high concentration of selenium plays a relevant part on cellular antioxidant systems *(Barrows, F and Lellis, W, 1997)*

Krill meal **fat** content, in an average of 15% (8 – 18%, up to 26-27% if used for human-grade krill oil extraction), depends on fishing season and processing conditions. For traditional krill meal-processing layouts, around 70% of raw krill original fat content remains bonded to krill meal protein. This fat contains high Omega-3 concentrations linked to phospholipids, whereas EPA & DHA are found in the range of 19 to 24%, or higher (as part of lipids). The fat has a high content of phospholipids (30-50% of lipids). Fish fed with diets containing krill meal increase their natural Omega 3 and natural astaxanthin content.

In a study on the effect of dietary lipid level on muscle composition in Atlantic salmon, muscle fatty acid composition reflected dietary fatty acid profiles, containing similar percentages of total saturated, monoenic and Omega-3 fatty acids in fish in all dietary treatment groups *(Hemre & Sandnes, 1999).*

Krill meal is added in aquaculture feed diets in a range of 1 to 8% *(Dimitri Sclabos unpublished reports 2001 and 2005),* used at pre-harvest or throughout the whole rearing and growth phase, depending on diet's target. Markets for these feeds include shrimp, trout and salmon-feed manufacturers.

Best krill meals are a result of fresh and whole raw krill processed on board (at-sea) factory trawlers within the first 2 hours after the krill has been captured allowing the highest freshness expressed in a very low TVN value in the range of 5 – 20 (mgN/100g). *(Raul Toro, Mr. Dimitri Sclabos, independent report 1999-2003, unpublished data).* Recent publication expands this concept.

Krill Meal shows a remarkably low content of undesirable substances such as heavy metals and dioxins, closely related to the unpolluted waters where it is captured and processed *(Dimitri Sclabos & Raul Toro Aquafeed.com report June 2003).* South Antarctic krill fishing grounds has its own natural barriers such as sea current activity, circumpolar atmospheric winds and a limited human intervention. Industrial contamination is at a minimum. Heavy metals found in this area come primarily from volcanic activity, the main estimated pollutant source for Antarctic marine species *(Knox, 1970; Beckman, 1992).*

Arsenic (As) comes from volcanic sources and it is a natural element found in water, soil and air. In marine species it mainly comes on its organic [80-99%] non-toxic form. Arsenic inorganic form is found in krill in an amount of less than 0,01ppm while fish have 1-10ppm of As/kg (wet weight). In whole krill, Arsenic level reaches 3 ppm As/Kg *(Deheyn, D. et al, 2000).*

Cadmium and Lead levels
Antarctic Krill Meal and Fish Meal

Material	Antarctic krill meal Mean(ppm) n=4	Norwegian fish meal Mean(ppm) n=15	Feed Material -EU Regulation Upper Limit
Cadmium	0,1	0,45	2,0
Lead	< 0,5	0,43	10,0

(*) Regular brown & white fishmeals have a Lead average content of 3,72ppm (IFFO 1976)

Mercury (Hg) is widely distributed in nature, found in water, soil, and air and in several organisms. In marine species, organic mercury (methyl mercury) is considered a toxic compound, thoroughly concentrated throughout the food chain. Inorganic less-toxic mercury is accumulated at lower concentrations. Methyl mercury found in fish feeds is accumulated in fish's flesh and slowly eliminated. Tuna, halibut, sharks, and other predatory species accumulate higher mercury concentrations (0.5 – 1 ppm wet weight). The opposite is valid for species found at the beginning of the food chain, such as Antarctic krill that fed from plankton. It accumulates mercury at less than 0.1 ppm (wet weight).

Mercury in Antarctic krill Meal

Krill Meal Mean(ppm) N=6	Complete Fish Feeds Mean(ppm) n=54	EU upper level for feed material. Mean(ppm)	EU limit for complete feeds Mean(ppm)
< 0,05	0,05	0,5	0,1

(*) Regular brown & white fishmeals have a Mercury average content of 0,15ppm (IFFO 1976)

Dioxins

Dioxins are a group of 210 polychlorinated substances spontaneously created from industrial contamination and wastewater, 17 of them considered toxic being these targeted in lab analysis.

Dioxins are a serious toxic material and active at very low dosage; they accumulate in fatty tissue and are not easily eliminated, either in marine species or humans.

Dioxin content in South Antarctic Krill Meals
Expressed as ng-WHO-TEQ/kg

Orkney Island Jan.26-Feb.28 '02	Orkney Island Mar.15-Apr.18 '02	South Georgia's Jun.22-Jul.31 '02	EU max level for fish meals
0,2657 (*) Fat 13,0%	0,3259 (*) Fat 13,9%	0,2054 (*) Fat 12,9%	1,25

(*) Average value

The Fluoride Question

Soevik & Breakkan, 1979, first indicated the high fluoride content of the exoskeleton of krill for E. superba but all other krill species so far examined have similar high levels (*Sands et al., 1998*). It seems that high exoskeleton fluoride concentration is a general feature of euphausiids, hence, feed users have to take this feature into account when assessing potential products.

Aquafeeds.com published about krill Fluoride matter in June.24.2003.

All krill species contain high levels of natural organic fluorine in their shells (*Nicol & Stolp 1991; Soevik & Breakkan 1979; Virtue et al., 1995*). However, South Antarctic krill is a key food source for a huge number of predators, being fluorine involved in the synthesis of bones and scales (*Steffens, W. & lbrecht, M., 1982*). This feature has proved a problem for producing human consumption end products and pet foods (*Budzinski, et al. 1985*). Despite the high fluoride level of whole raw fresh krill, they are, however, suitable for aquaculture feed (*Storbakken 1988*).

Euphausiids have the highest fluoride concentrations of a range of several Antarctic marine crustaceans; up to 5 477 µg g-1 found in the exoskeleton of *Euphausia crystallorophias*. Copepods have the lowest level (0.87 µg g-1 whole-body). There is no apparent relationship between the lifestyle of crustaceans and their fluoride level.

Krill contain high concentrations of fluoride (up to 6 000 mg/kg dry-weight) which, through the interference with the calcium metabolism, it is considered toxic to humans above 150 mg/kg. However, krill derived fluoride has been shown to have a very low retention in salmon and cod (*Moren et al. 2005*) and, when retained, it is largely stored in the fish skeleton (*Virtue et al. 1995*).

Fluoride is not evenly distributed; the exoskeleton of the head, carapace and abdomen contain the highest concentrations of fluoride, followed by the feeding basket and pleopods, and the eyes. The mouthparts of *E. superba* contain almost 13 000 µg F g-1 dry wt. Antarctic krill tail muscle have low levels of fluoride (*Sands M. et al., 1998*).

The fluorine in krill comes from seawater by biological absorption of the krill. The natural F- content of seawater is only 1.3 mg/kg.

Krill meal typical processing layout using fresh raw krill (including the exoskeleton), resulting krill meal have natural organic fluorine content in a range of 1 000-3 000 ppm.

There have been efforts made to produce low shell (hence low fluoride) krill products. Some processes generate low fluoride krill meal by removing exoskeletons from dried whole fresh krill to give a fluoride content of approximately 230 ppm vs. 870 ppm for whole fresh raw krill. There are other methods like organic acid washing or by simple water washings, or the addition of calcium, but this are not practical procedures to run onboard factory trawlers.

Many surveys have demonstrated that the use in aquaculture of crustacean meals, despite its high fluoride content, has no risk for animal's health. Fishes don't accumulate fluoride in its fillets, so is no harmful for human consumption.

Fluorine in Antarctic Krill Meal
(Unpublished Research Tharos Ltd)

Lot Nº	Date	Catch Coordinate Latitude (S)	Catch Coordinate Longitud (W)	Sea water Temp. (ºC)	Fluorine level (ppm)	Moisture (%)
14	Feb-11	60º 25´	46º 48´	0.6	1073	8.7
21	Feb-18	60º 30´	46º 44´	0.8	2079	7.2
23	Feb-22	60º 17´	46º 29´	0.8	1705	9.4
27	Feb-26	60º 23´	46º 18´	0.7	1849	7.6
29	Mar-15	60º 26´	46º 27´	1.0	1548	7.9
35	Mar-22	60º 26´	46º 39´	0.8	1493	7.6
46	Apr-02	60º 17´	46 º 17´	0.6	1690	6.7

Since *Soevik and Braekkan (1979)* found high concentrations of fluoride in krill (1 300-2 400 ppm d.w. in whole krill), the problem in using Antarctic krill for human nutrition increased. Krill fluoride shows good bioavailability and high amounts of fluoride are toxic. Less than 4 mg F- daily is considered harmless to humans. In the long term, higher amounts lead to fluorosis with symptoms such as changes in bone structure and enzyme inhibition (*Eagers, 1969*).

Estimated total annual predators' krill consumption ranges 150 – 300 millions tones (*Miller et al., 1989*). Humans safely and directly consume several of these species with no reported risk of fluorine contamination.

A December 2006 study carried out at Kochi University (Japan) by *Bunji Yoshitomi, Masatoshi Aoki and Syun-ichirou Oshima* to totally replace fishmeal (FM) in diets by low fluoride krill (*Euphausia superba*) meal (LFK). LFK was prepared by removing exoskeletons from dried whole fresh krill to give a fluoride content of approximately one-fourth of krill meal's with 230 ppm for LFK vs. 870 ppm for krill meal off whole fresh raw krill.

Following table shows the composition of each component. Because of the removal of the exoskeleton, the crude protein of LFK was approximately 10% higher than for dried whole krill. Crude fat, ash and astaxanthin of LFK were lower than for dried whole krill and for the removed exoskeleton because the fat tissues of krill that contained astaxanthin adhered firmly to the removed exoskeleton.

The fluoride content of the LFK was approximately one-fourth of dried whole krill at 230 mg/kg and 870 mg/kg, respectively, and the removed exoskeleton contained 1800 mg/kg of fluoride. Overall, although F- content is lowers with the exoskeleton removal, other variables face the opposite trend such as triacylglycerol's and pigments. (*Yoshitomi, et al., 2007*).

Composition of krill meal and low fluoride krill meal (dry weight as %)

	Dried whole krill	Low fluoride krill meal	Removed exoskeleton
Crude protein	66.0	76.8	56.7
Crude fat	19.9	13.3	21.5
Crude fiber	2.4	0.1	4.5
Ash	11.7	9.2	14.8
NFE*	0.0	0.8	2.5
Astaxanthin (mg/kg)	90	38	96
Fluoride (mg/kg)	870	230	1800
Fatty acid composition			
14:0	11.3	10.8	11.5
16:0	21.7	22.1	21.8
16:1n-7	8.1	7.7	7.8
18:1n-9	19.1	19.3	19.3
18:2n-6	1.4	1.5	1.5
18:3n-3	0.7	0.8	0.8
18:4n-3	2.4	2.2	2.5
20:1n-9	1.0	1.0	1.0
20:4n-3	0.4	0.4	0.4
20:4n-6	0.3	0.3	0.3
20:5n-3	14.2	14.3	13.6
22:5n-3	0.4	0.4	0.4
22:6n-3	7.1	8.1	6.9
Lipid classes			
Hydrocarbon	0.0	0.0	0.0
Wax ester	Trace	Trace	Trace
Triacylglycerol	26.2	20.6	26.1
Free fatty acid	1.0	1.4	1.3
Sterol	0.8	0.7	0.8
Phospholipids	72.0	77.3	71.8

*NFE: Nitrogen-free extract.

Yoshitomi, B. *et al*., 2007 study consisted in the replacement of fishmeal with LFK in experimental diets at the replacement proportion of 0.0%, 7.7%, 15.4%, 30.8%, 46.2% and 100.0%, fed to groups of rainbow trout (*Oncorhynchus mykiss*). I n all experimental groups, feed intake, feed efficiency, specific growth rate and hepatosomatic index were unchanged compared with fish fed the control diet. After 95 days, the fluoride concentration in dorsal muscles of the fish of each experimental group, except LFK100, was below the detectable limit (1 mg/kg), and in vertebral bones it was between 220 mg/kg and 420 mg/kg. The total replacement of fishmeal by LFK in aqua diets was successful, with no defects in growth performances.

Krill Meal Lipids

Is there a standard fat content in krill meal? Is the fat content stable throughout the entire season?

South Antarctic krill contains 4 to 5% of its natural weight composed of extractable lipids, more than half of which are in the form of phospholipids — phosphatidylcholine (PL) (33–36% of the sum of the lipids), phosphatidylethanolamine (15–17%), lysophosphatidylcholine (3–4%), and others (2–3%). Among phosphorus-free components, triacylglycerols predominate (32–35%). Among other factors, krill meal lipid content is related to the lipid content of raw fresh krill and size of each specimen.

Tharos At-Sea (80's – 2000's) Lipid Analysis
(Raw Krill)

Average size (mm)	Mass copies of krill (mm)	Moisture	Lipids	Protein	Minerals
29.3+-5.2	0.18+-0.02	78.1+-0.8	3.4+-0.8	14.2+-0.3	2.3+-0.1
38.8+-2.0	0.36+-0.02	76.4+-0.7	5.1+-1.3	14.5+-0.2	2.3+-0.2
44.8+-1.9	0.54+-0.03	75.3+-0.7	6.9+-1.2	14.4+-0.7	2.4+-0.2
51.7+-2.8	0.91+-0.05	74.1+-0.5	7.5+-1.0	15.6+-1.0	2.4+-0.2
54.8+-5.9	1.96+-0.08	80.0+-0.5	3.9+-1.0	12.9+-0.5	2.5+-0.1
52.4+-3.9	1.22+-0.21	81.5+-1.7	1.6+-0.8	13.6=-0.5	2.6+-0.1

Source: **Unpublished Research. Tharos Ltd 1993-2009**

In general, the larger the size, higher the amount of lipids within the same season and fishing region.

Krill Chemical Composition by Fishing Region
(wet weight)

District and date of harvest	Moisture	Lipids	Protein	Ash	Shell
Scotia Sea (February)	78-80.0	2.5- 4.0	12.8-15.3	3.0-3.8	1.9
South Orkney (March –April)	77-80.0	4.0- 4.6	12.7-15.2	3.0-3.6	1.8
Bransfield Strait (May)	76-77.0	4.2- 6.0	14.8-15.7	2.0-4.0	1.7

Source: **Unpublished Research. Tharos Ltd 1993-2009**

South Antarctic raw krill lipid content also varies on seasonality and fishing ground. It is not possible to secure a stable one-single fat content level for aqua-grade krill meals, rather min - max levels.

Lipid Content in South Antarctic Fresh Raw Krill

Month	Lipids Content Raw krill (%) Wet Base (Range)	Fishing ground
Jan	2.0 – 3.0	North Antarctic Peninsula, Bransfield Straight
Feb	2.0 – 3.0	Orkney/Elephants Islands
Mar	3.0 – 4.0	Orkney/Elephants Islands
Apr	4.0 – 6.0	Orkney/Elephants Islands
May	4.0 – 6.0	Orkney/Elephants Islands
Jun	3.0 – 4.0	Orkney/Elephants/South Georgia Islands
Jul	2.0 – 3.0	South Georgia Island
Aug	2.0 – 3.0	South Georgia Island
Sep	2.0 – 3.0	South Georgia Island, North Antarctic Peninsula
Oct	2.0 – 3.0	North Antarctic Peninsula
Nov	2.0 – 3.0	North Antarctic Peninsula
Dec	2.0 – 3.0	North Antarctic Peninsula

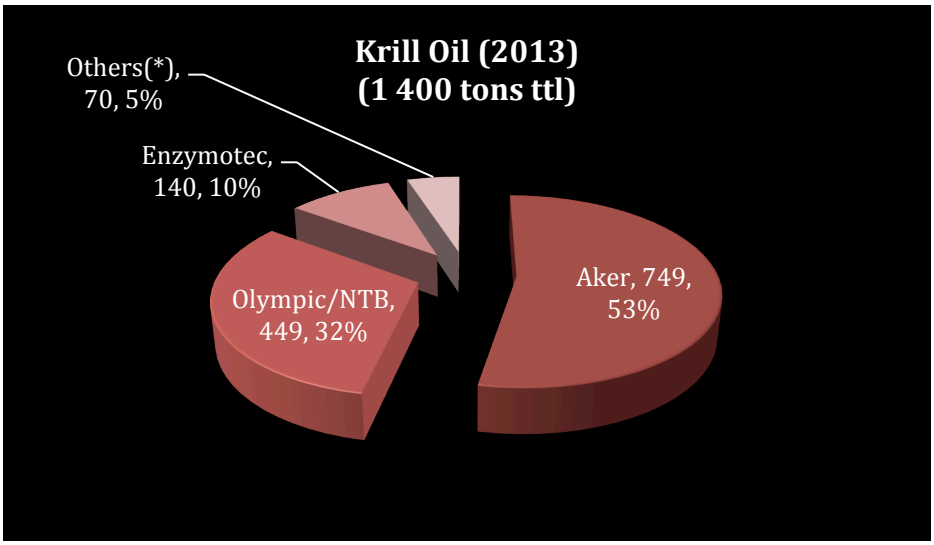
Source: **Unpublished Research. Tharos Ltd 1993-2009**

Valuable krill meal lipids are used by several of current krill operators to extract pricy supplement and pharma-grade krill oil. This oil is entirely extracted onshore from krill meal previously manufactured at-sea and transported to onshore extraction facilities. Such extraction processes use chemical solvents (e.g. acetone, ethanol) at one point of the manufacturing steps, model that prevents biological and chemical valuable raw krill compounds remain in the oil. More at WorldFishing.net. Tharos new-patented process gets rid of all solvents and extracts pure 100% solvent-free krill oil directly at sea.

Current Antarctic krill fishing operation models do not allow krill oil to become a competitively priced feed-ingredient. Will remain a niche food, supplement and pharma ingredient with the USA as its biggest market (43% of world krill oil sales], Asia in second place, for now.

Krill oil production (2013) is in the vicinity of 1 400 tons (PL-enriched krill oil) from which 65-75% was sold in the same year valued USD105-135MM with a market potential of USD500MM within the coming 3 to 4 years

Krill oil key players are Norwegians Aker and Olympic, Canadian Neptune Technologies and Israeli Enzymotec, Aker being the sole fully vertically integrated company. Several Chinese krill oil manufactures has entered the market.



In terms of raw fresh krill, 1 400 tons krill oil equals app. 50 000 tons, approximately 16% of 2014 raw fresh krill capture.

Current prices limits krill oil to expand to the feed category, in the vicinity of USD125 per kilo FOB bulk for supplement/pharma grade krill oils. Prices will drop once new processing technologies go commercial and planned new krill operations enter the fishery (2015-2016).

Triglycerides-enriched krill oil prices were in the low USD1 per kilo range (early 2000s) up to USD7-23 per kilo range (early 2010s) subject to quality, used as a blender for phospholipids-enriched krill oils.

Krill Meal Pricing

Has krill meal price a direct relationship with fishmeal prices?

Krill meal can be sourced as a direct-target product (from raw krill), as a sub product of tail meat production (waste + raw) or as a by-product of oil production (waste from oil extracted from meal).

Krill meal prices remain above USD1.5 per kilo FOB in the least 10-years and almost always above fishmeal prices.

Given main krill meal features, the following products are relevant krill meal substitutes, either combined or independently; (a) Pigment (as astaxantina), (b) fish and vegetable proteins, (c) lipids and (d) attractants. These components have seen significant ups and downs in the same period although krill meal prices still show a rather stable trend.

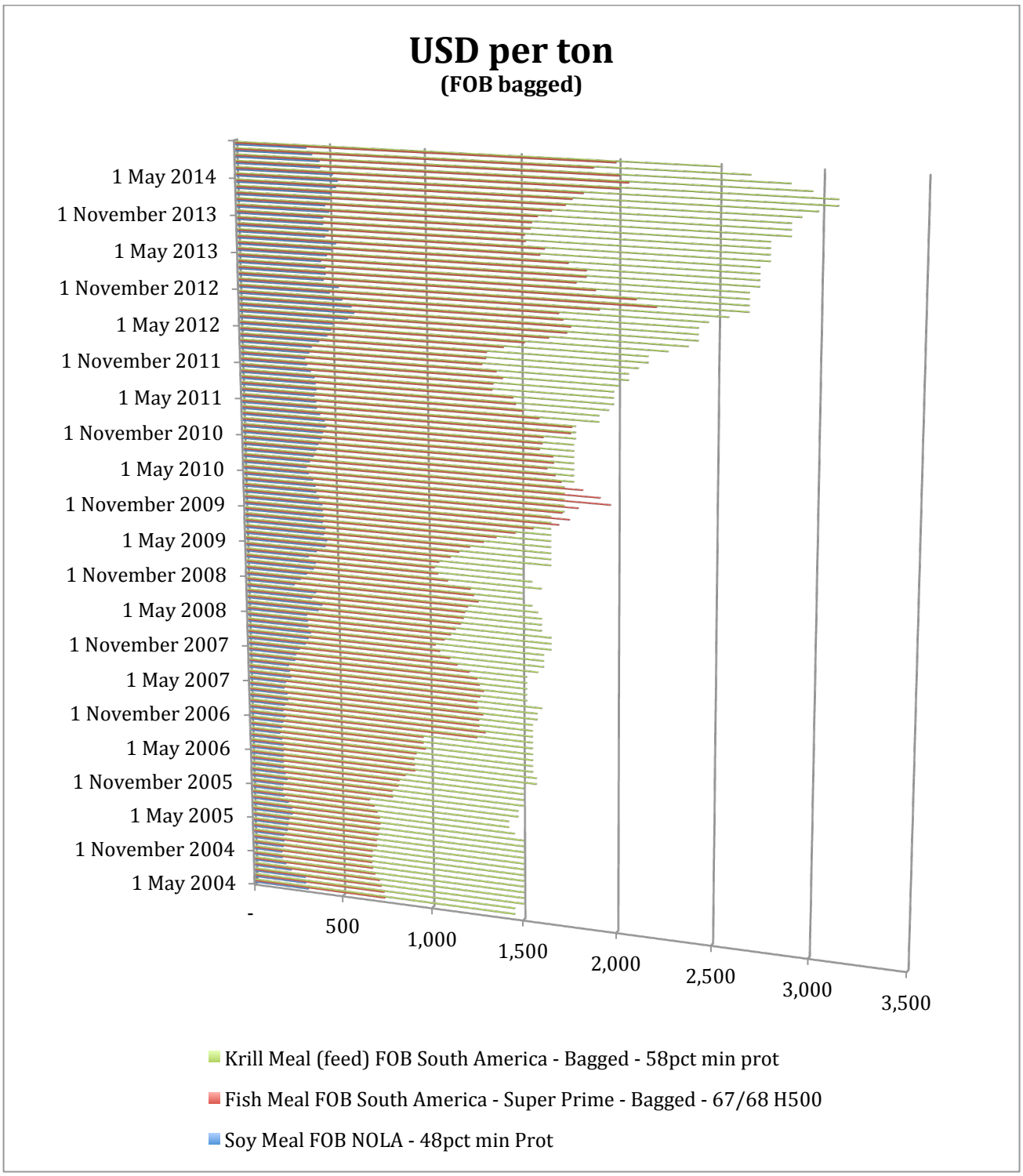
Tharos' mid 2000 market research estimated krill meal potential annual demand of around 117 000 tons of mid-high quality krill meal mostly for aqua-feeds for salmon/trout and farmed shrimp.

Late 2000s Tharos developed a krill meal and oil econometric price predictive model whose key influencing variables, in different proportions, proved to be rapeseed oil, soy oil, sunflower oil, fish oil, soy meal, fish meal, etc.

10-yr. avg. prices shown bellow apply for high-quality krill meals traded in the open market and through Tharos' world channels. The same model predicted the 4 to 6% price decrease seen since the end of Q3.'14, price expected to stabilize until Q2.2015 shipments in the range of USD2.45 to USD2.85 per kilo FOB for meal 58% prot. min, moisture 10% max, 18% max fat and 13% max ash content.

Future krill meal prices will be impacted by (a) feed substitutes prices and (b) krill meal demand used for krill oil extraction. The effect in krill meal prices might show a different path. FAO food price index on the downturn and expanded krill fishing operations and larger Chinese krill oil extraction facilities will impact krill meal prices in opposite directions.

More about krill end products at Aquafeeds.com publication October.6.2003.


USD per ton
(FOB bagged)
1 May 2014
1 November 2013
1 May 2013
1 November 2012
1 May 2012
1 November 2011
1 May 2011
1 November 2010
1 May 2010
1 November 2009
1 May 2009
1 November 2008
1 May 2008
1 November 2007
1 May 2007
1 November 2006
1 May 2006
1 November 2005
1 May 2005
1 November 2004
1 May 2004
-
500
1,000
1,500
2,000
2,500
3,000
3,500
Krill Meal (feed) FOB South America - Bagged - 58pct min prot
Fish Meal FOB South America - Super Prime - Bagged - 67/68 H500
Soy Meal FOB NOLA - 48pct min Prot

Krill meal vs. Fish meal

KRILL MEAL	FISH MEAL
Palatability Low molecular weight compounds that act as an effective attractant and flavoring agent.	**Palatability** Less effective.
Antioxidant Properties It has a high carotene (Asthaxanthin) content and natural tocopherols.	**Antioxidant Properties** None.
Fluoride High contents of natural organic fluorine.	**Fluoride** Low content.
Natural pigments Increases flesh pigmentation of farmed species. Acts as a powerful antioxidant.	**Natural pigments** None.
Steroidal components Growth promoting agent.	**Steroidal components** None.
Chitin Immune system stimulant for some fish species.	**Chitin** None.
Lipids Sufficient Omega3 fatty acids content. Fatty acids in the form of phospholipids (good bioavailability).	**Lipids** Sufficient Omega3 fatty acids content. Fatty acids in the form of triglycerides (poor availability).
Undesirable substances Low contents of Dioxins, PCB's and heavy metals.	**Undesirable substances** Risk of high contents of Dioxins, PCB's and heavy metals.