Sushi Way - An Investigation into Seafood Fraud in New York City

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ABSTRACT

Sushi Way investigated whether sushi restaurants in New York City are selling the fish they claim to be selling and if these same fish are being sold during the correct harvesting season. Mislabelling and out of season harvesting can be detrimental to the fish population and human health. The sushi vendors we picked were based on price range and health grade. The species of fish that we evaluated were Mackerel (*Scomber scombrus*) and White Tuna (*Thunnini sp.*) because they are two of the most commonly consumed items. Following the DNA Barcoding procedure, we collected samples of Mackerel and White Tuna from their respective sushi vendors and used Ready-to-Go PCR Beads in conjunction with COI Primers to sequence the species barcodes'. Our results revealed both seafood mislabeling and out of season harvesting. Escolar was found to be mislabeled and sold as White Tuna, while Mackerel was caught being illegally sold out of season.

INTRODUCTION

A simple search on Yelp will reveal that Manhattan, New York City is home to 2976 Sushi restaurants. (1) This raises an important question: How many of those locations truly serve what they advertise? More specifically, how many illegally harvested species of fish are potentially being sold for profit right under our noses? Oceana conducted an investigation, during December of 2012, into 81 retail outlets and 16 sushi bars in New York City, both of which sold various species of fish. They found that 58% of the retail outlets and 100% of the sushi bars sold mislabeled fish. (2) More specifically, they found that "white tuna" was the most commonly mislabeled form of fish, as it was not tuna at all but escolar, a type of snake mackerel. Escolar is problematic as it contains a toxin with purgative effects for people who eat more than a small amount of the affected fish. (2, 3) These conclusions are what laid the basis for our investigation into fish mislabeling within the borough of Manhattan.

According to New York Freshwater Fishing, a person is prohibited from fishing for certain types of species, even if they are immediately released, during the closed season. It is required by law that out of season fish caught during the closed season are unhooked and released immediately. (4) The reason for this is that catching a fish out of season has a plethora of effects. The most notable of these is the impact it has on the overall population of the fish species. If all fish were harvested year round, many of the fish species we enjoy today would already not exist anymore. Even a slight decrease in a specific fish species population can have huge, negative impacts on vendors that harvest and sell it in-season. (5) Fish collected out of season should be reported to the Department of Environmental Conservation. (6)

The two species of fish which we focused our efforts on are Mackerel (*Scomber scombrus*) and White Tuna (*Thunnini sp.*). Both are wildly popular throughout Manhattan and are also listed on Grow NYC's official seafood harvest calendar. This calendar indicates that Mackerel can only be fished from July up to October, and White Tuna from May up to November. (7) Therefore, if we were to obtain, for example, a Sushi dish containing Mackerel in from December to June in a given year, it was either not sustainably harvested, or the dish was made using another type of fish which was not correctly identified by the vendor.

We predicted that our samples would demonstrate extensive mislabeling of White Tuna and Mackerel throughout New York City's sushi vendors. In addition, we predict that these species will also be sold out of season. We concluded that these findings would aid us through gaining an increased understanding of DNA barcoding and its applications to modern society, while also informing the New York City community, as the people in it will now be more aware of the true ingredients in some of their most popular fish-based meals.

MATERIALS AND METHOD

Samples of Mackerel and White Tuna were purchased from different restaurants throughout the borough of Manhattan and tested for mislabeling. The project went through several rounds of genetic testing and there were several trials for each sample from the different restaurants. We targeted the Mackerel and White Tuna samples while they were in season, as well as out of season, to see whether our Genetic Barcode findings will be the same, or different. The latter would indicate fish mislabeling.

We collected two samples of White Tuna and Mackerel sashimi, each, from two sushi bars based in Manhattan. This was done while both species were still within their respective harvesting seasons, in October and November 2018. Once the harvesting season had ended, we resampled the same sushi bars, in January and February 2019, in addition to purchasing samples from six other Manhattan-based sushi bars.

The DNA extraction was conducted based on the protocols established by the Urban Barcoding Project. (8) The extraction required a sample of 20 mg of tissue from the samples. (9) We used the Ready-to-Go PCR Beads to amplify the DNA and used gel electrophoresis to test if the PCR worked. The PCR product was sent to Genewiz in New York City for sequencing. We utilized the online DNA Subway platform to analyze our sequences. The final, successful, sequences were published on GenBank. Non-successful samples were re-extracted and sent off for sequencing again. All genetic materials used throughout this investigation were stored on-site in a refrigerator at The Browning School. The samples were also processed inside the science lab at The Browning School. The reagents used for extraction of the samples will be provided by the DNA Learning Center.

Figure 1 | Legal Mackerel Sashimi

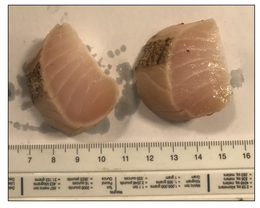

Figure 2 | Mislabeled Mackerel Sashimi

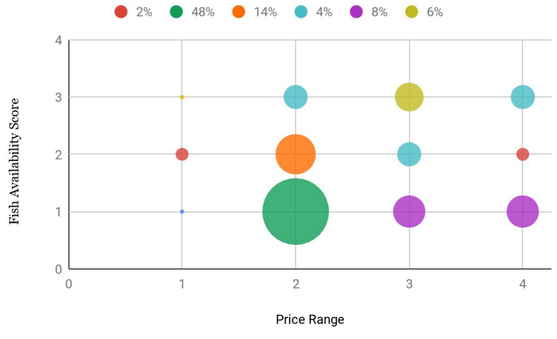

Figure 3 | The price range of vendors is based on the dollar sign system where $ is the lowest possible pricing and $$$$ is the highest possible pricing. Each dollar sign has received a numerical equivalent. $ = 1, $$ = 2, $$$ = 3, and $$$$ = 4. A similar system applies to the fish availability score where 1 = both species of fish (White Tuna and Mackerel) were found to be available out of season, 2 = one species of fish (White Tuna or Mackerel) was found to be available out of season, and 3 = both species of fish (White Tuna and Mackerel) were found not to be available out of season.

RESULTS

Before we sent off our samples for sequencing, we surveyed the menus of 50 local sushi restaurants and looked to see if they offered the tuna and mackerel only seasonally. Of the 50 restaurants sampled, 74% sold out-of-season mackerel (*Scomber Scombrus*) and 85% sold out-of-season tuna (*Thunnini sp.*) (Table 1). Most of the restaurants we surveyed were predominately grade "A," yet, surprisingly, most of those were still found to be selling out of season fish. More specifically, 39 out of the 48 restaurants with an "A" grade sold out of season tuna, while 35 of those sold out-of-season mackerel. (Table 2) We investigated whether there is a correlation between restaurants' price ranges and their susceptibility to sell out of season fish (Figure 1). This was based on the results obtained in the fifty restaurant survey. Our results indicate there seems to be a stronger association between out-of-season fish being served at lower-priced establishments.

We sent 30 samples to be sequenced, only 12 came back were successful (Table 3). The mackerel samples came back positive and the white tuna samples came back as escolar (*Lepidocybium flavobrunneum*). Many of our samples were not successfully sequenced and six of our sequences, when analyzed using BLAST through DNA Subway, came up as non-fish species. The majority of our sequences were unsuccessful and indicated either contamination or mishandling during the sequencing process. The successful sequences came back pointing towards fish mislabeling (escolar instead of white tuna), out-of-season harvesting of mackerel. Specifically, samples ZT, 1T, and 3T were sold as white tuna sashimi, but sequencing revealed that they were actually composed of escolar. Samples ZM, 1M, and 2M were sold as mackerel sashimi, and although it was mackerel, this species of fish should not be available in March, meaning that it was illegally harvested during that off-season.

Table 3 | The sequencing results of all samples that yielded some form of sequencing result. Samples that did not receive a sequence are not listed. Samples ZM, 1M, and 2M tested positive to seafood fraud, while samples ZT, 1T, and 3T tested positive to seafood mislabeling. The rest of our samples did either not result in a successful sequence, or were contaminated by bacteria. The yellow highlights indicate faulty sequencing, the red highlights indicate fish mislabeling, and the green highlights indicate out of season harvesting.

Name	Result	Expected Result	Season
AM18-M13_B0.ab1	*Impatiens capensis*	*Scomber scombrus*	In Season
FM18-M13_D0.ab1	*Phytolacca americana*	*Scomber scombrus*	In Season
AT18-M13F_A05.ab1	*Matteuccia struthiopteris*	*Thunnini sp.*	In Season
XT-M13_H0.ab1	*Acer pseudoplatanus*	*Thunnini sp.*	Out of Season
YT19-M13_E0.ab1	*Phragmites japonicus*	*Thunnini sp.*	Out of Season
ZM-M13_F0.ab1	*Scomber scombrus*	*Scomber scombrus*	Out of Season
ZT-M13_G0.ab1	*Lepidocybium flavobrunneum*	*Thunnini sp.*	Out of Season
1M_F+R-M13F_B08.ab1	*Scomber scombrus*	*Scomber scombrus*	Out of Season
1T_F+R-M13F_A08.ab1	*Lepidocybium flavobrunneum*	*Thunnini sp.*	Out of Season
2M_F+R-M13F_D08.ab1	*Scomber scombrus*	*Scomber scombrus*	Out of Season
3T_F+R-M13F_E08.ab1	*Lepidocybium flavobrunneum*	*Thunnini sp.*	Out of Season
ZT_F+R-M13F_E09.ab1	*Clarias gabonensis*	*Thunnini sp.*	Out of Season

Table 1 | Analysis of Vendors Selling Out of Season Fish and Offering Seasonal Menus

	Tuna	Mackerel
Vendors offering out-of-season species:	41 out of 50	34 out of 50
Vendors with seasonal menus:	8 (42 unknown)	8 (42 unknown)

Table 2 | Analysis of Vendors selling Out of Season Fish Based on Restaurant Grades

	Vendors offering out-of-season Tuna	Vendors offering out-of-season Mackerel
Grade A	39 out of 48	35 out of 48
Grade B	1 out of 1	1 out of 1
Grade C	1 out of 1	1 out of 1

DISCUSSION

The objective of this project was to determine whether there was food fraud and out-of-season harvesting of our target species in Manhattan sushi restaurants. Since we know from our earlier investigation that white tuna and mackerel cannot be commercially farmed, the restaurants we surveyed which still offered our target species in March were either selling illegal harvested or fraudulent fish (Table 2). Although only 6 of our samples were successfully sequenced, the presence of even one mislabeled and out-of-season fish supported our hypothesis.

Our results confirm that despite the increased scrutiny and the publication of the Oceana report (3), sushi restaurants continue to mislabel fish and to sell species outside their sustainable harvesting periods.

The main challenges associated with this project revolved around the Barcoding procedure. Although we were able to successfully extract and amplify the DNA our results indicate contamination. Better care must be given to sterilizing the reusable tools and not cross-contaminating our samples to get better quality sequences.

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