MARINE GEOLOGY

Nations Look for an Edge in Claiming Continental Shelves

Ocean mappers are getting funding from governments eager to divide up 5% of the sea floor. Some of the claims have already sparked controversy

Centuries ago, James Cook and other explorers set sail to lay claim to vast and valuable new territories. Modern ocean scientists are embarking on similar voyages of discovery, but this time the prize is under the surface: a swath of sea floor twice the size of Australia, with natural treasure worth trillions of dollars.

Under a little-known provision of international law, the United States, Russia, and dozens of other nations are preparing to divvy up some 15 million square kilometers of continental shelf, the submarine slope between the shoreline and the ocean bottom. The area represents about 5% of the total sea floor and contains valuable energy, mineral, and biological resources. New United Nations (U.N.) rules could allow some countries to expand their marine territories by 50% or more. But before governments can plant their flags, researchers must pinpoint where continents end and the abyss begins—and settle technical disagreements over how best to draw the boundary.

"This is research that has a potentially huge [economic and scientific] payoff," says Larry Mayer, a geoscientist at the University of New Hampshire, Durham, who is helping the U.S. government prepare a possible claim to 750,000 square kilometers of the Atlantic, Pacific, and Arctic oceans. Already, he says, the global mapping push has produced surprising new views of the dark, cold world of the continental edge.

Shelf claims, however, are likely to be dogged by scientific and legal questions. The governing international treaty includes vague and sometimes contradictory language, leaving geoscientists struggling to apply the rules. By staking a largely secret claim to nearly half of the Arctic sea floor, Russia has also raised questions about scientific transparency and how the U.N. will handle technical disputes. "Decisions will rest on interpretation, ... and there are going to be disagreements," predicts David Monahan, a marine geologist at the University of New Brunswick in Fredericton and head of Canada's ocean mapping program. Poor nations, meanwhile, worry about the cost of surveys needed to meet an initial 2009 deadline.

CREDIT: ADAPTED FROM P. COOK AND C. CARLETON, *CONTINENTAL SHELF LIMITS: THE SCIENTIFIC AND LEGAL INTERFACE*, OXFORD UNIVERSITY PRESS (2001)

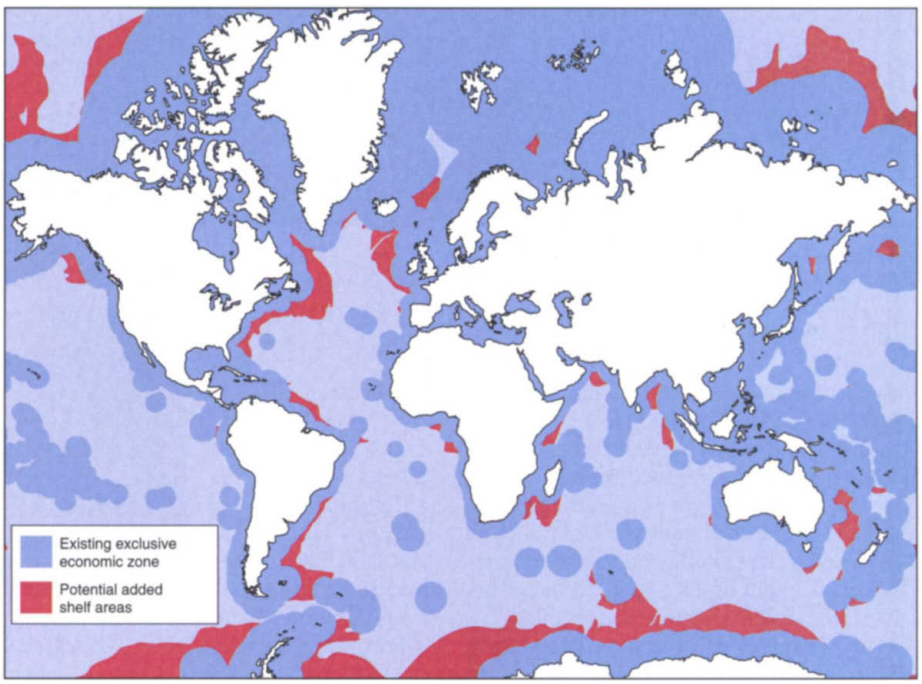
Long shelf life

The current surge of interest in the shelf grows out of the 1982 U.N. Convention on the Law of the Sea, which gave each of 151 coastal nations control of an exclusive economic zone. In many regions, the zone—which stretches 200 nautical miles offshore—easily covers the continental shelf. In places it doesn't, and the convention allows a nation to claim more territory if it can prove that the addition is a "natural prolongation" of its land mass. Originally, the first claims were supposed to be submitted by 2004, but it took the U.N. years to set up a review panel and write technical guidelines. When the new rules were approved in 1999, the U.N. reset the clock, with the first applications now due in 2009. Countries that don't apply lose their rights to the extra territory.

Analysts estimate that up to 60 nations could benefit from the provision, known as Article 76, with some cashing in bigtime. New Zealand officials, for instance, hope to add 2 million square kilometers, a 50% rise, and India could gain 1 million square kilometers. The United States could add territory off its northeast and northwest coasts and in Arctic waters off Alaska, holding an estimated $1.3 trillion in resources.

Before nailing down the extra territory, however, nations must meet complex criteria, which require them to document the depth and shape of the sea floor and the thickness of bottom sediments. To do that, some nations—including Australia, India, Brazil, and New Zealand—have already launched mapping programs, using sound produced by ship-towed seismic arrays to probe sea-floor geology and multibeam sonars to draw detailed three-dimensional maps of the ocean bottom.

The eye-popping maps have produced plenty of finds. Off New Zealand, for instance, researchers have documented chains of towering volcanoes and spectacular canyons. Off North America, they've been surprised by the number of giant undersea landslides. "It's really shocking," says Mayer. "We might have known there was a canyon here or a slump there, but now we're seeing them everywhere."



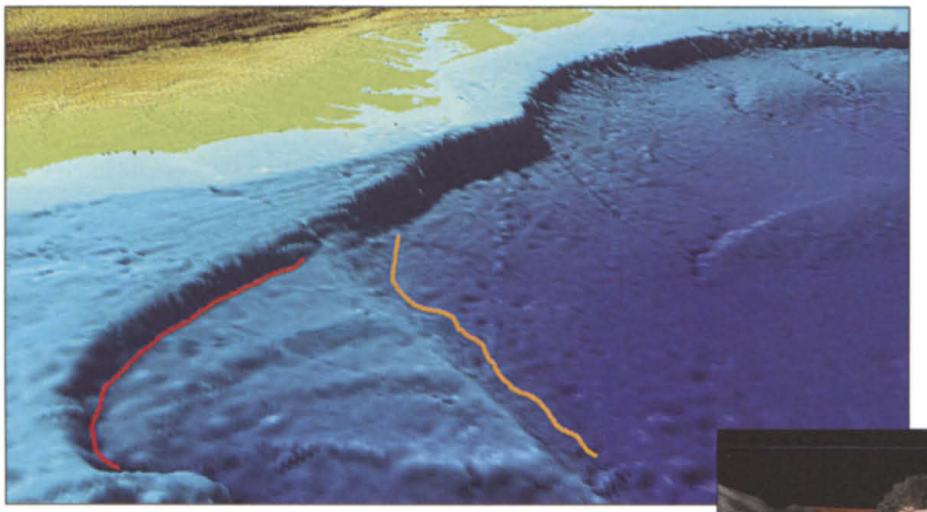
Pushing the limits. Up to 60 nations could extend their current exclusive economic zones (blue) out to the limits of the continental shelf (red) as they begin to implement the 1982 Law of the Sea convention.

Using the new maps, countries might be able to justify extending their boundaries up to 350 nautical miles offshore if there is an obvious shelf. Under more complicated scenarios, however, governments will need to show that submerged ridges are part of their continental crust, or lay claim to piles of sediment that have slid off the continental margin.

Such criteria can be a nightmare to apply, say Mayer and other researchers. One

challenge is pinning down a key baseline called the "foot of the slope"—the point at which the descending continental slope touches down on the relatively flat ocean bottom. But the line isn't easy to define on jumbled, real-world sea floors. Even in relatively clear topography, opinions can vary. "Presented with the same data, two researchers can end up kilometers apart," says Ron Macnab, a Canadian geophysicist who has spent years studying the issue.

Similar uncertainty can blur measurements of sediment layers, home to oil and gas deposits. In general, the convention envisioned national borders petering out at the thin seaward edges of sediment deposits. But the sound pulses used to probe marine sediments can be notoriously difficult to interpret. If a layer of molten rock invades an older sedimentary complex, for instance, researchers might detect a kind of "false bottom" and underestimate sediment thickness. "The margin of error can be huge," says Macnab. Further confusing matters, sediments don't necessarily become progressively thinner as they extend offshore. In fact, they can thicken farther from land due to currents or geological quirks.



An added dimension. A 3D view of the sea floor provides a clearer view of the foot of the continental slope (red line) than do older methods (orange line). Geoscientist Larry Mayer (*right*) is helping to develop these new sea-floor mapping tools.

Ruckus over ridges

The convention's most controversial provisions, however, deal with submarine ridges, say geoscientists. Governments can claim the sea floor along these underwater mountains if they are continental appendages. But Russia's attempt to claim one ridge has sparked a heated debate.

Last December, Russia became the first nation to submit a sea-floor claim to the U.N.'s Commission on the Limits of the Continental Shelf. The panel of 21 experts reviews shelf claims, and although it doesn't have the authority to reject them, it can recommend changes. The idea, say international law experts, is for the panel to give claims a scientific "seal of approval" that is accepted by all nations.

In its pathbreaking claim, Russia filed a plan that calls for adding nearly 1 million square kilometers to its Arctic territory. Although the claim's details are confidential—Russia was required to publicly release only a map showing basic boundaries—experts say it is based on the idea that the Alpha-Mendeleev Ridge System, a huge undersea formation that bisects the Arctic, is an extension of the nation's land mass. But the United States and some other nations disagree. "The submission has major flaws," U.S. officials wrote in a letter to the U.N., citing "mounting geologic and geophysical evidence" that the ridge was instead "formed on oceanic crust." The ridge's telltale magnetic signature, for instance, can't be found on Russian land, the letter noted, suggesting that the ridge isn't connected. If true, that would make the formation part of a common area open to all nations.

A seven-member review committee appointed by the commission apparently agreed with the critics and in July recommended that Russia reconsider its Arctic claim. "It pretty well crashed," says one informed source, who requested anonymity. Russian officials could not be reached for comment, but reportedly they are studying the recommendation.

Outside experts say that the commission did the right thing, but some question its reliance on secrecy. "The problem is that other nations can't learn from Russia's experience or independently evaluate the data upon which it based its claim," says one geoscientist. "So we're somewhat in the dark about what the commission considers to be a credible submission." Commission head Peter Croker, Ireland's petroleum resources chief, says he's sympathetic but that the commission's "hands are tied" by U.N. confidentiality rules. Still, he and others hope the body will find ways to release more information about future reviews and come up with a mechanism for resolving potential disputes.

The uncertainty hasn't stopped Mayer and others from figuring out how much new data their governments will need to draw defensible maps. In an analysis published this summer (www.ccom.unh.edu/unclos/index.htm), Mayer and two colleagues concluded that the United States already has most of what it needs to make a case for extensions off New England and Alaska, but not in the Arctic. Filling the gaps would take several years and cost up to $22 million, they estimate, and several agencies have already drawn up plans to start work as early as next year.

The United States will have 10 years to apply once it formally signs on to the convention. The odds of that happening improved with the retirement of Senator Jesse Helms (R–NC), a leading treaty opponent, whose successor takes office 3 January. Several government advisory panels have urged the Bush Administration to sign the treaty, and White House officials have signaled that they'll consider the idea. It is likely that the Senate would ratify that decision, observers say.

Current signatories, however, face a tighter 2009 deadline, and poorer nations are pushing the U.N. to beef up trust funds to pay for training and mapping so that they won't be left behind. Croker and other experts say poorer nations might be able to use publicly available mapping data to file a preliminary claim and then fill in gaps once they can afford to do their own surveys.

In the meantime, marine geoscientists are enjoying the view of the shelf produced by the latest land rush. Croker says the maps will lead not only to new political boundaries but also to novel ideas about how continents form, erode, and move. "We're just astonished," he says, "by our ignorance about continental margins." **–DAVID MALAKOFF**

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