Good oils and fishy tales

Bernd Kutzner, founder of Beku Environmental Products, and Dr Peter Nichols from CSIRO Oceanography: making more of Australia's deep-sea catch.

Scientists and entrepreneurs are working together to boost the value of south-east Australia's deep-sea fisheries. Gill Shannon reports.

If the wheel were to be reinvented, would it happen at a small factory in the suburbs of Hobart?

Spend 10 minutes talking to Dan Cudmore, marketing director of Tasmanian company Beku Environmental Products Ltd, and you might believe it possible.

Cudmore will tell you all about the products that have in four years propelled the company out of a home garage and onto the export market, so successfully that in 1995 Beku won best new exporter in the Tasmanian division of the Australian Export Awards.

Beku is one of a number of enterprising Australian companies with their sights set on markets in China, Indonesia, Taiwan, Japan and Vietnam, as well as Europe and the United States in the long term. What is the product they are banking on?

Take Cudmore at his word, and you'd think they were marketing in various forms the elixir of life. Actually, their goods are based on oils salvaged from the least-favoured parts of dead deep-sea fish.

Beku's product range falls into three categories which, curiously, roughly align with dictionary definitions for elixir. They are:

- an industrial degreaser and a metal cutting, tapping and drilling fluid (a liquor once supposed to have the power of transmuting metals);
- an emollient that can be used as a base for cosmetics such as skin creams and lipsticks (a powder for wounds; a panacea); and
- a general health tonic (a liquor once supposed to have the power of indefinitely prolonging life).

Beku's first product, the degreaser, was launched in 1991 following two years of research and development led by CSIRO's Division of Oceanography and company founder, Bernd Kutzner. The resulting processing technique has been patented worldwide.

The degreaser, a hand cleanser, and a soluble cutting oil due to debut this year, are based on wax esters derived from oreo dory and orange roughy. Cudmore says the

products contain properties much like the whale oils which were put to similar use until Australia's whaling industry was halted some 40 years ago. Mineral and vegetable oils have been used since, but involve problems relating to biodegradation, toxicity and bacterial build-up.

'Our range represents a world-first alternative to volatile, petrochemical-based hand cleansers, degreasers and cutting oils,' Cudmore says. 'We're reinventing the wheel with these marine-oil products.'

Enriching the catch

Determining the chemical composition of oils contained in various fish wastes is crucial to the product-development process. This work is done by scientists at CSIRO's Division of Oceanography in Hobart as part of its Marine Products Project led by Dr Peter Nichols. The oceanography scientists work closely with Dr Chris Strauss and Michael Bakes at the Division of Chemicals and Polymers in Melbourne, and Dr Nick Elliott from CSIRO Fisheries in Hobart.

CSIRO Oceanography's research and development on marine oils, begun in the 1980s, involves scientists working with industry to seek profitable uses for the by-catch and by-products of Australia's south-eastern fisheries (such as orange roughy, jack mackerel, blue grenadier and deep-sea shark). Companies to benefit from this collaboration include Beku, Clover Corporation Pty Ltd, Squalus Pty Ltd and Scales Fish and Bait Sales.

Manager of Scales, Richard Saul, says the company buys once-discarded waste products which are then converted to raw fish oil. He says the material sourced by Scales is drawn from lower value by-catch species which were previously of little or no worth.

'Research into uses for the oils available from such species and other discarded material is assisting industry to improve the ulilization of these Australian marine resources,' Saul says. 'CSIRO's Marine Oil Program is helping us to establish an industry with benefits not only for the fishing sector but the broader community.'

One of the first products studied by the research group was orange roughy waste. Of the orange roughy catch, approximately 30% is processed into fillets, the remainder being discarded as waste. Traditional low-value uses of fish waste include pet food, fertiliser, bait, fish meal and unrefined oils.

Characterising oils from fish waste. In the laboratory the oil is first extracted with a solvent which in turn is removed, leaving the oil. Bacteria and microalgae (which produce the oils incorporated by the fish) are also grown in cultures to obtain suitable amounts for analysis. The oil is then analysed to the molecular level using various analytical and instrumental techniques. In this picture, Dr Patti Virtue examines oil composition.

Oils from icy seas

Scientists at the Division of Oceanography, in addition to their shark and orange roughy oil research, are studying the potential of other marine organisms as sources of omega-3 oil. These are Antarctic krill, algae and free-floating bacteria.

The division is studying these ocean dwellers in association with the Antarctic Cooperative Research Centre, which in 1986 established the Australian Collection of Antarctic Micro-organisms. The collection provides a foundation for the potential commercial exploitation of microbes from Australia's cold, Antarctic waters.

In studies complementing the division's research into marine oils from fin fish, bacteria have been isolated that produce polyunsaturated omega-3 fatty acids. This work is being conducted as part of the PhD program of David Nichols at the University of Tasmania.

Nichols says many organisms contain high levels of the essential polyunsaturated fatty acids eicosapentaenoic acid (EPA, 20:5(3) and docosahexaenoic acid (DHA, 22:6(3) at low temperatures. New strains of bacteria isolated from Antarctic waters have therefore been examined.

Early results indicate that the proportion of Antarctic strains that produce EPA is considerably higher than found for temperate marine bacteria. Similarly, a number of strains that produce DHA have also been isolated.

Future research in this area will focus on lifeforms from an even colder environment: psychrophilic bacteria isolated from the Antarctic sea-ice. In time, chemicals such as essential fatty acids made by microalgae and bacteria could be obtained and purified by similar technology to that developed for the production of value-added products from fish oils.

The Antarctic bacteria have been used successfully in aquaculture feeding experiments with rotifers. Rotifers are normally enriched with EPA and DHA with an algal diet prior to feeding in aquaculture operations. The bacteria may be an alternative to algae as a feed for rotifers in future.

Studies of orange roughy waste revealed that some 18% of the fish is oil, 80% of which exists in waste products: the swim bladder, frame and skin. They also found that orange roughy oil, unlike that of most other commercial fish, is composed almost exclusively of wax esters, one of three classes of lipids presently sought in marine oils. The others are squalene-rich oils (and diacylglycerol ethers) from shark livers and triacylglycerol oils containing omega-3 polyunsaturated fatty acids.

Beku forsees a great potential for squalene, which is a popular health tonic in Asia. Cudmore says 1500-1800 tonnes of squalene is used worldwide every year. The company has tapped a tiny portion of the market with its export of 40-70 tonnes annually for encapsulation. In addition, it uses only 1-2% of the available resource.

The squalene exported by Beku and other companies is extracted and refined from the livers of deep-sea sharks. These sharks, as well as being fished in their own right, are an under-utilised by-catch of orange roughy and other deep-water fisheries. Their livers are large (about 20% of the total shark's weight), and can contain considerable quantities of oil. In the past, Australian shark liver oil was sold unprocessed to Japan for value-adding.

In a further process, called hydrogeneration, squalene can be converted to squalane, which has a variety of uses in the pharmaceutical and cosmetic industries, particularly as a lubricant, tablet coating and cosmetic-base oil. The divisions of Oceanography and Chemicals and Polymers have developed a process to produce squalane from shark liver oil and will be seeking industry partners in 1996.

Omega-3 oils are also of interest to Beku and the company is working closely with CSIRO on their chemical characterisation. Research into the health benefits of omega-3 oils is being conducted by CSIRO's Division of Human Nutrition in Adelaide.

Omega-3 fatty acids are polyunsaturated fats most readily found in fish and fish oils. Small amounts, of a different kind, are also found in linseed oil, soya bean and canola oil. The acids feed into various pathways in the human body with widespread effects. They have been shown to:

- reduce blood triglyceride levels (trigylycerides are a type of blood fat that plays some role in the development of heart disease);

Fatty acids essential for fish

Rising demand for marine oils to include in feeds for the aquaculture industry is the driving force behind CSIRO's Aquaculture Nutrition and Biotechnology Project based at the Division of Oceanography.

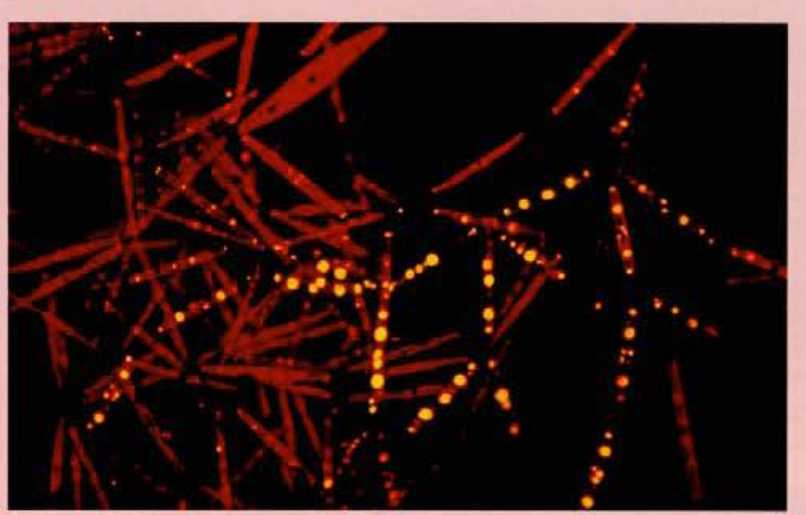
Project leader, Dr John Volkman, says marine oils containing two long-chain polyunsaturated fatty acids (eicosapentaenoic acid and docosahexaenoic acid) which are essential dietary components for most species reared by the aquaculture industry, both in Australia and overseas.

One of the main live feeds used in the aquaculture industry is microalgae, the staple food for many shellfish, and for prawns, crabs and crayfish during their early life stages. Microalgae are also an important food source for zooplankton such as copepods and rotifers (a food source for juvenile fish).

Graeme Dunstan and Stephanie Barrett have been studying the suitability of various microalgae as feeds for commercially important species. Dunstan has analysed selected strains of nutritious microalgae provided by colleagues from the CSIRO Division of Fisheries, and has identified several which contain high levels of polyunsaturated fatty acids. These are now used in Australian aquaculture hatcheries.

Dunstan is also investigating the dietary importance of lipids, particularly with respect to the early stages of the life cycles of a variety of marine animals such as abalone, where the greatest cost to industry is feed. He has shown that the growth rates of abalone are directly affected by the amount and type of polyunsaturated fatty acids in the diet.

Another potential feed source rich is polyunsaturated fatty acids is bull kelp, Durvillaea potatorum, a type of algae which is storm-cast in vast quantities on the beaches of Tasmania. Bull kelp is exported to Scotland to produce alginate, but could well be utilised as a feed for the aquaculture industry or in the pharmaceutical industry. Its lipid content is being studied by Dr Patti Virtue.



An alga from the Antarctic sea ice. The Nile red stain highlights lipid (yellow) stores produced under certain growth conditions against the background of chloroplasts (red). Methods for extracting and purifying the essential fatty acids contained in microalgae and bacteria are being developed.

In other aquaculture-directed research, the krill species Nyctiphanes australis, the most important food for a variety of abundant fishes in Tasmanian waters, is being examined. Krill are used extensively in feed for farmed salmon and other fishes in Japan and Canada. Virtue believes Nyctiphanes australis is ideal for farmed salmon as it has a near optimum range of essential fatty acids.

Much of the research described in this article has been co-funded by CSIRO and the Fisheries Research and Development Corporation and has been assisted by collaboration of colleagues in the aquaculture industry.

Marine oils: sources, markets and uses

lipids	wax esters	squalene-rich oils and diacylglycerol ethers (DAGE)	triacyglycerol oils (omega-3 polyunsaturated fatty acids:eicosapentaenoic acid (EPA) and docosa hexaenoic acid (DHA)
sources	orange roughy etc.	deep-sea shark livers	mackerel, tuna, sardines, anchovies and other fish
uses	• industrial degreaser (treatment for industrial dermatitis) • metal cutting, tapping and drilling fluid • as an emollient in cosmetics (face and hand creams, sun creams, lipsticks) • wood and leather treatment	*Squalene* in capsule form as a general health tonic and anti-oxidant, particularly in Asian medicine *DAGE* bolsters immune system	• reduces the incidence of coronary stroke and heart disease in humans • lowers cholesterol • DHA in particular a vital component of brain cell development in infants
markets	United States, Europe, Australia and Asia	Korea, China, Taiwan, Indonesia, Vietnam, Japan and Thailand	Europe, United States, Japan, Korea, Taiwan and China

- have anti-coagulant properties, thereby helping to prevent blood clots from forming too readily and so possible reducing the risk of heart attack;
- reduce the effects of inflammation and may therefore be useful in combating arthritis and rheumatism; and
- reduce blood pressure and potentially protect against heart rhythm disturbances.

Capsules of fish oils containing high levels of the essential eicosapentaenoic acid and docosahexaenoic acid (omega-3 fatty acids) are marketed aggressively internationally, and have captured a small market in Australia. Cudmore says Japan will be the major target market for Beku's omega-3 oils in the next 18 months.

Shark liver oils also can contain significant amounts of diacylglycerol ethers (DAGE). Australian industry presently imports these compounds from overseas, so there is potential for import replacement, and export markets are being developed into Europe, the US and Asia. A range of applications for the DAGE oils are being examined with particular emphasis on their activity in bolstering the human body's immune system and the implications of this for cancer treatment.

Cudmore says Beku's close association with CSIRO has been invaluable in the company's efforts to turn waste from the fishing industry into high value-added products, and in building a highly respected business profile overseas.

Another factor working in Beku's favour is its southern location. Australian marine oils have a natural advantage over those produced in the Northern Hemisphere, many of which contain traces of organic contaminants such as organochlorines. A recent Greenpeace report stated that traces of contaminants have been found in some health products deriving their oils from the north sea region.

Luckily, the seas around Australia can still be said to have a 'clean green' image. This is partly because the circulation in the Southern Ocean and adjoining seas helps disperse any contaminants over a wide area. Continued research by CSIRO will help Australian industries to develop new marine-oil products that benefit from this natural advantage.

More about marine oils

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Above: A fish meal and oil processing factory. Left: Through the Marine Products Project, Dr Patti Virtue, Dr Peter Nichols and Dr Nick Elliott are applying their research skills to help develop a new fishing by-products enterprise.