Matthew Morris

Naming as a Form of Stewardship: A Case Study on Fraudulent Fishes Sold in Calgary, Alberta, Canada

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In Genesis 2, Adam was given the task of naming the animals. Naming is a relational activity that promotes stewardship—we protect what we name. The naming of food products derived from these creatures is more complex, entailing both the common and scientific names of the species as well as cultural, commercial, and legal naming practices. This complexity of naming can result in the mislabeling of foods: "what you bought" is not "what you got." Fish are particularly prone to mislabeling, not least because North Americans are typically unconcerned with fish biodiversity, and those features that permit species identification are often removed during processing.

The recent collapse of many fish stocks has given correct naming of the fishes a new urgency. A dataset generated by students taking a Principles of Genetics class at faith-based Ambrose University in Calgary, Alberta, demonstrates that mislabeling rates can be high—from 20% to 35% of fish products from a dataset of nearly three hundred were mislabeled. However, there is more to naming than mislabeling. Legally permissible names excluded culturally significant sources of cuisine, conflating the mislabeling problem and distracting from the true sources of mislabeling. Legally ambiguous labeling, in which one market name is legally applied to several species, appeared to facilitate mislabeling and hid the sale of species at risk of extinction, hinting at how both consumers and regulators could reduce the impact on endangered species. Naming is a type of knowledge; we need to develop a greater knowledge of the fish we are eating in order to better fulfill God's blessing to the fishes.

When a child encounters a new food, typically the first question they ask (complete with wrinkled nose) is, "What is this?" Many of our foods come with complex names that have little to do with the ingredients of the food—"cheese puffs" bring to mind a particular texture, shape, and taste that is more than just cheese, and there are many brands of cheese puffs with their own peculiarities. Most food ingredients are derived from living beings, which themselves have common and scientific names. These different naming conventions—for the food and the species—can come into conflict when the food name masks its true creaturely identity.[1] For the Christian this takes on significance, not least because we are called to name the living world, and this naming is itself an act of stewardship.

In Genesis 1 and 2, humans were tasked with "ruling over" the animals. Such rule was in part modeled by Adam's naming of the animals (Gen. 2:19). Naming is a foundational theme throughout the Pentateuch, being wrapped up with themes of identity and relationship. It is striking that after God speaks the world into being, Adam is invited to name (speak) the animal component of that

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creation. We are invited, like Adam, to continue the process of naming:[2] to observe living things closely, to identify superficial and significant differences between them, to determine what is worthy of receiving a name. Naming, then, is a deeply relational form of knowledge; we name what we love. In turn, we steward what we name—both legislatively, as changes to the scientific name of a species can have dire consequences for implementing laws,[3] and socially, as there is little initiative to protect that which has not been deemed worthy of naming.[4] Indeed, the act of naming helps us see the natural world differently; those who lack names for plants literally cannot see the biodiversity around them, a phenomenon known as plant blindness.[5] We cannot steward what we cannot name. The significance of naming applies not only to the living; it also applies when species are turned into our food. A significant lack of public interest—one could say, a lack of love[6]—in the food we eat has led to the improper naming of food products.[7] Such food mislabeling can and has led to economic fraud, the depletion of wild populations, public health issues,[8] and a lack of sensitivity to cultural food practices.[9] Although mislabeling has been found in many food items around the world,[10] it is particularly prevalent in one of the few remaining wild food sources—fish.

Fish constitute an important source of global protein:[11] 3.3 billion people rely on seafood for 20% of their average animal protein intake,[12] and this is disproportionately true of the poor for whom seafood has historically been an easily accessible source of protein.[13] Despite the significance of fish, wild populations are often mismanaged to the point of collapse,[14] while aquaculture carries its own ecological concerns.[15] Such issues are exacerbated by blindness to fish diversity;[16] for instance, "fish" in North America once meant Atlantic cod (*Gadus morhua*), and fish sticks were understood to be cod sticks. But as cod stocks were depleted, fish sticks were increasingly made of haddock (*Melanogrammus aeglefinus*), and eventually pollock (*Gadus chalcogrammus*)—changes from tradition that were largely unnoticed by the public, in that these species continued to be marketed under the original name.[17] Despite there being more species of fish than birds, mammals, reptiles, and amphibians combined,[18] western consumers have tended to be more concerned about the mammal or bird on their plate than the identity of their fish. We do not order mammal sandwiches or bird salads, but routinely order "fish and chips" without concern for the type of fish being consumed—was it Pacific cod (*Gadus macrocephalus*) or the vulnerable Atlantic cod (*Gadus morhua*)? Was it tuna (and if so, what species?) or the dangerous escolar (*Lepidocybium flavobrunneum*)?[19] If plant blindness is defined by the inability to see or appreciate the beauty and significance of plants,[20] then fish blindness involves the inability to distinguish between the different species of fish we routinely encounter on our plate, to appreciate the significant roles they play in the ecosystem, or to recognize the complexity of their lived experiences.

Even if consumers wished to identify the fish they were consuming, the ways in which fish are processed and presented to the consumer pose challenges for correct identification—sushi comes with few identifying features, breaded fish sticks come with no features whatsoever, and some distinguishing features such as flesh color can be manipulated through fish diet.[21] These variations can result in the opportunity for mislabeled fish products—consumers are told that they are eating one species, but, in fact, they are eating another. Monitoring the naming of fish products is therefore vital for ensuring that fish stocks are properly managed. One important tool to identify mislabeled products is DNA barcoding,[22] which permits researchers to identify to species those food samples that have otherwise lost their distinguishing characteristics. DNA barcoding is akin to using a scanner at a grocery store to read a barcode and identify the product; by sequencing a region of the *cytochrome c oxidase subunit I* (*COI*) gene, researchers can compare the sample DNA sequence to a database of known species in order to return a match.[23] DNA barcoding has provided an opportunity to test mislabeling of fish products,[24] permitting citizen scientists[25] to ask if "what they bought" is "what they got." The answer has been a resounding no.

The mislabeling of fish food—sometimes called fish fraud, although fraud in the legal sense is difficult to prove, and the perpetrators of such fraud difficult to detect[26]—is a major global issue.[27] To determine mislabeling, three types of names have to be investigated: market name, legal name, and barcode name. The market name is the name of the food product as identified on the packaging or menu; the legal name is the list of species that can be sold under that

market name; and the barcode name is the actual species identification determined through DNA barcoding (fig. 1). As long as the barcode name of the product does not match any of the legal names associated with the market name, the product is considered to be mislabeled. For instance, in Canada, "basa" is the common name given to the freshwater catfish *Pangasius bocourti*. However, there is a related marine species with the common name of iridescent shark, *Pangasianodon hypophthalmus*. If a consumer purchases a product marketed as basa, they might reasonably expect to be consuming *Pangasius bocourti*. But if DNA barcoding reveals the tissue to actually belong to *Pangasianodon hypophthalmus*, no mislabeling has occurred, because, in Canada, basa can legally refer to either species, even if, in common vernacular, it applies to only one.[28] That is, the market name (basa) can have two legal names (basa or iridescent shark); if the barcode name is one of the legal names, mislabeling has not occurred. Mislabeling, then, is a legal, not a scientific, determination.

In every country in which mislabeling has been investigated, it has been detected[29]—and often at

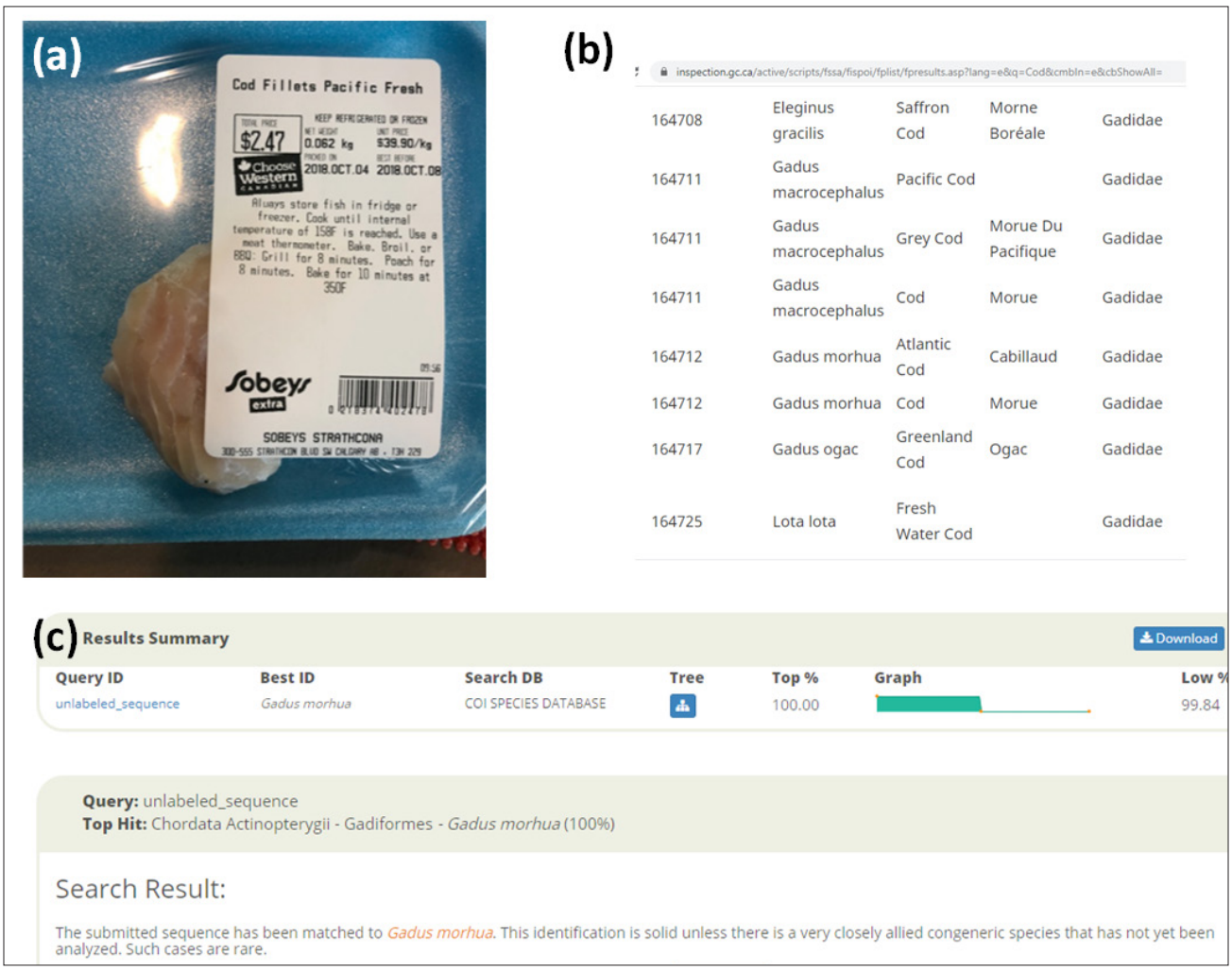

Figure 1. The determination of mislabeling involves comparing three different sources of naming. (a) The market name is the name advertised on the product, either on a label or in the menu. In this example, the name is not easy to determine—"cod fillets Pacific fresh" contains information about the species, the type of tissue, geography, and the method of preservation. The most likely interpretation of this label for the average consumer would be "Pacific cod." (b) In order to determine mislabeling, a standard for naming is required. The legal names for all legally sold species of fish in Canada are maintained by the Canadian Food Inspection Agency (CFIA) on their Fish List. A search for "cod" returns a variety of species. Note that cod is a legal name for two species of *Gadus*, while Pacific cod is a legal name only for *Gadus macrocephalus*. (c) The sample from (a) was DNA barcoded. The DNA sequence was compared to all animal species with DNA barcodes in the Barcode of Life Database (BOLD). Our sample had 100% sequence similarity to *Gadus morhua*, which from (b) goes by the legal names of cod or Atlantic cod. Therefore, this sample had a market name of Pacific cod but a barcode name of Atlantic cod; Pacific cod is not a legal name for Atlantic cod; therefore this product is mislabeled. Although this is a real example and the vendor is named in the image, this in no way means that the vendor was knowingly selling mislabeled products. Indeed, this is a rare example of mislabeling from a grocery store, and the mislabeling could have occurred anywhere on the supply chain.

high proportions. A recent Oceana meta-analysis of 55 countries reported a global mislabeling rate of 20%—that is, 1 in 5 fish products are in contravention of local labeling regulations.[30] Canada is no exception to the fish mislabeling problem. Surveys across several years and in many Canadian cities suggest anywhere from 19–47% of Canadian fish products for human consumption are mislabeled.[31]

Mislabeling is associated with reduced creaturely flourishing. Mislabeling can compromise human health, through poisoning (e.g., purchasing a product labeled as squid that actually contains a toxic pufferfish that, if cooked improperly, can be lethal),[32] to gastrointestinal distress caused by consuming fish with indigestible fatty acids,[33] to long-term health effects of consuming products that contain low doses of contaminants.[34] There are economic consequences, when mislabeling is committed in order to pass inexpensive products off as more-expensive products.[35] Mislabeling can also have serious implications for conservation. Mislabeling can permit consumers to unknowingly purchase endangered species, when they have been passed off as sustainably harvested species.[36] Less intuitive, but equally alarming, is the opposite occurrence—when a species on the brink of collapse is legally sold, but the product belongs to a sustainable or farmed species. This happens routinely with products sold as the marine "snapper" or "red snapper" that are actually farmed freshwater tilapia or other rockfish species. Flooding the market with non-snapper, but selling them under the name of red snapper, confuses the public as to the availability and conservation status of real red snapper (in Canada, red snapper legally must be either *Lutjanus campechanus* or *Sebastes ruberrimus*).[37]

Detecting fish fraud, given the relative simplicity of DNA-based species identification, lends itself to citizen science campaigns, whether among public or religious groups. Whereas published data are typically not available for analysis, citizen science puts the data in the hands of the public, permitting more robust discussions of the significance of mislabeling. Here I report multiyear sampling of fish products from Calgary, Alberta, Canada, conducted primarily by genetics students at faith-based Ambrose University. This local effort to uncover fish mislabeling has highlighted not only that mislabeling occurs, but also that there are significant social and legal dimensions to the naming of food products. Failing to take these dimensions into consideration can conflate mislabeling estimates and put fish species at risk of extinction.

Methods

To assess the extent of fish mislabeling in Calgary, Alberta, Canada, the second-year Principles of Genetics class at Ambrose University[38] has sampled Calgary fish products from grocery stores, restaurants, and sea food markets for the past several years (2014–2019). Sampling was always conducted in September. Photographs of fish products, including the market name of the product (that is, "what you bought"—whether found in a menu, a sticker, or printed on the packaging itself) and its retail value, were taken by students and uploaded to the Barcode of Life Data System (BOLD).[39] A sample, approximately the size of a kidney bean, was removed from each fish product and placed in a LifeScanner kit with DNA preservative, and shipped to Guelph, Ontario, Canada, for DNA extraction and sequencing.[40] A region of the *cytochrome c oxidase subunit I* (*COI*) gene on the mitochondrial genome was sequenced. An average of 562 nucleotides was sequenced, with a standard deviation of 163 due to variation in DNA quality. This region evolves at the sweet spot in fishes—many mutations are deleterious and quickly weeded out of the population, but enough neutral or adaptive mutations can accumulate in such a way that fish species can typically be identified one from another.[41] There are some caveats—barcoding poorly resolves hybrids, for instance, as only the maternal lineage is sequenced, and some economically important fishes, such as tilapia species (members of the genus *Oreochromis*), Atlantic and Pacific halibut (*Hippoglossus*), Pacific and Arctic cod (*Gadus macrocephalus* and *Boreogadus saida*), and many tuna species, cannot be differentiated by sequencing this region.[42] That is, a sample can convincingly be demonstrated to be halibut through its DNA sequence, but the species of halibut (Atlantic or Pacific) cannot be determined without sequencing at other regions or using morphological data.

Samples of 344 fish products were submitted, but due to varying states of DNA integrity, only 295 samples returned usable DNA sequences. For instance, of nineteen canned samples purchased, only three provided usable DNA. After 2017, students were advised to stop collecting canned products, as the per-sample

cost was too high to justify failed sequencing. All statistics will refer to the usable 295 samples. DNA sequences were uploaded to BOLD and searched for a match to DNA sequences maintained in the BOLD records.

In order to determine mislabeling, the market name and barcode name must be compared to a list of legal names. The naming of fish food products in Canada is regulated by the Food and Drugs Act and Regulations, and the Safe Food for Canadians Act and Regulations. The legal names for fish products are maintained by the Canadian Food Inspection Agency (CFIA) through their Fish List.[43] A product was determined to be correctly labeled if the legal name for the fish product, as determined by searching the CFIA Fish List for the market name, was a match to the barcode name. If BOLD identified multiple possible species that matched the DNA sample, and one of those was a legal match for the market name, the item was not considered to be mislabeled, although mislabeling could still be possible for that sample. All other possibilities, from the barcode name not matching the market name, to the market name having *no* legal names, were considered examples of mislabeling.

All market names were scored as "precise," meaning that the market name could apply to one and only one species on the CFIA Fish List; "ambiguous," meaning that the market name could apply to more than one species; or "not legal," meaning that the market name could not be found on the CFIA Fish List. The International Union for Conservation of Nature status of the barcode name or names was determined using the Red List of Threatened Species.[44] Associations between mislabeling, legally permissible ambiguous labeling, and conservation status were determined using Fisher's exact tests.[45]

Results and Discussion

An Overview of Mislabeling in Calgary

Of 295 fish samples, 102 samples (35%) were mislabeled (fig. 2). Across years this varied from 21% in 2019 (6/28) to 42% in 2017 (53/127).[46] These data encompassed 71 different market names, but the majority (55%) of samples came from products labeled as salmon, tuna, Atlantic salmon, sockeye salmon, red snapper, hamachi, yellowtail, basa, cod, and mackerel (table 1). Therefore, overall mislabeling rates are biased toward these labels, which probably reflect the fish products encountered by typical budget-wise Calgarians.

Sometimes a single species was represented by a variety of market names. Eel (*Anguilla rostrata*), for instance, was sold as unagi, freshwater/fresh water eel, dancing eel, and saltwater eel, encompassing a total of eleven products.

Mislabeling rates varied among species (table 1). The most egregious example of mislabeling involved 100% mislabeling of red snapper—these marine fish (legally either *Sebastes ruberrimus* or *Lutjanus campechanus*) were without exception freshwater tilapia from the genus *Oreochromis*. Tilapia also showed up in products labeled snapper, yellowtail, and albacore tuna. Salmon products were routinely identified as rainbow trout. Some important health risks were noted: for instance, butterfish (*Peprilus* spp.) and one sample of tuna were actually escolar (*Lepidocybium flavobrunneum*), which has been linked with gastrointestinal distress. Many species, such as sockeye salmon, basa, mackerel, and halibut were legally labeled.

Vendors could be subdivided into four main categories: grocery stores, including large chains and small convenience stores (n=127); Japanese-styled restaurants (n=141); western-styled restaurants (n=19); and seafood markets (n=8). Of these, no seafood market samples were mislabeled, 21% and 23% of western-styled restaurant and grocery store samples were mislabeled, and 49% of Japanese-styled restaurant samples were mislabeled.

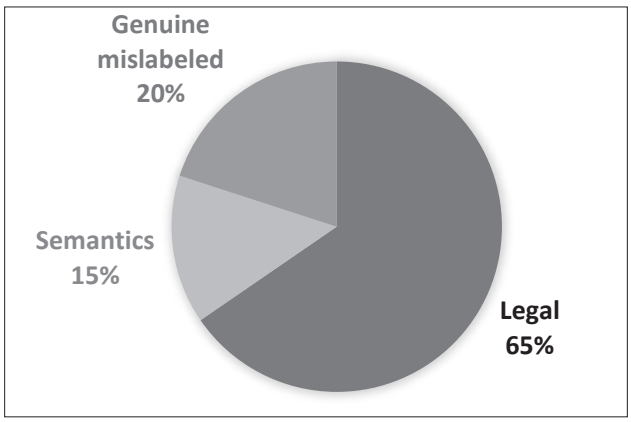

Figure 2. Proportion of fish sampled in Calgary that were legally labeled (dark grey), mislabeled due to semantics (sushi names or added geographic or habitat identifiers to an otherwise legal name) (light grey), and genuinely mislabeled (medium grey).

The above results could be summarized as follows: Calgary has a fish mislabeling problem that is in line with the rest of Canada.[47] Approximately one in three fish products were illegally labeled—what consumers "bought" is not "what they got." This is particularly true for sushi products coming from Japanese-style restaurants. The most commonly encountered sushi fish (tuna, salmon, hamachi, snapper, and eel) were also the most commonly mislabeled, while other species typically purchased as fillets (basa, sockeye salmon, halibut) seemed to fare better. However, although the above makes

Table 1. Occurrence of Mislabeling in Calgary Fish Products, 2014–2019. Percent mislabeled includes all sources of mislabeling, whereas percent genuine mislabeled refers to mislabeling not due exclusively to the use of common sushi names, or to the seemingly well-intentioned use of a descriptor in front of the species name. See text for details. BOLD-identified species are provided only for instances of genuine mislabeling.

Market name	No.	Percent mislabeled	Percent genuine mislabeled	BOLD-identified species
Red snapper	13	100%	100%	Tilapia
Snapper	7	100%	100%	Tilapia or incorrect species of *Sebastes*
Alaskan salmon	2	100%	100%	Sockeye salmon or *Sebastes*
Atlantic cod	1	100%	100%	Pacific cod
Butterfish	1	100%	100%	Escolar
Corvina	1	100%	100%	Whitemouth croaker
Golden threadfin bream	1	100%	100%	Japanese threadfin bream
Marlin	1	100%	100%	Black marlin
Sea bass	1	100%	100%	Chum salmon
Sea eel	1	100%	100%	Punctuated snake-eel
Freshwater eel / Unagi / Eel / Dacing eel / Saltwater eel	10	100%	20%	European eel
Hamachi / Yellowtail	13	100%	8%	Tilapia
Red tuna / Ahi tuna / Ahi red tuna / Red bluefin tuna / White tuna	16	100%		
Pacific rockfish	2	100%		
Albacore tuna	2	50%	50%	Tilapia
Pollock	2	50%	50%	Yellowfin sole
Salmon	36	39%	39%	Pink or Chum salmon, Chinook salmon, Rainbow trout, Tuna
Pacific cod	9	33%	33%	Atlantic cod
Pacific snapper	5	20%	20%	Incorrect species of *Sebastes*
Cod	12	17%	17%	Southern blue whiting, *Salvelinus* trout
Tuna	30	7%	7%	Escolar, Rainbow trout
Atlantic salmon	23	0%	0%	
Sockeye salmon	15	0%	0%	
Basa	12	0%	0%	
Mackerel	10	0%	0%	
Halibut	9	0%	0%	
Alaska pollock	7	0%	0%	
Tilapia	7	0%	0%	
Steelhead salmon / Steelhead trout / Trout	7	0%	0%	
Sole	5	0%	0%	
Bluefin tuna	2	0%	0%	
Other	31	29%	10%	Incorrect species of *Sebastes*, *Salvelinus* trout instead of whitefish
Total	295	35%	20%	

a nice sound bite, there are some important concerns that should be raised about this interpretation. Mislabeling rates on their own do not tell the whole story, as not all mislabeling is equal.

Canada's Labeling Laws Reject Traditional Japanese Names for Fish Cuisine

The CFIA does not accept commonly used sushi names for fish products—and this unnecessarily inflates mislabeling estimates. Unagi, hamachi, and ahi are well-known terms to sushi connoisseurs, and such consumers know that these labels refer to Japanese (*Anguilla japonica*) or American eel (*Anguilla rostrata*), Japanese amberjack (*Seriola quinqueradiata*), and yellowfin tuna (*Thunnus albacares*) respectively. Yet according to the CFIA Fish List, none of these terms are acceptable market names for fish, and therefore violate Canadian legislation. Oceana Canada most recently included hamachi in their mislabeling statistics, providing an overall mislabeling rate for Ottawa of nearly 50%.[48] To call such foods mislabeled seems to be stretching the definition of mislabeling to its breaking point. It is true that such terms violate the CFIA Fish List, but no informed consumer would believe that they had been intentionally misled when their unagi turns out to in fact be American eel. *Of course,* I am eating *Anguilla rostrata* when I order unagi. Not a single case of unagi was *not* a member of the genus *Anguilla*. And yet eel was one of the most mislabeled products in Calgary, simply due to semantics. The same was true for hamachi—it was always Japanese amberjack. Ahi was trickier to disentangle, as the many tuna species are genetically similar; but the DNA identification of ahi tuna, with one exception, contained yellowfin tuna as one possible match.

Vendors try to get around regulations against sushi names by including an English translation of the sushi item on the menu. Unfortunately, they do not typically follow CFIA conventions for these English names. For example, unagi often has the translation of freshwater or fresh water eel—neither of which is legal. But again, this hardly seems to be true mislabeling. Similarly, most sushi vendors translate hamachi as yellowtail. Yellowtail is a regionally acceptable name for Japanese amberjack,[49] but the CFIA restricts the name yellowtail to a species of flounder (*Limanda ferruginea*). Consumers familiar with sushi would be surprised if their hamachi turned out to be a type of flatfish, yet a 2018 report of Canadian fish mislabeling included yellowtail as one of the worst mislabeled products in Canada, when 100% of yellowtail were actually Japanese amberjack.[50] Given that other non-English names are included in the Fish List, such as ayu for sweetfish (*Plecoglossus altivelis*), one has to wonder why an entire category of popular cuisine is excluded from such consideration. If Canadians wish to enjoy Japanese culture, this involves engaging with cultural practices of naming. To suggest that one can enjoy Japanese cuisine without the cuisine names is to misunderstand the significant relationship between culture and food naming practices. As it stands, Japanese-themed restaurants sell more mislabeled fish products than any other type of vendor, in part for abiding by their cultural practices.

A Portion of Mislabeling Does Not Appear to Be Due to Ill Intent

Many species that vendors receive with identifying features can be difficult for non-experts to identify. The various species of rockfish on the Pacific coast of North America, for example, are a taxonomic nightmare; if even the experts are confused, how much more so are the vendors. Although the CFIA Fish List contains ambiguity when it comes to difficult fish such as the rockfish and snappers, vendors still routinely mislabel these fish. For instance, rockfish is a perfectly acceptable name for a variety of species, yet vendors would, perhaps in an effort to be helpful, add the unapproved designator Pacific, changing the name from rockfish to Pacific rockfish. This simple change matters, and is technically not legal; yet there is almost certainly no harm intended from such mislabeling. It comes from a lack of education on the topic, rather than intentional malfeasance. This is another example of semantics being confused with genuine mislabeling.

Mislabeling Rates Drop Dramatically When Restricted to the Types of Mislabeling of Interest to Consumers

Two major sources of mislabeling included the unnecessary addition of descriptors to a product name, converting a legal label into an illegal label (e.g., selling rockfish as Pacific rockfish), and the illegal use of sushi names. Yet, in both cases, the consumer typically "got" what they "bought." That is, they were not being hoodwinked; the problem lay in Canadian labeling laws, not with the product itself (e.g., Pacific rockfish was still a rockfish; freshwater eel was still *Anguilla rostrata*). In other words,

not all mislabeling is equal. Reports typically do not differentiate between these different sources of mislabeling. As already mentioned, Oceana Canada recently included all instances of hamachi in their mislabeling statistics, because Japanese amberjack can contain ciguatera toxin, while *Limanda ferruginea* does not.[51] Presumably, using the term "hamachi" was putting consumers at risk. This remains a problem, however, only as long as the CFIA does not recognize sushi names, including yellowtail, as valid. If we retain only genuine mislabeling—that is, mislabeling in which the customer did not "get" what they could reasonably have expected to have purchased based on the label—then mislabeling drops from 35% to 20%, or from just over 1 in 3, to 1 in 5. Although still substantial, this shows that a large portion of Canada's mislabeling problem is an issue of semantics rather than of fraud (fig. 2). Hamachi mislabeling drops from 100% to 8%; tuna mislabeling drops from 38% to 6% (table 1). Rockfish/snapper mislabeling, however, remains relatively high despite its prevalence in sushi.

Genuine Mislabeling Does Occur and Comes in Different Forms

Consumers, twenty per cent of the time (59/295), did not get what they reasonably should have expected to get based on the label. These sources of mislabeling can be subdivided as follows.

Legally ambiguous label, but wrong species—

The CFIA Fish List harbors a great deal of ambiguity in its naming of species (table 2). Vendors are legally allowed to apply the same label to a number of species—sometimes even if they belong to different genera or families. This should provide vendors with some legal leeway in the naming of species. For example, to be in accordance with regulations, they do not need to know the *exact* species of tuna they have as long as they label it as tuna, and it is one of the fourteen legal species of tuna. Yet, despite this, 29 of the 59 genuine instances of mislabeling fall into this category. This includes the constant mislabeling of tilapia as snapper, when snapper could have legally referred to any of twelve genera of fishes comprising 96 possible species.

Table 2. Legal ambiguity in naming results in one legal name being used for a variety of species. Some common representatives from the Canadian Food Inspection Agency (CFIA) Fish List are shown below.

Legal name	Number of listed species	Number of listed genera	Total number of species
Rockfish	**20**	**1**	**109**
Snapper	**1**	**12**	**96**
Croaker	28	1	38
Flounder	24	0	24
Sole	22	0	22
Tuna	14	0	14
Pacific snapper	**13**	**0**	**13**
Rosefish	**11**	**0**	**11**
Shark	7	0	7
Mackerel	2	1	6
Ocean perch	**5**	**0**	**5**
Tilapia	5	0	5
Redfish	**4**	**0**	**4**
Eel	3	0	3
Cod	2	0	2
Halibut	2	0	2
Red snapper	**2**	**0**	**2**
Salmon	1	0	1

Number of listed species = the number of species designated with Linnaean binomial nomenclature on the Fish List. Number of listed genera = the number of instances in which a genus name was followed by spp. (e.g., *Scomber* spp.)—indicating that all unnamed members of the genus can be marketed under that legal name. Total number of species includes all of the species that occur in a particular genus. Items in **bold** include rockfish and snapper species. This information was accurate as of August 2019.

The salmon problem—

Despite the common use of ambiguous labels to represent multiple species, there is one instance in which the CFIA uses an ambiguous label that can legally refer to only one species—salmon cannot legally refer to any Pacific species of salmon (genus *Oncorhynchus*), nor to brown trout (*Salmo trutta*), but exclusively to the Atlantic salmon (*Salmo salar*). Fourteen of 59 instances of mislabeling are oddly attributed to salmon being used as a label for a variety of species (table 1).

Unnecessarily precise, but wrong—

Given the leeway that legally ambiguous labeling provides, it is surprising that vendors sometimes go for the legal alternative, which is to be precise in their labeling. For example, cod can legally refer to Atlantic cod or Pacific cod—and some retailers want customers to know which species they are purchasing. Unfortunately, they are sometimes wrong, but this makes up a small portion of all mislabeling cases. One instance of Atlantic cod (*Gadus morhua*) was actually Pacific cod (*Gadus macrocephalus*—or a related but genetically similar species); three instances of Pacific cod were actually Atlantic cod; one instance of Albacore tuna (*Thunnus alalunga*) was actually tilapia; and one instance of golden threadfin bream (*Nemipterus virgatus*) was actually Japanese threadfin bream (*Nemipterus japonicus*—or a related species). Although there are serious conservation concerns in these few cases, they collectively made up only six of 59 mislabeling incidents, and only 2% of all samples.

Necessarily precise, but wrong—

Sometimes a species has only one possible common name on the Fish List, and this name is unique to that species. Yet, the DNA barcode revealed it to be a different species. Such mislabeling occurred only four times in our dataset, comprising <2% of all samples.

Not on the CFIA Fish List—

The remaining instances of mislabeling were also relatively rare (6 instances, <2% of all samples), but are interesting in their own right. These involved either labels on the package that could not be found in the CFIA Fish List, such that a consumer could not reasonably expect to know what they were purchasing; or DNA barcode results that pointed to a fish species that cannot legally be sold in Canada. Of the former, two products listed as Alaskan salmon, which is not in the CFIA Fish List, were returned as sockeye salmon and some member of genus *Sebastes,* respectively. Of the latter, the most interesting case was a product labeled "sea eel," which turned out to be a South American mesopelagic species of punctuated snake-eel, *Ophichthus remiger*, which is not approved for sale in Canada. It is always interesting when a food item not approved in Canada is found in Canadian markets, and the relative ease with which undergraduate students were able to unintentionally find these samples is striking.

There Are Consequences of Ambiguous Labeling

The CFIA Fish List is a living document of legal names that can be updated in light of better scientific naming practices, or to introduce new marketable species. As of this writing (August 2019), the CFIA Fish List provides information on 742 species of fish[52] that collectively have 1371 legal English names; 910 legal names are unique, due to certain legal names being used for multiple species (table 2). Any fish product, other than products containing mixtures of fish species, is required to have at least one of the legally permissible English, French, or Latin names displayed on the package—and these names must be a match to the contents of the package. The legal names are intended to do three things: (1) protect customers against "false, misleading, or deceptive" names; (2) showcase scientific knowledge; and (3) "foster fair market practices." For example, two fish of different market values should not share the same legal name. These are the ideals of the Fish List, against which incorrect or fraudulent labeling of fish foods is judged.[53]

The irony of the CFIA Fish List is that it contains built-in ambiguity that work against their own goals. Of the 910 unique market names found on the list, 138 (15%) can be applied to more than one species (table 2). Croaker, for instance, can apply to 28 different species plus all members of the genus *Nibea*, which in turn contains ten species. These ambiguous labels blur fair market practices and scientific knowledge. Yellowfin tuna (*Thunnus albacares*) and Atlantic bluefin tuna (*Thunnus thynnus*) can both be sold as tuna, but yellowfin tuna is typically a less expensive product. The label "tuna" can also be applied to species with very different International Union for Conservation of Nature (IUCN) Red List conservation statuses. A consumer could buy some-

thing labeled "tuna" and be eating either skipjack tuna (*Katsuwonus pelamis*) (status of least concern), or the near-threatened yellowfin tuna, or the vulnerable Pacific bluefin tuna (*Thunnus orientalis*), or the endangered Atlantic bluefin tuna, or the legally sold critically endangered southern bluefin tuna (*Thunnus maccoyii*) (table 3). The CFIA Fish List also intends to showcase scientific knowledge, but certain legal names have scientific connotations that are not implied by the label. For example, steelhead is a specific term referencing anadromous forms of rainbow trout (*Oncorhynchus mykiss*), but, on the Fish List, it is a term that can be applied to any rainbow trout, regardless of its life history characteristics. Although it would be difficult in practice to enforce (DNA barcoding would be unable to tell the difference between sea-run and lake forms of rainbow trout), labels like this simply do not showcase scientific knowledge, and seem to work against the mandate of preventing "false, misleading, or deceptive names" to those who have taken the time to learn their fellow fish. Despite these problems, this list is the benchmark for determining mislabeling; different countries with distinct regulations could take the same market names and the same DNA-based results and come to very different conclusions about the extent of mislabeling in their country.

Ambiguity, as already described, is built into the CFIA Fish List such that a consumer can legally not know the exact species of fish they are eating. Over two hundred products (n = 212, 72% of all samples) that were sampled had market names that were legally ambiguous, such that the consumer could not be reasonably certain of the identity of the species they *believed* they had purchased, let alone the species they had *actually* purchased. These vague labels appeared on 120 of all 193 legally labeled products. This ambiguity has two major consequences that to our knowledge have not been described before (table 4). Presumably this is not an issue isolated to Calgary.

First, *legally ambiguous labeling facilitates mislabeling*. Labels that fail to identify the species being consumed are the norm rather than the exception. This should decrease mislabeling, but oddly appears to facilitate it. Using only the genuine forms of mislabeling as previously defined, 12% of precisely labeled products were mislabeled and 29% of ambiguously labeled products were mislabeled (Fisher's exact test, $p < 0.01$). This disparity between legally precise and legally ambiguous labeling suggests that, on average, vendors apply precise labels when they are confident in the species ID, and ambiguous labels when they are not—and this lack of confidence translates into mislabeling. This is perhaps made most clear in a single species: products labeled "Atlantic salmon" are far less likely to be mislabeled than products labeled "salmon" (table 1). Both refer to *Salmo salar* alone. Of

Table 3. International Union for Conservation of Nature (IUCN) Red List global status of fish species legally sold in Canada that were potentially consumed by Calgary undergraduate students between 2014–2019.

Species name	Legal market names	IUCN Global Conservation Status
Anguilla rostrata	American eel, Eel	Endangered
Gadus morhua	Atlantic cod, Cod	Vulnerable
Hippoglossus hippoglossus	Atlantic halibut, Halibut	Endangered
Melanogrammus aeglefinus	Haddock	Vulnerable
Oreochromis mossambicus	Mozambique tilapia, Tilapia	Vulnerable
Pangasianodon hypophthalmus	Basa, Sutchi catfish, Swai, Pangasius	Endangered
Thunnus alalunga	Albacore tuna, Albacore, Tuna	Near threatened
Thunnus albacares	Yellowfin tuna, Yellowfin, Tuna	Near threatened
Thunnus maccoyii	Southern bluefin tuna, Tuna	Critically endangered
Thunnus obesus	Bigeye tuna, Tuna	Vulnerable
Thunnus orientalis	Pacific bluefin tuna, Bluefin tuna, Oriental tuna, Tuna	Vulnerable
Thunnus thynnus	Atlantic bluefin tuna, Northern bluefin tuna, Bluefin tuna, Tuna	Endangered
Trachurus japonicus	Jack mackerel	Near threatened

36 products labeled "salmon," 39% were mislabeled, while not a single Atlantic salmon product was mislabeled (Fisher's exact test, $p < 0.0004$).

Second, *legally ambiguous labeling facilitates the consumption of species of conservation concern*. There was a significant relationship between the conservation status of a DNA-identified product and the legal ambiguity of the label.[54] Ambiguously labeled products, whether mislabeled or otherwise, were more likely to include species that were designated as anywhere from near threatened to critically endangered, while precise market names were typically for species of least concern (Fisher exact test, $p < 0.00001$). Mislabeling, which was related to legally ambiguous labeling, also facilitated sales of species of conservation concern (Fisher exact test, $p = 0.0003$) (table 4).

Naming as a Call to Action

Given rampant mislabeling of fish products, both in Calgary and globally, what is a consumer to do? Some good first steps to prevent mislabeling involve changing your naming and eating practices.

(1) Avoid products with ambiguous names. Our study found that foods with precise labels, wherein one and only one fish species could legally have that market name, were less likely to be mislabeled than products with ambiguous names. Furthermore, ambiguous labels were more likely to be applied to species of conservation concern. By purchasing cod you could unwittingly be eating Atlantic cod. By purchasing Pacific cod the chances of your actually eating Atlantic cod appear to be reduced. Consumers have a great deal of power by voting with their wallet—but first you need to learn what constitutes a precise as opposed to an ambiguous species name. That is, you need to learn your fish.

(2) Purchase whole, head-on fish whenever possible. The color of fish flesh is easy to artificially manipulate; the best way to avoid mislabeling is to avoid eating, whenever possible, fragments of fish without first seeing the whole fish from which it came. If this is not possible, see points 7 and 10 below.

(3) Learn to name your fish. It is not enough to see a whole, head-on fish. You need to be able to identify its salient features in order to avoid mislabeled products. Learn to understand the difference between a sockeye (*Oncorhynchus nerka*) and an Atlantic salmon (*Salmo salar*). Be able to identify an Atlantic mackerel (*Scomber scombrus*). You will immediately be confronted with different types and shapes of scales, fins, lateral lines, mouths, etc. Foster the curiosity that results—*why* does the Atlantic mackerel have those vivid blue stripes down its body, and what are the significance of the pinnules (those little bumpy fins) that extend down its peduncle (tail region)? Why does the Atlantic cod have that strange little barbel on its chin? Just what is this creature that I am about to eat? On your plate is a creature that you are unlikely to see or encounter in your everyday experience; take the time to appreciate it for the good work of God that it is. Naming extends to educating children. Children often develop relationships with farm animals early in their childhood without ever seeing one, through books, toys, and television. I suspect we do not order mammal sandwiches or bird salads because of this early relationship.[55] There are many books about fish names geared for children that can better prepare them for ethical fish eating.[56]

(4) Eat sacrificially. According to Norman Wirzba, this entails thinking of sacrifice in terms of self-offering to God.[57] We need to recognize that God shows his love for us through food, but that this love is costly, "because for any creature to eat, other creatures must die."[58] Properly naming the things we eat—recognizing first that they are *worthy* of names beyond simply "fish"—is the first step in appreciating the sacrifice made by the creatures we eat. It is to recognize the cost of consumption, a cost that should pose serious questions about gluttony and food waste and that should raise interesting questions about the theology of fasting.

Table 4. Number of samples of least concern vs. those of conservation concern (near threatened, vulnerable, endangered, critically endangered) as identified from DNA barcoding

	Least Concern	Conservation Concern
Precisely labeled	55	8
Ambiguously labeled	48	82
Legally labeled	96	66
Mislabeled	9	26

(5) Eating sacrificially also means taking the time to respect the food by maximizing the flavor it has to offer—in other words, learn to respect the sacrifice by cooking it well. There are several books available on cooking sustainably harvested fishes that could guide you in this.[59]

(6) Eat locally. Although no study has been done on whether this reduces mislabeling, it greatly reduces the number of species you need to learn to identify. In Canada, there are more resources on how to identify various types of salmon or cod than there are about identifying punctuated snake-eels or orange roughy.

(7) Follow the labels. Marine Stewardship Council (MSC) labels are placed on fish products that meet certain sustainability criteria. Organizations such as SeaChoice and Ocean Wise Seafood also provide labels and information on sustainably harvested seafood choices.[60] These are excellent places to start educating yourself about which species are at risk and which are not, which populations are sustainably harvested and which are not, and which capture methods are better than others, in order to avoid eating at-risk species. There still needs to be trust that the market name is indeed an accurate representation of the purchased product; but by purchasing whole fish, mislabeling is less likely. Furthermore, there is good reason to believe that mislabeling is reduced for certified-sustainable products (see below).

(8) Put on political pressure for more precise market names for fish. This is done through your wallet (see point one), and also by writing to the CFIA with your concerns about legal ambiguity in its Fish List.

(9) Put on political pressure for the acceptance and enforcement of sushi names. Genuine mislabeling is still high in Japanese-styled restaurants, but gets lost in the high number of reported sushi semantics. Permitting culturally significant naming of foods not only respects those cultures and enhances our ways of thinking about different food sources, but it also protects the fish by putting the focus on genuine sources of mislabeling.

(10) Support traceability. When a fish is caught, it can move through multiple countries, processing plants, and middle men before arriving on your plate. These fish are typically not traced, and so there is no way to know who should be held accountable for mislabeling. This makes enforcement difficult. Support traceability by purchasing fish products that have been tagged from the moment they were caught and then followed through all steps of processing and transport. For instance, MSC-labeled products have enhanced traceability and therefore accountability. A recent study examined mislabeling of products with MSC labels and reported that mislabeling was less than 1% for MSC-certified products, compared to 20% or higher in other Canadian studies that did not focus on certified products.[61] Traceability clearly works.

Conclusion

The first blessing God gives in Genesis is not to humans, but to the fish and birds—a blessing to "be fruitful and multiply" (Gen. 1:22, NASB). Humans are then told to "rule over" the fish—and this command is linked to both human and fish flourishing. In other words, the responsibility to exercise God's divine blessing was given to humans. Historically, the tremendous abundance and reproductive capacity of fish gave the appearance that God's blessing on the fish could not be overcome by human effort. Indeed, as late as 1866, Thomas Henry Huxley and the UK Royal Commission on the Sea Fisheries were reporting that global fisheries were inexhaustible.[62] As long as fish were abundant, there was not much practical need to know fish names. However, today, fish blindness, resulting in an apathy toward the state of the ocean, is actively subverting God's blessing. Many fish species have gone extinct in human history, including several in Canada.[63] Fish mislabeling has diminished coflourishing by putting species at risk as well as putting human health and financial security in jeopardy, while at the same time preventing consumers from knowing the conservation status of the species they are about to eat. Problems with labeling regulations, particularly regarding ambiguity in legal names, has facilitated mislabeling and the sale of at-risk species. But this problem extends beyond the fish—an entire culture of eating has arisen that has forgotten the theological significance of food. Although this article has focused on naming and mislabeling fish, similar arguments could be made for any creature—plant, animal, fungus, alga—that we consume.

God asked Adam to name the animals; this means learning, at an individual level, to name the creatures that have been placed within our sphere of influence.

This is not an enterprise solely for the taxonomist—humankind was given this responsibility. "If you do not know the names of things, the knowledge of them is lost too,"[64] wrote the father of the science of naming, Carl Linnaeus, in 1751. Learning the names of the tremendous diversity of creatures we consume, and ensuring that "what we bought" is "what we got," is the fundamental first step in receiving God's love "made nutritious and delicious."[65] ◙

Acknowledgments

The author wishes to thank Dr. Beth Stovell (Ambrose University) for fruitful dialogue about the theological significance of naming; Megan Milton (Biolytica) for data management in BOLD; the anonymous reviewers for their helpful suggestions and comments; and Dr. Sean Rogers (University of Calgary), Dr. Jon Mee (Mount Royal University), and the multitude of undergraduate students who collected the data used in this article.

Notes

[1]Misleading names for food products has a lengthy history. Sometimes this is done to enhance an otherwise less desirable product—e.g., artificial crab (read: pollock) being sold as "krab." Sometimes misleading names are culturally entwined, such as the Japanese art of "surimi" in which fish paste is shaped to mimic other types of food. Mislabeling in this article is based on the Canadian Food Inspection Agency Fish List and does not consider these other forms of purposeful misidentification. Thanks to an anonymous reviewer for these important points. See also Mark Kurlansky, *Cod: A Biography of the Fish That Changed the World* (New York: Penguin Books, 1997), for a discussion on cultural uses and names for cod, and the sale of fish such as haddock under traditional cod names.

[2]The topic of naming and its theological significance deserves a paper in its own right. To prevent confusion, permit me a few words here about what I mean by naming. First, I view naming as a calling for all humans, not just Adam. From anthropological studies on how cultures name living things, there is good reason to believe that Adam's naming of the animals is built into the human condition; it is part of what makes us human. To that end, I do not view naming as an inherently scientific process that is conducted only through taxonomy. Nor do I view naming as being fulfilled when a scientist writes a formal paper naming a type specimen of a new species—although that is an important part of the naming process. Rather, I view naming as something we are all called to—to observe, engage with, name, and love the flora and fauna that are within our sphere of influence. When a child begins to discern the difference between a house sparrow and an American robin, even if they do not know the precise scientific names of these creatures—they are engaging with the Adamic task of naming. Naming is also a societal task, as we determine which things are worthy of formal naming and which are not—these decisions determine the things that are protected through conservation-related legislation. For more information on naming as an aspect of the human condition, see Carol Kaesuk Yoon, *Naming Nature: The Clash between Instinct and Science* (New York: W. W. Norton, 2009).

[3]For this reason, the International Commission on Zoological Nomenclature protects the names of endangered species, and has acted to suppress changes to scientific names when it could inhibit conservation. See https://www.iczn.org/about-the-iczn/why-is-the-iczn-important/conservation/ for case studies.

[4]In Canada, for instance, there is disagreement about whether we should name benthic and limnetic stickleback (*Gasterosteus aculeatus*) as separate species or as part of a species complex. These fish exist as recently evolved, reproductively isolated species pairs within several British Columbian lakes. Each population evolved independently. Should they be considered separate species? Under the biological species concept, all benthic stickleback would constitute one species and all limnetics another, as mate choice in this system is based on visual cues such as size. Two names for these fish would provide protection for each ecotype. Under the phylogenetic species concept, each benthic and each limnetic stickleback population is independently evolved and thus warrants its own species names, resulting in independent protection for each population in each distinct lake—there would be twice as many species as there are lakes containing them. Most recently the federal government recognized benthic and limnetic stickleback as simply belonging to the "species complex" *Gasterosteus aculeatus*. This has resulted in the Canadian government reducing their estimate of the number of fish species that have collectively gone extinct in Canadian history—because the benthic and limnetic stickleback that have gone extinct in particular lakes are no longer deemed worthy of naming, and have therefore been removed from such counts. Compare for instance the 2000 and 2015 reports on Canadian biodiversity: Canadian Endangered Species Conservation Council, *Wild Species 2000: The General Status of Species in Canada* (Ottawa, ON: Minister of Public Works and Government Services Canada, 2001), https://www.sararegistry.gc.ca/document/doc079/ind_e.cfm#tphp; and Canadian Endangered Species Conservation Council, "Wild Species 2015: The General Status of Species in Canada," https://www.wildspecies.ca/reports.

[5]James H. Wandersee and Elizabeth E. Schussler, "Preventing Plant Blindness," *The American Biology Teacher* 61, no. 2 (1999): 82–86.

[6]Yoon, in *Naming Nature,* writes, "Even in that undeniable connection to the living world that every one of us makes every single day—eating—we seem less and less able to see that what we are eating is in fact the living world" (p. 21).

[7]A word about food names. Taxonomists use binomial nomenclature to name species. This is a naming convention, popularized by Carl Linnaeus in *Systema Naturae* (10th ed. of 1758 used as the exemplar) in which organisms are given a genus and species name, e.g., *Gadus morhua* identifies a particular type of fish that is related to other species within the genus *Gadus*. This type of scientific naming is different from common names, which are used by different people groups in their common tongue to refer to creatures. For instance, *Gadus morhua* can be known as cod, codling, codfish, northern cod, Atlantic

cod, etc.—and that is just in English. The Linnaean system of naming was intended to reduce the complexity of names given by scientists, while also giving scientists a single name by which to refer to an organism that would be timeless and cross-cultural. Common names, in turn, are distinct from the cultural names given to food derived from the animal. Think, for instance, of bacon coming from a pig; similarly, historically, one could buy "fish sticks," "scrod," "saltfish," "salt cod," "cod-sounds," etc., depending on the part of the fish or its mode of preparation, but all were made of Atlantic cod. Beyond cultural names for food, there are also market names, which are the names under which a food product is advertised. Market names can include scientific names, common names, cultural food names, but they can also include commercial names designed to make food products more palatable to the consumer (e.g., "krab" for pollock designed to mimic crab meat). Legal names are those market names that are legislatively enforced, and can include scientific, common, commercial, and cultural names. DNA barcoding has resulted in yet another type of "name"—the Barcode Index Number (BIN) that comprises a cluster of DNA sequences from different organisms that have little sequence variation between them. Each unique number presumably corresponds to a species, and can thereby detect cryptic species—species that are morphologically similar but genetically distinct.

[8]See John Spink and Douglas C. Moyer, "Defining the Public Health Threat of Food Fraud," *Journal of Food Science* 76, no. 9 (2011): R157–R163; Karen Everstine, John Spink, and Shaun Kennedy, "Economically Motivated Adulteration (EMA) of Food: Common Characteristics of EMA Incidents," *Journal of Food Protection* 76, no. 4 (2013): 723–35; Marilisa Bottaro et al., "Detection of Mislabeling in Packaged Chicken Sausages by PCR," *Albanian Journal of Agricultural Sciences,* Special edition (2014): 455–60; Tara A. Okuma and Rosalee S. Hellberg, "Identification of Meat Species in Pet Foods Using a Real-Time Polymerase Chain Reaction (PCR) Assay," *Food Control* 50 (2015): 9–17; Angela Di Pinto et al., "Occurrence of Mislabeling in Meat Products Using DNA-Based Assay," *Journal of Food Science and Technology* 52, no. 4 (2015): 2479–84; Charles A. Quinto, Rebecca Tinoco, and Rosalee S. Hellberg, "DNA Barcoding Reveals Mislabeling of Game Meat Species on the U.S. Commercial Market," *Food Control* 59 (2016): 386–92.

[9]For example, naming is an important component in the marketing and consumption of edible insects. The western bias against eating insects is evident at many cultural and linguistic levels. See Heather Looy and John R. Wood, "Imagination, Hospitality, and Affection: The Unique Legacy of Food Insects?," *Animal Frontiers* 5, no. 2 (2015): 8–13; and Heather Looy, Florence V. Dunkel, and John R. Wood, "How Then Shall We Eat? Insect-Eating Attitudes and Sustainable Foodways," *Agriculture and Human Values* 31 (2014): 131–41.

[10]For example, chicken, pork and beef: Di Pinto et al., "Occurrence of Mislabeling in Meat Products Using DNA-Based Assay"; olive oil: Shashi Kumar, Talwinder Kahlon, and Shweta Chaudhary, "A Rapid Screening for Adulterants in Olive Oil Using DNA Barcodes," *Food Chemistry* 127, no. 3 (2011): 1335–41; invertebrates: Morgan L. Korzik et al., "Marketplace Shrimp Mislabeling in North Carolina," *PLoS One* 15, no. 3 (2020): e0229512.

[11]Food and Agriculture Organization of the United Nations, *The State of World Fisheries and Aquaculture 2018: Meeting the Sustainable Development Goals* (Rome, Italy: Food and Agricultural Organization, 2018), accessed June 12, 2020, http://www.fao.org/3/i9540en/i9540en.pdf.

[12]Food and Agricultural Organization of the United Nations, *FAO Yearbook: Fisheries and Aquaculture Statistics 2017* (Rome, Italy: Food and Agricultural Organization, 2019).

[13]Malcolm C. M. Beveridge et al., "Meeting the Food and Nutrition Needs of the Poor: The Role of Fish and the Opportunities and Challenges Emerging from the Rise of Aquaculture," *Journal of Fish Biology* 83, no. 4 (2013): 1067–84.

[14]Boris Worm et al., "Impacts of Biodiversity Loss on Ocean Ecosystem Services," *Science* 314, 5800 (2006): 787–90.

[15]Matthew Morris et al., "Prevalence and Recurrence of Escaped Farmed Atlantic Salmon (Salmo salar) in Eastern North American Rivers," *Canadian Journal of Fisheries and Aquatic Sciences* 65, no. 12 (2008): 2807–26; and Marcel Martinez-Porchas and Luis R. Martinez-Cordova, "World Aquaculture: Environmental Impacts and Troubleshooting Alternatives," *The Scientific World Journal* 2012 (2012): 389623.

[16]Even in the Old and New Testaments, in which food regulations play a significant role, mammals and birds are differentiated by species (e.g., ox and sheep, eagle and osprey—Deuteronomy 14), and yet all fish food is described using a single generic label (e.g., creatures with fins and scales—Deut. 14:9). Despite the significance of fishing in the New Testament, the diversity of fish species in the Sea of Galilee, and the role fish play in Jesus's miracles, not one fish is mentioned by name in the Gospels. This is not to say that fish are not worthy of being named; rather, it shows that fish blindness is nothing new. Of course, fish blindness varies culturally; traditional Japanese cuisine, for example, has multiple names for different types of food derived from the same fish—my thanks to an anonymous reviewer for this reminder.

[17]Kurlansky, *Cod: A Biography of the Fish That Changed the World*. Kurlansky writes, "'Fish,' it seems, is whatever is left" (p. 138).

[18]As of the January 2020 release of *Eschmeyer's Catalog of Fishes Online*, there are 35,401 valid fish species globally; 17,827 species are freshwater. Ronald Fricke, William N. Eschmeyer, and Richard Van der Laan, eds., *Eschmeyer's Catalog of Fishes: Genera, Species, References*, 2020, accessed January 29, 2020, http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp.

[19]Keflemariam Yohannes et al., "An Outbreak of Gastrointestinal Illness Associated with the Consumption of Escolar Fish," *Communicable Diseases Intelligence Quarterly Report* 26, no. 3 (2002): 441–45.

[20]Wandersee and Schussler, "Preventing Plant Blindness."

[21]Charlene Elliott, "Taste™: Interrogating Food, Law, and Color," *The Senses and Society* 7, no. 3 (2012): 276–88.

[22]P. D. Hebert et al., "Biological Identifications through DNA Barcodes," *Proceedings of the Royal Society of London B* 270, no. 1512 (2003): 313–21.

[23]International Barcode of Life, "DNA Barcoding: A Tool for Specimen Identification and Species Discovery," accessed January 29, 2020, https://ibol.org/about/dna-barcoding/.

[24]Dirk Steinke and Robert Hanner, "The FISH-BOL Collaborators' Protocol," *Mitochondrial DNA* 22, Suppl. 1 (2011): 10–14; and Robert D. Ward, "FISH-BOL, A Case Study for DNA Barcodes," in *DNA Barcodes: Methods in*

Molecular Biology, vol. 858 (Totowa, NJ: Humana Press, 2012), 423–39.

[25]Rachel Hodgson et al., "DNA Barcoding in the Classroom: Investigating Fish Labeling," *The Barcode Bulletin* 6 (2015): 6–7; and Kimberly A. Warner et al., "Seafood Sleuthing: How Citizen Science Contributed to the Largest Market Study of Seafood Mislabeling in the U.S. and Informed Policy," *Marine Policy* 99 (2019): 304–11.

[26]Mislabeling occurs at any point along the supply chain, from the moment of fish capture to purchase in a grocery store or restaurant. For this reason, the vendors cannot always be held culpable—they may be the victim as much as the consumer. Hanan R. Shehata et al., "Survey of Mislabelling across Finfish Supply Chain Reveals Mislabelling Both outside and within Canada," *Food Research International* 121 (2018): 723–29.

[27]Kimberly Warner et al., "Deceptive Dishes: Seafood Swaps Found Worldwide," Oceana: Protecting the World's Oceans (2016), accessed January 29, 2020, https://usa.oceana.org/publications/reports/deceptive-dishes-seafood-swaps-found-worldwide.

[28]In reality, the CFIA Fish List permits *Pangasius bocourti* and *Pangasius hypophthalmus* to be sold as "basa." A DNA-based identification of iridescent shark, however, will return the identity of *Pangasianodon hypophthalmus* because it was recently placed in a separate genus—a new scientific status that has yet to be updated on the CFIA Fish List. Interestingly, "iridescent shark," the typical common name of *Pangasianodon hypophthalmus*, is not a legally recognized market name for this species. The biology or lack thereof underpinning these regulations is fascinating in its own right.

[29]For example, Egypt: Asmaa Galal-Khallaf et al., "DNA Barcoding Reveals a High Level of Mislabeling in Egyptian Fish Fillets," *Food Control* 46 (2014): 441–45; United States: Ramin Khaskar et al., "Unmasking Seafood Mislabeling in U.S. Markets: DNA Barcoding as a Unique Technology for Food Authentication and Quality Control," *Food Control* 56 (2015): 71–76; Italy: Andrea Armani et al., "DNA Barcoding Reveals Commercial and Health Issues in Ethnic Seafood Sold on the Italian Market," *Food Control* 55 (2015): 206–14; Brazil: Daniel C. Carvalho et al., "Food Metagenomics: Next Generation Sequencing Identifies Species Mixtures and Mislabeling within Highly Processed Cod Products," *Food Control* 80 (2017): 183–86; China: Xiong Xiong et al., "Multiple Fish Species Identified from China's Roasted *Xue Yu* Fillet Products Using DNA and Mini-DNA Barcoding: Implications on Human Health and Marine Sustainability," *Food Control* 88 (2018): 123–30; and Mexico: Uriel B. Aké et al., "High Diversity of Dried Charales in Food Markets: A Mexican Barcode of Life Network Example in the Formation of Bachelor Students," *Genome* 62 (2019): 350.

[30]Warner et al., "Deceptive Dishes: Seafood Swaps Found Worldwide."

[31]Amanda M. Naaum and Robert Hanner, "Community Engagement in Seafood Identification Using DNA Barcoding Reveals Market Substitution in Canadian Seafood," *DNA Barcodes* 3 (2015): 74–79; Julia Levin, "Mystery Fish: Seafood Fraud in Canada and How to Stop It," Oceana Canada (2017), accessed July 6, 2020, https://www.oceana.ca/en/publications/reports/mystery-fish-seafood-fraud-canada-and-how-stop-it; Julia Levin, "Seafood Fraud and Mislabeling across Canada," Oceana Canada (2018), accessed July 6, 2020, https://oceana.ca/en/publications/reports/seafood-fraud-and-mislabelling-across-canada; and Sayara Thurston and Lesley Wilmot, "Mislabelled: Montreal Investigation Results and How to Fix Canada's Seafood Fraud Problem," Oceana Canada (2019), accessed July 6, 2020, https://oceana.ca/en/publications/reports/mislabelled-montreal-investigation-results-and-how-fix-canadas-seafood-fraud.

[32]Armani et al., "DNA Barcoding Reveals Commercial and Health Issues in Ethnic Seafood Sold on the Italian Market."

[33]Yohannes et al., "An Outbreak of Gastrointestinal Illness Associated with the Consumption of Escolar Fish."

[34]Spink and Moyer, "Defining the Public Health Threat of Food Fraud."

[35]Margot L. Stiles et al., "Seafood Sticker Shock: Why You May Be Paying Too Much for Your Fish," Oceana (2013), accessed January 29, 2020, https://oceana.org/reports/seafood-sticker-shock-why-you-may-be-paying-too-much-your-fish.

[36]Naaum and Hanner, "Community Engagement in Seafood Identification Using DNA Barcoding Reveals Market Substitution in Canadian Seafood."

[37]Donna-Mareè Cawthorn, Charles Baillie, and Stefano Mariani, "Generic Names and Mislabeling Conceal High Species Diversity in Global Fisheries Markets," *Conservation Letters* 11, no. 5 (2018): e12573.

[38]With assistance from molecular ecology classes at Mount Royal University and the University of Calgary. Mount Royal contributed 10 samples, and the University of Calgary contributed 46 samples, of the total of 295 samples.

[39]Barcode of Life Data System (BOLD) advances biodiversity science through DNA-based species identification, http://boldsystems.org/.

[40]LifeScanner underwent a change of ownership throughout this time. At first, samples were processed through the University of Guelph's Biodiversity Institute of Ontario, and then through Biolytica Inc.

[41]Ward, "FISH-BOL, A Case Study for DNA Barcodes."

[42]For some possible reasons for this, see Sujeevan Ratnasingham and Paul D. N. Hebert, "A DNA-Based Registry for All Animal Species: The Barcode Index Number (BIN) System," *PLoS One* 8 (2013): e66213.

[43]Canadian Food Inspection Agency, *Fish List*, last updated December 17, 2019, accessed July 6, 2020, http://www.inspection.gc.ca/active/scripts/fssa/fispoi/fplist/fplist.asp?lang=e.

[44]Established in 1964, the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species is a critical indicator of the health of the world's biodiversity. Far more than a list of species and their status, it is a powerful tool to inform and catalyze action for biodiversity conservation and policy change, critical to protecting the natural resources we need to survive. It provides information about range, population size, habitat and ecology, use and/or trade, threats, and conservation actions that will help inform necessary conservation decisions, https://www.iucnredlist.org/.

[45]For more information on this statistical test, see John H. McDonald, "Fisher's Exact Test of Independence," in *Handbook of Biological Statistics,* 3rd ed. (Baltimore, MD: Sparky House Publishing, 2014), accessed June 24, 2020, http://www.biostathandbook.com/fishers.html.

[46]The difference in mislabeling between 2017 and 2019 could be due to differences in student-led sampling or to chance; but it could also reflect real on-the-ground

changes caused by the Safe Food for Canadians Regulations that were implemented in January of 2019. It will be interesting to see how present mislabeling rates compare to future years as these new regulations get enforced.

[47]Thurston and Wilmot, "Mislabelled: Montreal Investigation Results and How to Fix Canada's Seafood Fraud Problem."

[48]Levin, "Mystery Fish: Seafood Fraud in Canada and How to Stop It."

[49]Anonymous, "Japanese amberjack," *Wikipedia*, last updated April 5, 2020, accessed July 6, 2020, https://en.wikipedia.org/wiki/Japanese_amberjack. For those who prefer, a search of FishBase returns yellowtail as an American market name for *Seriola quinqueradiata* (http://www.fishbase.org), while yellowtail is listed as an alternate name for Japanese amberjack in Wendy Sweetser, *The Connoisseur's Guide to Fish & Seafood* (New York: Sterling, 2009).

[50]Levin, "Seafood Fraud and Mislabeling Across Canada."

[51]Levin, "Mystery Fish: Seafood Fraud in Canada and How to Stop It."

[52]Not including shellfish—a variety of crustacean, mollusc, and echinoderm species are also included on this list.

[53]Canadian Food Inspection Agency, "Guidance on Determining the Common Names for Fish Sold or Processed in Canada," Government of Canada, last updated January 15, 2019, accessed January 29, 2020, https://www.inspection.gc.ca/food-label-requirements/labelling/industry/fish-and-fish-products/common-names/eng/1352987508427/1352993955238. As one reviewer noted, the Fish List does not have as a goal the protection of at-risk species. Presumably, such species, if from Canada, would be protected under the Species at Risk Act (SARA) and would therefore not be available for purchase—but species that are known to be at risk often do not get listed for protection under SARA. See Jamie M. McDevitt-Irwin et al., "Missing the Safety Net: Evidence for Inconsistent and Insufficient Management of At-Risk Marine Fishes in Canada," *Canadian Journal of Fisheries and Aquatic Sciences* 72, no. 10 (2015): 1596–608. Aquatic species listed under SARA can be found at https://www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding/listing-process/aquatic-species-protected-fisheries-act.html. As of June 2020, 75 fish species or ecotypes are listed under SARA. Species missing from SARA include the Atlantic bluefin tuna (*Thunnus thynnus*) and the American eel (*Anguilla rostrata*) which have been declared endangered or threatened respectively by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Similarly, only one Atlantic salmon (*Salmo salar*) stock is listed under SARA, despite recommendations by COSEWIC for further protection of other stocks. This reflection does not include consideration of at-risk species imported into Canada from other countries.

[54]To calculate this, all species not found in the IUCN database or which had a rank of "data deficient" were excluded. Only genuine examples of mislabeling were included. For DNA-based identifications in which multiple species were detected, the worst-case scenario was used: thus, if the sample was either a least concern or near threatened species of tuna, the near threatened category was used.

[55]As one reviewer noted, this only extends so far—we still order only chicken, not Rhode Island reds.

[56]A personal family favorite is April Pulley Sayre, *Trout, Trout, Trout! A Fish Chant* (Lanham, MD: Cooper Square Publishing, 2007).

[57]Norman Wirzba, "Food for Theologians," *Interpretation: A Journal of Bible and Theology* 67, no. 4 (2013): 374–82.

[58]Norman Wirzba, "Eating Our Way into the Care of Our Common Home," in *Theology and Ecology across the Disciplines: On Care for Our Common Home* (2018), ed. Celia Deane-Drummond and Rebecca Artinian-Kaiser (London, UK: T&T Clark, 2018).

[59]Thanks to an anonymous reviewer for these suggestions: Jill Lambert, *A Good Catch: Sustainable Seafood Recipes from Canada's Top Chefs* (Vancouver, BC: Greystone Books, 2009); and Jane Mundy, ed., *The Ocean Wise Cookbook 2: More Seafood Recipes That Are Good for the Planet* (Vancouver, BC: Whitecap Books, 2015).

[60]Check out SeaChoice (www.seachoice.org) and Ocean Wise Seafood (https://seafood.ocean.org/).

[61]Jaco Barendse et al., "DNA Barcoding Validates Species Labelling of Certified Seafood," *Current Biology* 29, no. 6 (2019): PR198–R199.

[62]David W. Sims and Alan J. Southward, "Dwindling Fish Numbers Already of Concern in 1883," *Nature* 439, no. 7077 (2006): 660.

[63]Don E. McAllister, Brad J. Parker, and Paul M. McKee, "Rare, Endangered and Extinct Fishes in Canada," *Syllogeus* 54 (Ottawa, ON: National Museums of Canada, 1985).

[64]C. Linnaeus, *Philosophia Botanica* (1751) as quoted in Karen Magnuson Beil, *What Linnaeus Saw: A Scientist's Quest to Name Every Living Thing* (New York: W. W. Norton, 2019).

[65]Wirzba, "Eating Our Way into the Care of Our Common Home."

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