Spectrum

Acoustics and the greenhouse effect

A quick look at a globe reminds us just how much of the world is ocean. And when we talk about changes to our planet, this is an obvious point to bear in mind.

It's predicted that the accumulation of carbon dioxide, methane, and other gases in the atmosphere will increase the natural greenhouse effect, causing Earth to warm. Naturally, we want to know if this is, in fact, happening. But how do we measure global warming?

As the oceans cover the bulk of the Earth's surface, they are perhaps the best place to start. Of course, individual readings may vary because of local factors that have nothing to do with global warming. The same problem faces those trying to assess global temperature change in the atmosphere from measurements taken on land, and the local small-scale warming induced by cities adds to the difficulty.

Now, Dr Walter Munk of the Scripps Institution of Oceanography, in California, has come up with a novel way of determining whether vast areas of the world's oceans really are warming. Essentially, his idea is all about making a noise. He bases it on his knowledge of what happened when a deliberate under-water explosion occurred off Perth in 1960.

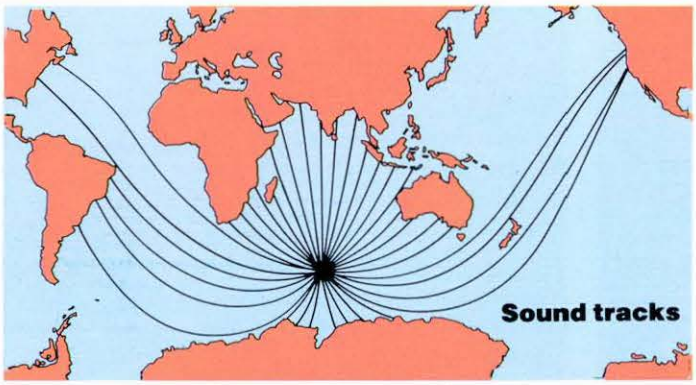
Site of the sound source — Heard Island in the cold Southern Ocean. The picture shows the snow-capped peak of Mt Mawson on the island's north-western side.

When scientists detonated about 130 kg of TNT in the Indian Ocean at a depth of 1 km, the noise was picked up 3 hours and 40 minutes later by hydrophones (under-water microphones) in Bermuda, about 16 000 km away. And so the science of long-range ocean acoustics was born.

Sound can travel a long way in water, and faster than in air — but if you look at an atlas, you'll see that Africa lies between Perth and Bermuda. So the sound must have followed a curved path, arcing around southern Africa. This is similar to a 'great circle' — the track that long-haul aircraft take — which is the shortest distance between two points on a sphere. Such a path on an elliptical sphere like Earth is termed a geodesic.

Dr Munk's calculations show that the sound from the Perth explosion didn't follow an exact geodesic — that would not have fitted with the time it took to reach Bermuda. He believes that the sound was refracted (just as light is by a lens) southwards of the geodesic path, and his calculations for how long the noise should take to travel this path fit to within two seconds of the actual time.

And what has all this to do with the greenhouse effect, as impatient readers may be wondering? The important point is that the speed with which sound travels in water depends on the temperature. If you measure accurately enough any changes in the time it takes to receive the noise, then you can calculate what has happened to the average temperature of the water it passed through.



The paths along which sound will travel from Heard Island to listening points around the world.

At a depth that averages about 1 km over the world's oceans, sound can travel rather like light in an optic fibre, bouncing between upper and lower layers of water. We have, therefore, a sort of 'sound channel' or acoustic waveguide in which most of the sound signal will travel. Its exact depth varies, being shallow in cold waters near the Poles and deeper near the warmer waters of the Equator.

Dr Munk hopes to start submarine broadcasting on a regular basis, and is collaborating with Mr Andrew Forbes, of the CSIRO Division of Oceanography in Hobart, to achieve this.

Together, and with the support of various agencies in the United States, they are mounting the first attempt in the world to measure global ocean warming directly. (Other scientists' proposals merely rely on inferring temperature changes from measurements of other factors such as sea level.)

If the oceans were to warm by only five-thousandths of one degree, this would lead to a reduction in travel time along a 16 000-km path of 140 milliseconds. Current equipment allows scientists to measure elapsed times with an

accuracy of 1 ms, so such a change would be easily detectable.

Dr Munk and Mr Forbes hope to start 'honking' in the sea off Australia's Heard Island (see the map) in February 1991. Rather than detonating explosives, they will make their noises with a device rather like a giant loudspeaker, that creates sound by bending an aluminium sheet backwards and forwards. It will transmit bursts of low-frequency (57 cycles per second) and long-wavelength (about 26 m) sound, that on land sounds rather like honking geese.

Although some marine mammals use sound signals as sonar (for locating objects) or to communicate, these generally have much higher frequencies (hundreds of thousands of cycles per second) than does the experimental noise. So the scientists don't expect that their work will interfere with the animals in the ocean. Whales, dolphins, and seals will undoubtedly be able to detect the sounds if they swim nearby, but at Heard Island, 50 km away, the signals will be barely distinguishable from the noise of crashing breakers.

But why go to remote Heard Island to make a noise in the ocean? The site is unique because, from there, sound following geodesic paths will be able to reach the five continents, traversing all the oceans of the world. So not just one patch of sea will be measured. Of course, this necessitates many strategically placed hydrophones — the more the better — to detect the sound, which will spread out in all directions from Heard Island. The team has already secured the collaboration of 17 receiving stations.

The sound will travel at varying speeds in the water, depending on temperature and pressure, but the measurement of its travel time will be an average reflecting all the conditions it encounters on the way. Local variations can be spotted by taking readings at intervals along the paths.

Many other people will find the data useful, as well as those trying to detect global warming. Oceanographers and meteorologists will find it interesting to spot any regular cyclic changes in ocean temperatures in various parts of the world. This makes it important to have receiving stations at varying distances.

For example, the New Zealand receiver will tell us about temperature in the Southern Ocean, between Heard Island and New Zealand. Subtracting the New Zealand leg from the time the same signal takes to reach Tahiti will tell us about the average temperature in the South Pacific, and a further comparison with the San Francisco record will give us information specific to the northern Pacific.

The scientists hope that the project will run for at least 10 years, as that would be the minimum time needed to accumulate definite evidence of global warming. Meteorological effects, such as the famed El Niño, cause cyclical disturbances in ocean temperature that persist for a few years, so a decade is necessary to distinguish these events from any long-term warming superimposed on them.

However, even before the verdict on greenhouse warming is in, the study will have collected much useful information that may increase our understanding of various phenomena affecting climate.

Mr Forbes visited a cold Heard Island in June 1990 to search for a suitable site for the under-water transmitter that the team hopes to use. About 50 km from the island, he found a spot where the water was 1 km deep, and he hopes to place the transmitters there 200 m down, which is the depth of the sound channel in those waters.

The scientists will test their acoustic signal in February 1991 for 1 week, switching it on and off in a slow-motion acoustic flash. Like light from a suspended bulb, the sound will travel in all directions in an ever-expanding sphere. (It will not be a narrow directional beam like sonar.) Within a few hours, it will cross the world. For more information, keep your ears to the ground... or the sea!

Roger Beckmann

Global ocean warming: an acoustic measure? W.H. Munk and A.M.G. Forbes. *Journal of Physical Oceanography*, 1989, **19**, 1765–78.

Cutting out the cholesterol

There's no doubt that dairy products and eggs are foodstuffs of the highest nutritional quality. Milk has a very good balance of necessary nutrients and is easily digested and absorbed by the majority of people. It is also the most efficiently produced food of animal origin and the cheapest source of high-grade protein.

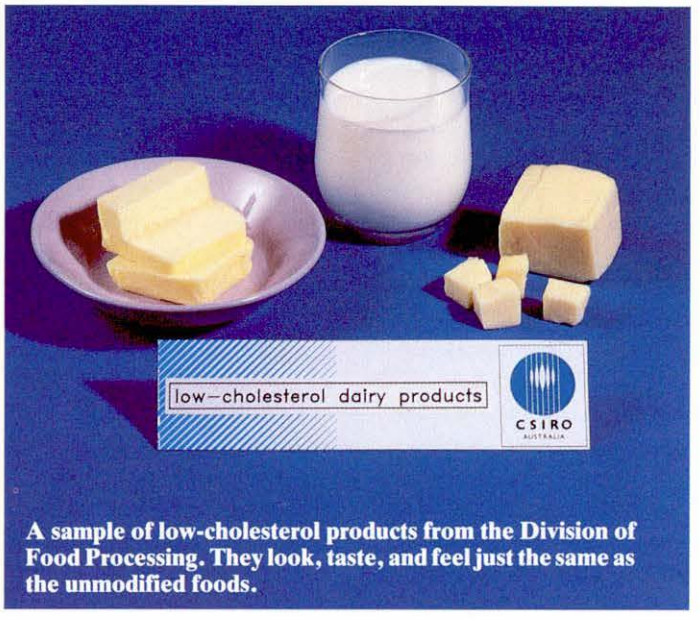
However, these products have two drawbacks — high levels of saturated fat, especially in full-cream dairy foods, and relatively high concentrations of cholesterol. Butterfat contains about 3 mg of cholesterol per gram, and egg yolks about 20 mg.

Consumption of the products is falling, as Australians, having heard about the implication of saturated fats and cholesterol in heart disease and stroke, avoid these foods. While cutting down on saturated fat is more important than reducing cholesterol intake, removing cholesterol from egg and dairy products is worthwhile.

Recent research shows that this can be done without altering the products' flavour and texture.

Dr David Oakenfull and Dr Charn Sidhu, of the CSIRO Division of Food Processing, have devised a simple and effective method for cholesterol removal, now patented, and discussions with a company for commercial development of the process are under way.

Most of us needn't be too worried about reasonable intakes of dietary cholesterol, as our own bodies produce far more of it than we absorb. If cholesterol in the diet



A sample of low-cholesterol products from the Division of Food Processing. They look, taste, and feel just the same as the unmodified foods.

increases, then a feedback mechanisms ensures that the body's main producer, the liver, makes less, so keeping the level in the blood reasonably constant — and it is the cholesterol in the blood, along with fats, that leads to deposits on the inside of arteries.

But the body's compensations don't mean that dietary cholesterol levels are unimportant. The average adult Australian consumes about 450 mg of cholesterol a day, and in the United States the dietary goals recommend a consumption of about 300 mg a day.

It seems wise to cut down a little on our cholesterol for other reasons, too.

In 20–30% of the adult population, the body's feedback mechanism doesn't work properly. Such individuals, known as non-compensators, need to keep their dietary cholesterol intake at very low levels. Unfortunately, we don't yet have an obvious and effective way of identifying non-compensators early in life, so meanwhile it seems prudent for us all to keep an eye on our dietary intake and blood cholesterol levels.

Furthermore, dietary cholesterol has a different fate from that synthesised internally. The latter remains as free cholesterol in the blood, whereas the dietary variety undergoes chemical modification in the intestine and tends either to be deposited in the liver, where it can be damaging, or to end up in fat particles in the blood that are atherogenic — that is, they help bring about the production of fatty plaques on the inner lining of arteries.

Given this knowledge, we may find that it's not only the non-compensators who may derive some benefit from low-cholesterol dairy and egg products, and a company selling such products should have a market advantage.

Not surprisingly, overseas scientists are also avidly looking at ways of removing cholesterol, as the potential market in developed nations — especially the United States — is huge. However, according to Dr Sidhu and Dr Oakenfull, the CSIRO process is both cheaper and more efficient than other methods currently under investigation.

Scientists know of various compounds that attach to cholesterol. For example, the saponins (see *Ecos* 51) found in a number of food plants can interact with dietary cholesterol in the gut and so prevent absorption of it. But for removing cholesterol from foodstuffs saponins are far from ideal. They are expensive and can't be recovered for re-use. Moreover, in sufficient quantity they are toxic.

But the CSIRO team has discovered a better compound for removing cholesterol. For commercial reasons it must remain secret, but we can reveal that it has a specific affinity for cholesterol molecules, is non-toxic, and is already an allowable food additive in some countries.

If bonded to a solid support, such as a mass of silica beads, the compound absorbs the cholesterol from a milk or egg mix, but remains attached to the beads. No trace of it appears in the food, and the coated beads can be washed free of the cholesterol and re-used.

Only cholesterol is removed and the product remains otherwise unaltered. Butter and cheese made by this process are indistinguishable from conventional products, with excellent flavour and texture. The procedure adds just a few cents per litre to the cost of milk.

As well as these dairy products, ice-cream, custards, milk shakes, egg mixes (but not whole eggs!), and baked goods could also be marketed. This technology should allow the dairy and egg industries to adjust to current consumer preferences and help lift their sagging sales. It will also be of great benefit to those of us who must stay on a low-cholesterol diet.

Roger Beckmann and Steve Davidson

Cholesterol in dairy foods and the technology for its removal. G.S. Sidhu. *Proceedings, Developments in Milkfat Technology Seminar, Melbourne, 1989.*

Keeping the flavour

If you fancy the taste of wine, the non-alcoholic variety — probably resembling grape juice — might not have seemed much of an alternative. But now, thanks to an invention of the CSIRO Division of Food Processing, the best bouquet can be yours — without any chance of intoxication, dangerous driving, or hangover.

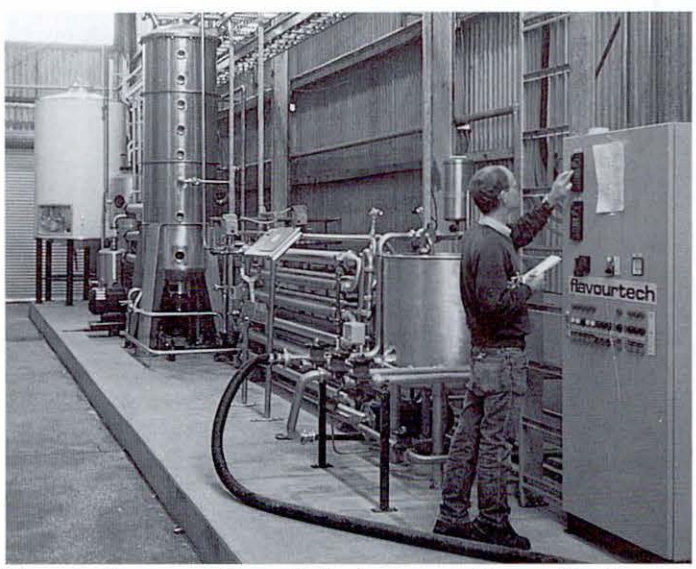
Also, the food industry can now produce packaged fruit juices that really taste like the fresh variety and drinks that have the smell and taste of exotic flowers. The common factor in all this is the 'spinning cone column'. Marketed by Flavourtech Pty Ltd, the device is based on pioneering research by CSIRO's Dr Don Casimir. The column can remove volatile substances from all manner of liquids, without prolonged high temperatures or the use of enzymes.

Usually, removing alcohol from wine is accomplished by heating it to make the alcohol evaporate. Unfortunately, this distillation also removes many other volatile components that give wine its unique smell and taste. But the spinning cone column changes all that.

Put simply, the idea works like this: a liquid is put in at the top of the column, and falls onto a series of vanes arranged rather like a Christmas tree. In the opposite direction moves a gas under pressure — it could be steam, nitrogen, or carbon dioxide — and the volatile components evaporate out of the thin films of liquid on the vanes and condense at the top of the column.

Large area of contact beteeen the liquid and the gas allows mass transfer to take place from one to the other. No heating is necessary, unless you wish to use the column for certain tasks such as the removal of sulfur dioxide.

Removing alcohol from wine involves more steps. First, the wine undergoes distillation, which yields a liquid containing alcohol and the volatiles responsible for taste and bouquet. This is then



The spinning cone column (in the background) operating in a winery.

put in the spinning cone column, and the alcohol extracted with carbon dioxide. The remaining volatiles are returned to the original wine-base. The result has all the flavour and aroma of the original, but less than 1% of the alcohol.

The device will also be a boon for lovers of fresh fruit juices. Usually, the fruit-drinks industry transports juice as a concentrate, which is made by evaporating the water off. Unfortunately, in the process many of the volatiles that give fresh juice its smell and flavour are lost as well.

With the spinning cone column, the volatiles are separated out before the water removal takes place. They can then be returned to the concentrate. When the resulting juice is reconstituted, it should have many of the flavour characteristics of the original.

The perfume industry could also use the column to separate out volatiles without distillation. There's little doubt that the device holds great economic potential. And the good news for those concerned about our export figures is that Australia is the only producer of this unique means of quickly and efficiently separating substances.

Roger Beckmann

More CSIRO books

Rainforests, remote-sensing, plants for medicines; those are some of the topics covered in books published recently by CSIRO. You can obtain a free illustrated catalogue of CSIRO books by writing to CSIRO Publications, PO Box 89 East Melbourne Vic 3002, or phoning (03) 418 7217. Here are a few examples of what's on offer.

Australian Tropical Rainforests

— Edited by L. J. Webb and J. Kikkawa

This 186-page hardback looks at northern Queensland's rainforests from a fascinating variety of perspectives. Contributions came not only from scientists involved in rainforests research but also from philosophers, sociologists, and a poet.

Introduction to Remotely Sensed Data

Introduction to Image Processing

— Both by B. A. Harrison and D. L. B. Jupp

These well-illustrated paperbacks — the first two volumes in the five-part 'microBrian Resource Manual' — will interest both students and professionals concerned with remote-sensing and its applications.

Regreening Australia: Caring for Young Trees 2

— Nan Oates

This 76-page illustrated paperback contains easy-to-follow practical information for anyone involved in tree growing. It describes gadgets and equipment ranging from hand tools to large mechanical planters and seeders, and including watering systems, tree guards, weeding devices, and much more.

Plants for Medicines: a Chemical and Pharmacological Survey of Plants in the Australian Region

— D. J. Collins, C. C. J. Culvenor, J. A. Lamberton, J. W. Loder, and J. R. Price

This copiously illustrated hardback presents the findings of screenings by CSIRO of nearly 2000 species for medically useful compounds.

Back issues

Copies of most *Ecos* back issues are still available — including No. 1, August 1974, which reported on an environmental study of the Kakadu area, the greenhouse effect, and a variety of other matters that are as topical now as they were 16 years ago.

Ecos first reported in depth on climate change in issue No. 3, on rainforest research in No. 6, and on land degradation in inland Australia in No. 8.

Subjects of articles in issues from the last few years include: the Antarctic ozone hole (Nos. 52 and 56), land-clearing and salinity (No. 58), endangered plants (No. 59), penguins (No. 60), and the problems of decaying infrastructure (No. 61).

The best guide to what appeared when is the index to *Ecos* issues 1–58. This is available free of charge. The cost of back issues of the magazine is $5 each; this includes postage. The index and back issues are available from: Ecos, PO Box 225, Dickson ACT 2602. Please include payment with your back issue orders.

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