HOT TOPICS IN MARINE BIOLOGY 18.1

The Return of the Molecular Sleuth: Keeping Whalers Honest

As we have been discussing, one of the most important problems in fisheries biology is the identification of stocks, which are a series of populations of a species that respond to different factors, usually because they are somewhat isolated from each other in specific geographic areas. If stocks can be identified, it is possible to study the separate populations and perhaps to develop a fisheries management strategy to manage the stocks.

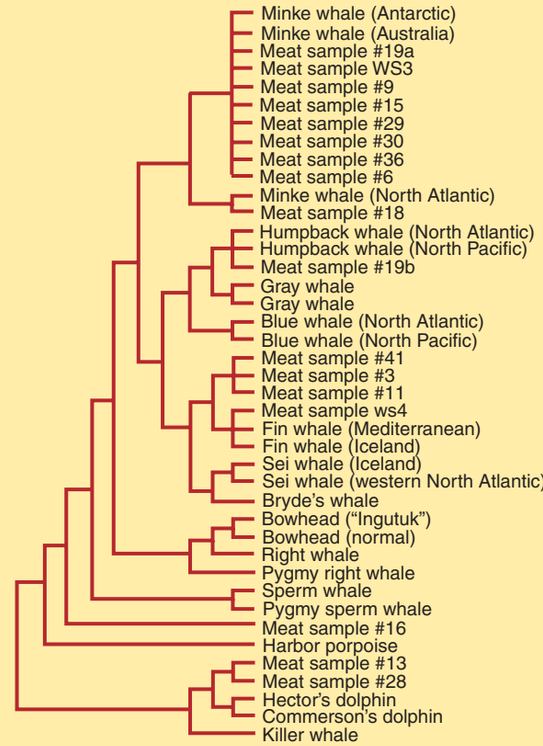
Compliance with fisheries management plans may have the teeth of the law on its side, but fishers may purposefully or inadvertently hunt stocks that are prohibited from exploitation. Morphological identification of exploited species in a given stock is usually unlikely to be definitive. This problem has motivated research on more specific markers, and molecular markers have been developed to identify stocks. This is not as easy as it seems. Because the evolutionary separation of most stocks is probably geologically recent, one needs a genetic marker that can evolve quickly to detect genetic differences among the stocks.

Whaling is surely among the most controversial fishery management problems. As mentioned, whales have been hunted to very low numbers, almost to the brink of extinction in the case of the blue whale. In 1982 the International Whaling Commission (IWC) voted a moratorium on whaling, with the exception of so-called scientific whaling (done by Japanese whalers) and subsistence whaling done by a few native peoples. Whaling thus continues, albeit at a substantially lower level than in the past. Such hunting is especially a problem if endangered stocks of some whale species are hunted. There also is good evidence for illegal whaling, aside from the limited International Whaling Commission allowances. Whale meat has been found in attempts to export several tons from Norway to South Korea and from Russia to Japan.

What can be done to enforce the IWC's present and future mandates? This is especially important inasmuch as whaling will eventually be resumed, when stocks of various species recover thanks to the moratorium. Markers are needed to trace whale meat in a can or in a freezer to its stock of origin.

C. S. Baker and Stephen Palumbi* took a molecular genetic approach to the tracing of whale meat to its stock source. There was some delicacy in this investigation because the investigators had to enter Japan, find cans of whale meat for sale, and study the meat without taking it out of the country, which would have violated export laws. It was not hard to find whale meat, which came frozen, cured in sesame oil and soy sauce, and dried and cured with salt. A portable laboratory was set up in a hotel room to extract DNA, and copy it many times by means of an amplification technique known as the polymerase chain reaction (PCR—see Chapter 9). One stretch of whale mitochondrial DNA, the so-called control region, was extremely variable and, therefore, a good candidate to distinguish among stocks.

The sequences could be compared with those taken from various whale populations around the world, and the results were striking (Box Figure 18.1). By examining sequence differences it was possible to construct a tree of genetic resemblance. This is not entirely a straightforward procedure but we will gloss over the details. If you look at the top of the tree you can clearly see that a group of whale meat samples cluster closely with sequences from minke whales found in Antarctica and Australia. Other samples could be associated with North Pacific humpback whales. All in all, different whale species could be discerned, as could stocks of individual species, at least to a limited extent. The presence of meat from a North Atlantic minke whale was especially interesting, since it suggested that the meat had been imported into Japan in violation of the IWC understanding. The prospects for detection of illegal fishing were now greatly improved.



BOX FIGURE 18.1 Identification of whale stocks and origins by means of a molecular marker, the mitochondrial control region. A tree is established based upon similarities of sequences between different stocks. (After Baker and Palumbi, 1999.)

A couple of discoveries demonstrate the power of using molecular markers to trace whale stocks. One can only call this a lucky accident, but Frank Cipriano and Stephen Palumbi† managed to match the control region sequence of mitochondrial DNA in a Japanese

*See Baker and Palumbi, 1999, in Further Reading, Hot Topics in Marine Biology.

†See Cipriano and Palumbi, 1999, in Further Reading, Hot Topics in Marine Biology.

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meat sample to a specific whale that had been harpooned in the region of Iceland in the North Atlantic in 1989. The whale turned out to be a hybrid between the blue whale and the fin whale. Subsequent investigation confirmed this match with the sequencing of other genetic loci.

So how did whale meat get from Icelandic waters to Japan? Was it legal? All indications are that, technically, there was no illegality in the killing of whales and the export of whale meat to Japan (some thousand tons in 1990). Iceland also had permission from the IWC to do "scientific whaling," and its citizens were not restricted from shipping the meat to Japan. The Convention on International Trade in Endangered Species might have been a regulatory instrument to prevent Iceland's export of whale meat to Japan, but Japan was entitled to file an objection to the classification of the whales caught as "endangered." This permitted Japanese importers to bring the whale meat into their country legally.

The saga continues, only we now move to South Korea, to a shop where minke whale is for sale, cut into strips of skin, meat, and blubber, parboiled, and put on display (Box Figure 18.2). Is it legal? Well, yes, probably. Minke whales that are entangled and drowned accidentally in fishing gear used in the Sea of Japan may be sold at market, so long as they are properly reported. And here is where the molecular sleuths come back! The minke whales in the Sea of Japan were known to be a distinct stock that was in sharp decline until the IWC moratorium was imposed in 1986. C. Scott Baker and colleagues‡ used methods similar to the ones we mentioned above to identify whales individually from the market samples. Using genetic data based on a complex capture-recapture model that takes into account the time a whale enters the market and leaves the market by sale, they estimated the number of minke whales that had entered the South Korean market trade during the period 1999–2003 at 827, nearly double the number of 458 that had been reported to the IWC. This represents a serious difference that might contribute to the decline of minke whales in the Sea of Japan.

BOX FIGURE 18.2 Minke whale meat on display in a market in South Korea. Whales sold in these markets are supposedly from animals killed accidentally during legal fishing activities. (Courtesy of Greenpeace; photo taken by Natalie Behring-Chisholm.)

The technology of DNA sequencing is now sufficiently fine-tuned that a collection of samples can be taken from all whales killed, which will allow scientists to follow the trail to processed meats, even if they have been transported for thousands of kilometers. It is remarkable that DNA markers can be used to identify not only stocks but even specific whales that have been taken. Illegal whalers can run, but they can no longer hide. ■

‡See Baker and others, 2007, in Further Reading, Hot Topics in Marine Biology.

Many activities cause direct mortality in fish populations. The intakes of power plants are often the site of extensive larval and adult fish mortality. In many of the power plants, water is taken in to cool the turbines, and warm water is piped out into estuaries and coastal areas. The pump intake region entrains fishes and draws them through the intake pipes. When the larvae or adults approach the intake pipes, the sucking force may impinge them on the intakes, although a variety of diverting screens have been placed on intakes to prevent this.

Structural habitats are often endangered by human use. A multitiered strategy is essential for protection.

Structural habitats often depend upon the maintenance of a suitable substratum and the species that construct a biological landscape, such as corals in coral reefs, or kelps in kelp forests. Therefore, conservation efforts must include the metapopulation concept but also pay attention to the integrity of the structural habitat. Coral reefs are an excellent example. They are endangered from many directions today, but tourist visits are especially worrisome. With tourists come organic pollution and direct disturbance of the reef through diving, boat anchor damage, taking of rare live marine specimens, and even hammering and blasting out coral colonies.[32] Sea turtle fisheries have also been devastated because of development of many tropical beaches, where egg laying and hatchling return to the sea occurs. While attention has been paid to reducing the take of sea turtles, many nesting beaches are no longer available because of tropical resort and home development. Unfortunately, we do not have a complete idea of where highly endangered turtles used to nest, although historical records provide some intriguing clues. For example, Sáenz-Arroyo and colleagues[33] used historical records for the sixteenth to the nineteenth century to reconstruct turtle nesting sites. A striking exception of endangerment of turtles is

[32] See Luttinger, 1997, in Further Reading, Fisheries.
[33] See Sáenz-Arroyo and others, 2006, in Further Reading, Fisheries.