

South Antarctic krill Oil Industry

Tharos' Involvement and Historical Perspective

Former Soviet Union and its Republics - Russia and Ukraine



In the 60's, the ex-Soviet Union operated an important fishing fleet in the South Atlantic waters, catching and freezing white fish. In this area, they also detected the presence of high densities of a little shrimp-like species that "*turned the sea red color*" It was South Antarctic krill (*Euphausia superba*, Dana).

With this information at hand, USSR's Fishing Ministry realized the potential of this resource. Following their centralized planning system, a working program was developed to exploit krill throughout the following years, giving instructions to different ministries for the development of the krill fishery: It resulted in the construction of new and large factory trawlers, the design of new fishing systems as well as the design and development of new on-board and on-shore processes to obtain end-products targeting human and animal consumption.

The main processes developed by them focused on food-grade canned and frozen krill meat, feed-grade dried krill meal and some average-low quality whole frozen krill.

Nonetheless it was studied, krill oil was not a target, probably due to its complex extraction process and low yields achieved through to the at that time low-yield existing extracting technologies. In those years, information on the applications and potential of omega-3, phospholipids and astaxanthin was not available.

In the 90's, Perestroika-supported, the USSR krill fishing fleet was divided into different republics, in relation to each of previous participation in this fishery, e.g. Ukraine's Sevastopol port, Russia's Murmansk port, etc. This was the last sub-division and the last day when strong government subsidies existed. New fishing operations should and must be auto-financed.

Former USSR's Ukraine Republic had an important fleet oriented to the South Antarctic krill fishery. Early 90s, the Ukrainian company Atlantika, with its six stern-factory krill-specialized trawlers RKTS-type was a major participant on this fishery. Jointly with Atlantika, the Chilean company Tepual S.A. became partner of Atlantika targeting feed-grade krill meal production as well as R&D work on krill meal processing technologies, and with it krill oil extraction.

This joint venture (until end 1995) resulted in the first ever 15 tons krill oil production. This initial production contained mainly neutral lipids and astaxanthin, low omega-3 and low phospholipids content.

Tepual S.A., in association with Tharos' R&D department, continued exploring different krill oil extracting systems possible to obtain high-concentrations omega-3's, phospholipids and astaxanthin.

Towards mid 2000s, Ukrainian RKTS factory trawler "*Konstruktor Koshkin*" re-appeared in this fishery (2004 ~ 2007) ¹, manufacturing mostly food-grade canned krill meat and feed-grade dried krill meal. Tharos' technical assistance included on-board quality and processing supervision, lab-quality control and new product development. On-board krill oil production oil was one of the new processes developed with Tharos' assistance focused on triglycerides-rich + low EPA/DHA krill oil. Low volumes were produced mostly for marketing and R&D purposes.

We do not see major changes on the Ukrainian operation for at least the coming 2 seasons (2010-2011).

Regarding the current Russian operation through Murmansk-based company Murmansk Trawl Fleet (MTF) and its factory trawler "*Maksim Starostin*", besides the onboard triglycerides-rich low EPA/DHA krill oil secured as a by-product from the aqua-grade meal processing line, there are no phospholipids-enriched high EPA/DHA oils to be manufactured for the coming 2010 season.

¹ It was part of the old USSR krill fishing fleet, the days of the RKTS' trawlers

Factory trawler “*Maxim Starostin*” started its krill operation in 2008. This is a refitted trawler (Moonzond type) targeting aqua-grade krill meal and krill oil as a by-product, plus small volumes of sport-bait and/or food-oriented whole frozen raw krill.

MTF and Tharos worked together on several krill related issues as well as quality supervision. Nonetheless, we do not see any further improvement to what has been done so far as MTF has not included key and critical changes to their existing processes.

Tharos was involved on this project after the trawler business model was defined and the vessel outfitted. Since end 2007 until mid 2009, Tharos’ onboard personnel was the quality and processing supervision responsible entity on meal, oil and raw whole frozen krill. Tharos’ quality certificates and sales activities supported MTF initial activities.

New Russian operations (est. 2011-2012) plan to bring onboard regular layout as above, unless new technologies are applied.







Japan



Japan, while fishing whales in the Antarctic area, also observed the same abundance pattern as former USSR companies regarding the krill resource. Soon after, two companies, Nippon Suisan Kaisha (Nissui) and Taiyo Fisheries (later renamed as Maruha), started krill exploitation (1960s.) These companies produce mainly sport-bait purpose raw whole frozen krill, feed-grade krill meal and a small amount of food-grade frozen krill meat.

The Japanese fleet does not produce at present any by-product krill oil, either direct as oil, or as a by-product from the krill meal process. Nonetheless, Nippon Suisan does offer Phospholipids-enriched krill oil (> 40%PL) from on-shore processes.

Taiyo Fisheries quit the South Antarctic krill fishery while Nissui still remains (2010) with an old trawler (FT "*Fukuei Maru*" which replaced former FT "*Nitaka Maru*") targeting mostly sport-bait quality raw whole frozen krill, feed-grade krill meal and a limited volume of food-grade frozen krill meat. Nissui's past and recent krill oil extraction patents (using solvents) will result on phospholipids-enriched high EPA/DHA oils not before the 2011 season, if not later, depending on the current evaluation Nissui is making to actual incumbents' performance.

Japanese krill fishery has a long data. It goes back to the 60s and 70s as USSR did. They have access to excellent in-house and government-sponsored technology. It also posses plenty of fishing experience and background on krill resource.

Nissui's krill oil extraction plans should be seen as a switch towards new operating regions, for example using Nissui's Chile-based fishing operation, either from Central-South or South-Chile regions, either alone or in collaboration with their Chilean partners.

Nissui holds several krill oil extracting patents. Their recent (2009) applied patent brings in similar technologies as Norwegian Aker Biomarine and Canadian Neptune Technologies and Bioresources do. Tharos was consulted by Nissui on Tharos' chemical-free krill oil extraction procedure and eventual correlation to recent Nissui's patent application. None so far are found neither any association agreed. Nissui will be anyway forced to work with new at-sea processing facilities if it wants to secure fresher raw material used as the backbone for theirs phospholipids-enriched high EPA/DHA krill oils. Their sourcing for this product scheduled for not before 2011.





United States of America (USA)



Mid 90's, Korean-origin USA (Kodiak)-based church-related corporation Top Ocean inc began the first USA krill project while its at-sea operation began by 1999 through theirs FT "Top Ocean" factory trawler.

Tharos acted as their business and krill-expert consultant since late 90s. This operation was focused primarily on food-grade frozen krill meat and dried aqua-feed grade krill meal. There was no krill oil production and only few decanting-based krill oil tests were made by Tharos' onboard personnel.

Top Ocean's krill oil processing plans were at the beginning only at the level of R&D and no further on-board work was done. Limited krill oil volume was produced by Tharos' on-board personnel, at a lab scale and for further lab testing purposes.



Canada



Late 90s Messrs Genevieve Martin and Adrien Beaudoin applied for what was later known as Neptune Technologies and Bioressources (NTB) krill oil patent, giving birth to NTB's NKO krill oil brand focused to the dietary supplement and nutraceutical market niche. The patented production process was originally applied through the Canadian *University de Sherbrook*. It corresponds to a low-temperature acetone-based extraction principle.

Proteins and krill material are removed from the lipid extract through filtration. The acetone and residual water are removed by evaporation. Resulting phospholipids content ranges 38 ~ 50 %, Omega 3's EPA and DHA circa 22-35%, wherein the major amount of these omega-3s are attached to phospholipids plus astaxanthin.

NTB also patented phospholipids-rich, omega-3 and astaxanthin krill Oil for health applications, such as premenstrual symptoms reduction, hypertension prevention, high blood glucose levels and arthritis symptoms control, hyperlipidemia prevention and other health applications.

Neptune krill Oil is produced in Canada at NTB's Sherbrook location, processing whole frozen Antarctic krill captured by Korean, Russian or other factory trawlers.

Tharos 2007/early 2008 consulting work was focused on raw material sourcing as well as NTB's positioning within the "processors community". NTB is based on a non-vertical integration business concept. Its main and sole raw material remains whole raw frozen krill supplied by outsourced corporations. When such corporations eventually target the same end product, will bring in direct competitive forces that NTB will need to overcome. JV's were an option although so far (March 2010) none has been accomplished. NTB remains a "buyer".



Norway



End 2003, the Norwegian factory trawler “Atlantic Navigator” (bearing a Vanuatu flag) appears on the krill fishery. Owned by at that time Norway Seafoods (currently Aker Biomarine ASA) target a two-product production matrix: Both aqua-grade; dried meal and liquid oil. Krill oil was a by-product of krill meal’s process. This oil had very low Omega 3 content and negligible phospholipids content.

Tharos was at that time consulting the world aqua-feed largest producer, Skretting (Nutreco). Tharos appointed onboard technicians for quality and processing supervision on-board the FT “Atlantic Navigator”. This trawler was formerly known as “American Monarch” and later was replaced by the Norwegian flagged FT “Saga Sea” (still working as of season 2010).

Aker Biomarine detected krill oil’s potential as a superb aqua-feed ingredient adding natural compounds such as pigments and lipids. Nonetheless, Aker Biomarine realized that it needed high levels of phospholipids, omega-3 and astaxanthin compounds if it wanted to target the human health applications avoiding this way a low (or none at all) EBITDA. So far Aker’s operation has not achieved a positive EBITDA.

Second Aker’s problem was that its onboard krill-oil oriented processing layout did not achieve the desired krill oil quality. As Aker copied what it was doing on other resources, it found that krill species is a different one to work with and a copied theory does not apply to South Antarctic krill. The high-quality oil remained in the dried meal portion of the processing layout so no on-board high-quality krill oil was produced.

Aker Biomarine started expensive R&D, generating several processing patents. One of them becomes krill oil sourced from krill meal used as raw material, applying supercritical fluid extraction in a two-stage process using solvents. This process is made on-shore at Aker’s French partner Naturex plant (since 2008). This is a new krill oil composition characterized by high amounts of phospholipids, astaxanthin, esters and omega-3’s.

Another of Aker patents applies for a new krill oil extraction method that cooks raw krill in two stages obtaining a “krill milk” which is heated to obtain protein and lipids precipitate rich in phospholipids and omega-3.

Aker Biomarine has also patented several krill oil health applications. Aker claims that the krill oil it obtains is more bio-effective than its direct competitors in a number of areas such as anti-inflammation, anti-oxidant effects, improving insulin resistances, improving blood lipid profile, improve DHA transfer to the brain and other human health applications”.

Other two Norwegian operators Emerald Fisheries/Ervik Marine FT “*Juve!*” and krill Sea AS and its FT “*Thorshovdi!*” bring in hydrolysis and beehive-based de-shelling processing principles, respectively. Each target food and feed-grade products.

krill oil sourcing in both operations are based on a combination of known processing principles that they expect will assure Omega 3-rich oil source although remains to be seen how much phospholipids-enriched krill oil can result as this are new operations. So far (as of March 2010) no positive results on both operations are seen on such krill oil quality.















China



China brings in for the first time (season 2010) one (max two) trial-trawler operation focused primarily as a trial season rather a commercial-scale profit-oriented operation. Its sole production will be whole frozen raw krill as no meal or oil or any other end-product is expected to be produced, in line with their “solo” processing layout which targets primarily whole frozen fish (from their “mackerel-oriented” work in the South East Pacific waters).

No krill oil at least for the 2010 season by the Chinese operation.

China anyway is place for some on-shore krill oil reprocessing from whole raw frozen krill supplied by Korean, Japanese and even Polish operations. The resulting oil quality is unknown although volume is limited. There are strong indications that some of this krill oil might end up mixed with other marine-origin oils to produce a falsely labeled “krill oil” presentation. This volume is still limited, unknown quality and following a high risk of contamination. Their processing principles are not known neither if patents are infringed.

Tharos was contacted for support on W/R raw krill processing although no agreement was reached.





Port





Spain



Spain involvement in the krill fishery comes from early 2000s when Tharos sold Spanish Pescanova Corporation several whole Frozen krill tons plus some frozen meat.

Pescanova's original target was the food human-grade market. Not until end-2000s when Spanish interest on krill become stronger, it saw renewed interest to get presence in this fishery through the purchase of processing equipment targeting same production matrix as others do: aqua-grade krill meal + oil.

Alfa Laval processing equipment supplier is their main contractor for equipment focused on meal as a one end-product, and oil as a by-product. Nonetheless, Pescanova targets also customers with different demand ideas; human-grade quality krill oil. Both ideas do not match so we see Pescanova not ready for the krill fishery before 2011. There is a miss-match between what their business model says and what their equipment provider proposes. See Aker's history!

This disparity might be overcome not before the 2011 season where some low-phospholipids krill oil is sourced by them with more EPA/DHA content (circa 12-13%).

San Sebastian based Angulas Aguinaga Company was other leading Spanish company researching on krill end-products. Although krill oil was an option, it focused on krill meat as a market category extension to their eel-like end-product.



Poland



Poland's involvement in the South Antarctic krill fishery is also a long data one. Since the 80s, when three Polish corporations were fishing and processing krill, until today where just one remains (Dalmor S.A.), Poland has been actively engaged on this fishery.

Its work has been mostly focused on the Asian (e.g. Japan) sport-fishing bait industry with whole frozen raw krill. Some food-grade meats and dried meals have been also produced although no krill oil so far produced.

Tharos' work with Polish operators has been only centered on their trawler's work as transshipment options as well as used as a aqua-grade krill meal production center but not oil. This no-oil production status will remain as such for the coming 2 seasons (2010-2011).

Uruguay



Uruguay's krill work was performed mid/end 90s through Krisel S.A. company. It was co-financed by Chilean Tepual S.A. Tharos' consulting participation was on their Uruguay flagged trawler "*Rudolf Sirge*" where the first tandem-production matrix was applied towards high-quality aqua-grade krill meal production.

Some oil was also produced but only triglycerides-enriched krill oils and low Omega-3' content.





South Korea



Korean krill fishery participation goes back to the 70s and 80s where South Korea was one of the pioneers on this fishery which, as Poles and Japanese's, its work has been mostly focused on the Asian (e.g. Japan) sport-fishing bait industry through whole frozen raw krill.

For the current two-Korean companies working on the krill fishery, none of them hold krill oil processing capacity (season 2010).

Tharos' work with one Korean operator (2007-2008) was focused on Canadian Neptune Technologies' whole round raw krill sourcing as well as for the Japanese market, but no oil at all on this period was produced by Koreans, neither scheduled for the coming 2 seasons (2010-2011).

Chile



Chile's government, through its Fisheries Development Institute (IFOP), financed and developed what was known at that time as the "Krill Project". It researched on krill fishing technologies, processes and product development. The work was done simultaneously on-shore as well as on-board R&D trawlers. On-board and on-shore work was sometimes backed by Japanese private fishing corporations whom gave access to their fishing infrastructure for onboard R&D. This Krill Project was carried out between 1975 and 1980.

Some of the developed processes and products were, for example raw krill meat mechanically rolling-peeling processed; frozen krill meat sticks etc., jointly with Findus Corporation.

IFOP also performed work on oceanic paste as a protein isolate, krill meal and krill oil, plus chitin/chitosan, hydrolyzed, and others products.

The Chilean private fishing corporations did not invest in these new fishing and technological breakthroughs so, for the krill oil case, there was no krill oil produced at that time neither at present.

The main “result” of IFOP’s work was the talent of their researchers, several of them at present working for Tharos.

Others

Other companies, not necessarily fishing operators, also have seen krill oil’s potential as a food supplement and pharmaceutical applications, based on its high levels of phospholipids, EPA, DHA and astaxanthin.

Among these companies, Enzymotec (Israel), Pronova Biopharma Norge (Norway), Nutrizel (New Zealand), Triple Nine (Denmark), Alfa-Laval (Denmark) and Nutrimarine (Norway) have worked intensely in R&D for obtaining krill oil rich in phospholipids, omega-3, and astaxanthin. They have patented several methods, but almost all of them are based in an extraction using solvents.

Tharos, as a consultant in Antarctic krill’s processes and market development, has also developed krill oil processes as an important target. After several years of R&D, Tharos developed a method for obtaining krill oil with high levels of phospholipids, omega-3 and astaxanthin, free of solvents and chemical residues.





