

Retail Seafood Waste Prevention: Reducing Retail and Consumer Fresh-Fish Waste by Cooking Directly from Frozen

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Abstract

More than 30% of fish caught from the world's oceans are never eaten by consumers adding a significant but unnecessary strain to the sustainability of global fisheries. Although a lot of this loss occurs at sea, in developed countries, a significant amount happens at retail stores and in households. People can help with this problem if they find and use new ways to interact with their retailers and with the way they store and cook seafood at home. Consumers can primarily purchase seafood that has never been frozen, was previously frozen, or is still frozen. Nearly all retail waste occurs when consumers do not buy seafood within a few days after it is in the unfrozen, display cases, forcing the stores to dispose of the fish in landfills or sewage plants. An estimated 220 million 4-ounce meal portions of the most popular seafood in the United States including shrimp, salmon, and cod meet this fate. This number can be reduced to the direct extent consumers can be persuaded to buy and cook from frozen. Retailers are motivated to sell more frozen seafood because profit margins are reported to be higher and labor and disposal costs are lower. Many stores also benefit from their brand's sustainability image, and contributions to corporate, national, and international waste reduction goals. Their challenge has been to educate and encourage consumers to choose frozen before fresh. Taste-testing evidence gathered in this study demon-

strated that consumers could adopt easy, new culinary skills to cook seafood from frozen that tastes just as good as what they are used to. Our studies also highlighted other consumer benefits, including: less fish handling required, simple preparation, easier meal planning, water savings, and higher levels of food safety. Based on these results it will be beneficial for stores to commit resources to consumer education and promote more frozen seafood sales in other ways that satisfy their management goals. Increasing consumer adoption can drive changes at the store level that will provide measurable contributions to seafood waste reduction.

Keywords

Seafood, Waste, Cooking, Fisheries, Consumers, Retail

1. Introduction

Globally, over a third of commercially caught fish is never eaten by people [1]. Much of this loss occurs during fishing when unwanted fish or parts of a fish catch are discarded back into the oceans. However, in developed countries much more is wasted at the retail store and household levels [2]. Reducing production discards and consumer waste is vital if the growing demand for fish is to be met in the most sustainable way possible, one that conserves each fishery, particularly wild fisheries that are so strained. Specifically, sixty percent of the world's fisheries are fully-fished to capacity and one-third are over-fished, according to estimates from the FAO [3]. The causes of consumer-stage fish loss and waste are the focus of this paper, emphasizing how retail stores manage their customers' purchasing options and behavior.

Estimates of Seafood Retail Sales and Waste

According to data compiled by the National Marine Fisheries Service, fish products in retail stores are predominately fresh and frozen. Approximately one-third of these products are sold in retail; the rest are sold in food service and restaurants (Table 1).

Fresh fish—or previously frozen fish—in retail stores are offered for sale either packed in ice or refrigerated in a glass or similar display case. Once in this condition, the fish quickly loses its freshness and appeal and after just two to three days it is usually discarded. It is unsafe to repurpose or refreeze the fish after this time, and even if it were, the loss of quality leaves the fish unsuitable for sale. Purveyors report that they won't sell any food that they would not eat themselves [4]. Trapped in this loop, the only practical place for two to three-day-old fish is in the trash or sink grinder. The desire of store owners and the appeal of shoppers to see abundant fish on display and to participate in the purchase choice results in lots of high-value seafood products being thrown away, over and over.

Table 1. 2015 Value of fish products sold into the retail and restaurant market in the United States ([8], p. 61). Nine percent of these products are sold directly into industrial markets.

Edible Fish	Value in Dollars	Percent of Total Retail
Fresh and Frozen	\$7,816,335,000	84
Canned	\$1,302,131,000	14
Cured	\$163,166,000	2
Total	\$9,281,632,000	100

Shoppers have come to believe that never-frozen fish is the freshest; and therefore, the most healthy and tasty. While this might be true for fish that is caught and eaten the same day in coastal areas, it is not true for most commercially caught fish. For most of the world, the highest quality fish are actually those that were properly handled and then flash frozen as quickly as practical after being caught [5]. Vacuum sealed is also reported as a preferred method to preserve the quality of fish [6] [7]. Frozen fish in high quality packages retains the greatest degree of freshness. Fish-on-ice, even if packed quickly, begins to deteriorate. Therefore, a solution to the loss challenge includes changing consumer behavior and preferences towards buying frozen. This leads to important questions: 1) What type of seafood is lost, and how much of each type is lost? And 2) How much can behavior changes at retail hope to reverse this loss?

According to the National Marine Fisheries Service [8], the U.S. supply of edible, commercial finfish and shellfish in 2015 was 11.9 billion pounds. This is the whole fish weight, both edible and inedible parts. The portioned-out weight of fish fillets and steaks for restaurant and retail sales totaled a little more than 1.9 billion pounds. Popular Shellfish meat for the year was found to be 2.5 billion pounds. This equates to 17.6 billion, 4-ounce meal servings before any post-harvest food system losses. Most all of this fish was made up of the 19 most popular species (Table 2)—a clear target for beginning waste prevention actions. According to SeaFoodHealthFacts [9], one-third of seafood is purchased in retail. Shrimp leads the list for shellfish while salmon, cod, and pollock are the most popular finfish in the country. Other highly popular marine seafood products include hake, lobsters, crabs, oysters, scallops, and clams. Tilapia is the dominant freshwater fish. The popularity of these fish has remained consistent since at least 2006.

Most of these fish are imported, and programs to improve retail sale of these products by reducing waste would be helping improve the sustainability of 97% of international fisheries. Table 2 also shows the current sustainability status of each fish type. The Marine Stewardship Council (MSC) and Seafood Watch are two well-known rating agencies that match fishing pressure to the level of fish production by species. Reported ratings vary by where each species is caught; hence, ratings are by both fish type and the country providing the products for commercial markets. For example, cod is broadly certified by the MSC except

from ocean sources exploited by Russia and Japan. This complicates the impact of fish loss reduction management plans, but having this data can inform target fish sources for organizations that want to make the most of their purchases on overall sustainability. Eleven of the nineteen species listed in **Table 2** are either partially unrated or listed as “red-avoid” by the rating agencies. This is an environmental and ecological warning on the status of the fisheries that provides a large portion of the most popular fish in the United States. These ratings do not consider commercial fishing, including aquaculture and processing, that uses conscripted slave laborers, and other forms of worker abuse, an issue that is receiving increasing attention and concern as people become more aware of the extent of this practice and proof that United States retailers are purchasing seafood caught and or processed using labor practices that violate international law [10].

Table 2. Amount of the most popular fresh and frozen fish sold in the United States in 2015 ([8], p. 62, 98, 100, 101).

Fish Fillets and Steaks	Total Pounds	2018 Sustainability Rating*
Alaskan and Atlantic Pollock	462,028,000	MSC Certified**
Salmon, species	95,120,000	Seafood Watch*** mostly farmed and red
Cod	63,973,000	MSC Certified but avoid Russian and Japanese sourced
Hake	26,004,000	Seafood Watch yellow but mostly unrated fishery
Haddock	13,917,000	MSC Certified
Flounders	11,517,000	Seafood Watch, mostly red
Tilapia	9,764,000	Seafood Watch yellow but 50% unrated
Tuna species	8,023,000	Seafood Watch, mostly red
Halibut	3,405,000	MSC Certified
Dolphin fish	3,167,000	Seafood Watch, mostly red
Rockfishes	2,572,000	Seafood Watch, green and yellow
Perch, Atlantic and Pacific	2,088,000	Seafood Watch, mostly green but Atlantic perch is not rated
Swordfish	2,052,000	Seafood Watch, mostly red
Subtotal	703,630,000	
Shellfish		
Shrimp, heads-off, all species	1,796,684,000	Seafood Watch, mostly yellow
Crab, meat King and Snow	64,845,000	Seafood Watch, mostly yellow
Clams, meat	105,480,000	Seafood Watch, green or unrated
Oysters, meat	57,437,000	Seafood Watch, green
Scallops, meat	62,000,000	MSC Certified or unrated
Lobster, tails and meat American and Spiny,	58,707,000	American MSC Certified; Spiny, mostly red in Latin America
Subtotal	2,145,153,000	
Total	2,848,783,000	

*FishChoice, <https://fishchoice.com/>; **Marine Stewardship Council, <https://www.msc.org/about-the-msc/what-is-the-msc>; ***Monterey Bay Aquarium, <https://www.seafoodwatch.org/3.248>.

Based on anecdotal information, there is a significant range in the proportion of fresh versus frozen product sales. This information is not publicly reported yet; however, there is some mention of proxies that can provide insight into the different product formats, for example product display areas in stores. Wegman's Food Markets [11] estimates that about a third of their seafood is displayed fresh. Other stores that were qualitatively evaluated for this research have indicated that 30 - 40 percent is fresh—unfrozen. There are not publicly available quantitative data about the amount of different fish species that are sold fresh versus frozen in retail. For example, pollack is very popular in frozen products but not so much in fresh displays in some stores. This is particularly meaningful because this fish is sold more than all the other listed, popular fish combined. Clams are another example because of its popularity as fresh, frozen, and canned. Future research should clarify the ratio of fresh versus frozen so measures to target loss prevention appropriate for the different formats can be efficiently deployed.

Table 3 assumes that one-third of the seafood supply goes on to retail stores, and second, that 45 percent of average fish sale capacity is fresh. Once in the retail market, 13% percent of fresh fish is thrown out [2], which represents an average of 9% of the total seafood supply [12]. Frozen waste is minimal and typically occurs due to a mechanical failure such as a broken freezer that causes a break in the cold chain or damaged packaging. Using the fish data from the previous table, 55 million pounds of the total reported weight of the most popular fresh fish from supermarkets is wasted each year, representing an equivalent of about 220 million, 4-ounce meal portions. Production data on species other than those listed can be found in Lowther and Liddel [8]. Both store, customer, and sustainability advocates can lead the way to resolving the important challenge of reducing this seafood waste.

Fresh shrimp sales at almost 600 million pounds comprise over 80% of the shellfish market. Sales of other popular shellfish sell in weights range from 19 - 34 million pounds. The story with finfish is similar because previously frozen or fresh pollock is at 152 million pounds and comprised about 65% of the market. In combination, the largest sellers, shrimp and pollock, represent 79% of the fish listed in **Table 3**. Reducing wastage of these two species alone would have an outsized impact on the entire seafood waste scenario in retail. In fact, if pollock and shrimp waste, distributed in retail as described in this report, were decreased by a bit less than two-thirds, the overall waste reduction would be 50% without improvements in any other loss fractions.

Information about lost sales revenue can be a stand-alone driver for managers to evaluate objective and subjective reasons for changing store waste prevention strategies. **Table 4** summarizes the estimated dollar value of the fish species listed above. The estimates are based on average processed cost of each type of fish plus average retail markup percentages that were provided by the National Marine Fisheries Service [8]. Although the details of managing fish waste are not

yet widely available, sufficient anecdotal feedback and reporting is emerging to start designing safe, store-based programs that may be incentivized by revenue and cost recovery. World Wildlife Fund [13] highlighted the following motivators: 1) lower disposal cost, 2) more sales revenue, 3) less handling time by store clerks, 4) new relationships and value-added opportunities with suppliers, and 5) happier customers that want to help reduce food waste.

Table 3. Estimated fresh fish wasted at USA retail (pounds, adapted from [6]).

Fish	Estimated Sold Fresh and Frozen Retail in Pounds (33%)*	Estimated Sold Fresh in Pounds (45%) **	Estimated Fresh Retail Waste in Pounds (13%) ***
Alaskan and Atlantic Pollock	152,469,000	68,611,000	8,919,000
Salmon, species	31,390,000	14,125,000	1,836,000
Cod	21,110,000	9,500,000	1,235,000
Hake	8,581,000	3,862,000	502,000
Haddock	4,593,000	2,067,000	269,000
Flounders	3,801,000	1,710,000	222,000
Tilapia	3,222,000	1,450,000	188,000
Tuna species	2,648,000	1,192,000	155,000
Halibut	1,124,000	506,000	66,000
Dolphin fish	1,045,000	470,000	61,000
Rockfishes	849,000	382,000	50,000
Perch, Atlantic and Pacific	689,000	310,000	40,000
Swordfish	677,000	305,000	40,000
Subtotal	232,198,000	104,490,000	13,583,000
Shellfish			
Shrimp, heads-off, species	592,906,000	266,808,000	34,685,000
Crab, meat, King and Snow	21,399,000	9,630,000	1,252,000
Clams, meat, species	34,808,000	15,664,000	2,036,000
Oyster, meat	18,954,000	8,529,000	1,109,000
Scallop, meat	20,460,000	9,207,000	1,197,000
Lobster, tails and meat, American and Spiny	19,373,000	8,718,000	1,133,000
Subtotal	707,900,000	318,556,000	41,412,000
Total	940,098,000	136,046,000	54,995,000

* Seafoodhealthfacts.org; **Benwick, 2018 and personal research; ***Love *et al.*, 2015, supplemental table S10.

Table 4. Estimated 2015 cost of fresh fish losses in retail [8].

Fish	Estimated Retail Loss in Pounds	Process Cost for Fillets dollars per Pound	Processed Cost, Dollars	Retail Cost, Dollars (markup 1.8%*)
Alaskan and Atlantic Pollock	8,919,000	1.36	12,102,000	21,784,000
Salmon, species	1,836,000	5.05	9,267,000	16,680,000
Cod	1,235,000	3.96	4,887,000	8,796,000
Hake	502,000	1.30	653,000	1,175,000
Haddock	269,000	4.68	1,260,000	2,268,000
Flounders	222,000	4.05	900,000	1,620,000
Tilapia	188,000	3.26	613,000	1,104,000
Tuna species	155,000	9.47	1,468,000	2,643,000
Halibut	66,000	8.47	559,000	1,006,000
Dolphin fish	61,000	5.02	307,000	551,000
Rockfishes	50,000	3.07	153,000	276,000
Perch, Atlantic and Pacific	40,000	1.67	67,000	120,000
Swordfish	40,000	8.75	350,000	630,000
Shellfish**				
Shrimp, heads-off, species	34,685,000	4.21	146,022,000	262,840,000
Crab, meat, King and Snow	1,252,000	5.97	7,469,000	13,445,000
Clams, meat, species (prices for canned variety)	2,036,000	1.12	2,289,000	41,202,000
Oyster, meat (prices for canned variety)	1,109,000	2.79	3,096,000	5,573,000
Scallop, meat	1,197,000	7.20	8,623,000	15,521,000
Lobster, tails and meat, American and Spiny	1,133,000	9.22	10,446,000	18,803,000
Total				416,037,000

*retail markup and value-added markup; ** average import cost.

Causes and Challenges of Seafood Waste

Is it possible, and does it make sense to use resources for waste prevention and to reduce retail loss on the fresh fish display, or would the built-in years of inefficiency and loss be too strong of a barrier to overcome at a store level? After all, consumers will always prefer fresh over frozen fish to some degree. The Commission for Environmental Cooperation [14] recently completed an evaluation of food waste and loss in North America. Their approach included surveys and interviews related to conferences and workshops, all to gather the most current information. Awareness about the list of factors that cause food waste at the retail level has grown, and the CEC report highlights some that are particularly relevant to wastage of fresh fish, including: food safety concerns and management or marketing practices.

Food safety is on the minds of consumers, and in the case of seafood, concerns

center around freshness and pollutants. Toxins in fish meat have been reported for some time; however, fisheries with low levels of pollutants of concern like lead, PCBs, and mercury are also being documented [14]. Customers can check and verify their purchases to take advantage of healthier fish supplies. Issues with freshness and microbial safety can be reduced by purchasing frozen and cooking according to the suggestions provided later in this paper. Management can be encouraged to modify their store practices by helping them understand some of the benefits that come from reducing fresh fish waste in favor of more frozen sales. Potential rewards include: increased sales, reduced waste disposal costs, improved corporate sustainability, and less pollution.

Better Retail Practices for Sourcing and Selling Seafood

The CEC report also pointed out different individuals that would have the most influence on changing marketing strategies and methods to reduce wastage. Included are store managers and employees, processors, distributors, and service providers that support both products and sales. There are sufficient detailed data and information available to begin to understand the loss factors and to suggest and target remedies. Seafood sales are going up in general, while fresh sales are increasing faster than frozen. This is the type of trend that leads to accelerating retail fish waste. It is possible that sales would increase even more if certain barriers were eliminated or lowered. Among these are people dislike for handling seafood and concerns for safety.

Encouraging more fish consumption for health reasons is at odds with consumer dislike for handling seafood. More inviting frozen-fish packaging that minimizes the tactile part of the culinary experience would help narrow the health-avoidance gap. Buyers already report that frozen offers more convenience and better storage options, both of which can lower waste at the consumer level. New frozen products are appearing in stores that minimize handling and offer recipes, sometimes with included ingredients. The availability of more types of frozen fish in new packaging then encourages consumers to buy frozen resulting in less retail waste. Stores benefit from more sales and less waste while consumers eat more nutritious fish.

Aquaculture production is increasing to fill the gap caused by a growing seafood demand that is outpacing global population growth and the capacity of wild-caught production. In total, constraints on the scalability of these systems and distribution limitations may still place a global deficit on available seafood as compared to recommended nutritional profiles for source proteins. Efforts to “sustainably source” wild caught seafood using standards like Marine Stewardship Council (MSC) and the Aquaculture Stewardship Council (ASC) have steadily increased among retailers and seafood purchasing groups. This trend is positive and one that must continue to accelerate and expose the limitations of wild seafood sources.

In order to achieve these goals, consumption patterns must be re-imagined and adjusted. Consumer focused pilots can address issues around consumer-generated seafood waste, such as frozen vs. fresh product, proper handling

and preparation, more efficient packaging that increases merchandising appeal and retail sales and the importance of sustainable purchases. This purpose and approach is the focus of the research work that is reported in this paper with an emphasis on using the culinary arts to give people real experiences with handling, preparation, recipes and cooking from frozen.

Initial Consumer Attitudes and Research Objectives

In 2017, the Drexel Food Lab conducted consumer interviews and in-store consumer surveys ($n = 100$) at a busy nationally branded, locally owned supermarket on the border between the city and the suburbs of Philadelphia. Respondents were given a modest gift card to the store to thank them for their time. No personal data were collected, and the research was given a Letter of Determination from Drexel's Human Research Protection Program (IRB). The store was chosen for its ability to attract a diverse clientele of city-dwellers and suburbanites across a wide range of race, ethnicity, and socioeconomic status. The exploratory research reported here challenged the culinary and consumer preferences for fresh (previously frozen) seafood and asked if high-quality culinary standards can be achieved to the same or higher levels by preparing frozen seafood products directly from their frozen state, "cooking from frozen." This research is especially relevant in consumer and commercial settings, since the perception of "fresh" is skewed towards higher temperature storage, rather than a consumer reluctance to rate frozen as higher quality, even though by food safety, sustainability, and true freshness standards, frozen is superior (**Figure 1**). Among 100 consumers that were queried, the majority (52) responded that fresh fish was fresher. Our supposition is that the largest perception barrier to frozen seafood is a reluctance to view frozen seafood as desirable from a culinary standpoint. We also asked consumers what they thought about the quality of fresh versus frozen and much like the freshness response, 50 percent of consumers replied that fresh fish was higher quality (**Figure 2**). This high response rate further encouraged the research that followed our supposition because of the possibility of influencing consumers in ways that would significantly help to reduce wastage.

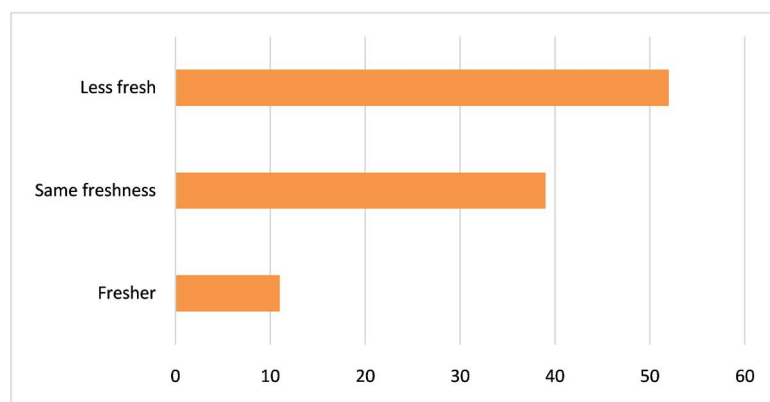


Figure 1. Consumer attitudes about the freshness of frozen fish compared to fish from counter.

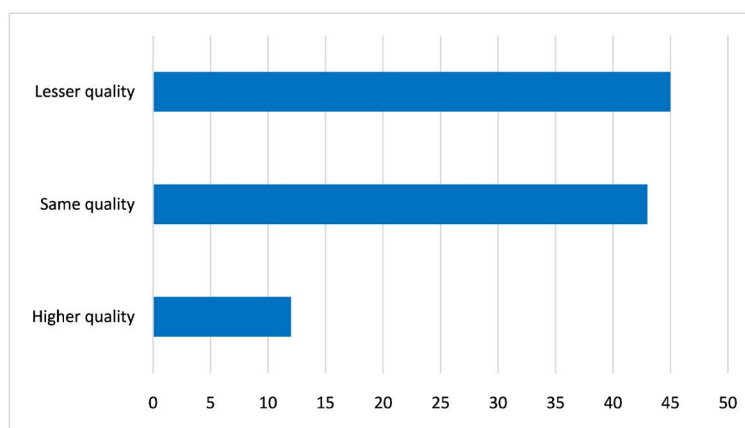


Figure 2. Consumer attitudes about the quality of frozen fish compared to fish from counter.

Food safety plays a large role in behaviors and patterns. Once defrosted, most fish cannot be safely re-frozen and typically goes to waste if not purchased or prepared. Defrosted fish also has a higher likelihood of being wasted at the household level. Purchased fish sits in a refrigerator and, as dinner plans change, it may be discarded without being cooked or re-frozen by the consumer after increased opportunity for microbial growth and oxidative rancidity (resulting in the characteristic fishy smell) from the defrosted stage [15].

Consumers shared that the step of defrosting frozen seafood is a deterrent to purchasing it. Package instructions typically indicate that the fish or seafood must be thawed under refrigeration for several hours or under cold running water (further wasteful from a sustainability standpoint). Consumers report hurdles associated with either of these scenarios including: not being organized enough to plan dinner days in advance and move seafood from freezer to refrigerator; not being patient enough to wait for defrosting under water; not wanting to waste water; and changing plans resulting in not getting around to cooking the defrosted seafood as intended. In addition, some consumers share insecurities with regard to proper handling and cooking of seafood, especially fin-fish, as well as expressing displeasure in having to handle raw fish during cooking. In short, consumers report wanting to eat more seafood but find the hurdles to buying and handling the products to be deterrents.

Inspired by knowledge of loss rates in the retail seafood supply chains, Drexel Food Lab principals and students investigated if it would be possible to cook fish directly from its frozen state at high culinary quality, the way one cooks a frozen hamburger patty. With some caveats, the answer is “yes” (Figure 3). Fifty-five of 100 respondents were positive about the idea of cooking from frozen in theory.

Research objectives evolved and expanded to gather real consumer feedback and see how the Cook-from-Frozen recipes and new knowledge collected during the investigation can influence sales. In collaboration with the supermarket, we obtained retail data and piloted a variety of interventions in stores. They confirm extensive losses and little conversion to prepared product at the fish counter and

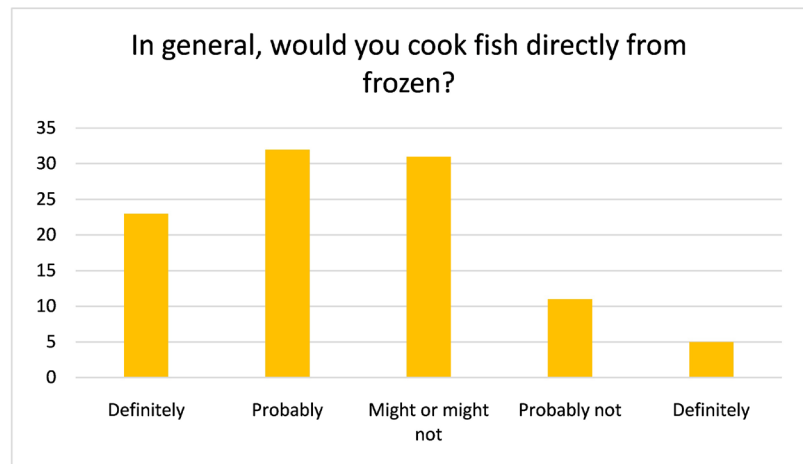


Figure 3. Consumer attitude about cooking from frozen if quality was certain (post tasting).

further confirmed that the stores have better profit margins on frozen fish (both in terms of gross margins on the products themselves and reduced staffing and loss management from waste). With these multiple benefits the store welcomed the opportunity to encourage a shift in sales to frozen seafood.

Our taste testing and marketing research had several specific parts:

- Complete recipe development and testing of Cook-from-Frozen recipes
- Engage a graphic designer for the layout and printing of customer marketing materials
- Taste tests of recipes at supermarkets
- Collect consumer acceptance feedback on the appeal of buying frozen fish as well as the success of the recipes.

Methodology for Recipe Development and Taste-Testing

In Spring 2017, several types of fresh and frozen seafood items were selected for evaluation based on sales priorities and sustainability—certified products provided by the retailer. The primary items were shrimp, salmon, and tilapia as proxies for a variety of related crustaceans, fatty fish, and lean fish. Culinary experiments found that methods like roasting, poaching, and baking en papillote were particularly effective, while frying and grilling resulted in difficulty achieving thorough cooking directly from frozen. Recipes and cooking recommendations were made (see below) for each fish type.

Communication

Following recipe testing, a consumer education brochure was designed for distribution in the customer's frozen seafood section of the supermarket. The brochure contained recipes for cook-from-frozen seafood, an explanation of the sustainability, food safety and convenience aspects of cook-from-frozen seafood, a description of the partnership/project, and an explanation of the company's overall work on sustainable seafood (recipe examples and the brochure are included in the supplemental materials).

Consumer feedback

The suburban Philadelphia store location that serves city and suburban customers was used to launch four weekly tasting sessions. Patrons had the opportunity to taste a Cook-from-Frozen fish sample (a tilapia curry or roasted salmon) and provide feedback via a one-minute survey. Shoppers were asked if they would like to sample a Cook-from-Frozen fish dish. Each participant was given a \$5 in-store gift card. Approximately 250 samples were served weekly and those who completed the tasting were asked if they would like to complete the survey as well. A 10% response rate yielded 100 completed surveys. Recipes and brochure handouts were available to everyone. Highlights of survey results are shown in **Figure 4**. About 34 percent of participants indicated that they would try this Cook-from-Frozen technique after trying the dish. Only 7 percent said they would cook from frozen before their tasting experience.

2. Summary and Conclusion

A 2017 report from IRI shows that fresh seafood has seen marked increases in consumer interest [16]. Increasing customer demands for fresh product are often derived from a perception that thawed fish is “fresh” simply because it most closely resembles the state of fish pulled immediately from the water. Once a human intervention is imposed (*i.e.*, fish is frozen), consumers perceive that the fish is no longer “fresh”. In reality, given the distances and the complexities of our fresh food supply chains, delivering *truly fresh* fish under these visually appealing circumstances is extremely costly and reduces the shelf-life of the product.

Since it is standard practice for many retailers to thaw previously frozen fish for display, we can conclude that thawing fish to display it as “fresh” is merely a marketing strategy to satisfy consumer visual impulses to see fish that was just pulled out of the river or ocean. The display life of this form of seafood is short. Loss is accepted in retail systems as a price of doing business, since it's assumed and seldom challenged that customers want to see thawed fish. Furthermore, loss rates are rarely if ever made public and are guarded under strict business confidentiality. Anecdotally, loss rates are typically estimated between 8% - 20% of total sales at most seafood counters.

This investigation tested the proposition that, with proper consumer education, frozen fish can be merchandised as high-quality and that preparation can be just as convenient as thawed fish from the seafood counter. If in-store marketing campaigns can sell the benefits of frozen and alternative packaging models, and if these new products can maintain or even increase seafood sales, it becomes a multi-faceted win for retailers: increased sales, less in-store shrink (increased margin), happy customers, and less stress on the environment.

From a culinary perspective, Cook-from-Frozen remains a promising cooking method, offering consumers a more convenient, safer, and more sustainable solution than buying fresh-from-frozen or defrosting at home. Quality of finished dishes was on par with fresh. For the typical consumer, cook-from-frozen seafood is an appealing alternative. Benefits include:

- Are you more likely to buy frozen fish and cook it directly from frozen after participating in the demo?

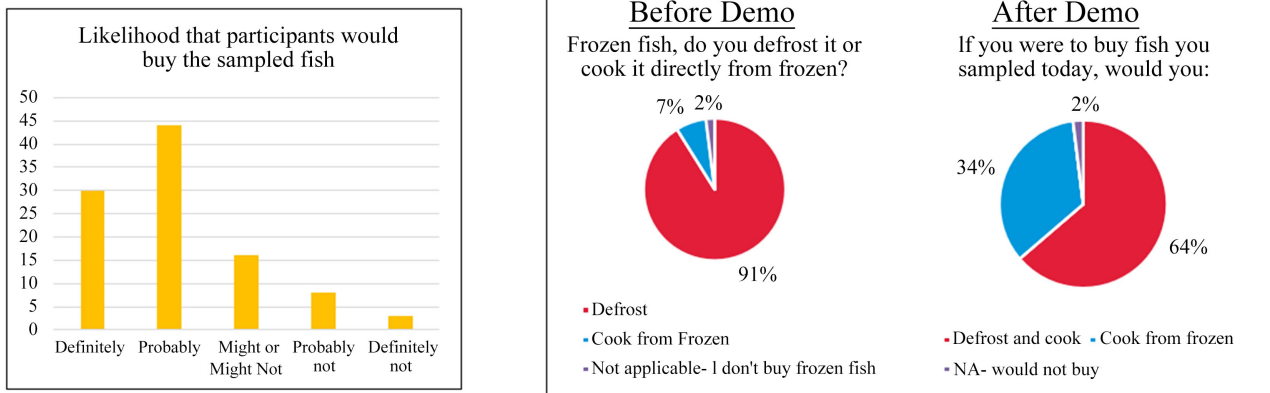


Figure 4. Summary of consumer feedback after participating in Cook-from-Frozen in-store tasting sessions.

- Limited handling required
- Simple preparation
- Makes advanced meal planning easier
- Saves water in defrosting
- Preserves cold chain at zero degrees F until the point of cooking.

Benefits to retailers include:

- Reduced personnel time and training needs
- Reduced cost of food loss
- Reduced store footprint (receiving, prep area and display)
- Easy recipe and cooking promotion opportunity for customers

This research has reached the following important conclusions: 1) Consumers perceive the thawed seafood is more fresh than frozen seafood. It is not. 2) Cooking demonstrations can teach consumers how to successfully cook from frozen. More consumer education in this area is useful and necessary. 3) Selling frozen product reduces seafood losses. Retailers benefit financially.

In summary, maintaining the current seafood merchandising system to appeal to consumer's actually increases waste and does not contribute to sustainable fish stocks. Educating consumers about how to purchase and cook-from-frozen is an incremental component of seafood waste reduction that directly enhances sustainable fisheries and builds consumer awareness of economic and healthy tools they can use to expand the potential of seafood to meet nutritional requirements.

Disclaimer

Any views expressed in this report do not necessarily represent those of the United States government or the Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Supplemental Materials

Sample recipe:

Roasted Salmon Sheet Tray Dinner with Soy Ginger Sauce by Alexandra Romey

Serves: 4

2 tablespoons olive oil

4 ShopRite Preferred Brand frozen salmon fillets

1/4 cup soy sauce

2 tablespoons sesame oil

1 tablespoon minced ginger

1 tablespoon honey

1 pound snap peas

8 ounces mushrooms

2 bell peppers, chopped

Salt and pepper to taste

- 1) Preheat oven to 350 degrees Fahrenheit.
- 2) On a baking sheet tray, drizzle olive oil. Place salmon on one section of the tray and roast for 20 minutes.
- 3) Meanwhile, in a small bowl, add soy sauce, sesame oil, ginger and honey. Stir.
- 4) Once the salmon is partially cooked, add snap peas to a section of the tray, mushrooms to another, and peppers in remaining area. Drizzle soy ginger sauce over salmon and vegetables.
- 5) Return tray to oven and cook for 20 - 25 minutes, or until vegetables are tender and salmon is cooked through.
- 6) Serve salmon, snap peas, mushrooms and peppers with brown rice.





Nutrition Facts	
1 Fillet (nutrition facts are for cooked fish only)	
Serving size	
Amount Per Serving	
Calories	260
% Daily Value*	
Total Fat 13g	17%
Saturated Fat 2g	10%
Trans Fat 0g	
Polyunsaturated Fat 6g	
Monounsaturated Fat 5g	
Cholesterol 70mg	23%
Sodium 420mg	18%
Total Carbohydrate 6g	2%
Dietary Fiber 0g	0%
Total Sugars 6g	
Includes 5g Added Sugars	10%
Protein 28g	56%
Vitamin D 14.4mcg	70%
Calcium 26mg	2%
Iron 2.52mg	15%
Potassium 470mg	10%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Consumer Educational Brochure

Promotional Brochure Developed in Partnership with Brown's and Wakefern

TILAPIA CURRY

Ingredients

- 2 tablespoons olive oil
- 2 large carrots, chopped
- 1 gold or russet potato, chopped
- 1 small head cauliflower, chopped
- 1 bunch scallions, chopped
- 2 tablespoons minced ginger
- 4 tablespoons minced garlic
- 1/4 cup Thai yellow curry paste
- 1 8-ounce can coconut milk
- 1 ground frozen tilapia fillets

Method

- 1) In a large pot over medium heat, warm olive oil. Add carrots, potatoes, and cauliflower. Season with salt and pepper and cook for about 10 minutes, until vegetables begin to soften.
- 2) Add scallions, ginger, garlic, and curry paste. Stir to combine and cook for about 2 minutes, until aromatic.
- 3) Add coconut milk and 3 quarts of water. Bring to a boil and reduce to a simmer. Cook for about 10 minutes.
- 4) Add tilapia and simmer for another 10 minutes, until tilapia is fully cooked and vegetables are soft. Remove from heat and garnish with cilantro.

Created by: Chelsea Torres, Student, DePaul Food Lab

Dear Customers,

ShopRite is dedicated to keeping seafood plentiful and safe for generations to come.

Our seafood supplier, Wakefern Food Corp., has partnered with Marine Stewardship Council (MSC) and Global Aquaculture Alliance (GAA) to ensure that our wild-caught and farm-raised seafood are sourced from certified, sustainable fisheries and farms.

Contact Us

- [@BrownSupplies](#)
- [Brown'sMarket](#)
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Wakefern Food Lab
The Fresh Grocer

Tasty and Sustainable Frozen Seafood Recipes

Delicious recipes that reduce waste, maintain food safety, and encourage more sustainable seafood consumption

Promotional Brochure
Developed in
Partnership
with Brown's
and Wakefern

WHAT WE HAVE DONE THUS FAR:

Working together to reduce sea-to-plate losses and improve food systems

- ✓ RECIPES DEVELOPED BY DREXEL FOOD LAB**
The Drexel University Food Lab is a research group that aims to solve real-world food system problems through culinary innovation and food product development. For information on collaboration or supporting the Drexel Food Lab, please email FoodLab@drexel.edu.
- ✓ COLLABORATED WITH THE WORLD WILDLIFE FUND**
The world's leading conservation organization, WWF works on 100 countries and is supported by 2.2 million members in the United States and about 2 million globally. WWF's unique tag of working combined global-impact with a foundation presence.
- ✓ CRAFTED**
Delicious recipes that highlight frozen sustainable seafood items, including Pacific Chinook Salmon and Topical Caviar.

DREXEL UNIVERSITY
The Food Lab
the fresh ROTTER
Wakefern

What's Sustainable About Buying FROZEN Seafood?

FRESH SEAFOOD

FOOD WASTE

FOOD SAFETY

Reduces stress on fisheries globally
It is estimated that between 40-67% of the US seafood supply is lost or wasted. By using more of what we already catch, we can reduce pressure on our over-fished oceans.

Reduces food loss
Buying frozen seafood, because it stays frozen from sea to fork, reduces the risk of spoilage and loss both during processing and along the supply chain.

Produces less waste at home
Frozen seafood allows you to cook what you are going to eat and save the rest.

Peak safety
The colder the better when it comes to fish safety. By keeping fish frozen, there is less chance of microbial growth and the development of histamines.

It's delicious
Tasting by the Drexel University Food Lab found that many diners preferred recipes with seafood that was cooked-from-frozen.

MUSTARD ROASTED SALMON

Prep: 10 minutes
Cook: 40 minutes

1. Preheat frozen salmon fillet
2. 1 tablespoon whole grain mustard
3. 1 tablespoon lemon juice
4. 1/2 teaspoon salt
5. 1/2 teaspoon ground pepper



Method

- 1) Preheat oven to 375°.
- 2) Place the frozen salmon in a small casserole dish. Spread the mustard over the fish, drizzle with lemon juice and season with salt and pepper.
- 3) Place the casserole dish in the oven and bake for about 40 minutes, or until the salmon is cooked through and flakes easily.

Created by: Abby Davis, Manager, Drexel Food Lab