

To build and maintain a profitable and sustainable business for all stakeholders, a holistic view of the end-to-end perishables supply chain is required.

# Building Sustainability and Trust in the Perishables Supply Chain

December 2023

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## Introduction

The Departments of Fish and Wildlife in California, Oregon, and Washington placed prohibitions on ocean salmon fishing in 2023 and will likely extend these to next year. Wild salmon populations have drastically decreased due to a perfect storm of factors destroying and warming their habitats and making it difficult for them to access the remaining cold freshwater rivers and streams. These factors include the construction of dams, water diversion to farms, drought, rising water temperatures (salmon eggs don't hatch if water becomes too warm), and climate change.

This IDC Spotlight is not about the fate of salmon (although we'll return to this topic) but about the factors impacting this species. They are valuable real-world touch points to consider and incorporate strategically when we think about the end-to-end perishables supply chain and the variables that must be taken into account to build one that is sustainable, trustworthy, fresh, and profitable to all stakeholders — from ocean, farm, or field to transportation and logistics to grocery stores and flower shops — and one that also delights the end consumer when its products hit their kitchen table. Even when food is safe, there is a significant difference between "won't make you sick" and "tastes delicious." Businesses are certainly aiming for the latter. To achieve this, they need to be able to answer the question, "How fresh is this product?"

Understanding product freshness requires knowing a product's condition at all times throughout its journey. Furthermore, creating a sustainable, efficient, and nonwasteful supply chain requires using that knowledge to impact processes and operations to preserve freshness and determine when a product's freshness cannot be preserved well enough to be worth the cost and resources of bringing it to market. In today's global economy, where supply chains are increasingly complex and partners often don't know one other, the condition of perishables can be even more difficult to ascertain for retailers and customers.

## AT A GLANCE

### WHAT'S IMPORTANT

Understanding product freshness requires knowing a product's condition at all times throughout its journey.

### KEY TAKEAWAY

Internet of Things/radio frequency identification technologies can enable tracking and tracing while providing intelligence about the condition of perishable products at all times, enabling businesses to provide safe, fresh, and delicious food to customers and to build trustworthy and sustainable supply chains.

What's the answer? Internet of Things (IoT) and radio frequency identification (RFID) technology offer tracking and tracing while providing intelligence about the condition of perishable products throughout the supply chain. Traceability initiatives and blockchain ensure compliance with regulatory mandates and that data-sharing agreements are honored. Together, they enable businesses to provide fresh, safe, and delicious food consistently to consumers and build a trustworthy and sustainable supply chain.

### *Challenges of the Perishables Supply Chain*

Ensuring the freshness, quality, and safety of food throughout the supply chain requires knowing the product's condition along its journey. Currently, this awareness is fraught with blind spots, where factors such as temperature and humidity and their impact on product condition are unknown. This often happens on small or midsize fishing boats as ocean and air temperatures rise during transit from boat to processor, from field to shed, from truck to warehouse, and in the warehouse or on the loading dock, for example — with products often losing as much as 25% of their shelf life unnecessarily. Considering the available shelf life of perishables, the time they spend in less-than-optimal conditions quickly degrades their freshness and limits the time they are salable. Consumers' 24 x 7 online buying habits create even more uncertainty, with third-party last-mile delivery partners providing another opportunity for product degradation.

This lack of knowledge leads to significant losses. Each year, 30–40% of the U.S. food supply is wasted, corresponding to approximately 133 billion pounds and \$161 billion in value according to the U.S. Food and Drug Administration. This happens at every stage of food production, distribution, and postpurchase; food is the single largest category of material in municipal landfills and represents wasted energy, water, and other natural resources and labor — not to mention nourishment that could be provided to those in need.

With increased knowledge about the condition of its products, a company can improve the product journey, ensuring greater customer satisfaction, environmental sustainability, and profitability.

Tracking and tracing are not new in current supply chains but have generally been limited to snapshots, such as a handheld reader scanning tags on perishable goods pallets or boxes and a reader mounted at a dock door or another fixed-point location. Any item can be brought back into temperature compliance, but this does not indicate what may have happened at other, non-monitored points along its journey to the consumer.

Tracking and tracing a product's freshness across the supply chain requires knowing its condition at all points. Condition intelligence enables taking appropriate actions in the present and can also prompt stakeholders along the chain to improve the way they handle, store, and move perishables.

### *Condition Intelligence Enabling Improved Perishables Management, from First to Last Mile*

Condition intelligence can be used by commercial fishing boats and natives (artisans) to make positive changes on the water; at farms and seafood processing plants; by businesses (from small to global enterprises), service providers, transportation carriers, and logistics providers; in grocery store back rooms; at deli counters, produce departments, and restaurants; and by consumers.

The plight of salmon is just a small example of how massive global shifts, including a change in the climate, can have an often deleterious impact on ecosystems. Warming waters and shrinking habitats mean fewer areas for fish to thrive; furthermore, fish caught in warm waters are not as fresh as when they swam through colder seas and rivers. Because of this, the journey from net to table requires even more careful handling. To maintain end-to-end quality, each event along the way must perform optimally and needs insight and accountability at each stage.

When business processes and/or custody owners can timeline track and share perishables' condition data among partners, the opportunities to improve processes and food freshness are significant. This is good business regardless of external circumstances — why waste anything, especially living beings? It is increasingly imperative to combat the harmful effects of rising temperatures and other challenges that are largely outside the control of an individual business or supply chain network. Opportunities include:

- » **Climate-optimized processes:** With ocean and air temperatures rising, maintaining wild-caught seafood's temperature as close to 32F as possible and minimizing the time between catch and freezing are critical. In Alaska, this has led to a new operating model in which vessels, called tenders, pick up fish from catcher's vessels and take it to at-sea processors rather than to processors on shore.
- » **Improved inventory management:** Complete insight into the condition of perishables allows businesses to understand where freshness is lost and adjust inventory management accordingly, improving practices such as smarter cold transport loading and routing.
- » **Improved visibility:** Understanding a perishable's condition at all points provides insight into its environment, the spaces it occupies, and the trips it takes, generating data that can be used to correct and improve supply chain journeys.
- » **Risk mitigation:** With insight into real-time conditions and data about where and how perishables most rapidly lose freshness, businesses assess situations and determine next steps faster in case of disruptions, such as power outages.
- » **Consistency and trust among partners:** Sharing data about a product's condition via blockchain or another secure method along the supply chain builds consistent and trusting relationships.
- » **Simulation:** The ability to collect data at all points along an item's journey enables the creation of perishable supply chain digital twins that can run what-if simulations.
- » **Outcome-based payments:** By understanding where a product degrades, buyers can pay suppliers fairly based on outcomes.
- » **Scorecards:** Condition intelligence by a process/custody owner enables scorecards for ingredient suppliers, seafood vessel operators and captains, aquaculture farmers, and logistics and transportation providers.
- » **Shared-value pricing:** Assigning a price value to freshness degradation is possible. Rewards for freshness motivate stakeholders to provide the freshest product possible and lead to more accurate assessments of the risks to perishables due to climate insecurity and supply chain interruptions. Incorporating perishable handling into environmental, social, and governance (ESG) calculations will reduce perishables losses. All of these actions provide value in terms of freshness and better prices for suppliers.
- » **Regulatory compliance:** Condition intelligence data can help companies comply with food safety regulations, reducing the risk of fines and penalties, as well as improving their brand reputation.
- » **Enhanced brand reputation:** Companies that demonstrate insight into the workings of their supply chains and their actions to reduce waste and improve product quality can improve their reputation.

- » **Lower insurance costs:** By demonstrating that they handle and store products correctly throughout the supply chain, companies may negotiate lower insurance premiums.
- » **Improved labor value:** By automating the process of monitoring product conditions, companies can potentially reduce labor costs while freeing up employees for more valuable tasks.
- » **Improved forecasting:** Condition intelligence provides valuable granular data on where and how products fail to comply or where conditions can be improved even if they are compliant. By improving conditions, businesses can forecast based on likely demand rather than on products that may head straight for the landfill, reducing waste and improving efficiency.
- » **Improved decision making:** Real-time intelligence can enable quicker, more informed decisions, helping prevent product waste and increasing desirable outcomes.
- » **Increased consumer trust:** Transparency about the condition of products throughout their supply chain journey can enhance consumer trust, both directly and indirectly, leading to greater loyalty and increased sales.
- » **Lower environmental impact:** Condition intelligence results in the smarter handling of inventory, which reduces waste and environmental impact and helps achieve sustainability goals.
- » **Enhanced transparency and accountability:** In addition to providing valuable data for compliance reporting, condition intelligence data can facilitate sustainability reporting and demonstrate that a company is taking concrete steps to improve its environmental performance.

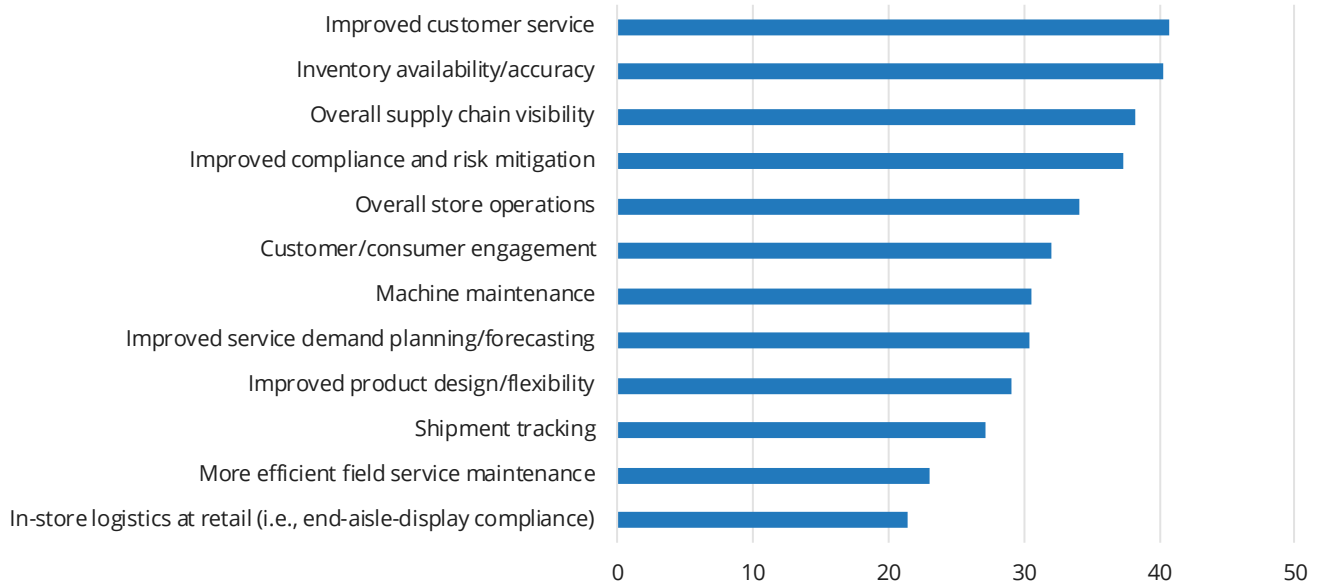
## Benefits

For grocers and suppliers that track and trace perishables continuously and effectively, the benefits are transformational. Hands-free, real-time tracking that can take a moment-in-time measurement and transmit that data elsewhere helps companies gain insight into the product's condition at every stage. Today, IoT formats such as Long Range (LoRa), Bluetooth Low Energy (BLE), and Narrowband (NB) IoT, which send the data directly to the cloud at user-specified times, support this continuous condition tracking.

Retailers and consumer packaged goods companies already employing some type of tracking sensor at the item, box, or pallet level recognize a range of benefits, as Figure 1 indicates. These benefits significantly increase when items are tracked with tags that can budget, track, and compare actual perishable conditions (i.e., the current state of freshness relative to the best-case freshness) and predict available consumer life at sale.

FIGURE 1: *Top Benefits of Tracking and Tracing Inventory with IoT/RFID*

**Q What types of benefits have you seen from IoT/RFID deployments in your supply chain?**



*n = 262 for retail*

Source: IDC's Supply Chain Survey, March 2023

The following provides a deeper look at some of the benefits of continuous product condition tracking and tracing throughout the perishable product life cycle:

- » **Improved customer service and greater consumer trust:** Consider the damage when a customer picks out a fruit cup in the prepared food section of a grocery store and one of the components (usually the cantaloupe) has become slimy. Opportunities to better serve the customer increase manyfold when grocers and suppliers have insight into freshness and taste. Measuring, making visible, and trusting a perishable's condition and knowing what to do when that condition is not up to par allow businesses to ensure consistent product quality and freshness, creating a positive customer experience and building loyalty.
- » **Improved temperature compliance and risk mitigation across the cold chain:** When buying printer paper, it doesn't matter if the ream spent a long time at the manufacturing facility. However, it's a different story when ice cream has a freezer burn from melting and refreezing several times along its journey. The stakes are even higher for food safety. According to the Centers for Disease Control and Prevention, approximately 48 million people become ill, 128,000 are hospitalized, and 3,000 die each year in the United States alone from food-borne diseases (e.g., the widespread recalls of romaine lettuce, spinach, and peanut butter). The Food and Drug Administration's Food Safety and Modernization Act (FSMA), which was signed into law in 2011, has issued seven major rules that will require compliance by 2026. These rules translate into specific actions at each point in the global supply chain to reduce contamination and tighten food traceability requirements.

Tracking and tracing using continuous intelligence has distinct advantages for perishables supply chains where maintaining consistent cold temperatures is crucial for product safety, longevity, consumer satisfaction, and compliance. Another important benefit is conveying real-time data to parties that can act on it, mitigating poor

environmental conditions before a product falls out of compliance. Although ensuring a bad product does not end up with consumers is the top priority, maximizing product freshness and shelf life and saving it from disposal is a close second.

- » **More efficient and sustainable operations:** Sustainability is a core component of consumer decision making. In IDC's August 2022 *Consumer Sentiment Survey*, 45.6% of consumers said that they make purchase decisions based on a retailer or brand's sustainability record. *Wall Street* also invests in environmentally conscious businesses. Retailers and brands identify reducing waste and driving cost efficiencies as their top sustainability goals. Much of fuel, energy, water, packaging, and inventory waste stems from significant insight gaps. In the modern digital age, technologies and capabilities, including IoT, cloud, AI, and modern infrastructures, can address these gaps. Each acts as a force multiplier on the others to create more efficient, sustainable, and profitable supply chains.

Digitalization involves automating processes, gathering the data, and making it visible and usable to all parties. Organizations can then make faster, better decisions that improve business and sustainability outcomes, such as:

- » Improved product groupings
- » Visibility into the shelf life of ingredients at receipt or in preproduction to maximize product yields
- » Rightsizing and appropriate allocation of inventories
- » Reduction in food and other resource waste (identifying issues that could lead to spoilage)
- » Optimization of energy use (cutting off refrigeration for an already spoiled batch)
- » Optimization of transportation (shipping products with a shorter shelf life via faster, potentially more energy-intensive methods while using slower, more energy-efficient methods for products with a longer shelf life)
- » Promoting more responsible resource use for a more circular economy (directing food that is no longer salable to other uses, such as animal feed)
- » Enhanced transparency and accountability

## Trends

Understanding where freshness is at risk is crucial to addressing the challenges of a perishables supply chain. Luckily, innovation trends, improved and more pervasive technology, standardization, and sustainability are coming together to draw more value from each perishable item — minimizing resource waste, improving efficiency, and ultimately delighting the consumer and delivering greater profits to all bottom lines. These trends include:

- » **IoT technology:** Today, tracking items through sensors, readers, or networks is common, especially to answer the questions of how many and where, but they have a limited ability to show the condition of items at all times. Some new classes of sensors can assess environmental conditions by measuring variables such as temperature and humidity and storing this data until the sensor is within range of a reader or Wi-Fi network.

Although end-to-end capabilities for 100% real-time intelligence are not yet available, they are close. By communicating with widespread communications networks instead of fixed-point readers, IoT sensors can convey constant, real-time condition information even in transit, assuming that a functioning network is in the vicinity.



- » **Broadband communications networks:** Communications networks are expanding in geography, capability, and capacity. These include 5G cellular networks and satellite constellations that operate in low Earth orbit and offer high-speed, low-latency internet globally, even in remote locations. For example, Starlink has been providing satellite broadband connectivity to most of Alaska since July 2023. Many other providers operate in this space, including Amazon, which plans to build a network of 3,236 satellites to provide high-speed internet as part of Project Kuiper.
- » **Smart consumer/commercial products:** A growing group of technologies and protocols can enable next-gen IoT capabilities and communications. These include long-term evolution machine (LTE-M) and narrowband IoT low-power wide area network (LPWAN) technologies that the Third Generation Partnership Project (3GPP) developed to enable devices and services specifically for IoT applications and real-time operating systems (RTOS) for IoT in space-constrained devices. Some examples of the latter include Amazon FreeRTOS, Google-Meta Zephyr RTOS, Microsoft Azure RTOS, and Aptiv-Wind River RTOS. Improved IoT technologies are spreading innovation across industries in the form of intelligent products (smartwatches, appliances, and equipment) that can sense certain characteristics of the environment they're in and convey that data in real time.
- » **Emerging business models:** The increasing number of objects connecting to the internet enables the automation of more processes and operations, from farm to fork or concept to consumer. More data becomes available to provide more insights. Although many gaps exist in terms of device connectivity and the use of device-generated data, as these products and their usage scale, new business models will emerge. For example, when refrigerators or storage containers can sense or know the condition of their contents, they can inform their owner of soon-to-expire foods, recommend recipes that might incorporate them, or adjust the temperature based on the contents. On the front end of the supply chain, technologies can enable precision agriculture by providing equipment that allows farmers to monitor, manage, and maximize farm operations, leading to greater efficiency, less waste, and higher yields.
- » **Standardization:** All these scenarios require sensors to track and trace items across the product life cycle, technology to transmit signals from the sensors, and infrastructure that can convey that data in real time. This requires governance and a high level of interoperability among various appliances, devices, systems, and networks to ensure that parties adhere to global standards, such as GS1's standards, to encourage a common language for business and trade.

## Considering Infratab

Infratab provides condition-intelligent radio frequency solutions for monitoring and tracking perishables and items whose condition is measurable. The company designs, develops, sells, and services tags, edge software, cloud services, and analytics that work together to answer the key question "How fresh is this product?" Its Freshtime system allows companies to assess whether their items have preserved their quality across the cold chain, from harvest or production through to transport and sale to the consumer, and where freshness has been lost. It also enables stakeholders across and adjacent to the cold chain to understand where problems occur and address them.

Infratab's products monitor, track, and trace the temperature and condition of perishables (and other goods that degrade) across business partners, locations, and processes. The company offers a holistic view, grading freshness across the ecosystem and considering the product's entire life cycle as the baseline of its total shelf life. Infratab assigns 100

points to a product's shelf life at its "birth" and 0 points at the end — its quality or best-before date. This points scale enables brands to set sell-by points and, most importantly, points that represent the brand's quality standards. For example, for flowers to bloom and remain fresh for seven days at home, a florist must typically set the consumer's buy points at 60. Knowing this enables setting and measuring points budgets for harvesting, transporting, and selling. By establishing a range or a band of points (e.g., premium fresh or generic fresh), condition-intelligent supplier scorecarding and inventory management are simple and fast. Metrics such as preferred flavor and nutrient values can be added to these metrics.

Stakeholders can see a product's remaining shelf life when it hits retail. From there, they can determine how many freshness points they can use before the item lands on the consumer's plate and where to eliminate waste and make the product journey worthwhile. By measuring, quantifying, and validating a product's condition, Freshtime can build trust among supplier partners and customers and offer several benefits, such as rewarding suppliers at each stage for improving processes and technology to reduce points. It can help grocers determine when to mark down products and inform consumers about how quickly to consume what they buy. All parties can act on the data to make better decisions.

Infratab's sensors enable the timely collection of data that blockchain or other systems can share among shareholders. Through analytics and AI, that data can pinpoint particular challenges and identify specific disruptions before a product becomes nonsalable. The sensors are reusable and contribute to a circular packaging model and greater overall sustainability.

### Challenges

Total condition intelligence in the end-to-end supply chain is achievable but certainly not easy. As is often the case with new paradigms in business, the infrastructure, technological resources, standardization, human resources, and mindset to support them are just becoming available. The first step is to understand where shelf life is unnecessarily lost to fine-tune processes that put the perishable at risk. The goal is gaining shelf life visibility by using partners' internal and critical processes, which is where traceability and data-sharing agreements come into play to provide the necessary visibility and trusted collaboration between partners. Other challenges to adopting condition intelligence capabilities across supply ecosystems include:

- » **Costs:** Infratab's challenge has been providing affordable IoT tagging not just for global enterprises but also for small and midsize enterprises (SMEs), including the businesses of indigenous communities. To decrease perishable losses from 30% to 15% or lower, small businesses need to participate. However, this can be challenging because of their small accounting staff and lack of computing capabilities beyond smartphones. The solutions are circularity, tag reuse, rewards for returns, and tags for only those for whom quality is a concern. The cost then drops to 0.5% or less of the value of a producer's shipments, and the challenge lies in the proof.
- » **Data sharing:** The widespread adoption of sensors across the supply chain will enable unprecedented data sharing — if stakeholders along that chain are willing to share. Businesses of all stripes have long been protecting data from partners, customers, and other interested parties. A shift in mentality must occur to recognize the value that condition intelligence sharing across the supply chain brings to everyone. The main value of Infratab's technology is the cumulative effects it offers by measuring across nodes and sharing that data with all parties; however, the need for universal buy-in across the ecosystem could hamper adoption efforts. A key to success would be enabling the sharing of key data while ensuring the privacy of confidential data specific to the grower, the fisherman, and the



producer that contributes to a unique competitive advantage. Another solution would be to harness valuable data for technologies such as GenAI for the common good without compromising individual businesses.

- » **Development of new standards:** Although Bluetooth is available, 3GPP standards and the knowledge and skills to handle issues of privacy governance, roaming, and data sharing from telcos will take time to develop.
- » **Knock-offs:** As condition intelligence technology grows, other companies will enter the market, which may lead to RF sensors that provide inaccurate information and damage trust in the overall industry. The benefits of condition intelligence accrue first to the brand. It is at the brand level that new packaging can be tested, new seedlings and breeds can be cultivated, nutrients added, and processes refined. To have trust in shelf life, the shelf-life model must be that of the brand owner, and users must be aware of the accuracy of the sensing device.
- » **Legacy and different technologies:** Homegrown or legacy applications and infrastructure often hamper the modernization and digitalization of supply chains and stores, increasing the difficulty in implementing new technologies and making them less effective and more time-consuming and expensive. In addition, many retailers and consumer packaged goods companies have implemented RFID over the past two decades to track and trace inventory and may not have sufficient motivation to adopt 100% condition intelligence. This would require a change when they already have something that meets many of their needs.

## Conclusion

A holistic view of the end-to-end perishables supply chain is required to build and maintain sustainable, trustworthy, fresh, and profitable business for all stakeholders. This view includes the product journey from ocean, farm, or field to transportation and logistics, to grocery stores and flower shops, to the kitchen table. A combination of technologies including Internet of Things and radio frequency identification for tracking and tracing while providing comprehensive intelligence about the condition of perishable products, combined with traceability initiatives and blockchain to ensure compliance with regulations and the ability to honor data-sharing agreements together, can businesses to provide fresh, safe, and delicious food consistently to consumers and build a trustworthy and sustainable supply chain. Given today's challenges of a warmer planet, an increasingly elaborate regulatory environment, and growing complexity in supply chains, IDC believes the market for intelligent end-to-end perishables supply chain tracking will grow in importance. To the extent that Infratab can address the challenges of capturing and reporting condition intelligence across the supply chain, the company has a significant opportunity to succeed in improving this market by helping to build a better end-to-end business model for perishables.

## About the Analyst



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Jordan Speer is research director for IDC Retail Insights, responsible for covering the global retail supply chain, with emphasis on product sourcing, fulfillment, and sustainability. Her core research examines how digital technology creates opportunities to better connect and optimize the execution of the end-to-end product life cycle, from the design and sourcing stages through to order orchestration and fulfillment to the customer. Her research covers product development and sourcing, demand forecasting, order orchestration and last-mile omni-channel fulfillment, returns and reverse logistics, and track and trace, with particular emphasis on how software applications and technology such as AI, RFID, IoT, and robotics can enhance these processes to enable more sustainable products and enterprises.

## MESSAGE FROM THE SPONSOR

Understanding the freshness of perishable goods at any time in a perishable's life is a challenge. It is easiest for those who make and then sell directly to a known, repeat buyer. It becomes easier to sell worldwide when there is a known and agreed-upon vocabulary for business, product markets, and condition. It is why our products are compatible with GS1 IDs and data used in barcode labels, traceability documents, and blockchain smart contracts. It is why we have condition vocabularies and APIs available to partners and users.

Infratab has been a pioneer in applying the IoT to the perishables supply chain. The advances made in RF sensor chips with AI capabilities make hands-free use of tags a reality and make integration with the billions of RF sensor devices already in the market simple and maybe even fun. We are currently readying version 3 of our flagship product, Infratab Freshtime, with full traceability and data sharing for perishables on the US FDA's FSMS traceability list — with special emphasis on seafood, wild-caught and farmed.

In seafood, we are driven to ensure that all seafood eaten in the United States (of which 80% is imported) is legally caught, honestly labeled, and freshness-managed. Our solutions span global enterprises, independent commercial fishing vessels, sportfishing operators and fishers, and native indigenous fishing communities. We are concerned with U.S. and EU import and export compliances. We are out to prove that our seafood solution only requires vocabulary change for the perishables market (berries, vegetables, beef, cosmetics, industrials, pharma). We hope you join us in our quest.

To learn more about how Infratab can help enhance your perishables supply chain, visit [our website](#) and explore our range of innovative solutions.



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