The coast road

America's first inhabitants were people from Asia who migrated over a now-submerged land bridge between the two continents. But when did they come, and where did they go after making their crossing? Rex Dalton reports.

INSET, D. LOVE

Going underground: Timothy Heaton hopes that his summer caving expeditions in Alaska will shed light on the route taken by the first Americans, who hiked across a desolate strip of tundra thousands of years ago.

Along the storm-lashed coast of southeast Alaska, where dense forests shroud weather-pocked limestone formations, Timothy Heaton spends his summers prowling remote islands in search of a special cave. He drops into sinkholes, squirms through narrow tunnels, and probes the sediments of underground caverns.

The object of his dirty, challenging quest is a cave containing specimens that will answer one of the great mysteries surrounding the peopling of the Americas: the date at which the first human colonists crossed from Asia over a land bridge that now lies submerged beneath the Bering and Chukchi Seas, and where the travellers went after that.

Heaton, a vertebrate palaeontologist at the University of South Dakota at Vermillion, is one of a growing number of experts who believe that the first Americans migrated along the Pacific Coast among the islands and bays of Alaska and Canada, at a time when the North American interior was an inhospitable, ice-covered wasteland. Recent discoveries have cast doubt on the conventional wisdom that North America was first colonized by a culture of big-game hunters called the Clovis, who ventured south across the continent's central plains only after the ice sheets retreated, reaching what is now the southwestern United States at least 11,500 years ago.

Now there is an explosion of interest in studying the climatic, environmental and geological conditions that prevailed along the Pacific Coast during the past 35,000 years or so. Investigators have high hopes of finding physical traces of early coastal migrants, some of whom may have preceded the Clovis by many thousands of years. "We are just ramping up to nail down issues about the coastal route," says Julie Brigham-Grette, a geologist at the University of Massachusetts at Amherst.

Already, Heaton and his colleagues from the Institute of Arctic and Alpine Research (INSTAAR) at the University of Colorado, Boulder, have found a man-made tool that they have radiocarbon dated to about 10,300 years ago in a cave on Prince of Wales Island, southeast Alaska[1]. They have also found bear specimens dating back some 41,000 years[2] — which is tantalizing, because where bears can live, so can people.

Who came first?

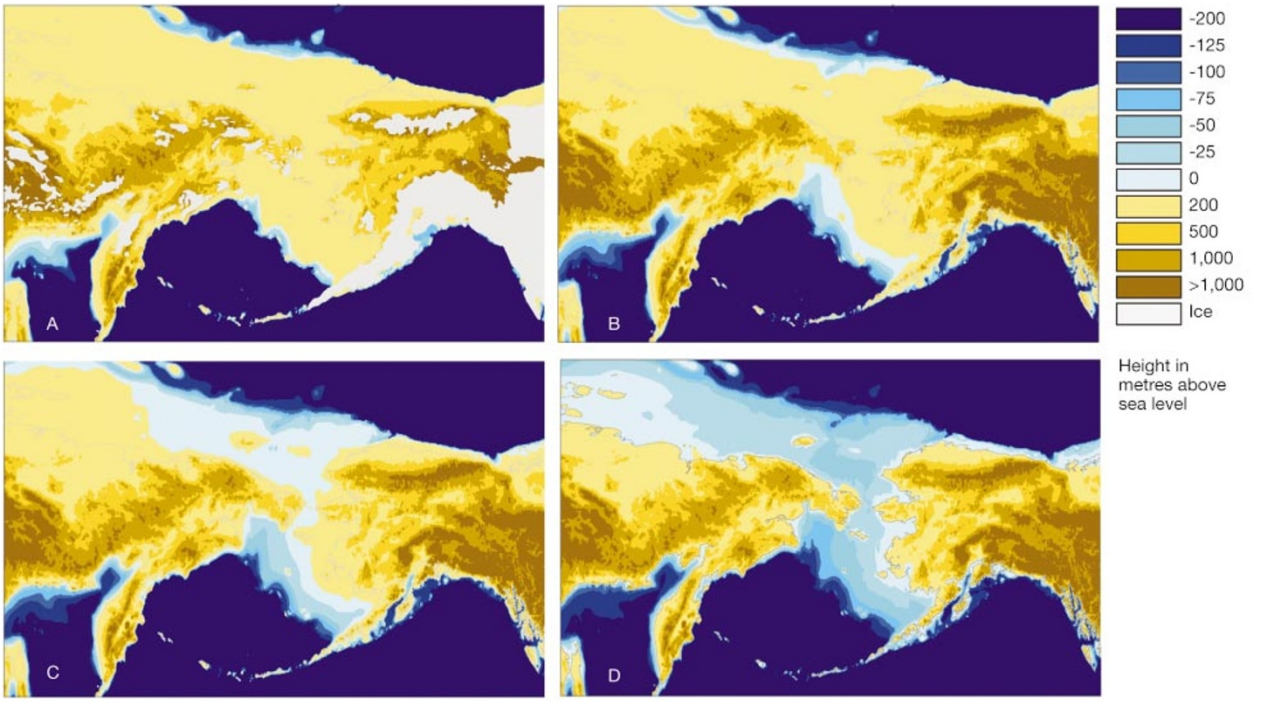
Archaeological discoveries made in New Mexico in the 1920s — in particular, distinctive fluted projectile points dating from 11,500 years ago — identified the Clovis as the first known Americans[3]. The timing seemed to make sense: before the ice melted, no one would have been able to migrate across the continent's frozen interior. And until about 2,500 years before the Clovis arrived in New Mexico, ice sheets extended throughout Canada and into the northern United States.

But more recent findings in South America have demolished the status of the Clovis as the original American pioneers. A quarter of a century ago, anthropologist Thomas Dillehay, now at the University of Kentucky in Lexington, made an astonishing claim: that a group of hunter-gatherers was well established at a site called Monte Verde in Chile 12,500 years ago[4]. For many years, the radiocarbon dating of Dillehay's specimens was disputed. But in 1997, Dillehay published a detailed monograph on the Monte Verde site[5] that silenced his critics once and for all.

If people had migrated almost to the tip of South America by 12,500 years ago, experts agree they must have begun trekking south from Alaska before the glaciers retreated from the American interior. So in the past few years, attention has turned to the coastal route, where the moderating influence of the Pacific Ocean may have kept conditions fit for human habitation. "We are seeing a major paradigm shift," says James Dixon, an archaeologist at INSTAAR who has investigated caves with Heaton.

Confirming the coastal route is no easy matter, however. The terrain is forbidding, harsh winters restrict field studies to the summer months, and much of what was then the Pacific Coast of North America is now underwater. When the glaciers finally melted, the sea level rose by some 125 metres, covering both the land bridge from which the first American colonists migrated from Asia — a strip of tundra some 1,000 kilometres wide known as Beringia — and regions that now lie on the coastal shelf off southeast Alaska and British Columbia.

Last summer, a team of 20 scientists from five US institutions began the most ambitious study yet of Beringia. Led by Brigham-Grette, together with Lloyd Keigwin, a palaeoclimatologist at the Woods Hole Oceanographic Institution in Massachusetts, and Neal Driscoll, a geologist at the Scripps Institution of Oceanography in La Jolla, California, they sailed aboard the *Healy*, a new icebreaker operated by the US Coast Guard, to the Bering



M. DUVALL/ BATES COLL./ WWW.NGDC.NOAA.GOV/PALEO/PARCS/ATLAS/BERINGIA/LBRIDGE.HTML

Bridging the gap: calculations of sea levels 18,000 years ago (top left) and 10,200 years ago (top right) show that a land bridge existed between modern Siberia and Alaska. By 8,900 years ago (above left) this land was submerged, creating today's Bering Strait (above right). Quoted ages are calibrated for consistency with archaeological radiocarbon dates, as given in the text.

and Chukchi Seas (see map, below right). There, the researchers collected cylindrical sediment samples, or cores, from the now-submerged land bridge and the neighbouring ocean floor. Previously, the Chukchi Sea's persistent ice had prevented studies. But in the event, unusually warm conditions meant that the *Healy*'s ice-breaking capabilities were not required. "It was embarrassing," confides Brigham-Grette. "We waited for an ice cutter and there was no ice."

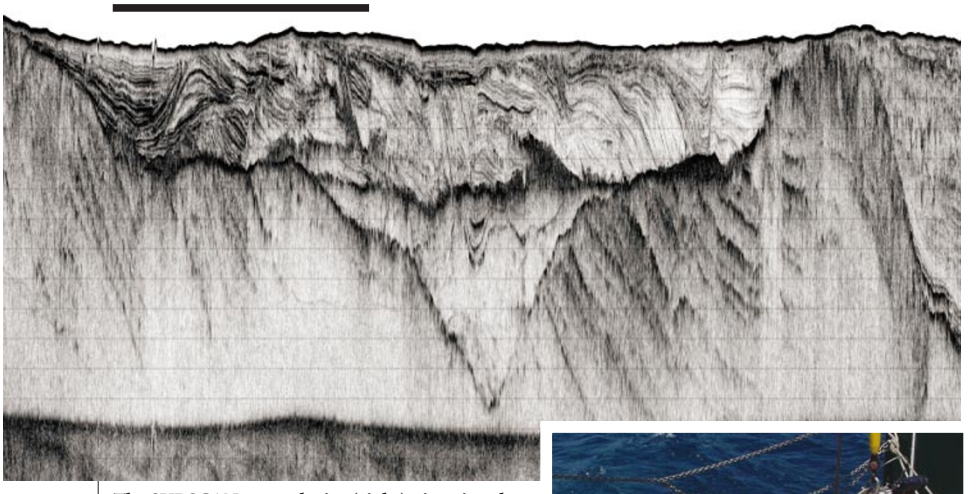
Steaming back and forth across the region over two cruises, each lasting three weeks, the *Healy*'s scientific crew pulled more than 100 cores from the sea floor. Some were at depths of 40–120 metres below the surface, on the former land bridge, whereas others came from depths of up to 2,500 metres in the deeper waters to the north and south. Now stored at Woods Hole, the cores will be subjected to extensive analysis to ascertain the climate, environmental conditions and sea level over the past 20,000 years. Research on the samples should determine, for instance, what portions of the land bridge were above water at what times.

Selecting sites for drilling, and obtaining intact cores, required some sophisticated technology. The scientists were particularly interested in sampling from former river valleys that are now submerged on the coastal shelf in the Chukchi Sea. But the valleys are overlaid by marine sediment, and are therefore hard to spot. Extracting intact samples from both marine and river sediments is also challenging because of their high sand content — which means that the cores are likely to fall apart when pulled from the ocean floor.

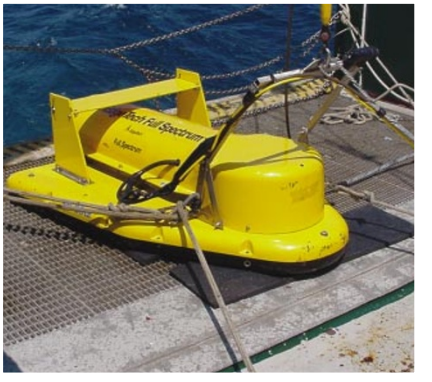
A state-of-the-art sonar device, called SUBSCAN, allowed the team to find the submerged river valleys. SUBSCAN — a bat-winged affair the size of a desktop — was developed by Driscoll, together with Steven Schock of the Florida Atlantic University in Boca Raton and a company called EdgeTech in the same city. Towed behind the *Healy* some 40 metres above the sea floor, SUBSCAN emits an acoustic pulse that penetrates the sea floor to a depth of 40 metres in sand, and to 100 metres in clay or silt. The device features an advanced system for analysing the reflected sound that allows it to build up an image of the sedimentary layers, from which the researchers can discern the difference between river and marine sediments. "The resolution of the images produced is just dynamite," says Brigham-Grette, who notes that they clearly reveal the elusive V-shaped river valleys.

To ensure that sandy cores didn't disintegrate, the *Healy* researchers used a device that was developed at the Coastal Carolina University in Conway, South Carolina. The apparatus is named 'Taz' after the Warner Brothers cartoon character, because of its dervish-like whirling action. After being lowered to the sea floor by a cable, Taz's two counter-rotating electric hammers produce a vibrating motion that forces a tube down into the sediment without disturbing the captured material. In conventional methods, a heavily weighted tube is driven into the ocean floor and pulled up with the core inside. But a sandy core has a tendency to fall out of the tube, so the Taz tubes feature 'fingers' at the bottom and also use suction to hold the sediment intact inside.

Although some 20 cores were pulled from



The SUBSCAN sonar device (right) pinpointed V-shaped river valleys in the Chukchi Sea floor.



Beringia's river valleys, there was a cost. 'Big Taz', the larger of the two devices, was lost after its cable snapped when the *Healy* was buffeted by a rough swell. It was a bitter blow for the Coastal Carolina team: "Those guys were almost crying," recalls Driscoll. But the researchers rallied, and welded a spare vibrating power head to a core tube to create a makeshift rig.

The cores will now be dissected to piece together a picture of life in Beringia. Pollen, other plant remains and beetles will be identified, and the specimens will be radiocarbon-dated. Various collaborators with special expertise will be brought in to assist the effort. For instance, Scott Elias, a palaeoentomologist at Royal Holloway, a college of the University of London in Egham, west of the city, will be looking for samples of beetles from lake sediment or peat bogs, which should reveal clues about Beringia's past climate and habitats.

Data from the *Healy* cruises should reveal when people would have been able to cross the land bridge, providing valuable background information for Heaton and his colleagues as they continue their search for signs of human activity in southeast Alaska. Heaton, a keen amateur caver, began exploring the region's caverns in 1991, and two years later struck lucky. In the north of Prince of Wales Island, he ventured into the 'On Your Knees' Cave — so named because it can only be entered by crawling through a narrow tunnel — which turned out to contain a host of specimens. Subsequent years of summer digs by Heaton and his archaeologist colleagues have unearthed the oldest signs of human habitation in the Pacific Coast region, from sediments in the cave's floor.

The specimens include a bone tool that has been radiocarbon dated to 10,300 years ago[1], a human bone dated at 9,200 years old[6], and blades made from obsidian — a volcanic glass found in lava beds — of the same vintage[7]. The latter have shown the ancient inhabitants of Prince William Island to be relatively well-travelled coastal seafarers. Craig Lee, an anthropology doctoral student now at INSTAAR, has used X-ray fluorescence spectroscopy to examine trace elements in the obsidian, and so determine its source. His studies show that the material in On Your Knees Cave came from Suemez Island, about 150 km to the south, and Mount Edziza, nearly 400 km to the northwest in mainland British Columbia[7].

First footers

In themselves, these findings don't explain how people got to Monte Verde so early, because they postdate Dillehay's Chilean discoveries. But Heaton is confident that much earlier signs of human settlement along the Pacific Coast of North America are just waiting to be found. "This was not the first guy in the area," he says of the single human bone uncovered so far. Indeed, his confidence received a major boost in 1994 with the discovery of the 41,000-year-old bear bones[2] in On Your Knees Cave.

Still, a significant problem remains, says Heaton: "So many of the areas where people roamed are underwater now." The key may be finding more caves like On Your Knees, which was exposed on the coast at the time of the initial southward migration and remains above sea level today. In this search, the work of Renee Hetherington of the University of Victoria in British Columbia could be crucial.

Tell-tale tool: this bone implement proves that humans lived in Alaska at least 10,000 years ago.

Hetherington studies molluscs, and last August in Anchorage, Alaska, at the seventeenth biennial meeting of the American Quaternary Association, she told how mollusc specimens, along with geological records, can point to areas where people could have survived during the most recent glaciation. As part of her doctoral studies, completed last spring, Hetherington investigated the region around Queen Charlotte Sound off the British Columbia coast — just south of where Heaton has been exploring.

Species of mollusc found in coastal waters — including clams, oysters and mussels — have certain environmental preferences, such as water depth, turbidity, salinity, temperature and sediment conditions. By carbon-dating mollusc shells, and studying the species present and the sediments in which they were found, Hetherington was able to determine the sea level and the positions of coastlines some 14,250 years into the past. Comparing her reconstructed map for this period with today's coastline revealed that hundreds of kilometres of the current British Columbia shoreline may have been exposed at the time when the migrants who eventually made it down to Monte Verde were passing through. "The trick is to determine an environment that is suitable for humans," says Hetherington. "The mollusc record can do that."

This June, Heaton will be returning to a promising cave he found in 2001 on Coronation Island, west of Prince of Wales Island. But he also plans to check Hetherington's maps for new targets to explore.

For Charles Schweger, an anthropologist at the University of Alberta at Edmonton, Canada, the convergence of the work of Heaton, Hetherington and the *Healy* crew is a welcome development. "People have languished far too long on the interior route," he says. "There are great new data and new ways to look at them."

Definitive evidence for the idea that America's first colonists migrated along the Pacific Coast during the most recent Ice Age may not yet have emerged, but Heaton suspects that there won't be a long wait. "It's just a matter of time," he says. ■

Rex Dalton is *Nature*'s US West Coast correspondent.

1. Dixon, E. J. *Quat. Sci. Rev.* **20,** 277–299 (2001).
2. Heaton, T. H. *Curr. Res. Pleist.* **12,** 92–95 (1995).
3. Haynes, C. V. *Science* **145,** 14098–14113 (1964).
4. Dillehay, T. D. *Sci. Am.* **251,** 106–117 (1984).
5. Dillehay, T. D. *Monte Verde: A Late Pleistocene Settlement in Chile* Vol. 2 (Smithsonian Inst., Washington DC, 1997).
6. Dixon, E. J. *et al. Geoarchaeology* **12,** 689–712 (1997).
7. Lee, C. M. in *32nd International Arctic Workshop of the Institute of Arctic and Alpine Research* 120–121 (INSTAAR, Boulder, Colorado, 2002).

E. J. DIXON/UNIV. COLORADO