Diving into the right whale gene pool

What is compromising the endangered species' ability to reproduce?

Like forensic detectives, a multi-institutional team of scientists has followed a thread of DNA from the highly endangered right whale population across the oceans and back through generations.

Using genetic techniques, the scientists undertook two studies: The first explored whether 16th-century Basque whalers struck a devastating blow to the North Atlantic right whale population and gene pool. The second sought to determine if a lack of genetic diversity (inbreeding) is now compromising the species' ability to reproduce.

Both studies resulted in surprising findings that change the explanations for the whale's near-extinction. They also will revise strategies to conserve the species, which has not recovered in the 70 years since whaling was banned. Fewer than 350 remain, and the whales are having fewer offspring than expected.

In the first study, scientists from the New England Aquarium (NEAq) in Boston and Trent University in Ontario extracted DNA from skin samples collected from 56 percent of North Atlantic right whales identified since 1935, including 66 percent of the current population. By correlating the samples with a photographic catalog of whales identified over 26 years by NEAq, the researchers created "family trees" or genealogical charts for right whales.

"It shows us who mated with whom, who had successful calves, and who isn't having offspring anymore," said Trent University biologist Brad White.

The DNA profiles turned up genetic material in calves from fathers that have never been identified. These new paternity data suggest that there may be many more male right whales—representing perhaps an uncounted 10 to 15 percent of the entire male population—living in currently unknown habitats.

Family tree analyses also showed that successful pregnancies occur only between whales with sufficiently different genetic profiles. Inbreeding and genetic similarity in animals (including humans) often result in unsuccessful fertilization and in high rates of spontaneous abortion. The study suggests that the low level of genetic variation in the small North Atlantic right whale population may partly explain its low reproduction rate, said Moira Brown and Rosalind Rolland at NEAq.

Moira Brown, New England Aquarium

▲ **Equipped with bug jacket and sterile drill bits (lower right), Trent University graduate student Brenna McLeod extracts samples for DNA analyses from two whale rib bones, perhaps left behind by 16th-century whalers, in Five Leagues Harbour on the lower north shore of Quebec.**

For the second study, scientists from NEAq, Trent, and Woods Hole Oceanographic Institution traveled to remote regions of eastern Canada to search for old bones left behind by Basque whaling.

"In 1535, Basque fishermen initiated a whale fishery in the Strait of Belle Isle, between what we now call Newfoundland and Labrador," said WHOI biologist Michael Moore. "To the Basque it was a land of opportunity, a gold rush for whale oil to light Europe, which lasted to the early 1600s."

In the 1980s, scientists exhumed preserved whale bones from the wreck of a Basque galleon that sank in 1565 in Red Bay, Labrador. Based on their physical characteristics, half the bones were initially identified as right whale bones. That led scientists to believe that extensive Basque whaling caused a dramatic decrease in the North Atlantic right whale's population and extensive genetic loss.

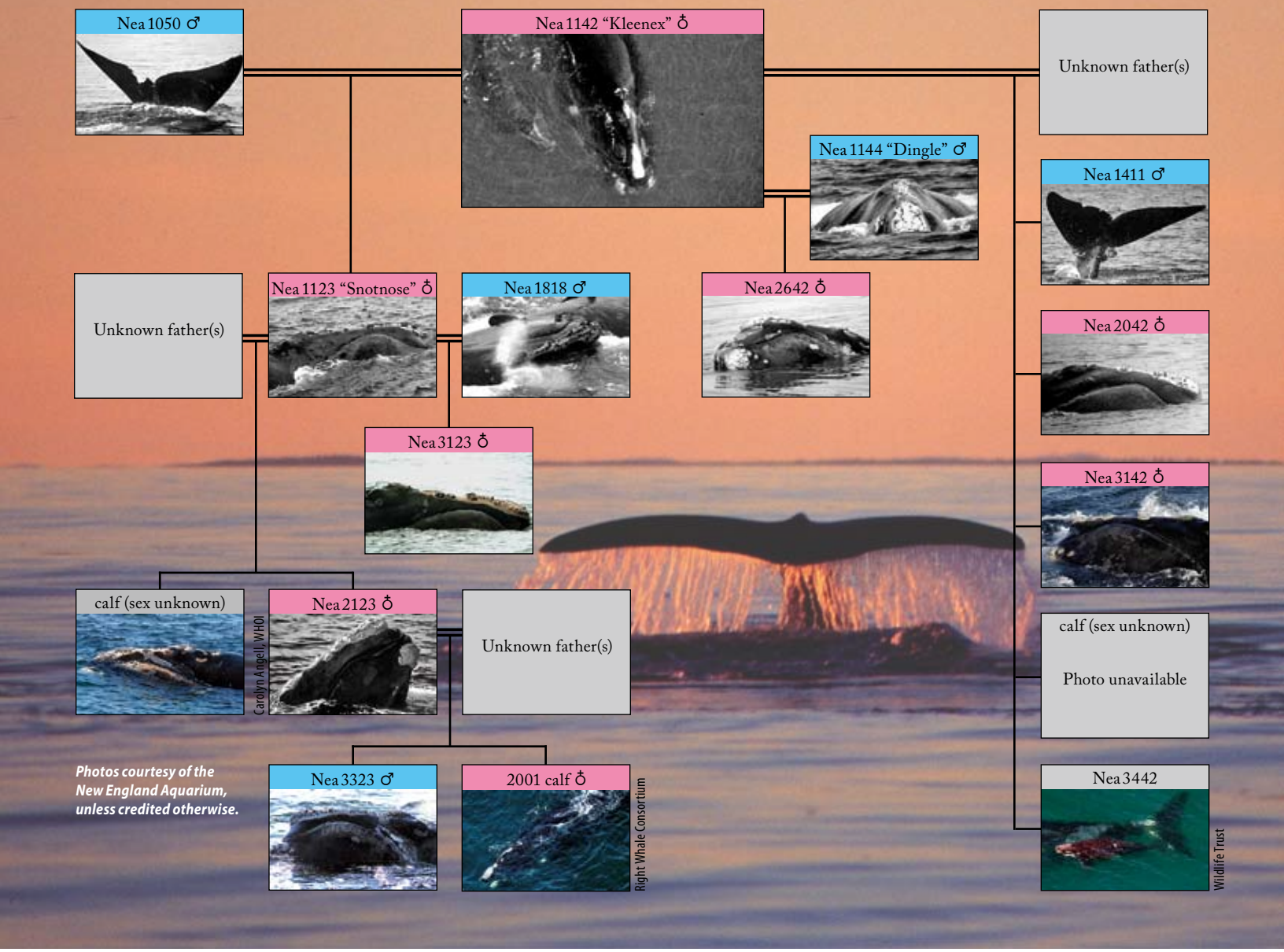
With the advent of molecular genetic techniques, scientists began to extract DNA from the old bones. A pilot study in 2003 showed that DNA could be gathered from more weathered bones found on land, significantly increasing the potential number of samples to test the Basque theory.

In 2004, the research team launched an expedition aboard Moore's sailboat *Rosita* to search for samples that had rested undisturbed on beaches for 500 years. They ventured near previously identified Basque whaling ports on the Strait of Belle Isle, which Moore called "a place of cold water, icebergs, gales, and fog, often all at once."

Many sites were identified by the presence of terra cotta tiles, which the Basques used first for ballast and then for roofing over cooperages and blubber-rendering ov-

The "Kleenex" Family Tree

Combining DNA analyses with an extensive catalog of photo-identified whales, researchers can now construct "family trees" for right whales, like this one for a matriarch whale named "Kleenex."



ens. The researchers walked along the shore, sometimes through vegetation infested with mosquitoes and black flies, to collect bones. In 2005, the team investigated 16 more potential Basque whaling stations in ever more remote areas, many inaccessible by road.

DNA analyses were conducted on 81 of the 215 bones collected in 2004. The results showed that 80 came from bowheads, one from a finback, and none from right whales. To date, 210 bones from 10 known Basque whaling sites have been analyzed, and only one specimen came from a right whale. The genetic characteristics of that single right whale bone resembled those of whales in the current population.

The studies suggest that the Basques had little impact on right whales and that the species' population size and genetic variability has been low for much longer than previously believed. If that's true, the species' potential to recover is lower and may take longer than previously assumed.

"These initial analyses have rewritten the history of the species, revised estimates of historic population size, and revealed previously unknown aspects of reproductive success," the researchers said. "They could have significant implications for present recovery strategies."

—Lonny Lippsett

This research was funded in part by the Penzance Foundation, through the WHOI Ocean Life Institute's Right Whale Research and Conservation Initiative. The research team for the genetic diversity study, led by Moira Brown and Rosalind Rolland at NEAq, included Heather Pettis (NEAq); Brad White, Roxanne Bower, Tim Frasier, and Brenna McLeod (Trent University); marine archaeologists Robert Grenier and Willis Stevens from Parks Canada, and Stephen Cumbaa from the Canadian Museum of Nature. The research team for the Basque bone study included Brown, McLeod, White, and Michael Moore (WHOI).