Crossing borders:

Long Distance Migrations and Marlin Populations

By **Nadya Mamoozadeh and John Graves,**
Department of Fisheries Science, Virginia Institute of Marine Science, College of William & Mary

Nobody said my dissertation research was going to be easy. After all, if one is interested in studying population structure or the process of speciation, highly migratory pelagic fishes would certainly not be near the top of the list. If you think about it, highly migratory species such as the billfishes and tunas live in a continuous environment that lacks physical barriers to movement, and these species literally swim thousands of miles a year. There is clearly potential for a lot of mixing. Despite this, anglers and scientists alike have observed physical and even genetic differences within some billfish species from different parts of the world. Does this also mean that billfishes can be subdivided into populations? Do these populations span entire oceans, or are they more regional? Is there movement between populations, or are they effectively isolated? Which anglers interact with which populations?

These types of questions form the basis of my dissertation research on billfishes at the Virginia Institute of Marine Science (VIMS), where I am working with Drs. John Graves and Jan McDowell. This research is focused on two closely related sister species that inhabit different oceans: striped marlin (found in the Indo-Pacific; Figure 1),

Figure 1. Striped marlin (Kajikia audax). Figure courtesy of X.

and white marlin (found in the Atlantic; Figure 2). For decades now it's been a well-known fact among sportfish anglers that if you want to catch a big striped marlin, you'll have to head to the waters of the western South Pacific. In fact, the International Game Fish Association world record striped marlin was captured off New Zealand. But why is it that striped marlin from this part of the world are so different from everywhere else? Similarly, even though white marlin are considered overfished throughout the Atlantic Ocean, steady increases in catches of white marlin off the mid-Atlantic United States over the past 15 years have made places like Ocean City, Maryland a world-class destination for marlin fishing. Scientists and fisheries managers alike think these increasing catch rates could be the result of sustainable practices in the United States' recreational billfish fishery, such as the adoption of circle hooks. But if white marlin are one big Atlantic-wide population, shouldn't increased catch rates be reported everywhere?

This brings me to the task of studying population structure in species that span entire ocean basins...how does one tackle that? For striped marlin and white marlin, two general approaches have been used: tagging of individual fish with conventional and/or satellite tags to get an idea of movement patterns, or making genetic comparisons of groups of marlin from different geographic regions. For striped marlin, these approaches have collectively identified multiple populations in the Pacific Ocean, including one population that apparently spans the entire north Pacific, from Japan to California (United States). However, there are some discrepancies between

Figure 2. White marlin (Kajikia albida). Figure courtesy of Dr. Ken Neill III.

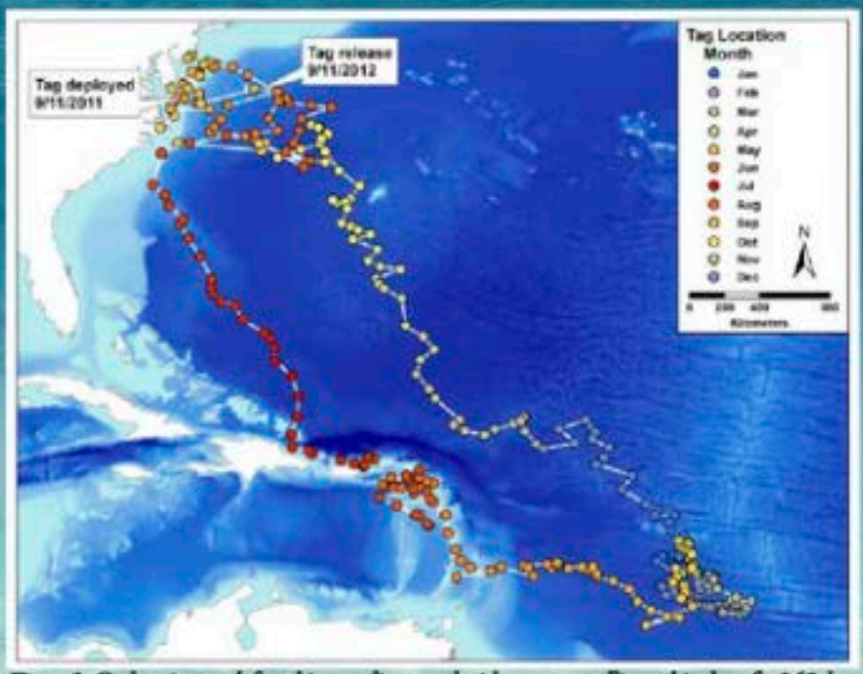


Figure 3. Geolocation track for white marlin tagged with pop-up satellite archival tag for 365 days from September 11, 2011 to September 11, 2012. Figure courtesy of Emily Loose.

inferences made from tagging and genetic data. For example, a previous genetic study found striped marlin sampled off California (United States) to be genetically distinct from striped marlin sampled off Baja California (Mexico), but movements inferred from tagging suggest that striped marlin regularly migrate between these two regions. Perhaps most importantly, no previous genetic study has evaluated striped marlin from the Indian Ocean, and tagging in this region has been limited. To-date, population structure for striped marlin in the Indian Ocean, as well as the relationship between striped marlin from the Pacific and Indian oceans is therefore entirely unknown.

The story is perhaps even more complicated for white marlin. Early biological information on this species suggested the presence of two populations in the Atlantic Ocean; however, results from a genetic study completed in the year 2000 were consistent with a single Atlantic-wide population. Since that time, movements inferred from satellite tags suggest that at least some white marlin make regional (as opposed to ocean-wide) movements (Figure 3), and an additional genetic study reported a low level of genetic differences between white marlin sampled from the North Atlantic and South Atlantic oceans. To make matters even more complex, previous genetic studies have not been able to distinguish striped marlin and white marlin as separate species. This issue brings me to the speciation side of my dissertation research: do striped marlin and white marlin represent distinct species generally confined to the Indo-Pacific and Atlantic oceans, respectively, or do these 'species' actually represent sub-populations of a single species?

To address these questions, my research at VIMS has been focused on using genetic techniques to assess ocean-wide population structure for white marlin in the Atlantic Ocean and for striped marlin in both the Pacific and Indian oceans, and to determine whether striped marlin and white marlin represent distinct species.

To accomplish this work, new molecular technology was used to analyze tissue samples of striped marlin and white marlin from the Atlantic, Pacific, and Indian oceans. Obtaining these samples was no minor feat and would not have been possible without help from the recreational sportfishing community (including a number of captains and anglers from all over the world) who worked alongside agencies such as the International Game Fish Association and the African Billfish Foundation, as well as scientists from academic institutions, and the United States National Marine Fisheries Service to collect (non-lethal) fin clip tissue samples for this work. I also received support from organizations such as the International Women's Fishing Association (thanks IWFA!). Samples collected by this global network of anglers were shipped to VIMS, where they were processed in a series of laboratory steps (Figure 4).

Figure 4. VIMS PhD student Nadya Mamoozadeh processing marlin tissue samples in the lab.

Currently, I'm analyzing the resulting genetic data to determine if groups of marlin sampled from geographically distant regions are genetically similar (and likely belong to the same population) or different (and likely represent different populations). These comparisons are being performed both within and between species.

continued...

Crossing borders: (continued)

So what kind of results are we seeing so far? Preliminary results for striped marlin population structure include the presence of multiple populations in the Indo-Pacific (Figure 5A). Similar to previous studies, I identified a population spanning the North Pacific Ocean and a population in the eastern Central Pacific Ocean. Interestingly, striped marlin in the western Indian Ocean appear to represent a third population that is distinct from striped marlin in the eastern Indian Ocean. Even more surprising, striped marlin sampled off western Australia may belong to the same population as striped marlin sampled off eastern Australia and New Zealand.

Figure 5: Panel A

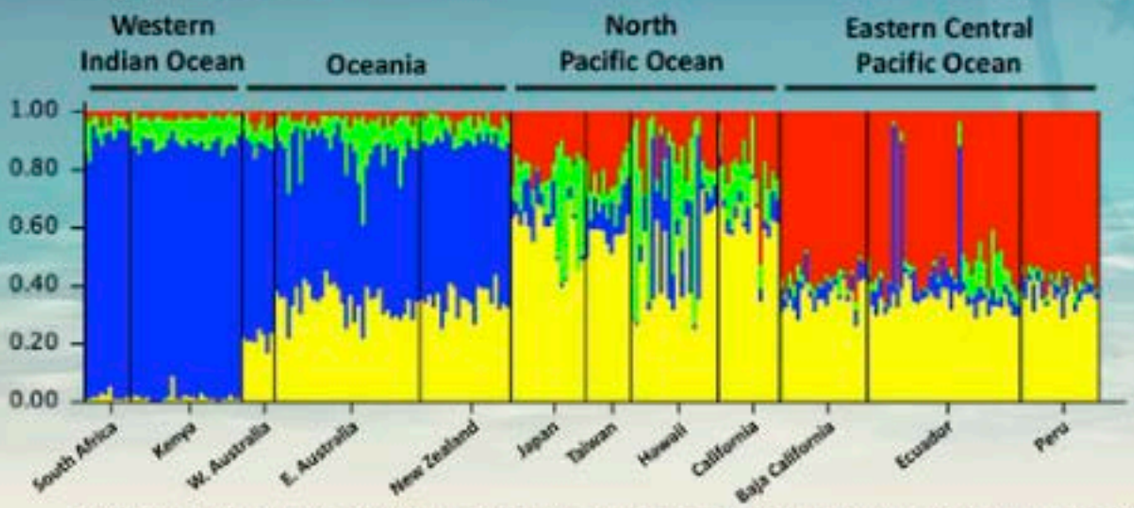
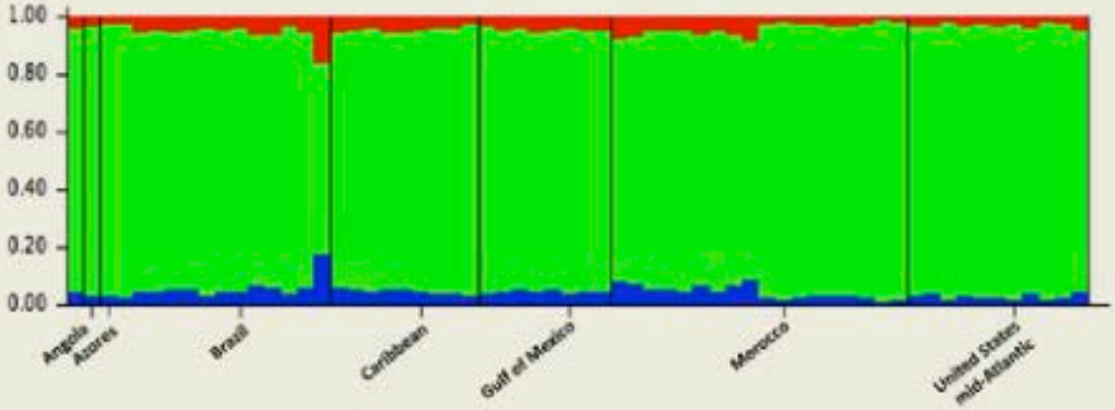


Figure 5. Results from genetic data for striped marlin (Panel A) and for white marlin (Panel B). Each vertical bar represents an individual fish, and bars are colored to reflect genetic composition. Bars with similar color composition likely belong to the same population. Geographic sampling locations are shown at bottom of both panels, while larger geographic regions are shown for striped marlin at top.

This is in contrast to recent genetic work on black marlin, for which fish sampled off eastern and western Australia were found to belong to different populations. In comparison, my genetic results for white marlin show a lack of population structure in the Atlantic-ocean (Figure 5B). Though this result seems pretty straightforward, the reason for a lack of genetic differences could be more complex: if distinct populations of white marlin do actually exist, it would only take a few individuals per generation that stray to a new population and reproduce to make two biologically distinct populations appear genetically similar. If that is the case, a non-genetic approach will be necessary for determining population structure in white marlin. As for the species relationship of striped marlin and white marlin, that's a work in progress, but early analyses suggest that the current recognition of distinct species may be correct. Stay tuned for updates!

Figure 5: Panel B



Results from this work will provide information to fisheries managers that will reduce uncertainties currently associated with the assessment and management of striped marlin and white marlin. Ultimately, we hope that more informed decision-making will assist the conservation of these incredible species, and ensure future anglers have access to this resource. The collaborations required to complete this research are a perfect example of the critical role the recreational angling community plays in supporting fisheries science. We hope that such partnerships will continue to facilitate new and exciting opportunities in billfish biology!