Orcas in the Ross Sea.
JOHN B WELLER

THE LAST PRISTINE OCEAN

THE ROSS SEA

DR DAVID AINLEY describes the Ross Sea in Antarctica, a rich biodiversity hotspot and perhaps the last remaining ocean on earth where top predators abound and drive the ecosystem.But industrial fishing, with New Zealand companies being major participants, threatens to destroy this unique ocean habitat and its abundant life.

The Ross Sea, an embayment nestled between East and West Antarctica, is only two percent of the Southern Ocean, yet this most southern ocean holds perhaps the greatest proportion of top predators. Thirty-eight percent of the world's Adélie Penguins (3 million birds) make their home in the Ross Sea, along with 26 percent of the world's Emperor Penguins (240,000 birds), and 30 percent of the world's Antarctic Petrels (5.5 million birds). They are joined by roughly one million Snow Petrels (whose global population is yet to be defined) and about 19,000 South Polar Skuas – including the largest colony of this species in the world at Cape Crozier, Ross Island. The Ross Sea is home to 6 percent of the world's Antarctic minke whales, perhaps 50 percent of Type C orcas, known as the "Ross Sea killer whale," which feed primarily on toothfish instead of seals or whales), and tens of thousands of Weddell seals, about half the population in the South Pacific sector of the Southern Ocean. The Ross Sea slope is also considered a 'hotspot' for the rare Arnoux's beaked whale and is home to more than two hundred thousand crabeater seals, perhaps 8000 leopard seals and 5000 Ross seals. Most importantly, given that fish are the major predators in healthy marine ecosystems, the Ross Sea still has an abundance of Antarctic toothfish, the most voracious piscine predator of the Southern Ocean. Adult toothfish can reach 100kg and 2m in length. In an environment where sharks are absent, these massive carnivorous fish occupy this ecological niche.

It's mind-boggling to imagine how all these top predators fit in such a small area as the Ross Sea. With such an immense biomass of top predators, the Ross Sea seems anomalous compared to other modern ocean ecosystems which are increasingly dominated by phytoplankton and invertebrates, particularly gelatinous ones. The standard textbook description of an ecological pyramid (or trophic pyramid) displays high-level predators at the top, occupying the smallest part of the pyramid, and phytoplankton at the bottom, occupying the largest part of the pyramid. In these standard trophic pyramids, the primary producers (phytoplankton) drive the system. Yet in the Ross Sea, we observe an inverse, or upside down, pyramid where the predators provide a huge proportion of the system's biomass and essentially propel the entire ecosystem.

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Unique ocean ecosystem

Is the Ross Sea really an anomaly? Or is it possible that before the advent of industrial fishing, which is responsible for the removal of 90 percent of the top ocean predators, most ecosystems had upside down pyramids?

In 2006, marine biologist Jeremy Jackson published a chapter in a book titled *When ecological pyramids were upside down*,"[1] making the case for an era when perhaps marine trophic pyramids were inverted. He imagines a world prior to industrial exploitation with intact trophic systems, where all the top predators still abound. He pictures ocean ecosystems not unlike that seen in the Ross Sea today, or in virgin rain forests or coral reefs, with a huge density of upper-level predators bringing pressure downward on food web processes and with vital nutrients recycling from within. But the food webs we see elsewhere across the globe today are nothing like the Ross Sea. The ocean's ecological pyramids are increasingly driven by massive phytoplankton blooms (with all kinds of accompanying 'red tides,' toxic algal blooms, and anoxic dead zones), then a smaller biomass of invertebrate grazers, though increasing numbers of jellyfish are filling this role. Ecosystem pyramids now have a minuscule contribution of top predators and some cease to have any at all, instead resembling a pyramid missing its top.

But in the Ross Sea, the whales, penguins, seals and toothfish drive the ecological system. These top predators along with the small toothfish cousin, the Antarctic silverfish (considered the 'herring of the Southern Ocean'), graze the zooplankton, comprised largely of crystal and Antarctic krill and copepods. By the late summer, this intense feasting depletes the zooplankton, forcing the silverfish to become cannibalistic. The whales and penguins turn from eating krill to consuming silverfish, competing with the toothfish and forcing them to become cannibalistic as well. With the krill and other zooplankton depleted, a large portion of the phytoplankton, which the krill normally feast on, goes ungrazed and sinks to the ocean floor contributing to an amazingly lush benthos, rich in 1000-year-old sponges and corals. This benthic floor is a biodiversity hotspot for invertebrates, according to a recent survey by Andrew Clarke and Nadine Johnston of the British Antarctic Survey.[2]

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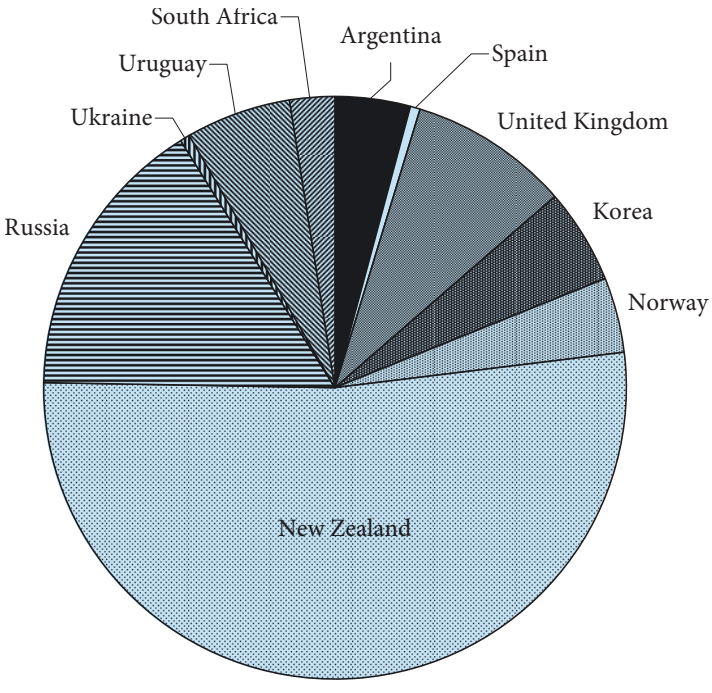
Over 400 Antarctic invertebrate species were first described from Ross Sea specimens. At least 40 of these species are endemic, meaning they are found only in the Ross Sea. Notably, at least seven species of fish are also endemic to the Ross Sea, a large number given its small size. Adding to all this, the Ross Sea is considered to be the most productive stretch of water in the Southern Ocean and, despite its small size, contributes roughly a quarter of all the primary productivity generated in all the waters south of the Polar Front. Its 'pyramid' appears to be shaped more like a 'column' or 'trapazoid,' similar to tropical rain forests and coral reefs.

Incredibly, this remarkable and dynamic ecosystem is still almost wholly intact. A recent analysis published in *Science* by Benjamin Halpern and 18 co-authors concluded that out of all the world's oceans, the Ross Sea was the least affected by humans, deeming it to be the most pristine stretch of ocean on the planet.[3]

But things are changing. At the time of Halpern's analysis recent fishing activity tapping into the Ross Sea's riches was not included. Japanese whalers now engage in regular removal of Antarctic minke whales for "scientific" purposes. And in 1996 New Zealand led the charge for fishing Antarctic toothfish, also known as "Chilean Sea Bass." Toothfish take as long as humans to mature and live up to 50 years. An international fleet of vessels now extracts from the Ross Sea thousands of tonnes of Antarctic toothfish every year, with New Zealand companies taking half the total catch.[4]

ANTARCTIC TOOTHFISH CATCH BY COUNTRY, 1998–2008



SOURCE: DR DAVID AINLEY, FROM CCAMLR 2009 STATISTICAL REPORT FOR THE ROSS SEA AREA

Adelie Penguins.
JOHN B WELLER

The rays' consume vast quantities of bivalves, and as they migrate through Chesapeake Bay they ravenously devour the local scallops. As a result, the scallops that once proliferated along the eastern coast of North America have virtually disappeared. There are similar examples of dramatic changes to food webs related to the removal of other top predatory fish, like the Atlantic cod in the North Atlantic and groupers in tropical coral reefs.

The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) states in its charter that fishing should not alter marine ecosystems beyond their ability to recover in 20–30 years.[6] Yet the Ross Sea toothfish fishery has operated now for 12 years with 5–20 industrial-level vessels yearly. Over a million of these large predatory fish are now gone, along with the 1000 year-old sponges ripped up in the long-lining process. How can a fish that doesn't mature until 16 years old possibly recover its role in an ecosystem, once depleted, in two-three decades? An increasing group of scientists feel this fishing has to stop. If not, we risk turning the last intact oceanic marine foodweb on Earth into a 'normal' pyramid driven by phytoplankton blooms and jellies instead of the great predators that thrive in the Ross Sea today.

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Dr. David Ainley has studied Ross Sea ecology for more than 30 years and is internationally recognized for his extensive research in the ecology and trophodynamics of top-trophic marine predators. He has published more than 180 papers in peer reviewed scientific journals and four books and seven monographs.

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