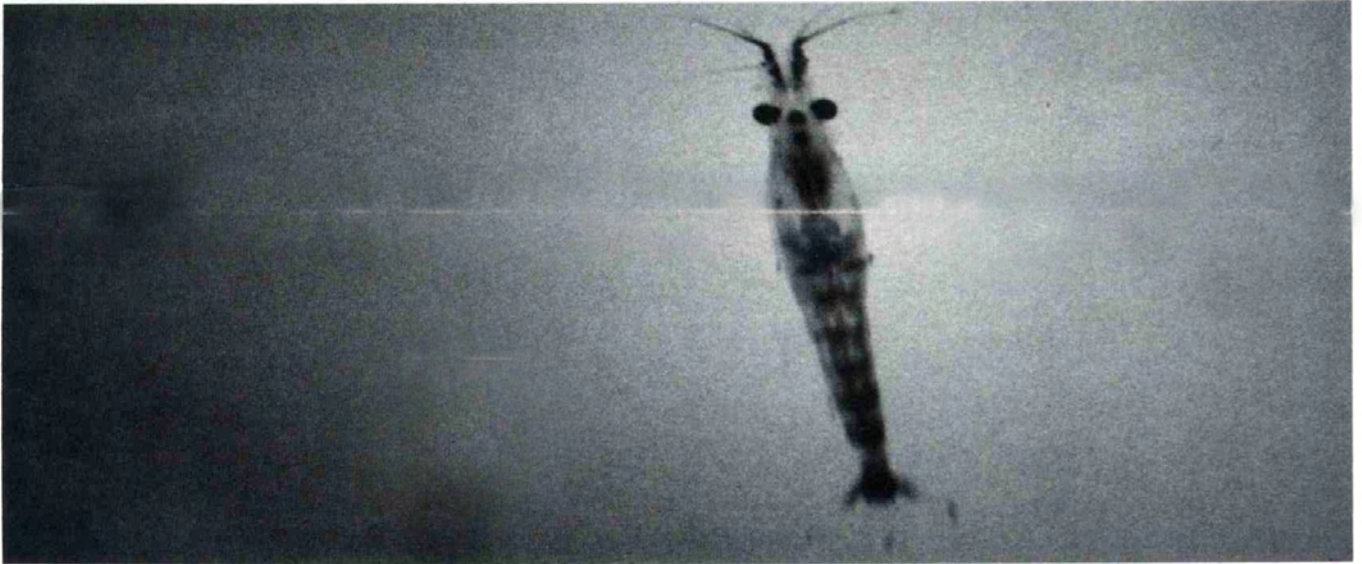


The Antarctic Century

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Krill: The Antarctic Power Lunch

Can you name the 2 1/2 inch-long animals that literally fuel the entire Antarctic ecosystem?

Everyone — whales, penguins, and even human fishermen — exploits these tiny animals, which are spectacularly nutritious, containing up to 20% protein when wet (and up to 80% protein when dried).

Believe it or not, these animals are a form of shrimp, having the scientific name of Euphausia superba, and are better known as Antarctic krill. Krill may assemble in large swarms extending for miles on end, and millions upon millions of tons of them are consumed each year by predators and human consumers. They may be the key to the future of the vast Antarctic marine ecosystem.

No doubt, krill are the "power lunch" of the Antarctic, but are there enough to go around? In terms of Antarctic ecological concerns, minerals exploration and exploitation are many years away — and may prove to be impossible, altogether, but krill exploitation — and other fishing activities — are a present reality.

Many Krill Questions, Few Certain Answers

Krill's life history isn't completely understood. There are many questions about krill's actual lifespan, sexual maturity, growth rate, and reproductive rate — all of which impact on the most important question of all: how many krill actually exist?

The answer is, at best, an estimate. That's unsettling because we remember that the large Antarctic whale stocks were just recently over-exploited under a management system that tried to assess the same kinds of questions.

The new Antarctic Living Marine Resources Treaty (the "Krill Treaty"), which went into effect in 1982, is the mechanism by which scientists and the The Antarctic Treaty countries (see [The Antarctic Century Newsletter, Number 1](#)) hope to learn more about krill. The Krill Treaty allows for quotas, seasons,

(continued on page 2)

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and other necessary measures to prevent krill's over-exploitation, and to insure that their fate is different from that of the great whales.

Krill's Life History

Krill are most intriguing crustaceans, and we are just beginning to understand their habits and life history.

They spawn, generally, during the Antarctic summer, in January and February, with each female laying several thousand eggs in the upper levels of the ocean. The eggs sink for about 10 days, and hatch as "nauplii," perhaps one-half mile below the surface. These nauplii develop through various larval stages, migrating upwards, until becoming juveniles and, ultimately, adults.

Krill are not distributed evenly, and sometimes may gather in large swarms. A few years ago, one particularly immense swarm, covering more than 150 square miles of ocean and estimated to contain 2 million tons of krill, was described.

When a large swarm is present, trawlers can take about 10,000 tons a day. The presence of the large swarms cannot be predicted accurately, although they are linked, probably, to large masses of phytoplankton on which the krill are feeding.

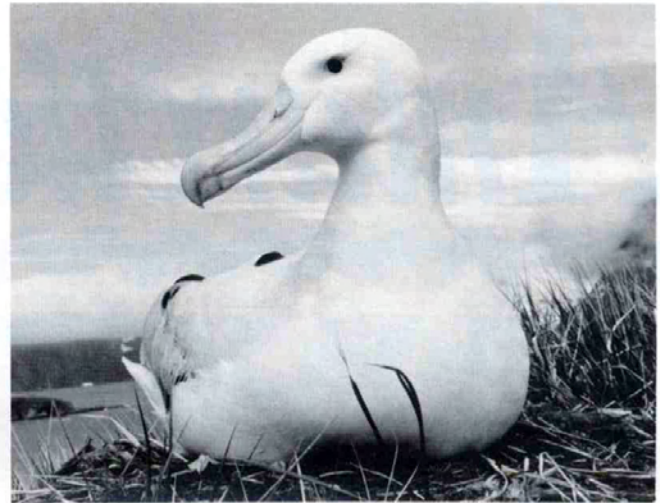
Krill also undertake a vertical migration, coming close to the surface at night or dusk, then move 300-600 feet below the surface during daylight. Krill are fast swimmers and may move up to 60 miles a day. Apparently, they devote about a third of their energy to feeding on phytoplankton.

How Many Krill?

After some of the life history factors are entered into the relevant statistical equations, a range of population sizes emerges.

One high-end estimate indicates that there may be at least 700 million tons of Antarctic krill (what biologists label a "biomass"). However, while most crustaceans appear to have a short lifespan — say, 2-3 years — Antarctic krill may live for as long as 7-8 years, in which case, according to some scientists and population experts, there may be as little as 100 million tons.

Further complicating all of this is a lack of agreement about the amount of newly spawned krill that may be added each year (the so-called "annual production"), how many young or old krill are removed by natural mortality (other than predation), and whether or not the population as a whole is growing or shrinking. In fact, for a while each year, the krill population actually may double because of annual production, before decreasing as natural mortality runs its course, and predators and fishermen have their fill.



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A Vast Ocean, and Lots of Consumers

The enormous Antarctic and Southern Ocean ecosystem that krill inhabit is the largest and most fertile on Earth: 14 million square miles, equal to 10% of the world's oceans, and extending from the Antarctic continent to the Antarctic Convergence, the boundary where cold Antarctic water meets warmer sub-Antarctic water from the Atlantic, Pacific, and Indian Oceans (located between 47° - 63° S. Latitude).

The richness is staggering: an annual production of phytoplankton and microplankton that may reach 6,400 million tons; 33 million seals weighing 7 million tons; 500,000 whales weighing 9 million tons; more than 60 million seabirds weighing more than 200 million tons; and, anywhere from 100 to 700 million tons of krill.

One estimate suggests 500 million tons of krill being taken annually by seabirds, whales, seals, whales, fish, squid, and other predators (assuming, of course, the high-end estimate of krill abundance).

(continued on page 5)

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A Letter From Pekoe

January 30, 1989
POINT THOMAS

Dear Ron:

Hey, guy, it's bad enough with krill being so scarce this spring and, now this! What's going on?

How could that ship go down? How is it possible for just one ship to do so much potential damage? 250,000 gallons of fuel can muck-up and maybe kill lots of krill and penguins. Our waters and shorelines might be devastated.

The word from the Adelies and Giant Petrels who've seen it, is that the Bahia is probably going down, and that the oil's already appearing everywhere near and around Torgersen Island and Arthur Harbor. It will be worse if the tanks and barrels rupture, and the bulk of the junk gets out.

We've visited with you Redhoppers so many times, and trusted that you and everyone else would be down here in safe ships. How could this happen?

What went wrong? Was the weather bad? Could the accident have been foreseen? Were the rocks on the charts? Was it bad navigation? Aren't all the ships down here reinforced? Who's going to clean-up the mess?

This has never happened before.

I'm scared, and I'm not very happy,

Pekoe

Ed. Note: Pekoe is our feisty Chinstrap Penguin friend who lately has been breeding at King George Island in the Antarctic Peninsula. Through these letters, we hope to keep up-to-date on Antarctic events from Pekoe's point of view.

The Antarctic Century BOARD

• Interview with Captain T.L.M. Sunter, HMS Endurance

I had a unique opportunity during this Antarctic season to work aboard the HMS Endurance, the British Royal Navy's ice patrol ship. The science, conducted by me and Frank Todd, involved on-site and aerial censuses and behavioral surveys of the major penguin and seabird colonies on the north coast of South Georgia. The HMS Endurance, officially named after Sir Ernest Shackleton's famous ship, was a wonderful platform for the ornithological work that we were doing. She is affectionately called the "Red Plum" by those who know her well. HMS Endurance entered service in 1968, and is dedicated to supporting British interests in the South Atlantic and Antarctic. She carries a complement of approximately 130 men and utilizes helicopters to achieve its various objectives of mapping, surveying, and assisting scientific research. The scientific work involved spending more than a month with a dedicated and committed group of Antarcticists, led by Captain Tom Sunter, whose interview follows. Captain Sunter is concluding his second year commanding the Endurance. Combined with his previous experience aboard a frigate in the South Atlantic, he has honed some strong and personal feelings about the Antarctic and the role that the 38 Treaty countries play. I was present during the ship's first work period (of four). During the next, a team of Antarctic inspectors will board as Endurance heads south to work in the Peninsula and, then, below the Antarctic Circle. The interview with Captain Sunter took place on December 19, 1988, while Endurance was on buoy in Stromness Harbor, South Georgia.

Ron Naveen

Ron Naveen: How important is the tradition of Ernest Shackleton?

Captain Sunter: In one sense, the prototypical Antarctic hero was Scott, because he died in this great British tradition that we seem to have! But for those who have studied or worked The Ice, and certainly to those of us with responsibility for vessels in the Antarctic, Shackleton is the great hero because he never lost a man under his direct command. This became a very significant factor in his leadership. He was very charismatic, and planned his trips in great detail, generally getting it right; but, when plans went wrong, he made sure that he didn't lose anyone. Shackleton might have been a greater hero if his feats had not been overshadowed by the First World War.

RN: Can you tell us a bit about the role of the Royal Navy and Endurance in The Ice?

CS: The role that the Royal Navy and Endurance have played is accepted as being useful and, I personally think it's very valuable — but I'm biased! We'd like to feel that this role — the non-military, organizational role — will be continued in Antarctica because we know that it has a value.

Endurance is officially called an "ice patrol vessel," and is distinctly different from that of the two vessels supporting the British Antarctic Survey program. It really is in Antarctica on a mission. The first role of the ship and, by delegation, its captain, is being the official representative of the British government in the Antarctic. All nations who sign the Treaty are entitled and encouraged to insure that everybody else is measuring up, and playing the Treaty by the rules and the spirit of the rules. In this sense, then, Endurance is the physical, British government representative in The Ice.

Second, while there are many more people utilizing Antarctica, there are very few charting the routes, trying to make sure that we don't suffer anymore of the 40-foot gashes that Endurance received a few years ago. So, surveying is our second major aspect. We don't want people dying because they're hitting uncharted rocks. We carry survey boats and teams, and in combination with sophisticated satellite communication and navigation equipment, we do lots of aerial photography, and we're producing routes. It's still an unknown continent.

The third role is that we support and assist whatever scientific work is occurring in the Antarctic. Most of that comes under the

auspices of the British Antarctic Survey, but there are other worthwhile projects that we sometimes can help. Although we're not a scientific research vessel per se, we've got two helicopters and boats, and the capacity to move people to many places that they've never been to before, and can allow them to be, perhaps, the first scientists to set foot in some very special areas.

RN: *What excites you about HMS Endurance and its Antarctic responsibilities?*

CS: Commanding the Endurance is a dream, a "one-off" job that I never envisaged happening. There's no doubt that the Antarctic is "thumping" in my blood, just as it did — and continues to do so — for my nine predecessors who have commanded this ship. Tradition has created a very tight, close-knit "club," if you will, always willing and able to help or advise me if needed, and I will do the same for my successors.

To anyone who goes to the Antarctic, there is a tremendous appeal, an unparalleled combination of grandeur, beauty, vastness, loneliness, and malevolence — all of which sound terribly melodramatic — but which, truthfully convey the actual feeling of Antarctica. Where else in the world are all of these descriptors really true?

RN: *What do you anticipate regarding Antarctica's future?*

CS: Let me be careful, and say that I'm speaking for myself, and from the perspective of one who's worked in Antarctica and who has spent much time talking with others who are involved in other aspects of the Antarctic situation. With about three-fourths of the world's population involved in the Antarctic Treaty system, we already have a good working agreement. The vast majority of the world's population already has decided that Antarctica is not to be militarized or nuclearized, and that there shall not be a misuse of the resources or a misuse of the environment. With this support, it seems to me, as an individual, that there's no necessity to have a replacement organization in its stead. If countries want to join in the Treaty, all they must do is show a scientific interest, and they can become signatories and voting parties just as Spain and Sweden have recently done.

Not only is it those who work in Antarctica and who are deeply influenced by its atmosphere, I've also found that the administrators and the diplomats really want to produce answers. When they sit around the table and talk about Antarctica, uniquely in my experience, nobody goes to the table to say "no." The Treaty nations come to these

meetings to find a way to say "yes," even to bend to do so. That's got to be unique in the world. I think it would be valuable to all of our children and grandchildren if the Treaty were allowed to keep working the way that it is.

The other thing that I've noticed is that, obviously, with those of us who work in the Antarctic, there's a great togetherness. The simple fact is that I might have to pick up a Spanish seaman who's injured, fly him with my helicopter to the Russian hospital for emergency treatment, then take him over to the Chilean base for a C-130 to fly him home. Now, that sort of cooperation, which you don't find anywhere else in the world, is unique. And it's not just for emergencies. Everybody knows that the sheer malevolence of the environment is such that you've got to work together. If there's anything that I can do to help one of the other bases — emergency or not — I'll do it. If they can do anything to help me, they'll do it.

RN: *You refer to Antarctica's sometimes malevolent atmosphere, the haunting beauty of this fantastic continent. Can you mention some of the Antarctic experiences that have left indelible impressions on you?*

CS: I can mention a few. We were anchored in Dorian Bay, doing some long and time-consuming survey work. I went ashore for a walk, and went out of sight of the ship, ultimately just me and some penguins, all alone. The sound of the icebergs calving — breaking off of the glaciers and the ice front — was a very strange experience. One might expect to hear silence in Antarctica; rather, I heard the fantastic rushing noise of the ice, that roaring waterfall-like sound. I found that very eerie.

I'll always remember, though, and thinking of the photograph over my shoulder (Hurley's famous nighttime photograph of Shackleton's *Endurance*, beset in the Weddell Sea ice), getting this ship solidly beset in the ice pack 40 miles southeast of Rothera Station. Realizing that the horizon was a mixture of ice and sky, and everything was very gray, and that all around was solid ice, with our little red ship in the middle of it, made me suddenly appreciate the old mariner's prayer: "Oh, God, never let me forget that your sea is so big and my ship is so small." I got a definite feeling of personal insignificance on that occasion. We waited for a wind shift, which finally occurred, and which allowed us to turn the ship into one of the leads and escape.

Other memories are tied to going through very narrow channels, the Lemaire being one, which are very photogenic, usually having to contend with lots of ice floes.

The great black towering cliffs on either side. Ice looking like its defying gravity, hanging precipitously, all ready to come falling down. Where else are you going to find such a scene.

A New Zealander who was with us last year said it best: "In Antarctica, you can walk in any direction, and feel the freedom."

• **News** Sadly, we must report the tragedy of the Argentinian supply vessel/tourist ship *Bahia Paraiso*, which struck submerged rocks near the U.S. Palmer Station in Arthur Harbor and the large Adelie Penguin rookery at Torgersen Island. All crew and tourists have been evacuated safely. At this writing, she is reported to be breaking-up, with the potential of releasing 250,000 gallons of oil and fuel should her tanks rupture. This could be the worst-ever oil spill in the Antarctic, and the consequences are staggering. The U.S. National Science Foundation is spearheading an effort to airlift tons of cleanup equipment to Punta Arenas, Chile, from which it will be placed on the research vessel *Polar Duke*, for immediate transport to Arthur Harbor. Another Argentine ship is racing to the scene, and will attempt to refloat the grounded vessel. . . .

The U. S. National Oceanic and Atmospheric Administration vessel *Surveyor* is working The Ice this season, assisting the U.S. research effort under the Krill Treaty. . . . Brazil's new oceanographic vessel, the *Almirante Álvaro Alberto*, also is making its first trip to the Antarctic. . . . Argentina is redeploying the formerly abandoned station at Half Moon Bay; it is called Tienente Camera. . . . The fiscal year 1990 budget of the outgoing U.S. administration targets \$30 million over four years to clean-up the debris from past U.S. Antarctic operations, and to bring present operations into agreement with current regulations and technology. The Bush Administration's version of the FY 1990 budget will be submitted in February, and it is unclear if changes will be made to this specific item. . . . The commission under the Krill Treaty banned the fishing on a second species of Antarctic cod fish, the ice fish *Champscephalus gunnari*, in response to extensive fishing activities by the Soviet Union; the ban, however, did not take place until after the Soviets had concluded their fishing for the season. Progress also was reported on a Treaty-wide observer and inspection scheme. . . . A bust of Captain C.A. Larsen, the famous Antarctic captain and whaler recently was dedicated at Grytviken, South Georgia.

Because krill are such an important, potential source of protein, it's not surprising, then, to find man entering the picture. Can humans take krill without harming other participants in the food chain? The reality is that no one knows for sure.

Some will argue that the over-exploitation of the whales left a "surplus" of the whales' main food item — krill — available to man. A counter-argument to this is that there have been large, compensating increases in other prime consumers of krill, like Chinstrap and Macaroni Penguins, Crabeater Seals, and Minke Whales, that negate any alleged surplus.

Human exploitation of Antarctic krill began in the 1960s and, in recent years, one-third to one-half million tons of Antarctic krill have been taken annually by international fishing fleets. This compares to the total world consumption of fishing products of about 70 million tons.

Krill for Protein

The krill taken by the international fishing fleets is used mostly for animal feed and fishing bait, and the rest is processed for human consumption as paste (like a cream cheese spread), frozen sticks and tails. Greater human consumption is hindered by technology: krill deteriorate rapidly, large-capacity freezer ships are expensive, and it's a long distance from the Antarctic to major markets. Moreover, we haven't yet figured-out how to de-shell krill effectively.

But, given krill's protein content, it's not a fantasy to suggest that, one day, we'll turn to krill to satisfy the world's protein needs. What's in store for krill if technology solves the transport, deterioration, and de-shelling problems, and makes this protein-rich product available to the masses?



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Now, admittedly, even quadrupling the present human catch (taking it up to 2 million tons) would seem to have little effect on the high-end estimate of krill (700 million tons). But, what if we've severely over-estimated krill's abundance, and that the low-end estimate of 100 million tons is more accurate? Then, the removal of just one or two million tons would have a potentially detrimental impact.

Moreover, with technology paving the way regarding krill transport, shipboard freezer capacity, and de-shelling, there's another possibility. Remember that, worldwide, we're consuming 70 million tons of fisheries products each year. What if krill became a major component of this prodigious demand, either by choice or because of the failure of other fisheries? Clearly, on this scale, the krill stakes would be enormous.

Enter the Ozone Hole

However, fisheries interactions aren't the only reason for concern. A recent article in *Natural History* suggests a possible link between ozone depletion and negative effects on ocean resources. It must be emphasized that there are no conclusive results, but these preliminary studies suggest that increased radiation — a result of a thinning of the protective ozone layer — may have a detrimental effect on plankton productivity and, in turn, on the viability of the entire Antarctic food chain. If this link is proved, ultimately, then another critical variable enters the equation, scrambling the estimates even further.

Krill's Future: Fear or Hope?

As usual, with respect to Antarctic science, the more that questions are asked, the more that new questions seem to arise. Answers are difficult, and we try to make decisions on the best available estimates and data. Such is progress. But, krill is an issue — now.

An entire Treaty is devoted to Antarctic krill and fish research, attempting to prevent a repetition of the whales' over-exploitation. Krill are already being taken, and there is the spectre — perhaps dim at this point, but nonetheless, there — of humans demanding huge amounts of this rich source of protein.

The fear is that krill will be over-exploited because we've failed to estimate the relevant life history parameters — and krill's abundance — with any precision. If the krill population plummets, the entire Antarctic food chain is jeopardized. Yet, under the Krill Treaty, many countries now are engaged in state-of-the-art krill research, pursuing the difficult questions that scientists are asking. The more hopeful view, as science marches on, is that some of the critical answers might be ascertained — or, at least, estimated, with greater confidence. Then, we might have a better idea of which harvesting levels are most appropriate.

ATA GLANCE

Ernest Shackleton

On January 19, 1915, Ernest Shackleton's ship, the **Endurance**, was beset in the Weddell Sea, the beginning of perhaps the most unbelievable story of human survival. Shackleton had hoped to traverse the Antarctic Continent; instead, he had to fight for his men's lives — and not one was lost. In late October 1915, the men of **Endurance** had to move onto the ice. **Endurance** was starting to break-up, and, indeed, on November 21, she sank. The men attempted to march to Paulet Island, but the pack had drifted too far north. The next hope was for Elephant Island. On April 9, 1916, the men were forced into the lifeboats — the **Stancob Wills**, the **James Caird**, and the **Dudley Docker**, as the ice began to break and shift. On April 14, the men landed at Cape Valentine, Elephant Island, and three days later, shifted to Cape Wild, which had been scouted by Shack's second-in-command, Frank Wild, and which provided greater protection. On April 24, Shackleton commenced the greatest open-boat voyage of all time: 800 miles across the open Southern Ocean, in the largest of the boats, the **James Caird**, hoping to reach South Georgia, its whaling stations, and civilization. The Boss took Worsley, Crean, McNeish, McCarthy, and Vincent with him, leaving Wild in charge of the 22 men at Elephant Island. On May 10, miraculously, Shackleton reached King Haakon Bay, on the south side of South Georgia. However, all of the whaling stations were on the island's northern coast. On May 19, Shackleton, Worsley, and Crean began the overland trek of 17

miles, across the South Georgian Alps, to the Stromness whaling station. It took four rescue efforts and a total of 105 days for Shackleton to return, on the Chilean vessel, **Yelcho**, under the command of Capt. Louis Pardo, to rescue his men from Cape Wild.

Reflecting upon his and his men's ordeal, and with special reference to the journey over the top of South Georgia, Shackleton felt that there was a "fourth presence," watching out for his welfare, and that of his men. This received more widespread attention when T.S. Eliot used Shackleton's comment as a basis for a stanza in the fifth section of his famous poem, *The Waste Land*. In his own words Shackleton said, of his journey, that: "... in memories we were rich. We had pierced the veneer of outside things. We had suffered, starved, and triumphed, grovelled yet grasped at glory, grown bigger in the bigness of the whole. We had seen God in his splendours, heard the text that nature renders. We had reached the naked soul of man."

Let's Hear From You.

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