



**A Journey To The Past**  
**How Krill Oil Reached Our Lives**  
*(Update 2010 Report)*

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## Former Soviet Union - Russia and Ukraine



In the 50s and 60's, the ex-Soviet Union operated the largest fishing fleet in the South Atlantic waters, catching and processing white fish and whales. In this area they also detected the presence of high densities of a little shrimp-like species that "*turned the sea red*", the South Antarctic krill (*Euphausia superba*) as it was named back then.

With this information at hand, the USSR's Fishing Ministry realized the potential of this resource to feed its population.

Following USSR's centralized planning system, a working program was developed to exploit the South Antarctic krill fishery throughout the following years, instructing different ministries for such development. It resulted in the construction of krill-specific new large factory trawlers (RKTS class), the design of new fishing methods, as well as the development of new on-board and on-shore processes to obtain end-products to target human and animal applications.

The main processes at that time focused on food-grade canned krill meat. It included feed-grade dried meals obtained primarily from shells off the meat process, and average-low quality whole frozen krill.

Krill oil was not a target. It was probably due to its complex extraction process. Low extraction yields in concordance with the processing technologies at hand at that time. It was a bit far from the "*food-people first*" centralized planning. In those years, information on the applications and market opportunities for Omega-3s, phospholipids and astaxanthine was not available.

In the 90's, Perestroika-triggered, the USSR krill fishing fleet split into different "new countries", republics spin-offs in relation to each previous participation in this fishery, e.g. Ukraine's Sevastopol port, Russia's Murmansk and Vladivostok ports, etc.<sup>1</sup> This was the last sub-division and the last day when strong government subsidies existed. New fishing operations were then forced to be auto-financed.

Former USSR's Ukraine Republic had an important fleet oriented to the South Antarctic krill fishery. By 1991 the Ukrainian company ATLANTIKA, with its six stern-factory krill-specialized trawlers RKTS-class was the major participant in this fishery.

The Chilean company TEPUAL S.A. partnered with *Atlantika* to improve their quality feed-grade krill meals, and open new markets. TEPUAL assembled an R&D team to develop better krill meal processing technologies and krill oil extraction ideas.

This joint venture lasted until end 1996 resulting in the first ever 15-ton krill oil shipment for Japan. This production was triglycerides-enriched (neutral) krill oils, high in natural antioxidants (as astaxanthine), and low in Omega-3 and phospholipids.

TEPUAL S.A., in association with Tharos' R&D department, continued exploring different krill oil extracting concepts to obtain oils with a higher concentration of Omega-3's, phospholipids and astaxanthine.

Towards the mid 2000s, Ukrainian RKTS factory trawler "*Konstruktor Koshkin*" re-appeared in this fishery (2004 ~ 2007)<sup>2</sup>, manufacturing food-grade canned krill meat and feed-grade dried meal. Tharos' technical assistance included on-board quality and processing supervision, online-lab control and new product development.

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<sup>1</sup> <https://www.nutraingredients.com/Article/2016/12/19/How-the-fall-of-the-Soviet-Union-changed-the-face-of-Antarctica-s-krill-fishing>

<sup>2</sup> As part of the past USSR krill fishing fleet, the days of the RKTS' trawlers  
Krill Oil History - 2020 Version





On-board krill oil production oil was one of the new processes developed with Tharos' assistance focused on triglycerides-enriched + low EPA/DHA krill oil. Low volumes were produced for marketing and R&D purposes.

Regarding Russian krill operations, it showed up late 2000s through Murmansk-based Company MURMANSK TRAWL FLEET (MTF) and its factory trawler "*Maksim Starostin*". It manufactured onboard triglycerides (TG)-rich, low EPA/DHA krill oil as a by-product of the aqua-grade meal process. No phospholipids-enriched high EPA/DHA oils were manufactured.

Factory trawler “*Maxim Starostin*” started its krill fishing in 2008.

It was an outfitted super trawler *Moonzund class*<sup>3</sup> targeting aqua-grade krill meal and TG krill oil as a by-product, plus small volumes of sport-bait and food-oriented whole frozen raw krill.



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<sup>3</sup> <http://soviet-trawler.narod.ru/pages/ussr/moonzund.html>

MTF and Tharos alliance included processing control (meal and frozen krill), on-line quality supervision and krill oil processing concepts.

MTF's krill meal bags included Tharos' seal, as part of Tharos' quality certification, a marker of high-quality meal, with premium prices in certain Asian markets.

Since 2009, Russia does not show any krill operation. Throughout 2020, several publications signal to a renewed interest to go back to this fishery.<sup>4</sup> <sup>5</sup> <sup>6</sup>

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<sup>4</sup> <https://www.seafoodsource.com/news/supply-trade/russia-exploring-move-into-antarctic-krill-fishery>

<sup>5</sup> <https://www.seafoodsource.com/news/supply-trade/russia-to-investigate-viability-of-arctic-antarctic-fisheries-in-2020>

<sup>6</sup> <https://www.undercurrentnews.com/2019/04/30/russian-fishery-next-horizon-could-see-krill-harvesting-move/>



## Japan



Japanese krill fishery has a very long data, as USSR/Russia's, going back to the 60s. They had access to excellent in-house and government-sponsored technology. It also holds plenty of fishing experience in the krill resource.

Japan, while fishing whales in the Antarctic area, observed the same krill abundance pattern as the USSR did. Thereafter, Nippon Suisan Kaisha (NISSUI) and Taiyo Fisheries (later renamed as MARUHA) companies started the South Antarctic krill exploitation.

They manufactured sport-bait purpose raw whole frozen krill, feed-grade krill meal and small amounts of food-grade raw frozen krill meat.

Japan quit the krill fishery mid 2000s. Thereafter NISSUI offers Phospholipids-enriched krill oil (> 40%PL) from on-shore processes. It has its own technicians onboard South Korean and Chinese trawlers.

TAIYO Fisheries quit the South Antarctic krill fishery while NISSUI remained fishing few years until mid 2000s with their old trawler F/T "*Fukuei Maru*" which replaced former F/T "*Nitaka Maru*". This trawler targeted sport-bait fresh 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) result in phospholipids-enriched high EPA/DHA oils.

Nissui holds several krill oil extraction patents. In 2009 they applied for a new extraction patent similar to Norwegian Akerbiomarine's.

As NISSUI and AKER, world's precursor of the phospholipids-enriched krill oil production, the Canadian company NEPTUNE Technologies and Bioressources held a similar patent, using solvents, but the extraction was made from raw fresh frozen krill.

Aker's buyout of NEPTUNE brought in-house Neptune's patent portfolio:

- a) *Neptune Technologies & Bioresources, Inc.* USA Patent Nbr. 8,030,348;
- b) *Neptune Technologies & Bioresources, Inc.* USA Patent Nbr. 8,057,825;
- c) *Neptune Technologies & Bioresources, Inc.* USA Patent Nbr. 8,586,567

Nissui and Tharos shared concepts in the 90s and 2000s about solvent-free krill oil extraction and how these correlate to Nissui's patent portfolio. None were found.

Nissui works with raw material provided by third parties (South Korean krill operations primarily) to secure the raw material from where to extract phospholipids-enriched high EPA/DHA krill oils.



## United States of America



Mid 90's, Korean-origin USA-based<sup>7</sup> TOP OCEAN Inc. began the first USA South Antarctic krill operation. Its at-sea operation started 1999 through theirs "*Top Ocean*" factory trawler.

Tharos consulted this operation from 1999 till 2002, focused primarily on food-grade slightly cooked frozen krill meat, plus aqua-feed grade krill meal.

Top Ocean's krill oil processing plans were at the beginning only at an R&D level. Tharos' produced limited krill oil volume on-board at a research scale.

TOP OCEAN's meat was Tharos' 10-year work to bring the best of former USSR krill meat technology, using newer Western technology, and switching cans to frozen krill.

This development earned Top Ocean the Silver Medal at the 2002 Boston Seafood Show (USA) on the New Products Category. An award that triggered interest from Asian and EU markets.



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<sup>7</sup> Kodiak, Alaska



## Canada



Late 90s Messrs.' *Genevieve Martin* and *Adrien Beaudoin* applied for what was later known as Neptune Technologies and Bioresources (NTB) krill oil patent, giving birth to NTB's NKO krill oil brand for dietary supplement and nutraceutical markets.

The patented process was originally applied through the Canadian *University de Sherbrooke*. It corresponds to a low-temperature acetone-based extraction principle using raw frozen krill as its raw material, USA IP Number 6.800.299.

Proteins and other 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 22-35%, wherein the major amount of these omega's are attached to phospholipids and astaxanthine.

NTB also patented phospholipids-rich, omega-3 and astaxanthine 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:

- a) *Neptune Technologies & Bioresources, Inc.* USA Patent Nbr. 8.030.348;
- b) *Neptune Technologies & Bioresources, Inc.* USA Patent Nbr. 8.057.825;
- c) *Neptune Technologies & Bioresources, Inc.* USA Patent Nbr. 8.586.567

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

Its flagship brand, NKO<sup>8</sup>, it is now owned by Akerbiomarine after its USD34M buyout in 2017.<sup>9 10 11 12</sup>, NTB stopping its NKO manufacture.



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**CERTIFICATE OF ANALYSIS**

NEPTUNE KRILL OIL ( 100% Pure NKO <sup>TM</sup> )		LOT #: <b>NKO-XXXXXXX</b>	
MANUFACTURING DATE:	Month, year	EXPIRATION:	Month, year
		REVISION:	Month day, year
PARAMETER	STANDARD SPECIFICATIONS	RESULTS	METHODS
<b>PHYSICAL PROPERTIES</b>			
Appearance	Red Viscous Oil	Conform	Visual
Odor	Light Shrimp Odor	Conform	Olfactive
Humidity	<0.9 %	%	A.O.A.C. 984.20
Viscosity	550 ± 100 cP	cP	Brookfield 021, 1.5 rpm, 25°C
<b>PHOSPHOLIPIDS</b>			
Total phospholipids (at release)	41.0 ± 2.0 g/100g	g/100g	A.O.C.S. Ja 7-86 modified
Ratio w/w of EPA-PL / total EPA	%	%	A.O.A.C. 991.39, 963.22, 996.06
Ratio w/w of DHA-PL / total DHA	%	%	A.O.A.C. 991.39, 963.22, 996.06
<b>FATTY ACID PROFILE</b>			
Total Omega-3	> 30 %	%	A.O.A.C. 991.39, 963.22, 996.06
EPA	> 15 %	%	A.O.A.C. 991.39, 963.22, 996.06
DHA	> 9 %	%	A.O.A.C. 991.39, 963.22, 996.06
EPA g/100g (expressed as TG)	13.5 ± 1.0 g/100g	g/100g	A.O.A.C. 991.39, 963.22, 996.06
DHA g/100g (expressed as TG)	8.5 ± 0.5 g/100g	g/100g	A.O.A.C. 991.39, 963.22, 996.06
EPA g/100g (expressed as PL)	19.5 ± 1.5 g/100g	g/100g	A.O.A.C. 996.06 modified
DHA g/100g (expressed as PL)	11.5 ± 1.0 g/100g	g/100g	A.O.A.C. 996.06 modified
EPA g/100g (expressed as FFA)	13.0 ± 1.0 g/100g	g/100g	A.O.A.C. 991.39, 963.22, 996.06
DHA g/100g (expressed as FFA)	8.0 ± 0.5 g/100g	g/100g	A.O.A.C. 991.39, 963.22, 996.06
Total Omega-6	< 2 %	%	A.O.A.C. 991.39, 963.22, 996.06
Total Omega-9	> 12.5 %	%	A.O.A.C. 991.39, 963.22, 996.06
Total Trans Fat	< 0.1 %	Not detected	A.O.A.C. 991.39, 963.22, 996.06
<b>ANTIOXIDANTS</b>			
Pigments			
Esterified astaxanthin	> 125 mg/100g	mg/100g	HPLC
Vitamins			
Vitamin A		IU/g	J. Sci. Agri. Vol. 29 Pg 697-702
Alpha-Tocopherol		IU/g	J. Sci. Agri. Vol. 29 Pg 697-702
<b>NUTRITIONAL ANALYSIS</b>			
Total lipids as fatty acids	79.0 ± 3.0 g/100g	g/100g	A.O.A.C. 996.06
Saturated fatty acids	29.0 ± 2.5 g/100g	g/100g	A.O.A.C. 996.06
Monounsaturated fatty acids	22.5 ± 1.5 g/100g	g/100g	A.O.A.C. 996.06
Polyunsaturated fatty acids	31.5 ± 2.5 g/100g	g/100g	A.O.A.C. 996.06
<b>STABILITY INDEXES</b>			
Saponification value	180.0 ± 10.0 mg KOH/g	mg KOH/g	A.O.A.C. 920.160
Iodine value	140.0 ± 5.0 g I <sub>2</sub> /100g	g I <sub>2</sub> /100g	A.O.C.S. Ja 14-91
p-Anisidine value			A.O.C.S. Cd 18-90 modified
Peroxide value	<0.2 mEq peroxide/kg	mEq peroxide/kg	A.O.A.C. 965.33
Tox value	<1.6		By calculation
<b>MICROBIAL ANALYSIS</b>			
Total aerobic count	<100 CFU/g	Not detected	MFHPB-18
Total coliform & E. coli	<10 CFU/g	Not detected	MFHPB-34-35
Yeast & Molds	<100 CFU/g	Not detected	MFHPB-22
Staphylococcus aureus	<10 CFU/g	Not detected	MFLP-21
Listeria monocytogenes	Absence	Not detected	MFHPB-07
Pseudomonas aeruginosa	Absence	Not detected	ILMC-027
Salmonella spp.	Absence	Not detected	MFHPB-20

Preservative free.

<sup>8</sup> <https://www.ingredients-insight.com/contractors/other-ingredients/neptune-technologies-bioresources/>

<sup>9</sup> <https://www.akerbiomarine.com/news/akbm-neptune>

<sup>10</sup> <https://www.nutraingredients-usa.com/Article/2017/08/08/Aker-buys-bulk-krill-oil-business-from-Neptune>

<sup>11</sup> <https://www.naturalproductsinsider.com/lipids/aker-acquires-neptunes-krill-business-neptune-focuses-other-ventures>

<sup>12</sup> <https://www.seafoodsource.com/news/business-finance/aker-biomarine-acquires-usd-34-million-krill-oil-business>



## NEPTUNE KRILL OIL



- ♦ SUPERIOR SAFETY
- ♦ SUCCESSFUL CLINICAL STUDIES
- ♦ THERAPEUTIC & COST EFFECTIVENESS
- ♦ REPLIES TO HIGH INDUSTRY DEMANDS
- ♦ REGULATORY APPROVAL
- ♦ INTELLECTUAL PROPERTY PROTECTION

### PHASE II

- ♦ CHRONIC INFLAMMATION 20% CRP REDUCTION (7 DAYS)
- ♦ OSTEOARTHRITIS 25% IMPROVEMENT (7 DAYS)

### PHASE IIIa

- ♦ PREMENSTRUAL SYNDROME 42% IMPROVEMENT
- ♦ HYPERLIPIDEMIA 34% LDL REDUCTION  
44% HDL INCREASE
- ♦ ADULT ADHD 60% INCREASED CONCENTRATION  
48% INCREASED FOCUS

### PHOSPHOLIPID PROFILE

	g/100g
<b>TOTAL PHOSPHOLIPIDS</b>	<b>41.0 ±2.0</b>
PHOSPHATIDYLCHOLINE	≥ 60%
LYSOPHOSPHATIDYLCHOLINE	2.5-5%
PHOSPHATIDYLCHOLAMINE	2-5%
PHOSPHATIDYLINOSITOL	1-3%
PHOSPHATIDYL SERINE	1-2%
SPHINGOMYELIN	1-2%

### ANTIOXIDANTS

#### PIGMENTS

ESTERIFIED ASTAXANTHIN	132.5 ±7.5 mg/100g
ORAC	TOTAL FL > 350.0 µmol/g

### NUTRITIONAL ANALYSIS

	g/100g
FAT	≥ 98.0
TOTAL LIPIDS AS FATTY ACIDS	79.0 ±3.0
SATURATED	29.0 ±2.5
POLYUNSATURATED	31.5 ±2.5

### FATTY ACID PROFILE

<b>TOTAL OMEGA-3</b>	> 30%
EPA	> 15%
DHA	> 9%
EPA g/100g (EXRESSED AS TG)	13.5 ±1.0g/100g
DHA g/100g (EXRESSED AS TG)	8.5 ±0.5g/100g
EPA g/100g (EXRESSED AS PL)	19.5 ±1.5g/100g
DHA g/100g (EXRESSED AS PL)	11.5 ±1.0g/100g
EPA g/100g (EXRESSED AS FFA)	13.0 ±1.0g/100g
DHA g/100g (EXRESSED AS FFA)	8.0 ±0.5g/100g
<b>TOTAL OMEGA-6</b>	< 2%
<b>TOTAL OMEGA-9</b>	> 12.5%
<b>TOTAL TRANS FAT</b>	< 0.1%

### MINERALS

	mg/100g
ZINC	≥ 0.1
SODIUM	≤ 247.0
POTASSIUM	≥ 95.4

### VITAMINS

	µg
A (ALL-TRANS RETINOL)	≥ 153.0
E (ALPHA-TOCOPHEROL)	≥ 0.6

### STABILITY INDEXES

PEROXIDE VALUE (PV) (mEq PEROXIDE/kg) <	0.2
p - ANISIDINE (A) <	1.2
TOTOX VALUE (2PV+A) <	1.6
OIL STABILITY INDEX HOURS AT 97.8°C >	50
SAPONIFICATION VALUE (mg KOH/g) 180.0 ±10.0	

### PHYSICAL PROPERTIES

VISCOOSITY	550 ±100 cP
DENSITY	0.9671
PHYSICAL DESCRIPTION	RED VISCOS OIL
ODOR	LIGHT SHRIMP

Neptune also manufactured a low-phospholipids krill oil (Junior®) and a dried protein-based by-product labeled as NKA®.



## SPECIFICATION SHEET

### Junior Krill Oil

PARAMETER	STANDARD SPECIFICATION	METHOD
<b>NUTRITIONAL ANALYSIS</b>		
<b>PHOSPHOLIPIDS</b>		
Total phospholipids	36.0 ± 3.0 g/100g	Neptune IN-0901-36
<b>FATTY ACID PROFILE</b>		
EPA	13.0 ± 2.0 g/100g	Neptune IN-0901-04
DHA	6.5 ± 1.0 g/100g	Neptune IN-0901-04
<b>ANTIOXIDANTS</b>		
Esterified astaxanthin	850 ± 150 mg/kg	Neptune IN-0901-05
<b>STABILITY INDEXES</b>		
p-Anisidine value	< 2.1	Neptune IN-0901-25
Peroxide value	< 0.2 mEq p/kg	Neptune IN-0901-13
Totox value	< 2.5	Calculation
<b>MICROBIAL ANALYSIS</b>		
Total aerobic count	< 100 CFU/g	MFHPB-18
Total coliform	< 10 CFU/g	MFHPB-35
<i>E. coli</i>	Absence	USP 2022
Yeast & Molds	< 100 CFU/g	MFHPB-22
<i>Staphylococcus aureus</i>	Absence	USP 62
<i>Listeria monocytogenes</i>	Absence	MFHPB-07
<i>Pseudomonas aeruginosa</i>	Absence	USP 62
<i>Salmonella spp.</i>	Absence	MFHPB-20
<b>PHYSICAL PROPERTIES</b>		
Appearance	Red Viscous Oil	Neptune IN-0901-108
Odor	Light Shrimp Odor	Neptune IN-0901-108
Humidity	< 0.9 %	Neptune IN-0901-08

Preservative free.

The buyout included NTB's patent portfolio, most needed by Aker to cover the entire product and processing patenting landscape that NTB controlled in part. It also stopped lengthy and expensive litigations. Lately, RIMFROST renewed patent litigation with Aker has seen success taking down some of Aker's patent rights.

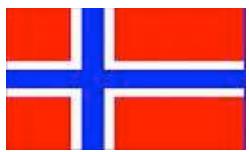
Tharos 2007/2008 consulting to NTB focused on raw material sourcing, market segmentation and NTB's positioning within the "*processors community*".

NTB was a non-vertical integrated business concept. Its sole raw material was whole raw frozen krill supplied by third parties. Some of such suppliers eventually targeted the same end product model that put them in direct competition with NTB.

NTB's oils were packed in capsules (delivered inside carton boxes), and 50kg plastic drums.



## Norway



End 2003, the Norwegian-built factory trawler "*Atlantic Navigator*" (handling a Vanuatu flag) appears in the krill fishery scenery. Owned at that time by *NORWAY SEAFOODS AS* (currently Akerbiomarine ASA), targeted a two-product processing matrix: Aqua feed-grade dried meal, and liquid oil in triglyceride (TG) form, the oil as a by-product of meal process, very low Omega 3's and no phospholipids.





The onboard manufactured TG- oil was packed in 1.250kg tote bags.



Tharos was consulting at that time world's largest aqua-feed producer, *Skretting*<sup>13</sup> (*Nutreco*<sup>14</sup>). Tharos supervise onboard "Atlantic Navigator" krill meal quality and processing conditions for meals purchased by *Skretting*.

The trawler "Atlantic Navigator" was originally christened in 1996 as "American Monarch"<sup>15</sup>, later replaced by current Norwegian flagged "Saga Sea".



Aker Biomarine detected krill oil's potential as an excellent aqua-feed ingredient, providing natural and valuable compounds such as pigments and lipids.

Simultaneously, eying Neptune's accomplishments, Aker focused on higher levels of phospholipids, Omega-3s and carotenoids (in the form of astaxanthine), if it wanted to access human health applications and dietary supplement categories, this was the oil.

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<sup>13</sup> <https://www.skretting.com>

<sup>14</sup> <https://www.nutreco.com>

<sup>15</sup> Designed and built in 1996 for Chilean hake surimi, a business that didn't proceed

Starting with basically a single krill meal-processing matrix, Aker financial ratios saw positive EBITDAs mid 2010s, and profits end 2010s.

With Aker's onboard process not yielding phospholipids-enriched krill oils, their alliance with French company NATUREX<sup>16</sup> help obtained a better financial outcome.

Aker process design on-board "*Atlantic Navigator*" was meant for other resources, realizing that krill species do not mimic such species' performance. The high-quality oil remained in the dried meal portion, without any on-board processed phospholipids-enriched oils.

Akerbiomarine focused to become a leader in this field, invested heavily in R&D obtaining several processing and products invention patents. One of them, krill oil rich in phospholipids sourced from krill meal as raw material, uses a two-stage supercritical fluid extraction (SFE) process with ethanol as the extraction solvent.

Aker invention patents are not free of litigation anyway<sup>17</sup>. It lost its bid to resurrect two krill oil patents after the USA Federal Circuit found they contained claims that were covered by prior inventions and other material.

*The Court of Appeals for the Federal Circuit* affirmed two earlier rulings from the *Patent Trial and Appeal Board* (PTAB) crash with Aker's, finding all claims of two patents from Aker un-patentable<sup>18</sup>.

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<sup>16</sup> <https://www.naturex.com>

<sup>17</sup> <https://news.bloomberglaw.com/ip-law/aker-biomarine-fails-to-reinstate-dietary-supplement-patents>

<sup>18</sup> <https://www.patentdocs.org/2019/10/aker-biomarine-antarctic-as-v-rimfrost-as-fed-cir-2019.html>

RIMFROST claimed victory for this ruling<sup>19</sup>, stating... “*We hope this will settle any confusion created by Aker Biomarine in the US market. No legal proceeding in the USA concerning its patents has gone in Aker Biomarine’s favor. That means the uncertainty which Aker Biomarine has sought to create around our products and ability to deliver is now repudiated,*” as stated by Mr. Stig Remoy, RIMFROST’s CEO.

Aker’s process was originally put in operation at Aker’s French partner NATUREX plant (2008), later moved to Texas (USA) with their own extraction plant.

In 2016, Akerbiomarine acquired complete ownership of the company’s krill-products manufacturing facility in Houston (Texas), purchasing the 50 percent joint-venture interest held by extracts specialist NATUREX. The oil obtained was characterized by high amounts of phospholipids, astaxanthine, esters and Omega-3’s.

Aker has registered several krill oil invention patents, although the relevant ones are few, from where the patent-tree grows further. The basic concept is krill oil extracted on-land from dried krill meal manufactured at-sea, using supercritical fluid extraction (SFE) in a two-stage process. Stage 1 removes the neutral lipids (triglycerides form) by extracting it with neat supercritical CO<sub>2</sub> or CO<sub>2</sub> plus approximately 5% of a co-solvent. Stage 2 extracts the actual krill oil by using supercritical CO<sub>2</sub> in combination with approximately 20% ethanol.

- a) USA Patent Nbr. 9.028.877;
- b) USA Patent Nbr. 9.034.388;
- c) USA Patent Nbr. 9.072.752

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<sup>19</sup> <https://www.rimfrostkrill.com/news/rimfrost-won-against-aker>

Another Aker patent applies for a krill oil extraction method that cooks raw krill in two stages obtaining a “*krill milk*”. It is heated obtaining protein and lipids precipitate rich in phospholipids and Omega-3; USA patent Nbr. 20140107072.

Akerbiomarine 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 resistance, improving blood lipid profile, improve DHA transfer to the brain and other human health applications. USA Patent Nbr. 8.697.138 titled “*Methods of using krill oil to treat risk factors for cardiovascular, metabolic, and inflammatory disorders*”.

To date, Aker has 4 krill factory vessels, three of them currently fishing and processing krill, especially feed and food grade krill meal:

- a) “*Saga Sea*”<sup>20</sup>;
- b) 2018-built “*Antarctic Endurance*”<sup>21</sup>;
- c) “*Antarctic Sea*”<sup>22</sup>.
- d) “*Juvel*”<sup>23</sup> taken from RIMFROST liquidation, remains idle. In all of them krill meal is primary end product, part of it used for oil solvent-extraction in USA.

Aker also owns one transport vessel that will be replaced by a new one within the coming 2 years<sup>24 25</sup>.

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<sup>20</sup> <https://www.ccamlr.org/en/node/100256>

<sup>21</sup> <https://www.ccamlr.org/en/node/103766>

<sup>22</sup> <https://www.ccamlr.org/en/node/100255>

<sup>23</sup> <https://www.ccamlr.org/en/node/97395>

<sup>24</sup> <https://www.akerbiomarine.com/news/aker-biomarine-to-build-new-state-of-the-art-support-vessel>

<sup>25</sup> <https://www.wartsila.cn/en/media/news/19-03-2019-wartsila-to-design-and-equip-state-of-the-art-transport-vessel-for-aker-biomarine-2403898>

Other two Norwegian operators went busted, EMERALD FISHERIES/ERVIK MARINE with its factory trawler "Juvel" (currently owned by Aker), and krillseaproducts AS and its trawler "Thorshovdi".



Norwegian OLYMPIC SEAFOODS took over Emerald Fisheries, and with it, krill oil brand RIMFROST.

After RIMFROST went bankrupt in 2016, it remained selling krill oil that was manufactured by third parties (Canada, China) using as raw material a dried pellet composed of lipids and proteins (named OLYMEG), that remained in stock after its bankruptcy. Nowadays it plans to solvent-extract their oil from krill meals manufactured by third parties, from Chile for example.

Olympic Seafoods used onboard "*Juel*" a hydrolysis process starting by a beehive-based de-shelling process for food and feed-grade end products.

November 2019 RIMFROST announced that it will build a new and modern krill factory vessel, investing more than NOK 1 billion (USD112M as of August 2020)<sup>26</sup> <sup>27</sup>.

krillseaproducts trawler "*Thorshovdi*" was also buyout by Aker. It never achieved any special krill oil production.

On the North Atlantic side, the Norwegian company NITG<sup>28</sup> assembled several investors<sup>29</sup> to put in operation its krill fishing trawler Røstnesvåg, a 65m length boat where Tharos' patented solvent-free extraction process was installed in a plug-and-play model. Click the video in this [link](#) to see that operation.

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<sup>26</sup> <https://www.rimfrostkrill.com/news/rimfrost-orders-worlds-greenest-and-most-modern-krill-vessel>

<sup>27</sup> <https://www.worldfishing.net/news101/industry-news/westcon-to-build-rimfrost-krill-vessel>

<sup>28</sup> <https://www.gceocean.no/news/posts/2020/july/cluster-insight-with-norwegian-innovation-technology-group/>

<sup>29</sup> <https://www.proff.no/roller/norwegian-innovation-technology-group-as/bergen/konsulenter/IF4IS5T00NR/>



The 2016-2018 operation included four-novel matrices, for the first time ever;

- a) 100% environmental friendly net-free fishing system called MANTA;
- b) 100% solvent-free, clean, negligible carbon footprint oil extraction;
- c) First ever North Atlantic krill fishery in Icelandic and Norwegian waters;
- d) An on-line state-of-the art laboratory to make all products final at-sea.





The krill oil successful market acceptance went live at the 2018 Supply Side West Trade Show (Las Vegas, USA). The special meal was distributed on key

markets and the entire project at present is pursuing financing to scale it up and expand its processing capacity.

One other Norwegian krill project on the design stage is the one managed by 1996-incorporated<sup>30</sup> Fish Group of Norway (FGN)<sup>31</sup>. It has been granted one of the Norwegian krill-fishing licenses.

FGN original business model use a large fishing trawler to freeze, store and transport the frozen krill to shore where final products will be processed, krill oil one of such products.

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<sup>30</sup> <https://www.proff.no/selskap/fish-group-of-norway-as/vigra/fiske/IG6OWL80COV/>

<sup>31</sup> <https://www.proff.no/roller/fish-group-of-norway-as/vigra/fiske/IG6OWL80COV/>

## Spain



Spain involvement in the krill fishery comes from early 2000s when Tharos sold Spanish Pescanova<sup>32</sup> several whole Frozen krill tons, and 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 renewed its interest to be present in this fishery through the purchase of processing equipment to source aqua-grade krill meal + oil.

Alfa Laval<sup>33</sup> was their main equipment provider focused on meal (as primary product), and feed-grade oil as a by-product. Nonetheless, Pescanova focused on customers which had a different idea; human-grade krill oil. Both ideas didn't match so Pescanova was not ready for the krill fishery by 2011, their launching year. A mismatch between their business model vs. markets and equipment providers offer.

This disparity was overcome late 2011/early 2012 when some low-phospholipids krill oil was sourced with EPA/DHA circa 12-13%.

San Sebastian (Spain) based Angulas Aguinaga<sup>34</sup> was one leading Spanish company researching on krill products. Although krill oil was an option, it focused on krill meat as a market category extension to their eel-like end product.

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<sup>32</sup> <http://www.nuevapescanova.com/en/>

<sup>33</sup> <https://www.alfalaval.com>

<sup>34</sup> <https://www.angulas-aguinaga.es/?lang=en>

## Poland



Poland's involvement in the South Antarctic krill fishery was also of a long data. Since the 70s three Polish companies, *Dalmor*, *Odra* and *Gryf*, were fishing and processing krill, primarily fresh frozen krill. There are no Polish fishing krill trawlers working as of today. No krill oils were manufactured on those years.

The Polish fleet was mostly focused on the Asian (e.g. Japan) sport-fishing bait industry with raw whole fresh frozen krill. Food-grade meats, and dried meals as a by-product, were part of the portfolio. No krill oil was manufactured.

Tharos' work with Polish operators centered on the following areas:

- a) Sourcing Canadian Neptune Technologies with frozen krill for oil extraction at their Canadian plant;
- b) A transshipment partner in high seas;
- c) Sourcing aqua-grade krill meals for Tharos' Asian markets;
- d) Supporting the R&D platform (1996) running ERVIK Marine pilot trials using enzymatic-processing model. ERVIK Marine sold its shares to RIMFROST. Between 1995 and 1997, Dalmor trawler "*Dalmor II*" received the hidrolization pilot plant that tested such model; the processing concept that was later installed onboard "*Juvel*".

## Uruguay



Uruguay activities in Antarctic krill was performed mid 90s through the now extinct company KRISEL, co-owned by the Chilean company Tepual S.A.

Tharos' consulting centered on their Uruguay flagged trawler "*Rudolf Sirge*", the first ever tandem-production matrix composed (a) high-quality aqua-grade krill meal; (b) TG-krill oil; and (c) hidrolyzation for feed and food-grade proteins.

"*Rudolf Sirge's*" triglycerides-enriched krill oil (TG) was very rich astaxanthine and low Omega-3' content, without phospholipids used on cosmeceuticals products.

"*Rudolf Sirge*" was a BMRT-class trawler, as some Pollock fisheries use.



## South Korea



South Korean krill fishery goes back to the 80s, one of the pioneers on this fishery. Alongside Poles and Japanese, its work was focused on the Asian (e.g. Japan) sport-fishing bait industry through whole frozen raw krill.

Current Korean companies INSUNG and DONGWON do not have their own krill oil processing (season 2020), but some of their krill meals source South Korean solvent-extracted krill oils on-land.

South Korean strong demand for krill oil has triggered several local companies to build solvent-extracted facilities. E-Marketing and active WEB channels, fueled by krill oil health properties, has multiplied krill oil demand 30x of what it was 10 years ago. And it does not show signs of slowing down.

Tharos' consulting INSUNG (2007-2008) was designed to source Canadian Neptune Technologies' with special quality of whole round raw krill material for oil extraction in Canada, as well as for the Japanese pet-food market.

Such frozen krill had a special quality in terms of fatty acid profile and lipid class. This profile helped ACASTI PHARMA<sup>35</sup>, Neptune's spin-off, to file new patents and expand Acasti's nascent work in hyper dyslipidemia control.

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<sup>35</sup> <https://www.acastipharma.com/en>

## Chile



Chile's government, through its *Fisheries Development Institute* (IFOP<sup>36</sup>/CORFO<sup>37</sup>), pioneered developed and financing what was known in 1975-80 as the "*Krill Project*". It researched on new krill fishing technologies, processing and product development for food and feed consumption.

This work was done simultaneously on-shore as well as on-board R&D trawler "*Arosa VII*". This work was sometimes backed by Japanese private fishing corporations whom gave access to their fishing infrastructure for onboard R&D, as NIPPON Suisan did with its trawlers "*Aso Maru*" and "*Yoshino Maru*", between 1978 and 1979.

Some of the processes and products were;

- a) Raw krill meat, mechanically rolling-peeled;
- b) Frozen krill meat breaded sticks, jointly with FINDUS Corporation<sup>38</sup>;
- c) Food-grade proteins:
- d) Feed-grade meals;
- e) Paste as a protein isolate
- f) Krill oil (feed and food)
- g) Chitin & Chitosan

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<sup>36</sup> <https://www.ifop.cl/en/>

<sup>37</sup> <https://www.corfo.cl/sites/cpp/webingles>

<sup>38</sup> <https://www.findus.com/en-us>

IFOP also developed important research in the biochemical area such as how to lower fluoride content in raw krill and its impact on products for human consumption; the seasonality of the resource, etc.

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

Tharos’ Chief Engineer *Mr. RAUL TORO* first assignment was precisely onboard NIPPON’s trawler “*Aso Maru*” and “*Yoshino Maru*”, making Raul Toro the most lasting at-sea experienced engineer known to date in the entire krill industry. A living legend that gathers close to 5 decades of work in the krill industry, seven years when adding his total days assigned at-sea, in North Atlantic and South Antarctic krill fishery.



Besides the work TEPUAL S.A. and its spinoff company INUAL Ltd did in the 90s, Chile had to wait until 2000s DERIS S.A.<sup>39</sup>/Pescachile<sup>40</sup> entrance to this fishery.

DERIS/PescaChile factory trawler “*Antarctic Endeavor*”<sup>41</sup> sources exclusively krill meal, food and feed grade, the former targeting solvent extracted oils in China, both qualities total annual meal volume circa 5.500 ton, and also krill hydrolysates under development through a sub-contractor.



<sup>39</sup> [https://www.dnb.com/business-directory/company-profiles.deris\\_sa.537f16082ee8e6cec94c10e01b6af1a9.html](https://www.dnb.com/business-directory/company-profiles.deris_sa.537f16082ee8e6cec94c10e01b6af1a9.html)

<sup>40</sup> [https://www.fis.com/fis/companies/details.asp?l=e&filterby=companies&=&country\\_id=&page=1&company\\_id=19668](https://www.fis.com/fis/companies/details.asp?l=e&filterby=companies&=&country_id=&page=1&company_id=19668)

<sup>41</sup> <https://www.ccamlr.org/en/node/100242>

## China



China's first Antarctic *Ocean Living Resources' Development and Utilization Project* was launched in Dalian, March 16th 2011, named "*Rapid Separation of Antarctic Krill and Key Technology of Deep Processing*"<sup>42</sup>

This project started October 2010 when the Chinese State Ministry of Science officially launched the "*863 Program*" to become a "*national strategy*", which in Tharos' opinion it has a very strong geo-political mindset.

In December 2010 a project team was put together counting nine universities and research institutions. In March 2011 the project was formally approved.

Some of the attendees where; (a) East China University of Technology; (b) China Academy of Fishery Sciences; (c) China Polar Research Institute; and (d) other national research institutes.

This project, aimed to start immediately, was the first organized by the so-called "*863 Project*". The "*863 Project*" belongs to China's *Antarctic Ocean Living Resources Development*, still valid as of 2018, under the umbrella of the *Chinese National High Technology Research and Development Program*. This project was the first one for the program *China Antarctic Ocean Living Resources Development and Utilization*, a multiparty and long-lasting Chinese engagement in krill activities.

- How long? = "*Twelfth Five-Years*" segments, around 60 years.
- Which products? = Marine-based health products, pharmaceuticals and raw materials. Oil and meal as primary targets, as well as some meat<sup>43</sup>.

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<sup>42</sup> Mainly oils, meats and meals.

Krill Oil History - 2020 Version

Among the planned research, one is the "*Rapid Separation of Antarctic Krill and Key Technology of Deep Processing*" focused on Antarctic krill exploitation and utilization. There is also the responsibility for organizing a number of research institutions and universities to promote the progress of the project, expected to become a breakthrough for the transformation of Chinese offshore fishing and a new growth area and development of the marine economy in the Liaoning Province.

As of 2018, this plan remains active; China is heavily investing in creating a solid and permanent foothold in the South Antarctic Sea, as well as in the Antarctic territory. It is a Chinese geopolitical decision, krill fishing as a part of the big goal to become actively present in this important "*linking region*", where Atlantic and Pacific waters meet.

The "*Rapid Separation of Antarctic Krill and Key Technology of Deep Processing*" project aims for an efficient on-board separation of South Antarctic krill; fast processed towards the procurement of high-value end products, test new technologies and equipment, systems integration and applications.

Chinese krill oil manufacturers use primarily high fat<sup>44</sup> dried meal for on-land solvent extraction, a handful of them, using a retreating model, use raw frozen krill.

Both raw materials are manufactured on-board (at-sea) and later converted to krill oil, on-shore, primarily in Qingdao and Shanghai. Krill meals and frozen krill are manufactured at-sea, and transported from far distances to on land premises where the oil is extracted.

Krill fishing, subsidized by the central Government, plays a pivot role. It is the entrance gate to control as much catch tonnage allocation as possible, and builds a significant catch history when TAC's will be allocated by past fishing effort.

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<sup>43</sup> There is a geopolitical match with China investing (already started mid 2010s) with > USD1bn in at least three new land-based Antarctic stations, claimed to be purely for R&D purposes.

<sup>44</sup> >24% lipid content (w/w)

China has therefore a strong number of personnel around this area, Punta Arenas (Chile) as a hub. A number of articles address this target;

- <https://thediplomat.com/2019/06/what-are-chinas-intentions-in-antarctica/>
- <https://www.ft.com/content/2fab8e58-59b4-11e8-b8b2-d6ceb45fa9d0>
- <https://www.abc.net.au/news/2018-10-28/china-and-russia-are-eyeing-up-antarctica/10433024>

Some Chinese krill oil brands go further on an expensive spree, buying whole frozen krill, convert that to dried krill meal (transformation done on-land) from where the oil is finally solvent extracted. No matter how cost competitive Chinese are, this “*triple-path-process*” is very expensive, prone to oxidation, the final oil quality severely compromised, and with it the entire category jeopardized.

Chinese companies that follow the “*triple-path*” has seen quality compromised in terms of freshness and a loss of crucial nutritional components. Being frozen krill and dried krill meal so important in the current krill oil value chain, incumbents and insurgents are revisiting their business model, precisely for these purposes.

In order to evaluate where the krill oil market is heading to, visiting the dried meal and frozen krill industry is enlightening. At present the latter pales in tonnage consumption compared to the former.

Shandong Keruier Company (SK)<sup>45</sup> was one of the first Chinese companies involved in krill oil extraction from frozen krill (late 90s/early 2000s), using solvents in their Jinan plant. It is no longer active but still listed in some portals<sup>46</sup>.

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<sup>45</sup> One of SK krill oil patents is “*Method of Extracting High-lipid Content From Antarctic Krill*”.

<sup>46</sup> [https://www.company-list.org/shandong\\_keruier\\_biochemical\\_company\\_ltd.html](https://www.company-list.org/shandong_keruier_biochemical_company_ltd.html)

Early 2000s SK sold its own-manufactured krill oil as fish food for fish bait manufacturers. The amount was small. SK in the end used Government subsidies to go into the real estate business piggy-bagging the “*krill umbrella*”.

Would SK had persevered manufacturing krill oil using its own process, it would have obtained a low-quality oil and might have failed securing the Chinese Health Food Certificate from SFDA.





- ▶ 透光膜的种类
- ▶ 口腔色标种类
- 材料及制作工艺：盒底盒  
标志印刷方式：凹印印刷

- ▶ PU 防震底盒
- ▶ 透光轻触板底
- 材料及制作工艺：盒底盒  
标志印刷方式：凹印印刷

Although Chinese krill fishing incumbents are registered for fishing under CCAMLR regulation, few make it every season. The ones registered for the 2020 season include *Liaoning Pelagic Fisheries Co. Ltd*<sup>47</sup><sup>48</sup>, *China National Fisheries Corporation*<sup>49</sup>, and *Fujian Zhengguan Fishery Development Co.*<sup>50</sup>.

Companies like *Shanghai Kaichuang Deep Sea Fishery*<sup>51</sup><sup>52</sup> and *Qingdao Deep Sea Fishery*<sup>53</sup><sup>54</sup> have worked before in this fishery and are planning their comeback.

This list will grow significantly end 2020 and in the years to come after new krill Chinese vessels reach the Antarctic krill fishery, end 2020, and two three new trawlers make it by 2022/23. You can read more about this on separate Tharos' reports.

All Chinese krill operators generate an ingredient (krill meal) that is transported to China for others to extract krill oil. Liaoning Pelagic Fisheries has its own oil extraction facility, as well as it sells its krill meal to third parties.

Such “others” include LUHUA BIOMARINE<sup>55</sup> and QINGDAO KANGJING<sup>56</sup><sup>57</sup> known brands. Akerbiomarine enter recently in China with its NY-03 krill oil brand<sup>58</sup> after obtaining import approval<sup>59</sup>.

Many other brands are showing up but few comply with the min standards Western markets are used to. Chinese demand will pick up anyway.

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<sup>47</sup> <https://world-ships.com/company/98558cebed45559331d5e935b924ee83#.X0fQjC2ZORs>

<sup>48</sup> <https://www.ccamlr.org/en/node/104912>

<sup>49</sup> <https://www.ccamlr.org/en/node/104914>

<sup>50</sup> <https://www.ccamlr.org/en/node/105131>

<sup>51</sup> <https://www.bloomberg.com/profile/company/SDFCLZ:CH>

<sup>52</sup> <http://www.skmic.sh.cn/en/about-937.html>

<sup>53</sup> <https://www.ccamlr.org/en/node/84006>

<sup>54</sup> <https://panjiva.com/Qingdao-Deep-Sea-Fisheries-Co-Ltd/30249232>

<sup>55</sup> <http://www.luhuabiomarine.com>

<sup>56</sup> <https://friendofthesea.org/chinese-company-qingdao-kangjing-marine-biotechnology-obtains-krill-oil-certification/>

<sup>57</sup> <http://www.qdkangjing.cn/m/view.php?aid=69>

<sup>58</sup> <https://www.seafoodsource.com/news/premium/foodservice-retail/aker-biomarine-launching-orivo-certified-krill-oil-product-in-china>

<sup>59</sup> <https://www.nutraingredients-asia.com/Article/2019/06/27/Blue-hat-certification-boost-for-krill-Aker-BioMarine-expects-China-application-results-soon>

Recent South Korean recall of several krill oil brands for infringing solvents used and other contaminants present in the oil is a reminder of this trend.

*Dalian Fishing* has krill oil in its krill portfolio as *Meixue Antarctic* krill oil.



*Shandong Success Pharmaceutical Co. Ltd.* imports medical devices as well as krill oil in bulk packed in drums, and bulk packed as soft gel capsules. Their krill Oil phospholipids  $\geq$  40%, Astaxanthine  $\geq$  1000ppm > 100,000 pcs RMB0.61/pc, USD0.1/pc equivalent app. USD160/kilo oil bulk.

Chinese krill oil market relevance is reflected on its vast amount of advertised products, as early as 2010 and 2011. Since then, offer has only seen growth. Recent changes on Chinese non-commercial import hurdles will not only help demand to grow, but competition to increase from foreign origin.

## CHINA - Novel Food Application Bulletin for Krill Oil

Chinese name 中文名称	磷虾油	
English name 英文名称	Krill Oil	
Main components 主要成分	DHA、EPA、Astaxanthine DHA、EPA、虾青素	
Basic Information 基本信息	Origin: Antarctic krill 来源：南极磷虾	
Brief production process 生产工艺简述	<p>Antarctic krill is processed through fishing, cooking, isolation and dry step to be powder, and then to be ethanol extracted, isolated, filtered and concentrated to be the final product.</p> <p>南极磷虾经捕捞、煮制、分离、干燥等工序加工成粉，再经乙醇提取、分离、过滤、浓缩等工艺而制成的暗红色粘性油状产物。</p>	
Application dosage 食用量	<p>≤3g/day ≤3克/天</p>	
Unsuitable crowds 不适宜人群	<p>People who are allergic to seafood 对海鲜过敏者</p>	
Specification 质量要求	Appearance性状	Dark red, viscous oil 暗红色粘性油

	DHA content DHA含量	$\geq 5.5 \text{ g}/100 \text{ g}$
	EPA content: EPA含量:	$\geq 12 \text{ g}/100 \text{ g}$
	Total Omega-3: 总Omega-3:	$\geq 22 \text{ g}/100 \text{ g}$
	Phospholipid 磷脂:	$>40 \text{ g}/100 \text{ g}$
	Astaxanthine 虾青素 :	$>50 \text{ ppm}$
	Water Activity,25°C : 水活性,25°C :	$<0.5$
Additional information 其他需要说明的情况		



## Others

Down and upstream, stakeholders monitor krill oil's potential as a dietary supplement and pharmaceutical applications, based on its high levels of phospholipids, EPA, DHA and astaxanthine.

Among these companies, Pronova Biopharma Norge (Norway)<sup>60</sup> currently BASF<sup>61</sup>, Nutrizeal (New Zealand), Triple Nine (Denmark)<sup>62</sup>, Alfa-Laval (Denmark)<sup>63</sup>, Haarslev<sup>64</sup> and many others. Some of these have patented several processing and health applications, all of them focused on solvent-extracted oil.

Tharos' 2 world patents on the contrary were developed to extract krill oil without the use of any solvents on its entire process, entirely processed onboard factory trawlers, at-sea, in less than 2 hours from catch, backed by in-house R&D partnered with world class research institutions.

Tharos' proof-of-concept run 2011 on-land, the final live test in 2013 in South Antarctic waters onboard Ukrainian flagged trawler "*More Sodruzhetsva*" concluding with final improvements and concentration trials in 2015.

This oil has high levels in phospholipids, Omega-3 and astaxanthine, free of solvents and chemical residues, very fresh and with less than 15% of the production cost vs. any other land-based solvent extraction method.

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<sup>60</sup> <https://www.norwayexports.no/listing/pronova-biopharma-norge-as/>

<sup>61</sup> <https://www.bASF.com/no/en/who-we-are/BASF-in-Norway.html>

<sup>62</sup> <https://www.999.dk>

<sup>63</sup> <https://www.alfalaval.com>

<sup>64</sup> <https://haarslev.com>



