Canadian Zooarchaeology / Zooarchéology canadienne

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Editor's Note / Note de l'éditrice

Canadian Zooarchaeology is back!! After a year's absence we are anxious to get back to reporting on all things zooarchaeological, and to hear from you what is happening in the zooarchaeological world.

In this issue we have 3 excellent features: a detailed, informative article by Stephen Cumbaa, Moira Brown and Bradley White.on whaling and archaeological whale bones from Red Bay, Newfoundland, and how zooarchaeologal analysis and DNA sampling complement each other to document the history of 2 endangered whale species. The article is accompanied by superb photos. Second, this year - 2002 - saw the 9th ICAZ conference, held in Durham, England, and we have a report on the goings-on at the meeting by Susan Crockford. And last, we have a commentary by Susan Crockford discussing recent views published in *Science* on dog origins and evolution, and how domestication of dogs has implications for human health care.

This issue is free to all our previous subscribers as thanks for your continuing support!! And please don't forget to send us a cheque for the two upcoming 2003 issues, for $8.50. No, we STILL haven't raised our subscription rates! Please subscribe, and also let us know what you have been up to -short or long reports on field-work, lab work, your current research, anything zooarchaeological would be much appreciated.

All the best for 2003!!
Kathlyn Stewart, Editor
Donna Naughton, Assistant Editor

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Cover by Debbie Yee Cannon

An ICAZ 2002 REPORT

by Susan J. Crockford

Knowing I was headed for the northern UK, my first priority was to satisfy my Toronto-bred passion for bagpipes, an appreciation that started in infancy and developed over many years of family parade attendance. A visit to the spectacular Queen's 25th Anniversary version of the annual Military Tattoo at Edinburgh Caste fulfilled that need. Then I was off to Durham for the 9th conference of the International Council of Archaeozoology (ICAZ), August 23-28.

An observation made by Jon Driver (Simon Fraser University, Vancouver) on the last day of the meeting prompted this piece: hadn't there been more papers specifically on dogs this time than at conferences held before the dog symposium I'd organized in Victoria (1998)? When I got home I added them up. Certainly there had been quite a few, with 21 papers and poster presented during a session organized by Lynn Snyder (Smithsonian Institution, D.C.) and an additional 13 scattered throughout other sessions. That total of 34 falls a bit short of the 50 presented in Victoria but it leaps beyond only 14 given at the 1990 conference in Washington, D.C. By percentage of total papers listed in the final programs, the numbers are quite impressive (I didn't take no-shows into account, assuming this phenomenon was as common for dog-related papers as others): dog papers comprised 4.3% of the total in 1990 (34/417), 15.5% in 1998 (50/323) and 8.2% in 2002 (34/328). So yes, I think it's safe to say that the Victoria symposium was successful at increasing the reporting of dog remains at these conferences.

Does this mean, as several have suggested, that a "Dog Working Group" is the next step? ICAZ working groups are meant to be special-interest focus groups that get together outside the quadrennial meeting to encourage and coordinate work on their subject. My opinion is that an ICAZ Dog Working Group would be the wrong way to go. As I pointed out in Victoria, dogs are the only animal that all ICAZ members have in common. People that deal with dogs from archaeological contexts are not a "special interest" group – it's all of us. What is called for here is either a dedicated organization with its own separate meeting or a format within ICAZ meetings that removes the conflicts with other topics. I admit even I chose to duck out of the last part of Lynn's dog session in Durham to sit in on some papers on the first steps of mammal domestication that I didn't want to miss. I was also disappointed to have missed two full days worth of sessions on interesting topics due to my hosting responsibilities in 1998. While a bit more care in scheduling might have avoided these particular kinds of conflicts, there will always be folks who are torn by competing interests.

I'm going to suggest an alternative for the next ICAZ meeting that I hope might be seen as a useful and viable option. I have a vision of a special poster/workshop session on dogs and their ancestors (i.e. wolves), where space can be set aside to group the presentations together, which could include both posters and actual specimens brought for display. Any aspect of archaeological canid remains could be presented (burial practices, size descriptions, butchering, pathologies, etc.), but with one qualifier: that an "essential data" sheet be provided for each individual animal or group of animals reported on in the poster. This essential data would include things like chronological date(s), location, sex and taxonomy (e.g. suspected hybrid). It would also include some basic skeletal measurements as well as descriptive information on traits identified at the 1998 meeting as potentially important in a global context: shape of the coronoid process of the mandible and tooth wear pattern (Crockford 2000). These data could easily be compiled into a central database regardless of the focus of the original presenter and in addition to any subsequent publications on the material.

As for other poster sessions, a late afternoon poster viewing session for the canid poster workshop could be worked into the timetable, with authors present to answer questions. I don't believe anyone should be required to present their data in this format, but if an oral paper is to be given, then the "essential data" sheet should be made available during the dog poster session as well. I don't believe that would be considered an unreasonable requirement.

What I hope would be accomplished by this specialized poster session concept is twofold: it would absolutely eliminate the problem of dog papers conflicting with other interesting sessions and would begin the important process of generating a global database on archaeological dog remains. As I've mentioned in my 1998 symposium proceedings commentary paper (Crockford, 2000), there are some questions about dogs we will never be able to answer until such a data base is compiled. We would still need someone, or a group of someones, to volunteer for the job of creating that data base, but I don't think that should be a major stumbling block.

I have advanced this idea to Raul Valadez, our colleague in Mexico who has devoted many years to the study of dog remains. Raul is the natural choice as local organizer of any dog session for the next ICAZ meeting in Mexico City (2006) and I'm still waiting to hear what he thinks. Regardless of his reaction, I would appreciate feedback from any archaeozoologist out there who has an opinion on this idea, pro or con: contact information is below. I'll let you know what the consensus is in a future issue.

Crockford, S.J. 2000. A commentary on dog evolution: regional variation, breed development and hybridization with wolves. pg. 295-312. in S.J. Crockford (ed.) *Dogs Through Time: An Archaeological Perspective*. Oxford, U.K. Archaeopress S889.

[this proceedings volume is available in North America through: **The David Brown Book Company, P. O. Box 511, Oakville, CT, 06779 USA - for a cost of US$94 plus S/H. This may seem expensive but it's the most comprehensive volume on dog skeletal remains available. Ask your librarian to order it.**
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NOT THE LAST WORD ON DOG ORIGINS

by Susan Crockford

Many of you will now have seen the two reports on dog origins in the latest issue (November 22) of Science (Savolainen et al., 2002; Leonard et al., 2002). Don't worry, these are not the last words that will be written on the topic. These authors seem unaware or unconcerned with the lively ongoing debate on the timing of human migrations into North America. In addition, as for an earlier Science paper on dog/wolf genetic relationships (Vilà et al., 1997), they draw their conclusions with little acknowledgement of the long and complex historical relationship that dogs have had with both humans and wolves. Dogs are a truly unique species and unravelling the where, when and how of their origins is going to require quite a different approach than has been used for other animals. Wolves and dogs are not only unlike wild species pairs, they are unlike other wild/domestic pairs in many important respects.

For example, the wolf is the only ancestral species of a domestic animal that has survived with an extensive distribution and relatively high population numbers into the 20th century.

In contrast, the last auroch individual (ancestral species to cattle) died about 500 years ago and healthy wild populations were probably rare long before that time. Although wild pigs, sheep and goats still exist, they all have rather limited geographic distributions and low population numbers. Dogs also differ from other domesticates in that they were uncontrolled and unconfined for almost all of their history: Dogs were generally not tethered, fenced-in or similarly restrained, except by a few noble classes in the last few thousand years (Crockford 2000a). This means that in most places of the world, dogs have been free to breed with whomever they chose, including the occasional wolf, for virtually all of their history.

The truth is that we know very little about how hybridization over time between wolves and dogs has affected the mitochondrial DNA (mtDNA) composition of living and extinct wolf populations. I learned this the hard way - the research team from the University of Victoria that I was working with on Northwest Coast prehistoric dogs had a couple of "wolf" samples donated by wildlife conservation officers that showed up with modern dog mtDNA (Koop et al., 2000). Genetic researchers Carlos Vilà and Robert Wayne declared a few years ago (1999) that hybridization with dogs has had a minimal impact on wolf populations world-wide. As I have stated in print before, I consider this statement to be premature (Crockford 2000a). These authors were only able to draw their conclusion because they overlooked vital aspects of the human/wolf/dog relationship, unfairly generalized a few relevant studies on wolves, ignored hybrid behaviour, and minimized our ignorance about the fate of known hybrids in the wild. In fact, female dogs are much more likely to mate successfully with male wolves on the rare occasions when crosses do occur: this is also true for most wild/domestic pairs. Using the domestic species as the female partner is by far the easiest way of deliberately producing a wolf/dog hybrid, as any hybrid puppy-mill owner will tell you.

Hybrid offspring of a female dog and a male wolf are also much more likely to leave their maternal group (with humans) and join their paternal species (wolves) in the wild. This would have been as true 10, 000 years ago as it is today. Because of the way that mitochondrial DNA is transmitted (passing unchanged from mothers to offspring), this would have occasionally moved dog mtDNA haplotypes into wolf populations throughout the Northern Hemisphere. Female wolves that possess dog mtDNA pass it along to all of their offspring and it becomes a genetic scar that not only doesn't go away, but increases in frequency with every generation. This potential for long-standing introgressive hybridization does not make wolves "hybrids," but given the dramatic fall in numbers of wolves in the 19th and 20th centuries (and subsequent population rebounds in some areas), it does raise the question of whether the mtDNA of any living wolf can really be counted on to represent a unique wolf haplotype. Could all living wolves possess mtDNA "scars" from hybridization events with ancient dogs, a 10,000-15,000 year accumulation of common and rare ancient dog haplotypes that no longer exist in living dogs? I contend we will only know for sure if we analyze the mtDNA of wolves before dogs came to be and work forward.

Another issue raised by these Science papers that is almost as important as introgressive hybridization is the fact that we still do not know what biological process rapidly transformed some wolf ancestors into this amazing species we call a dog. Contrary to what all of us have been taught to believe, there is growing evidence that the initial stage of domestication in most animals was actually a natural speciation process. In other words, some wolves simply domesticated themselves. People had nothing to do with it other than to providing the a new environmental conditions

(Coppinger and Coppinger 2002; Crockford 2000b). Recently, thyroid hormones have been implicated in this process - not only in domestication changes but in the speciation of all animals, including humans (Crockford 2002a, b, in press). If this hypothesis proves valid, there are enormous implications for human health care (in press). There is more at stake here than satisfying intellectual curiosity and contrary to popular opinion, simply decoding the dog genome is not apt to get us very far (Pennisi 2002). Understanding the biological process that turned wolves into dogs, and later allowed humans to turn a generic dog into morphologically and behaviorally distinct breeds may be essential for understanding how and why thyroid hormones have such a strong impact on human health. Yes, there is still a lot of work to be done on the topic of dog origins and evolutionary history - many important questions remain unanswered.

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ZOOARCHAEOLOGICAL AND MOLECULAR PERSPECTIVES ON BASQUE WHALING IN 16TH CENTURY LABRADOR

Stephen L. Cumbaa, Canadian Museum of Nature; **Moira W. Brown**, Canadian Whale Institute and Center for Coastal Studies; **Bradley N. White**, Trent University.

Abstract

Whale bones recovered from the excavation of a 16th century Basque whaling station in Red Bay, Labrador are providing valuable data for archaeological interpretation as well as for biological studies of extant whale populations. Zooarchaeological studies on more than 2000 bones found during exploration of the harbour, and of specific activity areas such as wharves and ovens, give insight to Basque whale hunting, flensing, oil production and carcass disposal techniques. The principal prey species, the North Atlantic Right Whale (*Eubalaena glacialis*) and the Bowhead (*Balaena mysticetus*), are endangered species not native to the area today. Work now underway will compare DNA extracted from bone dust or shavings from the archaeological specimens with DNA isolated from skin samples obtained from the extant populations of these prey species. This molecular work could help determine the historic levels of genetic variation within the whale populations, the mitochondrial sequence profiles of the populations of whales hunted by the Basques, and confirm the species identification of whale bones.

Introduction

The discovery and subsequent excavation of the wreck of the 16th century Spanish Basque whaling galleon *San Juan* in the harbour of Red Bay, Labrador (Fig.1), was the focus of a major multidisciplinary archaeological field research project from 1978 through 1985 (Tuck and Grenier 1981; Grenier and Tuck 1985). Underwater excavations in Red Bay harbour were under the direction of Robert Grenier of Parks Canada, and excavation of the vestiges of the shore-based whaling station surrounding the harbour and on its islands was under the direction of James Tuck of Memorial University of Newfoundland. One of us (Cumbaa) participated as project zooarchaeologist from 1980-1985. Much new information was discovered from the archaeological excavations and the subsequent study of bones and artifacts, and also from archival research on the earliest recorded European whaling in North America. We will summarize some of that information here as it pertains to whaling. The great majority of whale bones recovered by Parks Canada archaeologists, which form the basis of this study, have been stored in Red Bay, Labrador since their excavation. In 1999, two of us (Cumbaa and Brown) returned to Red Bay to sample some of the whale bones for DNA studies. Here we discuss briefly the relevance of molecular research now in progress on these samples taken from the bones of whales hunted by the Basques nearly 450 years ago.

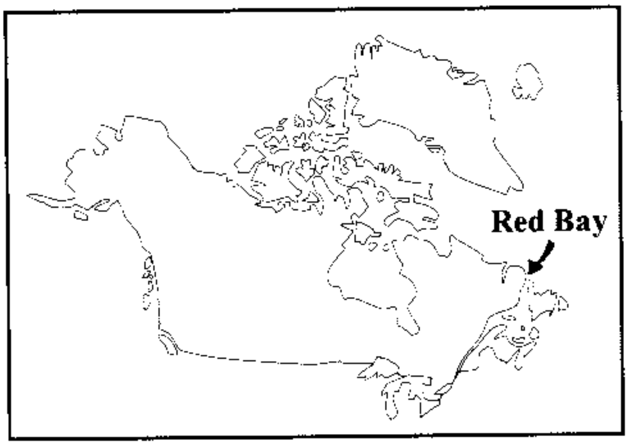

Fig. 1. Approximate location of Red Bay, Labrador on the Strait of Belle Isle.

Basque Whaling in Europe and North America

French and Spanish-speaking Basques living along the Bay of Biscay were Europe's first and most renowned whalers (Markham 1882; Proulx 1986). From at least the 11th century, they regularly hunted whales from small boats, primarily North Atlantic Right whales as they migrated north and south close offshore from the Basque ports. By the 15th and early 16th centuries, right whales were harder to come by along the Basque coast, but a few were killed up into the 19th century, the last one as late as 1880 (Markham 1882; Robert Grenier, pers. comm.to S. Cumbaa). These right whales were the target species, presumably due to their nearshore coastal migration habits, their slow swimming speed, and the fact that their thick blubber layer, which prevented the dead whale from sinking, produced copious quantities of economically valuable oil (Barkham 1984; Aguilar 1986). The Basques apparently hunted right whales as far north as the waters off Norway.

Basque Whaling in Red Bay

Historians debate the impetus for the Basques to have sailed westward from Europe to hunt whales in the cold waters off Labrador, but there is no doubt that they did, and in numbers. Some say they followed the cod fishermen; others give credence to Basques hunting whales farther afield, off Iceland and around to northern North America.

Regardless, off the shores of southern Labrador they discovered rich stocks of both Atlantic cod and whales. Although the journey was long and dangerous, the potential economic payoff was awesome. Research by Parks Canada historian Jean-Pierre Proulx has shown that a single season's full cargo of 1000 to 1500 barrels of oil could have been sold for enough to amply cover the cost of building and outfitting a new galleon, and leave a substantial profit besides (Proulx 1993). In today's dollars, Proulx estimates a full cargo of oil at a value of about 5 million dollars, with each whale worth at least a quarter-million dollars. By the late 18th and early 19th centuries the baleen plates, or whalebone, became more valuable than the oil, but there was no ready market for whalebone before about 1580. We do have some evidence of baleen removal from Red Bay whales; cuts on the ventral surface of one or two maxillae.

Archival research in the Basque country by Selma Barkham and others indicates that Red Bay was one of the most important of several whaling stations in operation along the Strait of Belle Isle in the 16^{th} century, largely due to its protected harbour (Barkham 1977; 1978; 1982). Red Bay was in operation on a more or less annual basis from at least the 1540s to the first decade of the 17th century, although only a few ships were making the voyage by late in the century. In peak years, about 20 Basque ships worked the Labrador coast, and more than half made the harbour at Red Bay their base during the June through November season (Proulx 1993). With crews of 50-120 men per ship, the summer population of 1,000-1,500 souls was far larger than the numbers Red Bay has seen since. Ships occasionally over-wintered, although apparently not on purpose, and there is both archival and archaeological evidence of lives cut short. Perhaps as many as 540 men died in the winter of 1577 alone, when two ships were trapped in the harbour by rapid ice development (Proulx 1993).

Whaling along the narrow Strait of Belle Isle was shore-based. Harpooners apparently operated from small *chalupas*, or whaling boats, possibly with lookouts at high points signaling the crews when whales approached (Proulx 1993). Once struck and killed, the whales were towed back to the ship or into the harbour for flensing. One such *chalupa*, discovered during the excavations and now conserved and reassembled, is on display at Parks Canada's interpretation centre at Red Bay.

Archaeological research at Red Bay shows considerable evidence of Basque whaling operations. Wreckage of 3 galleons, a cemetery, the remains of 9 oven complexes, 2 cooperages, several look-out posts and other structures, a wharf or cutting-in stage, and concentrations of whale bones can be identified. Most of the whale remains to be discussed here were excavated underwater from stratigraphically secure 16th century contexts, 20-40m offshore from the remnants of a large tryworks on the lee shore of Saddle Island, in the vicinity of the wreck of the *San Juan*, sunk in a November storm in 1565 (Barkham and Grenier 1978; Barkham 1984), (Fig.2).

Towed searches were completed of the harbour bottom, and land-based surveys on the islands and on the harbour shore, and in places considerable quantities of bone were found just under the sod (Cumbaa 1984). In a visit to Red Bay in 1705, a French sealer wrote that "One can still see the ovens where the oil was made, and the bones of the whales which lie on the shore like overturned tree trunks one atop the other. They must have killed more than two or three thousand, to judge from the quantity of bones which we counted: 90 heads in just one place, of enormous size"(Bélanger 1971). Inhabitants of Red Bay in the 1980s recalled boatloads of whale bone being removed in the mid-20th century by carvers based across the Strait of Belle Isle at the Grenfell Mission in St. Anthony, Newfoundland (Reg Moores and Ewart Bridle, pers. comm.. to S. Cumbaa). There were still at least 40 skulls there on what the local people call Bony Beach (Tracey Beach on maps) in summer 1999, 294 years after the sealer's visit (count by Cumbaa and Brown). Parks Canada's sample of excavated and catalogued whale bones from underwater excavations numbers approximately 2,000. These and other bones were identified by the senior author as part of a multi-year arrangement between Parks Canada and the Zooarchaeological Identification Centre of what is now the Canadian Museum of Nature.

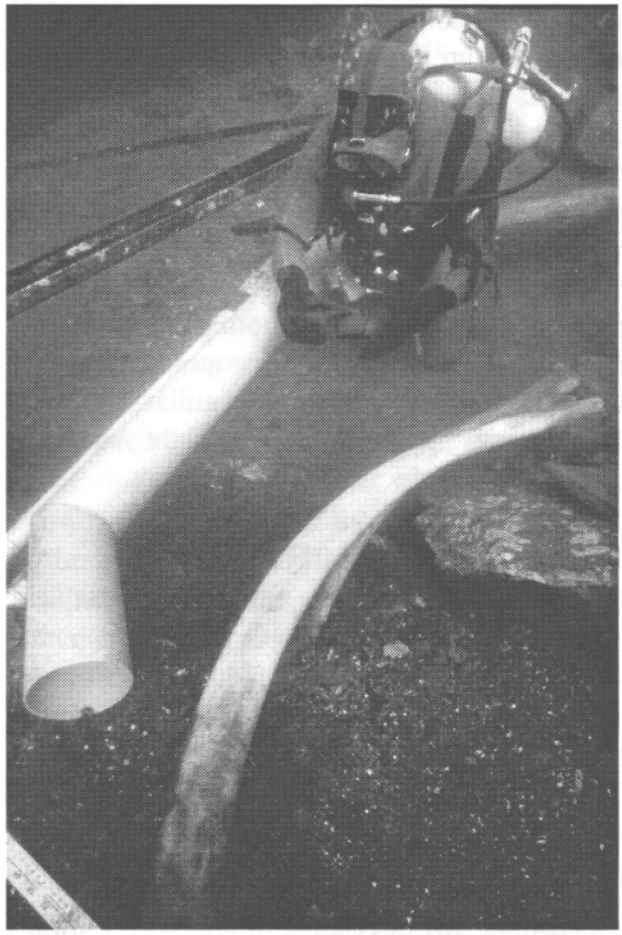

Fig. 2. Parks Canada diver using a dredge to uncover balaenid whale ribs from near a 16th-century Basque "cutting-in" stage, or wharf.

Prey Species: Identification, Processing Techniques, Seasonality and Numbers

Based primarily on differences in the skull, the humerus and the scapula, we know from examination of the bones recovered from Red Bay that the Basques were taking North Atlantic Right and Bowhead whales, both members of the family Balaenidae (Cumbaa 1986). Of nearly 2,000 whale elements recovered, only two - the tooth of a killer whale and a rostrum of a balaenopterid - are clearly not from one of the two principal species. As the killer whale tooth was excavated from within the wreckage of a *piñaza,* a small harbor yacht, it may have been a keepsake.

Neither the right nor the bowhead occurs in the Strait of Belle Isle today. The northern range of right whales is not much north of the Bay of Fundy, well to the south of the Strait of Belle Isle, and the bowhead is an ice-edge species, confined today to Arctic waters. The climatic variations of the Little Ice Age as well as much larger historical populations of these species probably had a fair bit to do with these differences in range. Both whale species were large - bowheads up to 65 feet long and 110 tons, and right whales up to nearly 60 feet and 70 tons, and the techniques for harvesting and processing them, based on documentary and archaeological evidence, were the same.

The bones found at Red Bay certainly did not fit the pattern of random drift as might be expected of dead, flensed whales left to founder. Rather, there appears to be a consistent pattern uncovered in the near-shore excavations that indicates a purposeful processing technique. A multitude of deep cut marks indicates that flippers were removed, sometimes used as a pad for chopping blubber, then were tossed over the side of a ship moored near shore or slid into the water from land (Fig.3).

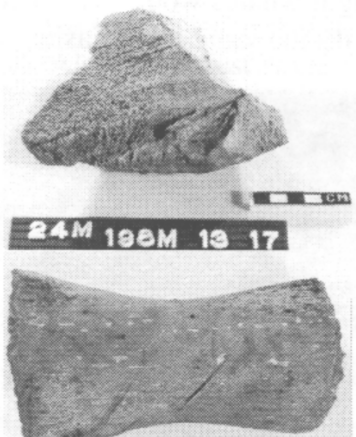

Figure 3. Cut marks on whale bones from the shore trench, which established secure context by stratigraphically linking the stern of the 1565 wreck of the *San Juan* with debris from 16th century Basque operations on Saddle Island in Red Bay harbour. Upper: Proximal humerus fragment exhibiting numerous heavy chop marks, possibly made by a heavy flensing tool when disarticulating the humerus from the scapula to remove the flipper. Lower: Phalanx with obvious heavy cut marks. On the stony ground or on board ship, a large, resilient flipper pad would have protected precious flensing tools or the ship's deck when chopping blubber into smaller pieces for the cauldrons.

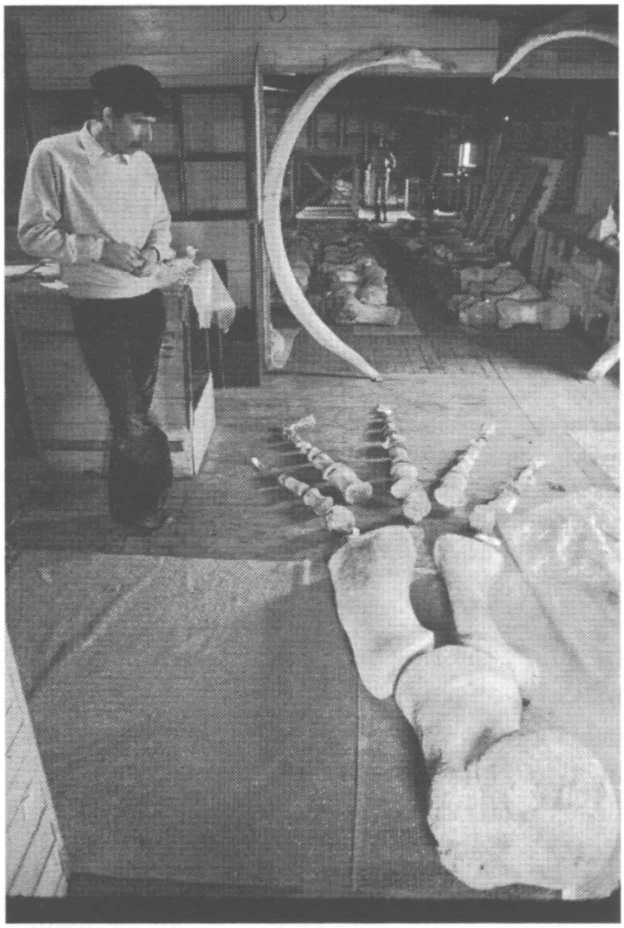

Figure 4. John Maunder, Newfoundland Museum, studies a Bowhead flipper re-assembled as found underwater by the Parks Canada marine archaeology team. This flipper is now in the Newfoundland Museum. Note ribs and rows of humeri in the background.

They settled, articulated, and several individual flippers were able to be "reconstructed" from Parks Canada's "as found" underwater photos and drawings (Fig.4). Consideration of the potential problems involved in turning a 60-ton whale to remove the blubber, with 7-10 foot long, paddle-like flippers attached, demonstrates the utility of removing them first. The same is true of the tail (caudal fluke). We found a number of articulated sets of caudal vertebrae, many also with cut marks (Fig.5). One relatively complete, semi-articulated skeleton was found during our harbour survey - a young Bowhead whale, missing the caudal vertebrae and both flippers. It may have drifted or been towed away after flensing.

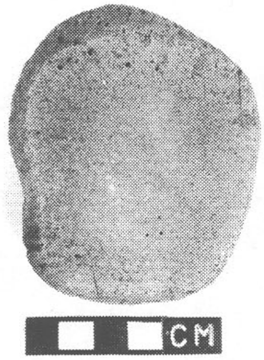

Figure 5. Chevron from set of balaenid whale caudal vertebrae found in anatomical position in the shore trench. Note cuts on dorsal and ventral edges. The anterior face of the centrum of the largest caudal vertebra from this and sometimes from other "sets" showed cut marks, probably made as the tail or fluke was removed from the whale.

Including the Bowhead carcass, the great majority of skulls, mandibles, ribs, and cervical, thoracic and lumbar vertebrae were found away from the ovens, on shores or up on beaches around the harbour such as 'Bony Beach'. Some of these shorelines do not collect drift today, and this may indicate purposeful removal of detritus from the main working areas (Fig.6). Certainly there are differences in flensing operations between the Basque operations at Red Bay and those depicted of Spitsbergen and later English and Dutch whaling efforts, which were primarily ship-based (Jenkins 1921).

Documentary evidence indicates the Basques in Labrador recognized two seasons for whaling, summer and late fall, and that might reflect the availability of the two prey species. It seems possible that the Basque whalers, arriving at stations along the Strait of Belle Isle in June, may have hunted the straggling remnants of the bowhead population heading north. More likely, from late June or early July to mid October they hunted right whales coming up from the south, and from about November until they left in early December the Basques must have hunted bowheads. The oil from 12-14 bowheads would fill a ship's barrels, but 18-20 of the smaller right whales would have been required to do the same job. Easier work, but

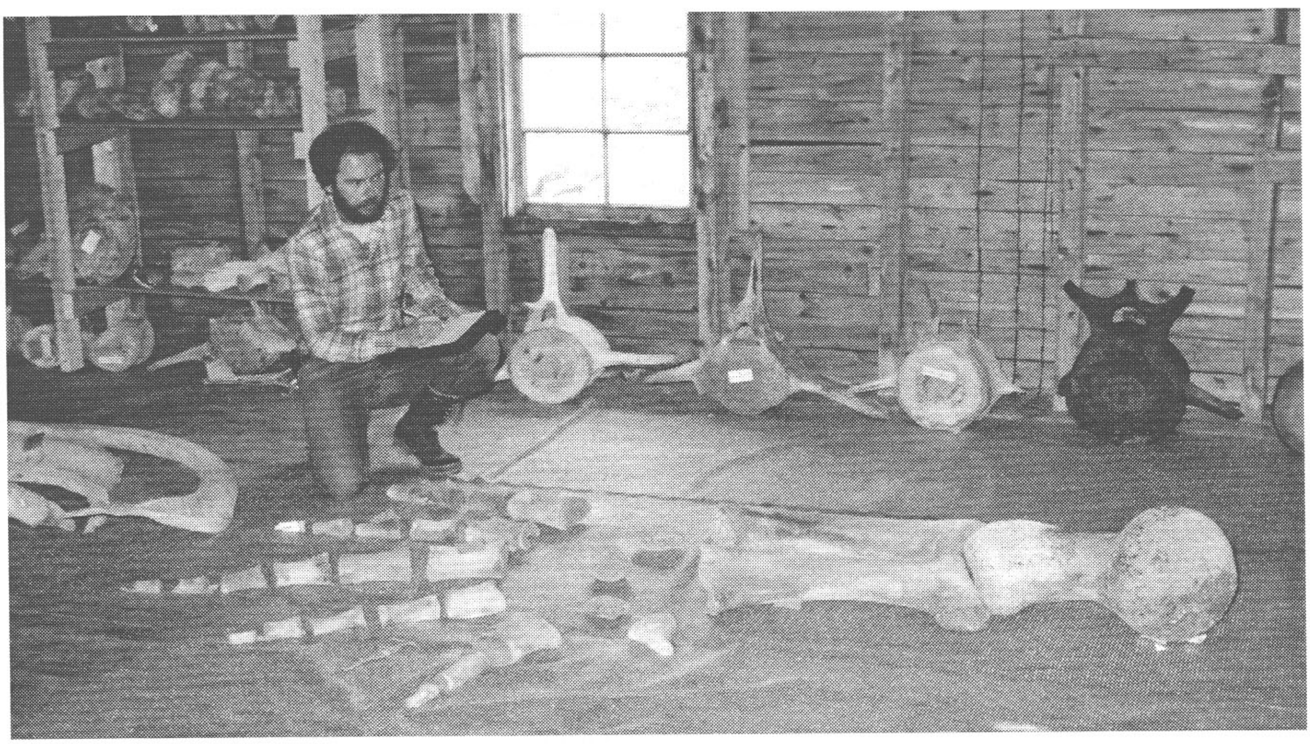

Figure 6. Steve Cumbaa takes notes on an "articulated" flipper from the shore trench. One or two sets of caudal vertebrae can be seen on the racks behind him. Relatively few mid-trunk remains were found during the underwater excavations along the Saddle Island shore in the vicinity of the *San Juan*; most of the larger vertebrae and some of the ribs are evident.

more risk late in the season to hunt bowheads.

To fill in slack time, there was always cod fishing, of which we have abundant evidence. Along the lee shore of Saddle Island in Red Bay harbour, between the wreck of the galleon *San Juan* and Basque structures on the island, Parks Canada archaeologists found a layer of tens of thousands of codfish bones. These bones, thousands of them, from the skull, lower jaws, branchial and gill apparatus and anterior vertebrae, were offcuts from the preparation of salt cod (Cumbaa 1979; 1981), and were found mixed with wood chips and shavings from barrel production on the adjacent shore. This organic layer enveloped many of the whale bones.

Ironically, some of the few bones found actually "on board" the 1565 wreck of the *San Juan* were found in the remains of a basket: several cleithra and caudal vertebrae (posterior to the vent) - the remains of salt cod (Fig.7). Also of interest is the partial skeleton of a black rat, *Rattus rattus* (one of the earliest documented in North America), found in the basket with the salt cod remains, and a knife-cut tibiotarsus from a Great Auk, *Pinguinus impennis*, which was lodged between timbers in the hold.

In the 50-70 years of Basque whaling along the Labrador coast, we estimate that a minimum of perhaps as many as 20,000 whales were taken, with probably at least 10,000 of this number from whalers based at Red Bay. This must have had a tremendous impact on the population of these species, and that is one of the things we are trying to determine. What proportion of these were right whales? Our osteological sample, admittedly small in terms of the total possible number of bones from thousands of kills, suggests a roughly even split between right whales and bowheads.

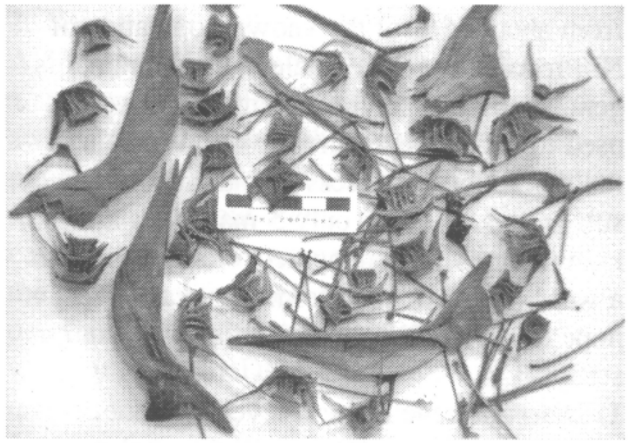

Figure 7. Caudal vertebrae and cleithra from at least four individual salt cod, found with the remains of a basket on the *San Juan*. The large partial cleithrum and the vertebra on the scale bar show heavy cuts. As the individual cod (*Gadus morhua*) were beheaded, gutted and split and the anterior vertebral column removed, the cleithra and caudal vertebrae were left in place to give structure to the split, salted fish as it dried on the wood "flakes".

Molecular Research: Goals

Today, neither species of these whales migrates into the Strait of Belle Isle. Both species are endangered, with fewer than 350 North Atlantic Right whales known to exist, and the eastern Arctic population of Bowhead whales reduced as well to a few hundred animals. Did the Basques, with their 16th-century technology, give all but the *coup de grâce* to these magnificent creatures?

We think there is a good chance to update this story and bring the past into the present by combining archaeological results with the molecular techniques of modern biology. In June 1999 two of us (Cumbaa and Brown) traveled to Red Bay, where the bones are still stored, to extract cores and shavings from these archaeological specimens for a comparative genetics study.

Since 1988, two of us (Brown and White) have been carrying out molecular analyses of living right whales, and have DNA samples from about 75% of the known population of North Atlantic Right whales. Each animal is genotyped, and zoo management software is used to establish pedigree relationships and the reproductive success of individuals and sub-groups. So far, only 5 matrilines are known for these endangered whales, which is a worry for their long-term survival. We hope to accomplish several things with our study:

1) Determine the historic levels of genetic variation of North Atlantic Right whales. In order to interpret the biological consequences of the present low genetic variation in the population, it is important to know the historic (near pre-exploitation) situation. The large number of well-dated bones from Red Bay provides this opportunity. Based on our present data we predict there has been a long period (300 years or more) with a small effective population size. There is no evidence of a bottleneck within the last 100 years.

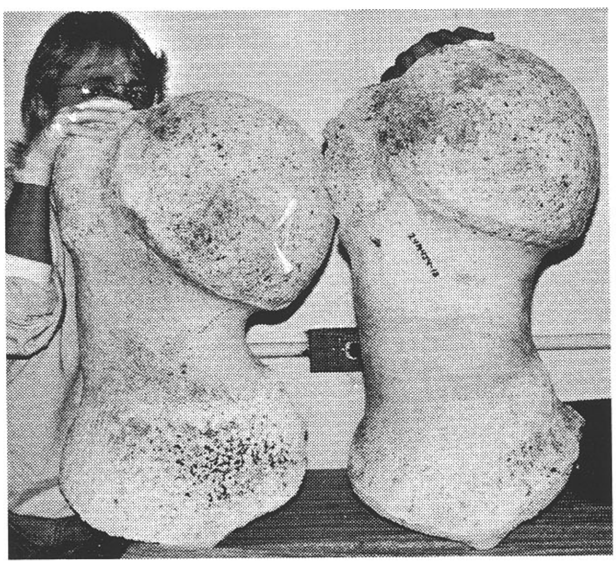

Figure 8. Moira Brown holding up two balaenid humeri for comparison. There are few comparative skeletal specimens available, but Cumbaa (1986) characterized the relatively squat humeri with a prominent midshaft notch (left) as North Atlantic Right Whale, and the longer, more columnar humeri (right) as Bowhead. The DNA work reported here will help determine whether that is accurate, or whether sexual dimorphism or ontogenetic changes are responsible for the observed differences.

2) Determine the mitochondrial sequence profiles for the population of right whales hunted by the Basques, and compare them to the haplotypes in the existing population. Do they represent original western and eastern North Atlantic populations that retained different mating grounds? Were the Basques hunting whales from a larger genetic pool?

3) Determine genetically which of the bones are from Right whales and which are from Bowhead whales, since we think we can distinguish them skeletally primarily on the basis of relatively few bones - the skull, humerus, and scapula (Eschricht and Reinhardt 1866; Van Beneden, P.-J. and Gervais, P. 1880; Turner 1913; Cumbaa 1986), (Fig.8). The DNA work will provide genetic confirmation of the species distinctions, permit other bones to be used, and will improve estimates of the composition of the whale harvest at Red Bay.

Methods

We selected the major bones of the flippers, the humerus, radius and ulna, for primary sampling for two reasons. The marrow is contained in the long limb bones, and thus we assumed that these bones would provide the best opportunity of getting DNA from white blood cells in bone marrow. Additionally, because of the way the Basques handled the whales they caught, numbers of flippers and tails were cut off and disposed of in water near the tryworks on the lee of Saddle Island, and were quickly covered by soft mud, sand and debris and protected from erosion. Consequently, many of these elements were recovered in good condition.

Sampling was relatively straightforward, and both bone plugs and bone and tissue shavings from the interior were collected with plug cutters and drill bits (Fig.9). We took several steps to avoid cross-contamination (bone to bone) and contamination by external DNA. To obtain bone shavings and bone dust, we used a 14.4 volt cordless drill bought for the purpose (Mastercraft™). Each bone was scrubbed clean in the area to be sampled with a sponge dipped in hot, soapy water. Drill bits and plug cutters were cleaned prior to sampling with DECON 75 (an SDS (sodium dodecyl sulfate) based detergent, BDH, Product no. B56019) prior to sampling to assist cleaning off any human DNA from handling. Following each sampling, the drill bit and plug cutter were scrubbed clean with a brush in hot, soapy water.

1. *Bone shavings/dust*:
A 3/8th inch (10mm) drill bit was used to drill a shallow pilot hole to clear away any outside material. Any bone shaving or dust in the pilot hole and on the drill bit were cleared away with a toothpick. The same drill bit was used to continue drilling up to the length of the drill bit (4 1/4 inches, or 11 cm). Bone shaving and done dust were collected after each sampling on fresh wax paper, and stored in labeled plastic vials.

2. *Bone plugs*:
A 5/8th inch (12mm) drill bit was used to bore a shallow pilot hole. The debris was cleared away from the hole with a toothpick. The plug was obtained with a 3/8th inch plug cutter to a depth of about 2 cm. Once the plug cutter reached its terminal depth, the ered to the laboratory for molecular analyses to determine if indeed the samples collected were suitable for DNA extraction and subsequent analyses. So far, only the shavings from the interior of the long bones have been examined; the bone plugs from the limb bones, the baleen, and samples from other bones have not yet been run.

Our results, however, have exceeded expectations. Researchers in Dr. White's laboratory at Trent University have been successful in amplifying mitochondrial DNA from many of our samples of 16th-century North Atlantic

Figure 9. Moira Brown in process of extracting bone shavings from the interior of a humerus at our impromptu lab in Red Bay. The darkened rectangular patch on the bone surrounding the sampling site is an area damp from scrubbing with detergent.

Right and Bowhead whale bones from Red Bay. This is a huge step, and we look forward over the coming months to further results from the archaeological samples, as well as those on extant populations of Bowhead whales for additional comparisons. There is a good chance now that information obtained from this important archaeological and biological resource at Red Bay can be used to improve our knowledge of the history of the stocks of Bowhead and North Atlantic Right whales, and also to improve the conservation techniques and population recovery expectations applied in the future to both of these endangered species, as well as improving our ability to distinguish between bones of very similar species, for which few comparative skeletons exist.

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