



A FRESH LOOK AT FROZEN FISH

EXPANDING MARKET OPPORTUNITIES FOR COMMUNITY FISHERMEN

Executive Summary

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ACKNOWLEDGMENTS

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As our global population continues to increase, so has demand for clean, healthy protein—including an abundant supply of seafood.

However, today's seafood industry is following closely in the steps of our terrestrial food system: global supply chains dominate.

Global supply chains, with a focus on efficiency, have intensified pressure on marine and freshwater fisheries. This pressure has led to widespread seafood fraud and mislabeling, as seafood brokers and distributors seek to meet demand for a finite resource. In addition, optimized for efficiency and profit over community and environmental health, industrial seafood production has the potential to leave a lasting impact: from depleted fish stocks to a disappearing way of life for many traditional fishing communities.

Seeking the best protein they can afford, most seafood buyers look for freshness as an indicator of quality, whether at the seafood counter or in a restaurant. However, in the global-industrial seafood market, “fresh” seafood is typically much less fresh than advertised, having been shipped long distances before sitting on the shelf for sometimes eight days or more.

According to National Oceanic and Atmospheric Administration, “up to 90 percent of seafood consumed in the United States is imported, and about half is wild-caught.” A significant portion of this imported seafood is caught by American fishermen, exported overseas for processing, and then reimported to the United States.

Often traveling thousands of miles and changing hands multiple times along the way before arriving on a dinner plate, the vast infrastructure of the global seafood supply chain is inherently hard to regulate. Without effective regulation, industrial seafood production can cause problems for both people and place. Ecologically,

overfishing and illegal, unreported, and unregulated (IUU) practices threaten the fragile balance of marine ecosystems and the future of global seafood supplies.

With a lack of traceability and transparency, purchasing decisions are fueled by consumer perception, rather than real awareness of where seafood comes from and the associated ecological and social costs.

In this system, consumers rarely get any window into the harvesting practices used, or the working conditions of the fisheries staff. Harmful, and perhaps even illegal, harvesting practices and working conditions often go unnoticed by the consumers and regulators alike. High prices for “fresh” fish, therefore, do not always reflect seafood produced with high standards around human and ecological impacts.

With so many uncertainties in today's seafood market, community-based U.S. fishermen are looking for a market differentiator that encapsulates the values consumers desire most: quality and freshness—while also delivering social and environmental benefits.

Flash-freezing seafood is one way to improve traceability, quality of seafood products, reduce waste, as well as support remote fishing communities.

Combined with careful handling, flash-freezing essentially “pauses” the degradation process, thereby increasing a product's shelf life. This enables small-scale producers to aggregate and distribute their high-quality seafood direct to consumers through a short and transparent supply chain.

Unfortunately, high quality flash-frozen seafood has yet to gain a foothold in mainstream markets. Driven by the perception that frozen means less fresh, most consumers are unaware that carefully handled flash-frozen seafood is of equal, if not superior, quality to fresh-never-frozen seafood. As a result, flash-frozen products are drastically undervalued. Furthermore, 23 percent of seafood at supermarkets never makes it the dinner plate and goes to waste—a challenge that could be addressed with greater consumer awareness and acceptance of high quality frozen fish.

Committed to creating market opportunities for communities and businesses that practice sustainable fishing methods, steward local fisheries, and produce high-quality seafood, a cohort of regional partners joined together in testing product quality and consumer perceptions of flash-frozen and fresh-never-frozen seafood productions.

The project team included three small-scale fishing businesses in Oregon, California, and Alaska: Port Orford Sustainable Seafood in Oregon, Real Good Fish based in Monterey, CA, and the Alaska Longline Fishermen's Association based in Sitka. Additional partners included Seafood Analytics, a Michigan-based company that developed a Seafood-CQR device used to instantly measure the freshness and quality of fish; Oregon State University's Food Innovation Center's (FIC) Consumer Sensory Testing & Research services; and Ecotrust, a nonprofit organization dedicated to fostering a natural model of development that creates more resilient communities, economies, and ecosystems.

In July 2016, partners received a \$100,000 grant from the National Fish and Wildlife Foundation's Fisheries Innovation Fund aimed at testing current consumer perceptions that frozen seafood is of lesser quality and exploring market opportunities for flash-frozen seafood.

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SEAFOOD IS ONE WAY TO
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FRESH
WHOLE
BLACK
COD

\$11.99/lb

Testing consumer preference

Ecotrust worked with partners to coordinate the shipment of flash-frozen sablefish (*Anoplopoma fimbria*) or “black cod” and coho salmon (*Oncorhynchus kisutch*) from small-scale fishers in Port Orford, OR, and Sitka, AK, to the Food Innovation Center in Portland, OR.

FIC’s chefs and technicians administered two days of blind consumer sensory-testing that compared line-caught, flash-frozen fish to fresh-never-frozen fish purchased from high-end grocers in Portland. Both fresh and flash-frozen fish were prepared in the FIC commercial kitchen, where study participants were asked to answer questions relating to the difference between each sample and overall acceptability.

SENSORY-TEST RESULTS

The objective of the FIC’s two-day blind consumer sensory-testing study was to determine if consumers could tell a difference between fresh-never-frozen and flash-frozen samples of sablefish and coho salmon, cooked identically, and if so, whether they had a preference. FIC’s chefs and technicians carefully prepared and served both fresh and previously frozen fish to almost 150 recruited participants.

Frozen salmon and sablefish fillets were received a few days prior to testing and were kept frozen until a day before the test at which time they were stored in a 36 degree refrigerator to thaw. On the morning of the test, the fillets were skinned and portioned into 1.5 oz. pieces and baked for approximately four minutes. No seasoning was added. Samples were coded with three-digit numbers and served side by side in a triangle test methodology for the first four sessions. Panelists were presented with one different and two alike randomized samples and were instructed to taste the samples from left to right.

Samples were then administered one at a time for the acceptability testing with the sablefish samples being served before the salmon. Sample presentation within each species was randomized over the entire test to avoid order effects.

Difference Results

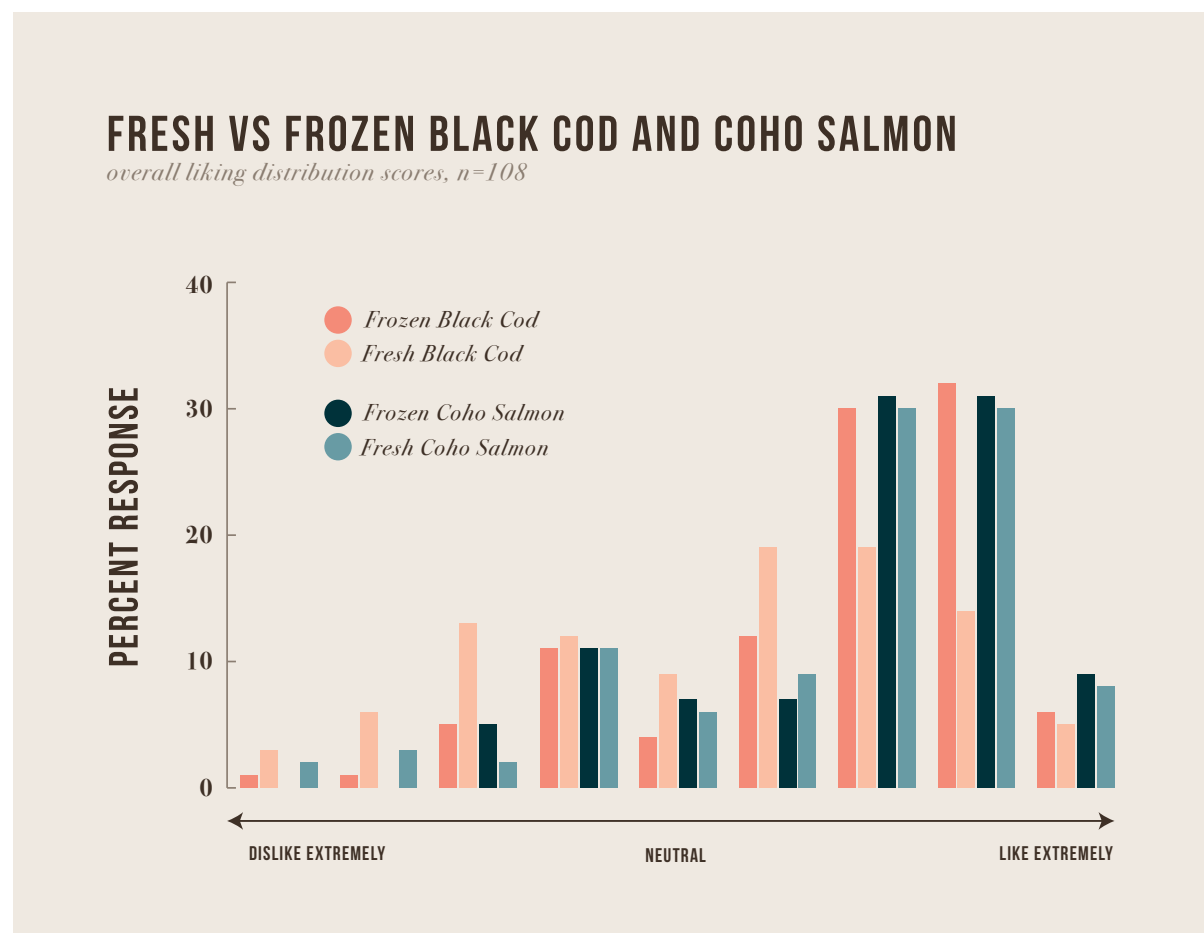
Using the triangle-testing method, 38 participants were asked to identify which fish sample, out of three provided, was different.

For both sablefish and Alaskan coho, consumers could tell a statistically-significant difference between the flash frozen and fresh fish samples. Flavor and texture were the two largest determinants in perceived difference between the fresh and previously frozen fish.

Acceptability Testing

108 consumers participated in acceptability testing, which addressed a range of factors including appearance, aroma, flavor, texture, quality, overall liking, and purchase intent. Across all categories, flash-frozen fish was rated as either more appealing or statistically the same as fresh fish. Looking specifically at sablefish, consumers preferred flash-frozen samples in every category except appearance, in which there was no statistical difference. Contrary to popular assumption, fresh fish was not a clear favorite among consumers.

Figure 1



Testing quality and freshness



Freshness + Quality Testing Results

Prior to consumer taste-testing, project partners measured the freshness and quality of the fish using the Seafood-Certified Quality Reader (CQR) device.

The CQR was developed by Seafood Analytics and measures the freshness and quality of seafood products, including both whole fish and fillets. The device sends a low frequency electrical current through the fish and collects data based on its relative conductivity. Once conductivity is measured, the reader assigns a Certified Quality Number (CQN) to the seafood product, which is an indicator of quality and freshness. The CQN scale ranges from a high score of 100 (just harvested) to less than 10 (several weeks old). In general, a higher CQN correlates to a fresher, higher-quality fish.

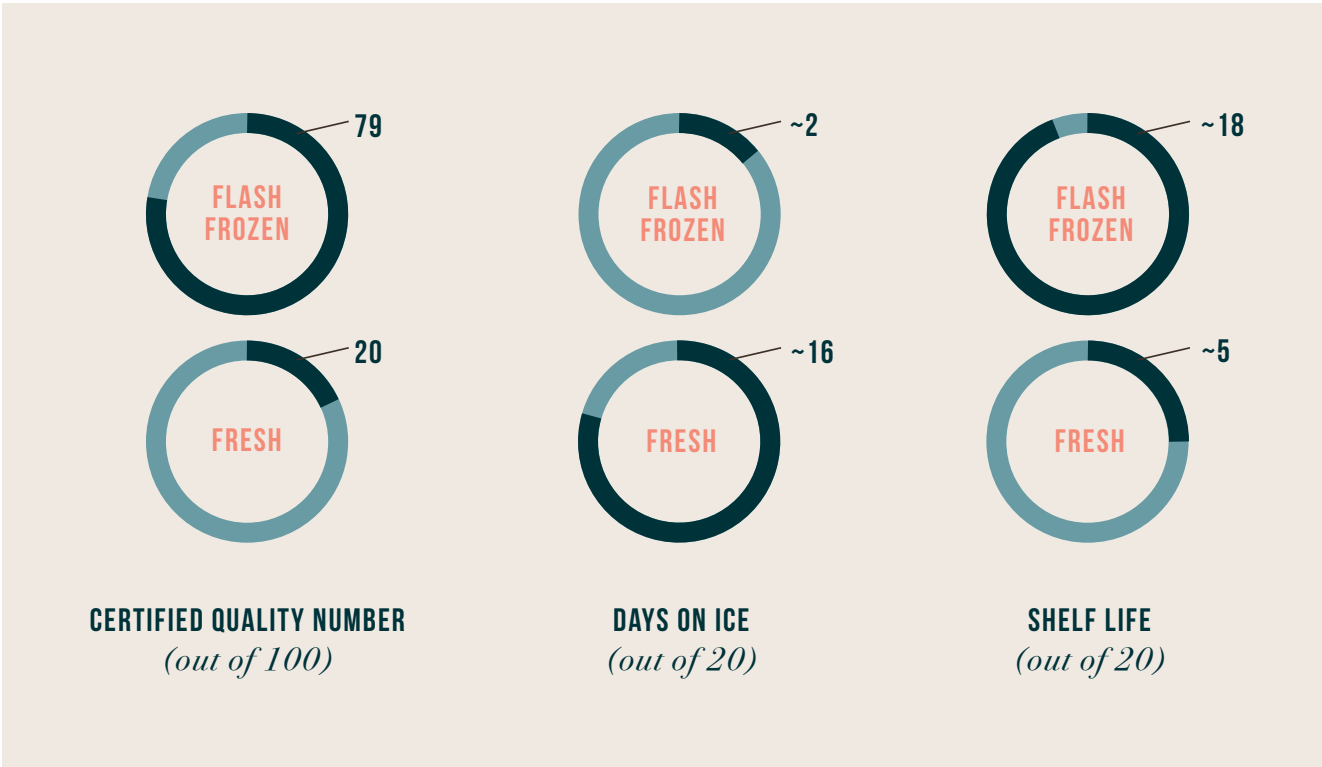
Each Seafood-CQR device has four electrodes and a digital reader. The outer two “signal” electrodes send a low frequency electrical current into the fish, while the inner two “detecting” electrodes receive the resulting data. Using the digital reader, device operators can select the particular fish species they wish to test.

When in use, the Seafood-CQR device measures conductivity at a cellular level, which enables it to determine the freshness and quality of the fish. In a very basic sense, each cell contains two parts: an outer cell membrane, and interior fluid within the cell. As a fish degrades, its cells release these inner fluids into the small, intervening spaces between cells, also known as interstitial spaces. Cell membranes themselves do not conduct electricity, but these inner fluids are conductive.

In that sense, as a fish degrades, two things happen: its tissue loses non-conductive cell membranes, and gains conductive fluids. Along these lines, a freshly-caught fish would be less conductive because its cell membranes would still be intact. By comparison, a fish that has begun to decompose, or has not been handled carefully, would contain more conductive fluid because its cell membranes have begun to break down. According to Seafood Analytics, “bruising, microbial growth, open sores, cuts, and scale loss increase the loss of non-conductive cell membranes, and therefore lead to loss of grade, soft flesh, and poor quality.”

In the case of line-caught flash-frozen fish, partners took Seafood-CQR measurements immediately prior to flash-freezing, in order to compare its shelf life with that of the fresh fish purchased from high-end grocers in Portland (Figure 2). Project partners anticipated that fish caught and immediately frozen would be of higher quality and have a longer shelf life after thawing than the majority of grocery-bought fresh fish.

Figure 2



Comparisons using coho salmon (Oncorhynchus kisutch). (Fresh and flash-frozen (dark blue) measured with a Certified Quality Reader (CQR). Comparisons were made between measures of the certified quality number (CQN) and between predictions (made from CQN) of days on ice and shelf life remaining.

Test results confirmed this assumption, revealing a stark difference in freshness between flash-frozen and fresh fish as measured by the Seafood-CQR device (Figure 3). Looking at the data, flash-frozen fish registered CQNs of 80 for sablefish, and 79 for coho salmon, while fresh fish of the same species came in significantly lower with an average score of 15 for sablefish and 20 for coho salmon. In general, the higher the CQN, the fresher (and therefore higher quality) of the fish. Based on these results, fresh sablefish and Alaskan coho purchased at retail were of much lower quality than line-caught

flash-frozen fish. Considering that fresh fish typically sits for up to a week or more behind the seafood counter, this result is not surprising. Additionally, as we learned through working with project partners, even slight variations in handling can affect the CQN. One partner was surprised to see lower CQN numbers registering on the Seafood-CQR, and later realized that fish had been sitting in an ice slurry with an overly high water content. This anecdote supports the fact that the device is sensitive to fish quality, and accurately reflects even slight changes in handling practices.

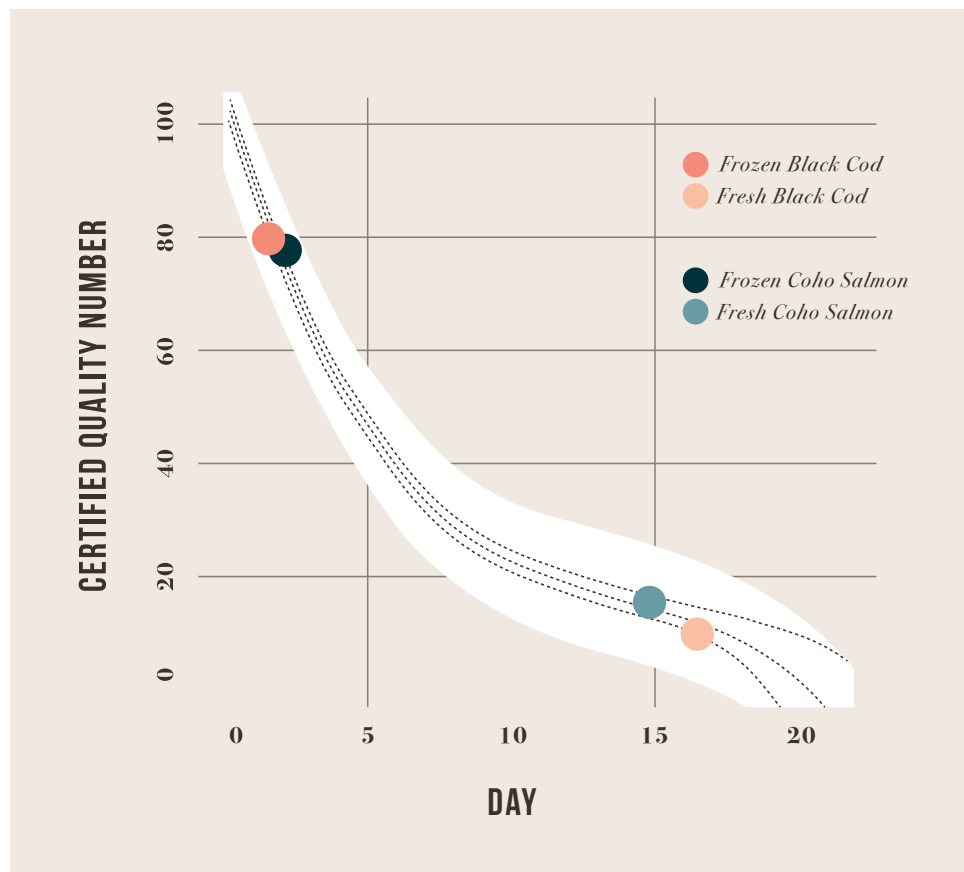


Figure 3

*Standard quality curve of salmon with scores from fresh and flash-frozen coho salmon (*Oncorhynchus kisutch*) and black cod (*Anoplopoma fimbria*). Fresh was measured upon availability at the retail level and was purchased in Portland, Oregon. Frozen fresh fish was caught and delivered to the processing plant where it was measured and immediately frozen.*

A man with a mustache, wearing a white button-down shirt and a white apron, is focused on a handheld electronic device. The device has a small screen displaying text and a keypad. The text on the screen includes "HSP Rockfish", "The current is", and "Press OK to". The device also features a logo with a fish and the text "SEAFOOD ANALYSIS". The man is standing in a kitchen or food processing area, with stainless steel surfaces and equipment visible in the background. In the foreground, several long, pinkish fish fillets are laid out on a white surface. The man's left hand is resting on the surface near the fillets, and he is wearing a black wristwatch. The overall scene suggests a quality control or food safety inspection process.

Conclusions

Consumer testing results, combined with Seafood-CQR data, indicate that flash-frozen fish can be a fresher, higher quality product than never-frozen fish purchased at retail. Consumers could tell a statistically-significant difference between fresh and previously-frozen products, and did not prefer the fresh-never-frozen fish in any category of acceptability.

Flash-frozen fish received an equal or higher rating than fresh fish across the board. Simply being rated equal to fresh fish indicates that consumers do not have an

automatic preference for fresh fish. these results run contrary to many consumer perceptions that fresh-never-frozen fish means highest quality.

In a larger context, results indicate the potential to shift consumer perception in favor of high-quality flash-frozen seafood. If, for example, consumers could receive better information about the added-value of flash-frozen fish, the implications for small-scale fishers and supporting regional seafood economies could be tremendous.

Figure 4

BENEFITS OF BUYING FLASH-FROZEN SEAFOOD



Quality & freshness Many fresh fillets may have been in the grocery seafood display case for eight days or more, and can take 10-16 days to even arrive at a retail location.



More species, less fishing intensity Freezing allows small-scale fishermen to develop markets for the entirety of their catch, including fish traditionally considered bycatch, thereby increasing resource utilization without increasing fishing intensity.



Less waste Flash-frozen seafood can help small-scale fishermen address challenges like seasonal swings in volume, distribution cost, and help them more accurately match supply and demand, thereby generating decreased waste. Frozen fish is also less likely to be wasted in retail and consumer settings.



Lower carbon footprint The majority of fresh fish fillets are often caught far from where they are consumed and must be shipped by air, one of the world's most carbon-intensive forms of travel. By comparison, flash-frozen fish can be distributed by freezer trucks with a much lower carbon footprint.