Fishcoin

White Paper

Fishcoin
A Blockchain Based Data Ecosystem
For The Global Seafood Industry

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Executive Summary

The seafood industry is on the verge of a massive transition. For millennia, fish and other seafood products have been harvested, processed, sold, exported, shipped, imported, resold by wholesalers, and ultimately sold or served to consumers. The industry has always had its challenges, but up to now it has functioned in order to bring us the seafood we consume. However, this ecosystem is rapidly growing to exceed sustainable capacity. Consider the following points:

- Global per capita seafood consumption has more than doubled in the past 50 years
- 89% of global wild fish stocks are already overfished or fully exploited
- Up to 50% of seafood is discarded or wasted along supply chains
- 1 in 10 people on the planet owe their livelihoods to fisheries and aquaculture

In recent decades, almost every agricultural industry has used data to drive efficiency and innovation, but seafood is lagging behind in this regard. While physical seafood goods are being transferred through global supply chains, what is not being transferred in any significant way is the related data. This lack of data comes at a cost. Without this data, fish stocks cannot be properly managed, supply chain efficiencies cannot be substantially improved, cold chain and logistics services cannot be easily coordinated, and the world's growing population, projected to rise by 37% by 2050, could inevitably drive the seafood ecosystem to the point of collapse.

Governments are aware of this problem and are introducing regulations requiring more data to be captured about the seafood we consume. Non governmental organisations (NGOs) and universities are searching for solutions to help the industry coordinate and share more data. Forward thinking companies are requiring more data to validate their sustainability commitments. These are all positive steps, but they are insufficient unless the harvest and flow of data can begin to mirror the harvest and flow of seafood goods. The problem is that the global seafood industry is fragmented – from independent artisanal fishers and smallholder fish farmers, to independent consolidators and processors, to independent exporters, importers and wholesalers, to independent restaurants and retailers – no single central actor, or even group of actors, controls the flow of goods. In such an industry, which actor can be trusted to control the flow of data?

The seafood industry would benefit vastly from a decentralized data ecosystem that operates in parallel to the decentralized ecosystem of physical goods. As seafood is exchanged from actor to actor, peer-to-peer relationships are formed in which data can be shared, and reputation can be established. Blockchain is a powerful decentralized architecture designed to serve as both a mechanism and incentive structure for such decentralized ecosystems. Therefore, to address this issue, a team of seafood industry veterans, along with experts in technology, legal compliance, and ecosystem design have come together to develop a blockchain based data ecosystem specifically designed for

the seafood industry. To facilitate and incentivize the exchange of data between actors, this ecosystem incorporates a utility token called Fishcoin.

Fishcoin is not meant to replace or disrupt fiat trade in the seafood industry. Instead, it is designed to incentivize the collection and input of data to help better manage resources. As the volume of data increases, efficiencies will be gained in the production and delivery of physical seafood goods, and with time, each mile of seafood supply chains will be transformed to become more sustainable, responsible and profitable. Fishcoin can be the reward for the millions of fishers and fish farmers who harvest the seafood we eat, as they harvest the data we need.

Introduction:
An Ocean of Opportunity

Overview

The $150 billion global seafood industry is rapidly expanding. Per capita seafood consumption has more than doubled worldwide in the past 50 years and today more than 1 in 10 people on the planet derive their livelihoods from fisheries and aquaculture (fish farming). This rapid growth has fueled significant challenges both for the seafood industry and the overall sustainability of our oceans. Currently, 89% of global fish stocks are overfished or fully exploited, yet the problem isn't simply consumption but also waste, as up to 50% of fish are discarded or wasted within supply chains. In addition, more than 700 kilograms of seafood are stolen every second through Illegal, Unreported and Unregulated (IUU) fishing.

The problem, and ultimately the opportunity, comes down to an existing lack of transparency with root causes that can be summarized by the fact that the seafood industry on the whole is currently: 1) information intensive, 2) filled with un-scalable gatekeepers, 3) highly fragmented and 4) characterized by extreme information asymmetries.[1]

> **1. Information Intensive:** At first glance many would conclude that the seafood industry is anything but information intensive. This is due in large part to the way the industry has been managed. However, in order to truly determine the legal status, safety, and quality of seafood, and ultimately the responsibility of its harvest, buyers need to know important details such as product specifications (species, size, weight, etc), location of harvest, time/date of harvest, the identity of the producers, and the way in which the seafood was handled. These data points don't simply need to be captured, but transferred through each member of, what in many cases are highly fragmented, supply chains.
>
> At present only some of this required data is being captured in more linear supply chains, but in the decades to come, seafood buyers and governments will require more data in order to verify that the seafood we consume has been responsibly sourced.
>
> **2. Filled With Unscalable Gatekeepers:** Part of the transparency problem throughout the seafood industry is due to the purposeful design of unscalable information gatekeepers in the form of "middlemen" that often add little to no value, but simply maintain their position by carefully guarding information and creating financial mechanisms that limit producers into having only a single option when the time comes to sell their harvest. Up to and until now, these information cartels have been tolerated because the industry is highly fragmented, producers on the whole had very little connection to other producers outside of their immediate area, and downstream players in the supply chain have not required key data elements (KDEs) for import and purchase. However, this is all changing as buyers and governments are requiring these KDEs in order to ensure legality via traceability back to the source, safety and quality (please refer to APPENDIX I for more details).

3. Highly Fragmented: Unlike many agricultural industries, seafood supply chains are highly fragmented with very little connection from the point of harvest to the point of consumption. This is because around 85% of the world's seafood by volume is sourced from developing nations[2], and much of that is harvested by independent smallholders, who sell their produce to independent intermediaries, who in turn consolidate batches of seafood to be sold to independent processors, and so on. This is a massive traceability challenge leading to the fact that, in many cases, global Hotel, Restaurant, and Catering (HORECA) brands are selling seafood to their customers whilst being completely unaware of the KDEs (who, what, when, where) from the point of harvest onward.

In addition to the economic risks ranging from health concerns and the possibility of safety recalls, this data ignorance is a massive brand risk as many of these same global brands strongly advertise their sustainability commitments while much of the seafood they are selling cannot be proven to be Legal, Reported and Regulated (LRR) as it lacks traceability all the way back to the first link in the supply chain. The technology to overcome this fragmentation is available, but importantly, in most cases the incentive structure doesn't yet exist to reward each player in the supply chain for capturing and passing along the required data.

4. Extreme Information Asymmetries: The combination of the above elements has led to extreme information asymmetries within seafood supply chains where ultimate buyers are unaware of, and disconnected with, seafood producers. As mentioned, this is in many cases by design from intermediaries that may operate like cartels releasing information only as needed, and maintaining the information asymmetries to protect their monopolies. In the past this situation was accepted as a feature and not a bug within the industry. However, in today's interconnected world where more and more brands are being held responsible by governments and consumers to ensure products are LRR, and not tied to issues such as human slavery and high carbon output, this information asymmetry inevitably must change.

To address these, and many other problems, governments such as the European Union and the United States are demanding traceability back to the source. On January 1st, 2018, fifteen major seafood species and species groups became subject to the US Seafood Import Monitoring Program prior to import[3]. However, global seafood supply chains do not yet have an accessible, affordable, and trusted mechanism that meets the needs of the various stakeholders in the industry, and that includes appropriate incentives for taking the extra effort to capture and transfer data along the supply chain.

Blockchain Based Traceability for the Seafood Industry

In order to address the needs of the many stakeholders involved such as fishers, fish farmers, fish processors, seafood exporters, and even governments, the seafood industry needs an interoperable system that is able to provide the appropriate data for each respective entity in a way that is trusted, transparent, and secure. Blockchain presents an ideal solution for many of these challenges, while a token ecosystem solves the essential challenge of creating appropriate incentives for those making the extra effort to capture data. In this respect, the Fishcoin Ecosystem creates a mechanism for rewarding seafood producers and supply chain intermediaries through micro-transactions, creating a virtuous cycle (carrot) for sustainable practices that extends beyond government mandates (stick) for traceability. Fishcoin tokens are not meant to be a currency for trading seafood. Instead, Fishcoin tokens provide a mechanism for incentivizing data capture and transmission in various forms beginning with the KDEs captured by fishers and fish farmers for the purpose of traceability.

Incentivizing Data Capture Within Supply Chains

By creating the appropriate reward structure for data capture along with an interoperable platform, the Fishcoin Ecosystem will allow for makers of third party tools such as Internet of Things (IoT) sensors and other data inputs to participate in the ecosystem and be rewarded accordingly. This will drive more data feeds into the ecosystem and ultimately allow seafood buyers to have a better understanding of the actual metrics that impact safety and quality, including, but not limited to, cold chain conditions from harvest to consumption, and bacterial count. The end result will be seafood buyers having the right quantity and quality of information to make better decisions, governments being better able to manage fisheries using up to date data, and producers and intermediaries being rewarded for data capture and responsible behavior.

The Importance of Understanding Real Trade

While there are other blockchain based traceability platforms that have emerged to address the very real supply chain problems that span industries, the seafood industry in particular has unique needs that can only be addressed by those with insider knowledge based on the realities of actual trade. This is where the team at Eachmile Technologies (hereafter referred to as "Eachmile") is uniquely qualified to design and develop the Fishcoin Ecosystem because of their decades of experience advising and trading in the seafood industry. This ongoing trade serves as a model and use case for a range of technologies developed and used by the Eachmile team and their partners. Below are some examples of these technologies:

mFish: mFish is a mobile application allowing producers in developing nations to digitally log their harvest for the purpose of traceability and fisheries management, as well as providing market and weather information to drive efficiencies. mFish was developed by the Eachmile team and sponsored by the US Department of State (Fig. 1) with the goal of not only improving the livelihoods of fishers and fish farmers through better information and market access, but also capturing critical data that can be used for traceability.

With more than 7,000 "Monthly Active Users", mFish will serve as a starting point for the Fishcoin Ecosystem. Given that approximately 85% of seafood volume worldwide originates in developing nations, mFish will link the masses of small-scale producers in the developing world to the Fishcoin Ecosystem allowing them access to developed markets. At the 2017 Our Ocean Conference in Malta, members of the Eachmile team announced their commitment to launch mFish in seven additional Asian countries, expanding the reach of mFish to as many as 100,000 users[4]. This success in connecting with smallholders has led to other top organizations such as Unilever and Facebook to engage the Eachmile team for similar projects.

Figure 1: US Secretary of State John Kerry announces mFish at the Our Ocean conference. See video at **https://youtu.be/fMbuNDWD3jk**

FishTrax: FishTrax is an early example of a traceability system used primarily in North America and originally developed through the collaborative efforts of Advanced Research Corporation, Oregon State University, the Oregon Salmon Commission, and Ariel Seafood. Eachmile members have been instrumental in shaping the more recent developments of this platform for its practical usage in facilitating trade, particularly in the developing world. Below (Fig. 2) is a FishTrax trace code showing the full chain of custody of prawns from aquaculture farms in East Java and ultimately sold to and served in the Grand Hyatt in Singapore.

These fully traceable prawns are an example of what large scale seafood buyers will expect in the coming years. Eachmile's in-depth experience in helping to evolve this early model of a seafood traceability platform will be carried over to the blockchain based Fishcoin Ecosystem, which will also include the critically important incentive mechanism of actually rewarding producers for capturing and communicating KDEs.

Figure 2: Chef at the Grand Hyatt Singapore behind fully traceable black tiger prawns from East Java. Scan the trace code to see the story behind the prawns.

Seafood Analytics: Seafood Analytics provides advanced sensor technology to fishers, processors, and retailers allowing them to obtain quantifiable measurements of quality and freshness along each point, from harvest to consumption, of the global seafood industry (Fig. 3).

Figure 3: A pre-processor in Alaska captures freshness and quality related data using a Seafood Analytics bio-impedance monitor.

A Decentralized Data Ecosystem

Overview

The seafood industry is a functioning business ecosystem whereby seafood products are harvested, processed, sold, exported, shipped, imported, resold by wholesalers, and ultimately sold or served to consumers[7]. This business ecosystem has many inefficiencies, but nevertheless it does provide us the seafood we consume. It even, in some cases, incentivizes data capture through price premiums, although the reach of those incentives only goes so far up supply chains. While value in the form of physical seafood goods is currently being transferred through this ecosystem, what is not being transferred in any significant way, is data.

Currently, the amount of data moving through supply chains is paltry compared to the abundance of possible data that could be captured and transferred in order to increase efficiency, quality, safety, sustainability and fairness within the global seafood industry. For example, as mentioned above, more than 85% of all seafood by volume is harvested in developing nations, yet more than 50% of developing nations do not collect adequate harvest data. This means that, at best, only 57% of seafood includes the most basic harvest data, that is, the KDEs at the point of harvest. This does not include the myriad of other data elements that would benefit downstream actors like importers and buyers, in order to verify legality, safety and quality of seafood. Such data could include cold chain conditions, complete vessel data, farm inputs and conditions, DNA for verification, bioimpedance data, and more.

The Fishcoin Ecosystem has been designed to create a data ecosystem that operates in parallel with the seafood industry's business ecosystem in order to make it more efficient and more valuable. As an example, within each transaction between independent stakeholders, two things are happening in parallel: a real world asset (a seafood harvest) is being traded for fiat currency, and the record of that harvest is unlocked through a smart contract by the next receiver in the supply chain in exchange for Fishcoin tokens. Because Fishcoin tokens represent a cost to the next receiver, that party's willingness to exchange Fishcoin tokens for the data indicate that the data is accurate and representative of the seafood asset since an inaccuracy could prevent a subsequent transfer alongside the asset, and in some cases could even prevent the sale of the asset altogether. Each time data is transferred between supply chain actors, that data is stored on the blockchain. The value of these harvest and batch records could be further validated by government inspections of mandated catch documentation at various points along the supply chain such as at ports (post capture), or prior to import to receiving nations.

Token Economics

By design, Fishcoin tokens flow in the direction from buyers to sellers in seafood supply chains, and therefore they will generally accumulate at, or near the point of harvest. This creates a virtuous cycle rewarding seafood producers who make the extra effort to capture and communicate the data needed to validate legality, traceability, safety, and quality of seafood. The economic burden for the reward is rightly shifted to downstream actors in the supply chain such as hotels, restaurants, and retailers who benefit most from data in the form of price premiums. The obvious question remains, what is the value of the Fishcoin token for seafood producers, many of whom are living at the base of the global economic pyramid?

While Fishcoin tokens will be listed on public crypto exchanges, this type of exchange is not likely to incentivize behavior change amongst the masses of small-scale fishers and smallholder farmers who live in developing nations. However, a powerful incentive for these producers is the ability to earn mobile airtime top-ups for their prepaid mobile plans. To facilitate this, Eachmile has partnered with a leading mobile airtime top-up provider, TransferTo, to access their network of 550+ mobile operators in 135+ countries[5]. Using the TransferTo API Eachmile will create a crypto-mobile exchange (please refer to Appendix 2 for further details). This will allow small-scale producers to exchange Fishcoin tokens for airtime top-ups on their prepaid mobile plans. This is extremely significant because many small-scale producers in developing nations are currently living at subsistence levels, they highly value mobile communications, and the cost of mobile data can be exorbitant relative to their income - and this is where the great bulk (approximately 85% of global seafood exports by volume originate in developing nations) of our seafood comes from.

Another important factor is the need for a market based mechanism to determine the appropriate reward needed to incentivize data capture and sharing at each node in the network. For example, a more affluent producer in Alaska will likely require more incentive for behavior change than a small-scale producer in a developing nation. Furthermore, not all data is of equal value. If the actors in the ecosystem were prescribed a certain level of reward for each data transfer event (e.g. a single token for each new data record stored) then such an arrangement would limit the ecosystem's ability to adjust based on market conditions, or evolve over time. Because of this, the amount of tokens needed for each peer-to-peer exchange is determined by the participants and not by a central authority. This also helps the ecosystem self-adjust for price fluctuations in the token over time so that the network remains viable.

Incentives

The real issue preventing data transfer within seafood supply chains is that incentives for positive behaviour are not getting back through the supply chains to the people that catch or farm our seafood (Fig. 4). In many cases, downstream buyers do not even know who the seafood producers are or even whether they are being paid for their work. With greater awareness of the problems of IUU fishing, environmental degradation, and regulatory actions being taken by governments in both supplier and buyer nations, there are a growing number of incentives and disincentives to collecting and submitting data.
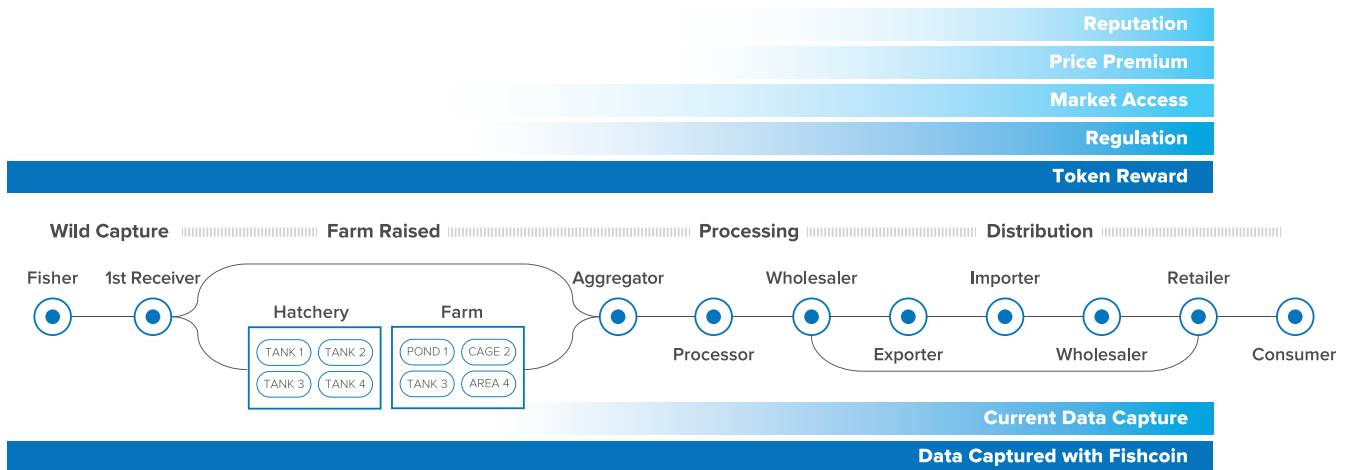
Figure 4: The current and future reach of incentives and data capture without and with Fishcoin tokens.

However, without the ability to identify, verify, and reward producers, the critical first mile is missing for all actors further downstream. The most important aspect of Fishcoin tokens is the potential for them to act as a reward (incentive) for producers to input the critical KDEs for traceability. This works after confirmation of the fish the first receiver wants to buy from the producer. Once confirmed the producer submits the KDEs (name, location, what fish, the weight etc.) and other data relevant to the transaction, or needed by the regulatory authorities, or by the buyer. After the smart contract has been executed, the data is stored on the blockchain and the producer receives Fishcoin tokens. The Fishcoin tokens can then be exchanged into a mobile data top up (or into fiat currency) on a Crypto Mobile Exchange (See Appendix 2).

Actors & Transactions

There are many supply chains within the seafood industry. The following example describes the actors and transaction flow for an Alaskan wild salmon fisher undertaking primary processing in Alaska and secondary processing in China with the product ending up as a pan-seared portion on the plate of a consumer eating at a major Singaporean hotel's fine dining restaurant (Fig. 5).

Figure 5: Actors and transaction flow for an Alaskan wild salmon fishery supplying product to a major Singaporean Hotel restaurant chain.

POINT OF HARVEST

Actors   *Transactions*

Fishers
Fishers of the wild salmon. Captains can be the owner operators of the boats, or contract fishers. Tender boats can be used to collect fish from fishing boats for transportation to the Preprocessors or Processors.

Fisher to Preprocessor

Activity
Wild Alaskan salmon fishers off-load their salmon catches to a Pre-processor for blast freezing whole.

Data
The state of Alaska already requires key data elements (KDEs) which include species, vessel information, captain, etc. (please refer to Appendix 1)

Token Flow
Fishers receive Fishcoin tokens from the Preprocessor in exchange for data according to the peer to peer interaction stated in Appendix 2.

Result
KDEs are communicated from fisher to preprocessor along with further data allowing fishing efficiencies and best practices to be identified and rewarded.

ALASKA

Preprocessor - Exporter
A Preprocessor conducts some initial primary processing of the product. If licensed to export they can also be an Exporter either immediately or after some domestic transportation (trucking/shipping) and/or storage.

**Preprocessor to IoT Sensor
(e.g. Seafood Analytics BIA)**

Activity
Preprocessor uses a sensor (e.g. bioimpedance sensor) to measure freshness and quality related indicators (e.g. the fat free mass (fat content), of a representative sample from the batches of salmon sourced from fishers.

Data
This data is used to indicate quality and freshness of the salmon prior to freezing.

Token Flow
Preprocessor provides Fishcoin tokens to IoT Company to receive data and analytics reports for internal purposes and to give to buyers.

Result
Best practices identified and rewarded. Better quality, fresher fish in the market.

CHINA

Importer - Processor - Exporter
A Processor transforms the product into its final value added form. Processors can also be licensed to import and export, and thus use the services of freight forwarders and third party logistics and storage providers.

**Preprocessor/Exporter to Importer/Processor
(via Freight Forwarder)**

Activity
Preprocessor contracts Freight Forwarder to arrange third party logistics to truck and ship the frozen whole fish to a Processor/Importer in China.

Data
Key Data Elements (KDEs) and chain of custody.

Token Flow
Importer/Processor transfers Fishcoin Tokens to Preprocessor/Exporter to receive data according to the peer to peer interaction listed in Appendix 2.

Result
The seafood is now able to access markets/buyers with strict traceability requirements.

To Point of Consumption

From Point Of Harvest

Actors

Transactions

CHINA

Importer - Processor - Exporter
A Processor transforms the product into its final value added form. Processors can also be licensed to import and export, and thus use the services of freight forwarders and third party logistics and storage providers.

Processor/Exporter to Importer/Wholesaler

Activity
After processing, the salmon portions are exported to the importer/wholesaler in Singapore.

Data
Key Data Elements (KDEs), chain of custody data and environmental conditions data.

Token Flow
Importer/Wholesaler transfers Fishcoin Tokens to Processor/Exporter to receive data according to the peer to peer interaction listed in Appendix 2.

Result
Able to access markets/buyers with strict traceability requirements.

Importer - Wholesaler
A Wholesaler sells seafood on a business to business basis (B2B). They can also be an Importer and an Exporter if they have licences. Some Wholesalers also have Processing and Storage facilities, as well as trucks for delivery, or use third parties for these services.

Importer/Wholesaler to Retailer

Activity
Importer/Wholesaler sells to Retailer

Data
Key Data Elements (KDEs), chain of custody data and environmental conditions data.

Token Flow
Because at this end of the supply chain many retailers will inevitably require these data as part of their purchase decision, the retailer will give tokens to the wholesaler in exchange for the data.

Result
Able to access markets/buyers with strict traceability requirements.

SINGAPORE

Retailer
A Retailer is the penultimate user such as a Hotel, Restaurant, Caterer (HORECA), or Supermarket. Some Retailers import and purchase direct from overseas Wholesalers, Processors and Producers.

Retailer to Consumer

Activity
Retailer sells to Consumer

Data
Country of origin, fisher, boat communicated on menu to customer, or by the customer looking at the record stored on the blockchain.

Token Flow
Either the retailer provides these data to the customer via their menu, or they may encourage customers to access the record on the blockchain where possible.

Result
Both retailers and consumers are able to trace where the seafood came from along with the full chain of custody, and the conditions along the supply chain.

Consumer
Consumers are you and I that eat out at restaurants or buy seafood for preparation and consumption at home.

POINT OF CONSUMPTION

The Fishcoin Network

Overview

As an open ledger, the Ethereum blockchain is an ideal tool for storing chain of custody and transactional data for the disconnected stakeholders within global seafood supply chains because it removes the need for a trusted third party intermediary. However, this is only possible if the architecture is: 1) open and interoperable for the various actors in the supply chain, and 2) not reliant on a central entity that manages transactions between actors. Thus, the Fishcoin network is not an application per se, but a series of open source tools and software development kits (SDKs) that can be utilized by supply chain actors and even third party developers who wish to integrate their decentralized applications (DApps) to the Fishcoin Ecosystem.

These tools can include various functions such as: 1) a function to create a Fishcoin wallet, 2) functions to transfer, withdraw, and deposit Fishcoin tokens, 3) a standard protocol for KDEs along with instructions for the required parameters and format, 4) standards for the transfer of harvest records whereby third party applications can send a JavaScript Object Notation (JSON) record with a request to store the verified harvest data on the blockchain, and 5) the ability to integrate existing tools within the seafood industry for data beyond harvest records such as time/temperature data from IoT sensors. This approach prevents the need for a centralized platform, making the Fishcoin ecosystem a series of peer-to-peer networks based on chain of custody, along with a protocol for validating data prior to being stored on the blockchain.

Data Validity & Attribution

In order to better understand the flow of data and Fishcoin tokens, some terminology will be used.

- **Fishcoin-Data transaction** – a transaction that involves the movement of data from the sender to the receiver of data, acceptance / rejection of the data by the data receiver, and a movement of Fishcoin tokens from the receiver to the sender of the data.
- **Data Access Smart Contract** – a smart contract containing data, the address of the current custodian of the data, data access and data-adding rights for said custodian, and a chain of the addresses of the previous custodians. Any other address accessing the data has to pay a fee in Fishcoin tokens, through the associated Validator Smart Contract.
- **Whitelist Smart Contract** – a smart contract that contains a list of addresses that are whitelisted for a Fishcoin-Data transaction and provides functionality to check whether a sender and receiver of a Fishcoin-Data transaction are whitelisted. Validator Smart Contracts interact with this smart contract as part of its transaction validation.
- **Validator Smart Contract** – a smart contract that validates only those transactions whose sender and receiver are on an official Whitelist Smart Contract. It facilitates the transfer of Fishcoin tokens for data, and is recognized in the ecosystem as a trusted validator. Upon validating a transaction, if the transaction is the start of the chain of custody, then a Data Access Smart Contract containing the data, the custodian's address, and access rights for the custodian will be initiated. If the transaction is not the start of the chain of custody, then a Data Access Smart Contract has to be provided for the Validator Smart Contract to add additional

data to the smart contract or change the custodian, or both.

- **Sub-custodian** – a custodian of a Data Access Smart Contract that has data-adding and access rights, given by the main custodian of the smart contract.
- **changeOfCustody function** – a function in the Data Access Smart Contract, only accessible by its associated Validator Smart Contract, to enact a change of custody (replacing of the old custodian's address with the new one's).
- **addData function** – a function in the Data Access Smart Contract, either called by the Validator Smart Contract when it validates a transaction that is not the start of the chain of custody (piggy-backing), or called by the custodian of the Data Access Smart Contract to add data.
- **addSubCustodian function** – a function for a custodian of a Data Access Smart Contract to add a Sub-custodian into the smart contract.

The flow of data and Fishcoin tokens is designed with these tenets in mind:

1. Evidence of Data Value

So how do we know that the data stored on the blockchain is relevant and valuable? Fishcoin tokens answer this question by providing a medium of exchange for the data that indicates evidence-of-value when transferred alongside actual seafood products. For example, the masses of fishers and farmers around the world have the ability to record their harvest within a catch documentation application such as mFish, thereby fulfilling all the requirements of the next receiver as the seafood is passed along the supply chain (Fig. 6).
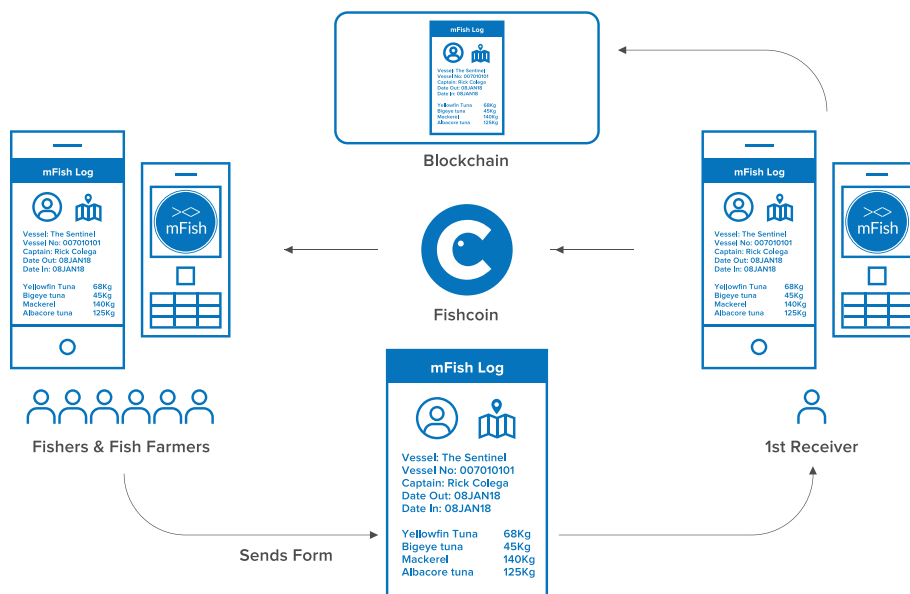
Figure 6: A diagram of the interaction between producers and first receivers. This is the basic peer-to-peer interaction in the Fishcoin network that establishes Evidence of Data Value.

At the point where the data is created by the seafood producer, it is stored locally on the user's device (e.g. within mFish or other digital logbooks), but not yet on a Data Access Smart Contract because evidence-of-value has not yet been established for that data. The reason for this is that a mistake could have been made in the data entry, or the record itself might not represent the actual seafood changing hands, or any number of other reasons why the data might lack integrity. Instead, the data is offered to the next receiver who must now accept the record as matching the seafood product that is actually changing hands by peer-to-peer consensus with the producer. Upon acceptance of the data by the first receiver, the Validator Smart Contract either initiates a Data Access Smart Contract or changes the custodian and/or adds onto the data of a reference Data Access Smart Contract. At the same time Fishcoin tokens are transferred to the producer's wallet thus completing the exchange.

2. Data Integrity and Reputation

Having Evidence of Data Value helps as a line of defense against fraudulent, or mistakenly input, data being stored onto the blockchain as seafood produce receivers will match the data provided with the associated seafood produce, and downstream pressure, especially regulatory ones, mandates that seafood produce ought to be accompanied by traceability data. However, this might not be sufficient enough as exploitation is possible due to the complexity and fragmentation of the seafood industry.

In order to further ensure data integrity, an address whitelisting scheme will be implemented. This means that actors in the ecosystem have to be fully verified. For instance, fishermen have to provide proper know-your-client (KYC) details in order to have an address associated with them. Addresses will be distributed either upon registration and full verification, or actors deciding which address to whitelist upon verification. The whitelisted addresses will be added to a Whitelist Smart Contract, which Validator Smart Contracts can access, to add, remove, or modify whitelisted addresses.

Whitelisting will ensure that actors stake their reputation in Fishcoin-Data transactions, with the more reputable ones being rewarded with increased demand for their seafood and the fraudulent ones being removed, or having to take action to improve their reputation.

3. Proof of Change of Custody

In order to establish a chain of custody, we need to generate validated proof that custody has been changed from one actor to another. That change of custody can be validated by a Validator Smart Contract, whose main purpose is to officially validate Fishcoin-Data transactions and either initiate or interact with Data Access Smart Contracts to enact a change in custody and/or add data onto the Data Access Smart Contracts. The Validator Smart Contract will be implemented in applications such as mFish or through SDKs built for the Fishcoin Network, and is officially recognized by the ecosystem as a validator. A change of custody can only be made by the associated Validator Smart Contract of a Data Access Smart Contract by exercising a changeOfCustody Function, meaning the custody of the data will be taken over by the new custodian, validated by the Validator Smart Contract.

4. Stacking of Data

Along the chain of custody, data might be added by custodians who have valuable data to add, to earn more Fishcoin tokens. In order to ensure that the data is appropriately attributed to the relevant custodian, whenever data is added, the data will be signed by the custodian.

Let c be the custodian,
D_c the data provided by the custodian,
sgn the signing function, and
vld the validating function

Signing of data:

$$sig_c = sgn(pubkey_c, privkey_c, D_c)$$

$$D_{c'} = D_c + sig_c$$

This data is then stacked on the existing data, or, if this is the data of the first transaction, be the first piece of data on the Data Access Smart Contract.

To check that the data is valid:

Given D_c:

$$val_c = vld(sig_c, D_c)$$

If $val_c = pubkey_c$, then the data is evidently added on by the custodian c.

Data can be added onto the Data Access Smart Contract through either piggy-backing the validated change of custody transaction, or by calling the addData function on the smart contract itself.

5. Trickling Fee for Data Contribution

As contributors of data to the Data Access Smart Contract, whenever the data is accessed by a party that is not a custodian, the said party must pay a fee in order to extract the data from the smart contract, through the associated Validator Smart Contract. A percentage of the fee could be distributed to all custodians of the data, based on the settings of the Validator Smart Contract. This further incentivizes actors upstream, along with the Fishcoin-Data transaction, to create data intellectual properties that could potentially form the basis for the collection of "royalties" for their data contribution.

6. Data Batching

In certain scenarios, data batching might be necessary to ease the flow of Fishcoin-Data transactions and save costs. For instance, receivers of seafood produce and its associated data
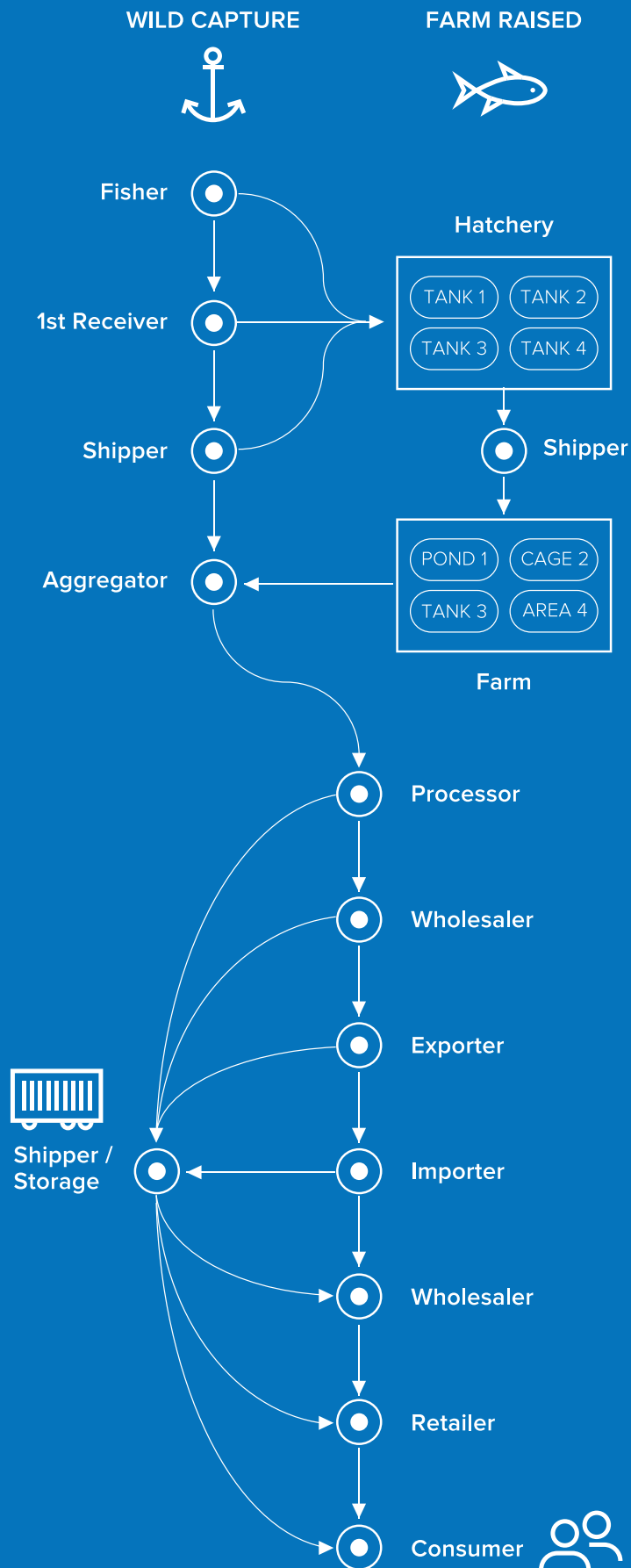
WILD CAPTURE

FARM RAISED

Fisher

Hatchery

TANK 1 TANK 2
TANK 3 TANK 4

1st Receiver

Shipper

Shipper

POND 1 CAGE 2
TANK 3 AREA 4

Aggregator

Farm

Processor

Wholesaler

Exporter

Shipper / Storage

Importer

Wholesaler

Retailer

Consumer

Figure 7: Fishcoin tokens flow from downstream actors to upstream actors and accumulate at the start of the supply chain — the fishers and fish farmers.

might batch up both the produce and the data before sending them on to the next receiver. The custodian of the individual Data Access Smart Contracts could do 2 things to batch all the data up:

1. either extract all the data manually, batch them together, and then stack them up in any one of the Data Access Smart Contract using the addData function; or

2. use the batchData function on any Data Access Smart Contract, with reference to the other Data Access Smart Contracts, to automate the batching.

7. Multiple Sub-Custodians
The Data Access Smart Contract can also allow multiple Sub-custodians to have data-adding and access rights to the Data Access Smart Contract. This can be done through the addSubCustodian function of the smart contract. The sub-custodian rights will be revoked once the main custodian is replaced.

With these 7 tenets, we can ensure proper chain of custody records are being created and data is being responsibly generated and stacked, while ensuring that participants are properly incentivized for the data they provide, both in the Fishcoin-Data transaction and through third-party access.

Example Use Cases

A Fishcoin incentivized supply chain will not only meet chain of custody requirements, but will also help to identify the various actors and allow them to be rewarded for their efforts in gathering data to improve the quality and sustainability of the fish they are harvesting. This reward trickles down through supply chains to the critical point where the millions of seafood producers engage with the first receiver. It is at this point where KDEs for traceability are first exchanged for Fishcoin tokens, and also at this point where the Fishcoin Ecosystem can reach critical mass. The flow of tokens through the supply chain shows the high number of potential transactions that can occur through a seafood supply chain (Fig. 7). While many supply chains would involve a smaller number of transactions for data, it is useful to recognize the complexity of the seafood industry.

Fishcoin tokens can also open up entirely new business models for sensor providers allowing for the potential to gain Fishcoin tokens in exchange for data as it is captured (Fig. 8). One of the core functions of utilising blockchain as the backbone of the Fishcoin Ecosystem is the interoperability that is inherent in a decentralized ledger. Companies and individuals that place sensors on assets, and in and around boats and farms could be rewarded with Fishcoin tokens in exchange for recording and transmitting data on top of the chain of custody of seafood products. This allows for a next level of data capture – beyond traceability – in order to understand and communicate quality related metrics, such as time/temperature profiles during transit, or bacterial count as the seafood travels along supply chains (please refer to Appendix 3: IoT Sensor Potential for Fisheries and Aquaculture for further details).

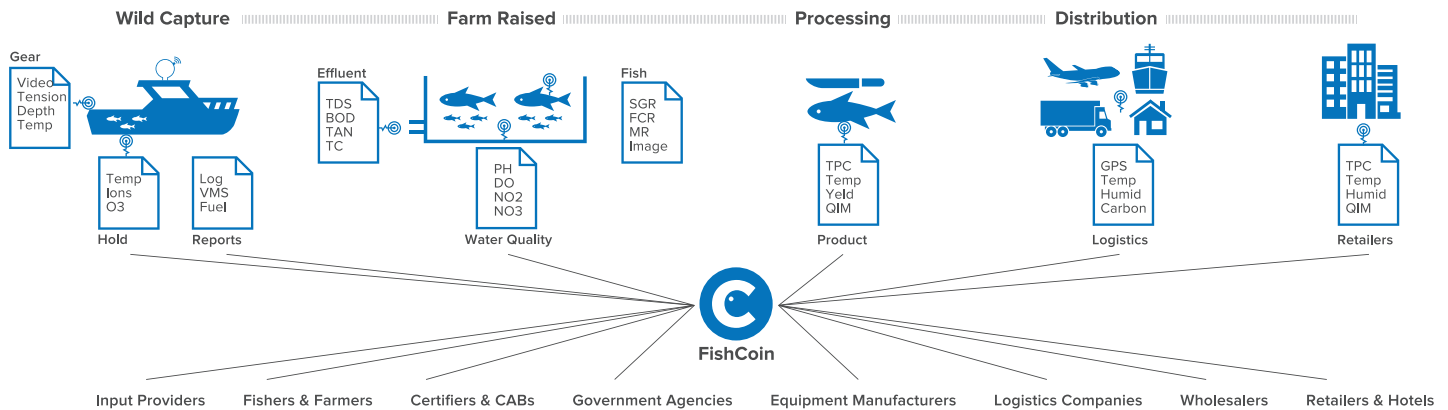**IoT Sensors & Secondary Ecosystem Actors**

Wild Capture ⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞ Farm Raised ⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞ Processing ⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞ Distribution ⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞⁞

Gear
Video
Tension
Depth
Temp

Effluent
TDS
BOD
TAN
TC

Fish
SGR
FCR
MR
Image

Temp
Ions
O3

Log
VMS
Fuel

PH
DO
NO2
NO3

TPC
Temp
Yeld
QIM

GPS
Temp
Humid
Carbon

TPC
Temp
Humid
QIM

Hold   Reports   Water Quality   Product   Logistics   Retailers

FishCoin

Input Providers   Fishers & Farmers   Certifiers & CABs   Government Agencies   Equipment Manufacturers   Logistics Companies   Wholesalers   Retailers & Hotels

Figure 8: IoT sensors and secondary ecosystem actors accessing data through the supply chain via Fishcoin tokens.

Accelerating The Ecosystem

The Fishcoin Ecosystem has been carefully designed to be decentralized, autonomously scalable and operating for the good of the community of participating actors, rather than for any one central company or "owner." This is why all of the tools developed for the Fishcoin Ecosystem will be open source and never designed around a single application or single point of failure. We refer to this arrangement as the Starfish Protocol. The name "Starfish" is relevant insofar as starfish have elements of decentralized morphology; they don't have a central brain and are not dependent on any one single limb for existence [6]. This is the intent of the core Project team, as well as each of the many advisors, because in order to truly transform an industry as large and complex as the seafood industry there cannot be any one single actor that has ownership or control.

However, in order to design and build the network of open source tools needed for this network, as well as to ignite usage and growth with the many industry players, there needs to be a lead actor that takes a centralized role in developing and then accelerating the ecosystem. This is where the Fishcoin team, led by Eachmile, has a unique role to play. Rather than simply building out a network of tools and technologies for the industry, this team has the capability and networks to actually engage in real seafood trade in order to demonstrate to the industry the value of the Fishcoin ecosystem, and ignite usage to the point where growth happens organically among independent actors through network-effects. As growth continues, Eachmile will evolve to being one of many actors in the supply chain, with their own independent business model designed around actual seafood trade. No one single actor is designed to benefit from the usage of the Fishcoin Ecosystem, yet every actor benefits from the greater availability of data that such an ecosystem provides as it becomes more ubiquitous throughout the seafood industry.

Team

Core Team

The design and deployment of the Fishcoin Ecosystem will be led by Eachmile Technologies Pte. Ltd., a Singapore based company with the core purpose of using technology to transform global agriculture supply chains. With backing from select investors, Eachmile includes a team of experts within various disciplines – from seafood and aquaculture, to technology, procurement, and supply chain management – in order to understand the mechanisms that drive change and unlock value. The Eachmile team has been called upon by some of the world's most trusted brands, including Unilever, Facebook, the Hyatt Hotel Group, Royal Dutch Shell, WorldFish, Swire Pacific, and World Wildlife Fund to advise their efforts in connecting with small-scale producers and/or capturing data along fragmented supply chains.

In addition to Eachmile, the Fishcoin team also consists of experts in the fields of technology (including blockchain and IoT), sustainable development, ecosystem design and venture capital. Complete bios can be found at **https://fishcoin.co**.

Alistair Douglas, PhD
Seafood expert with 20yrs experience in trading, assessment and traceability. Advisor to Unilever and Hyatt Hotel Group.

Mark Kaplan
Sustainable technology advisor to Unilever, Microsoft, MasterCard, ARM, GSMA, Facebook and the United Nations.

Alastair Smart, MSc
Internationally recognized global aquaculture expert and founder of one of the largest aquaculture consultancy groups in the world.

Jayson Berryhill
Mobile technology expert with experience connecting hard to reach users in seafood and agriculture supply chains.

Corey Peet
Sustainable seafood expert working with fisheries and aquaculture coops throughout Southeast Asia.

Vytautas Kašėta
Blockchain engineer and crypto-analyst with expertise in designing, developing and implementing tokenized ecosystems.

Core Team

Priyanka Pareek

Blockchain specialist and advisor on design and implementation of multiple blockchain projects and token offerings.

Vijayta Bhatt

Blockchain engineer with extensive experience in Ethereum, Solidity, Hyperledger, Stellar SDK, MEAN stack, and artificial intelligence.

Vignesh Iyer

Blockchain engineer with cross sector experience in enterprise mobile apps, industrial IoT solutions, and computer vision.

Pravin Tambe

Blockchain engineer and security specialist with experience across industries including logistics, finance and e-commerce.

Sanket Khandare

Full-stack IoT engineer with cross sector project leadership experience in IoT, artificial intelligence and machine learning.

KK Han

Supply chain automation expert with 25 years experience and an advisor to the Singaporean government.

Gil Sylvia, PhD

Marine Resource Economist, Professor at Oregon State University and Chairman of the FishTrax traceability platform.

Advisors

The Fishcoin advisors come from varied backgrounds including seafood technology, aquaculture, ecology, supply chain management, blockchain law, politics, philanthropy, sustainable development, ecosystem design and venture capital. The common thread among this group of experts is a shared vision to transform an industry as large and important to the world as seafood.

Tom Sweeney
Founder and CEO of JUN Capital Partners with investment activities spanning China, California, Tel Aviv and east Asia.

Wesley Xia
North America Regional partner of THBU (水木未名) Capital and co-founder of the only Chinese blockchain university, Qidian.

Greg Horowitt
Co-founder at T2 Venture Capital, Innovation Ecosystem Architect, Author, and Global Innovation Policy Adviser.

Antanas Guoga
Member of European Parliament, blockchain investor, philanthropist and founder of Blockchain Centre Vilnius.

Eva Kaili
Member of European Parliament, Chair of the Scientific Foresight Unit, involved in blockchain and cybersecurity initiatives.

Nathan Kaiser
Swiss Attorney-at-Law in Greater China (Shanghai, Hong Kong and Taipei) and crypto / blockchain innovation advisor.

Shannon McDiarmid
Sustainable seafood expert working to transform supply chains globally. Consultant with Future of Fish and advisor to Blue Apron.

Paula Sylvia, MSc
Offshore Aquaculture Program Manager and Business Development Director for the Hubbs-SeaWorld Research Institute.

Joseph Tuma
Managing Director of Alphatech Aquaculture, expert in the design of Advanced Fluidic Control and Recirculating Aquaculture Systems.

Advisors

Alistair Brown, PhD

Founder of Aquatic Veterinary Services, member of the Australian and New Zealand Veterinary College of Veterinary Scientists.

Allan Bremner, PhD

Professor of Food Technology, author, advisor to industry and government, Fellow of AIFST.

Glenn Shiell, PhD

Marine Ecologist, Adjunct Senior Research Fellow at Curtin University, Associate Principal and Quantitative Ecologist at BMT.

Sam Bowman

President of Heavenly Foods Canada, BC and Canada Export Award Fellow, seafood and aquaculture expert.

Appendix 1: Overview of Key Data Elements (KDEs)

Key Data Elements & Rankings (Bhatt et al*)			

Wild Capture	A	B	C
Latin Species Name	x		
Common Market Name	x		x
Catch Location	x	x	x
FAO major fishing zone	x		
Country of Catch	x		
Region	x		
Management Authority	x		
Stock	x		
Landing Date		x	x
Time of Harvest			
Vessel Info			
Flag of fishing vessel		x	
Name of fishing vessel	x	x	x
Captain name		x	
Home port		x	x
IMO	x	x	
Fishing Method	x		x
Total Weight of Catch		x	
Certification & CoC Status		x	x

Processing Stages	A	B	C
Species Name (Latin)	x		
Dates & Times Received	x	x	x
Location Received	x	x	
Weight	x		
Lot Number	x		
Batch Code	x		
Dates & Time Shipped	x	x	
Name of Processor/Packing Plant	x		
Pallet Identifier	x		
Supplier		x	
Customer		x	

Distribution	A	B	C
Product Name	x		
Weight	x	x	
Container/Seal Number	x	x	
Pallet Identifier	x	x	
Lot/Batch/Serial Number	x		
Dispatch Date	x	x	
Receiving Date	x	x	
Transport Companies	x	x	
GTIN/UPC Code	x		
Quantities	x		

KDE Rankings

"A" is a KDE essential for traceability and should be exchanged between trading partners (often referred to as an "external" KDE).

"B" is a KDE essential for traceability but is collected only for internal purposes and available upon request ("internal" KDE).

"C" is a KDE that is optional for value-added purposes. They may not be achievable without the presence of semantic interoperability.
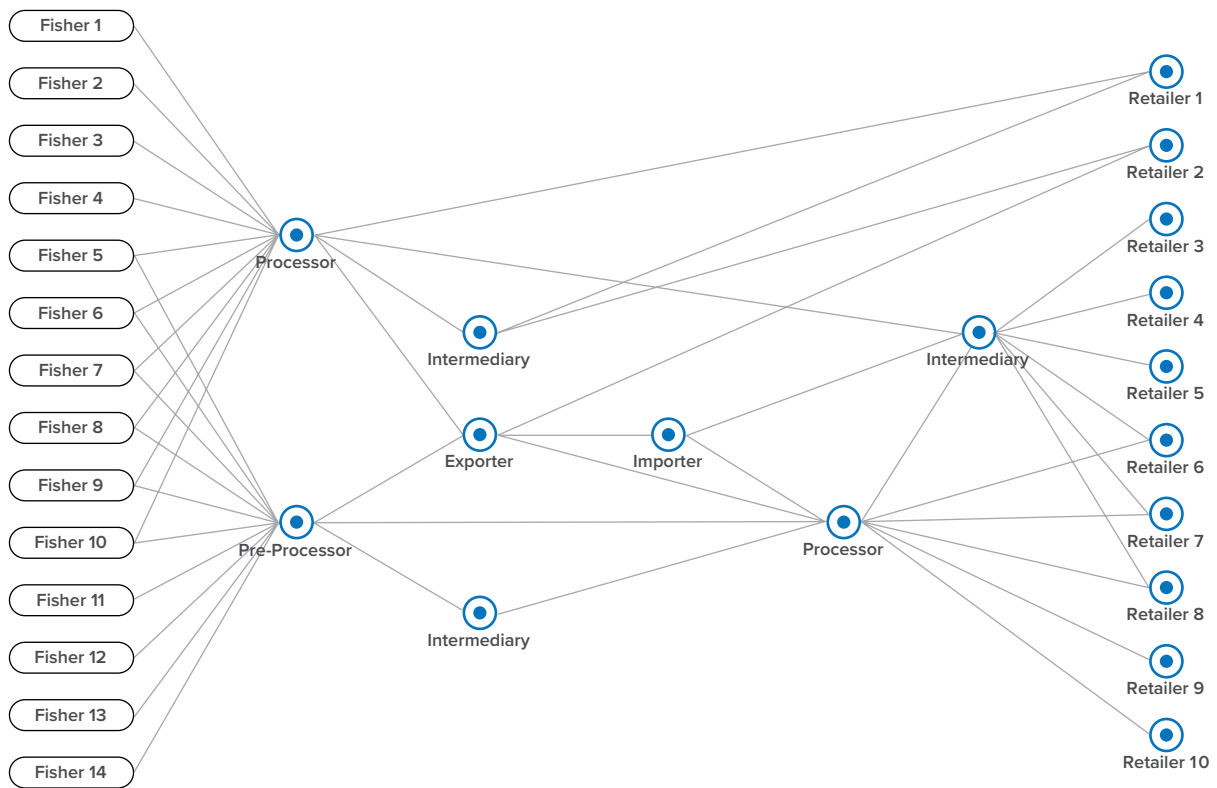
* Bhatt, T., Cusack, C., Dent, B., Gooch, M., Jones, D., Newsome, R., Stitzinger, J., Sylvia, G. & Zhang, J. (2016) Project to Develop an Interoperable Seafood Traceability Technology Architecture: Issues BriefComprehensive Reviews in Food Science and Food Safety

Figure 9: IoT sensors and secondary ecosystem actors accessing data through the supply chain via Fishcoin tokens.

Appendix 2: Crypto-Mobile Exchange

Incentivizing Usage and Distribution Among Rural Agricultural Workers

The Problem

Mobile Network Operators (MNOs) that have a strong presence in rural areas, particularly in developing markets, have a significant problem in that demand for data consumption can be strong, but the cost of data relative to income levels can create a ceiling for their average revenue per user (ARPU). Regardless of the promotions they offer, the ARPU for these MNOs could be limited by this income ceiling. In order to break out of that ceiling, MNOs are willing to introduce services that can justify additional spending for data. mFish was originally launched in partnership with the Groupe Spécial Mobile Association (GSMA), which is the association of mobile operators that includes more than 800 MNOs around the world, to be one of these services. While industry specific tools like mFish are interesting for MNOs, they will only produce marginally better ARPUs because while they provide a context for mobile data consumption, they are not a true solution for the income-ceiling problem.

The Opportunity

If seafood producers could "earn" airtime on their pre-paid mobile plan simply by capturing more data it could effectively create a strategy to not only increase data consumption, but also provide a way for fishers and farmers to pay for that consumption that is not tied to their income levels. This represents a significant opportunity. By creating a mechanism that allows producers to exchange Fishcoin tokens for airtime on their prepaid data plans, Fishcoin could generate a powerful incentive not only for seafood producers, but also for MNOs as they could increase their ARPU by promoting usage of Fishcoin in their network.
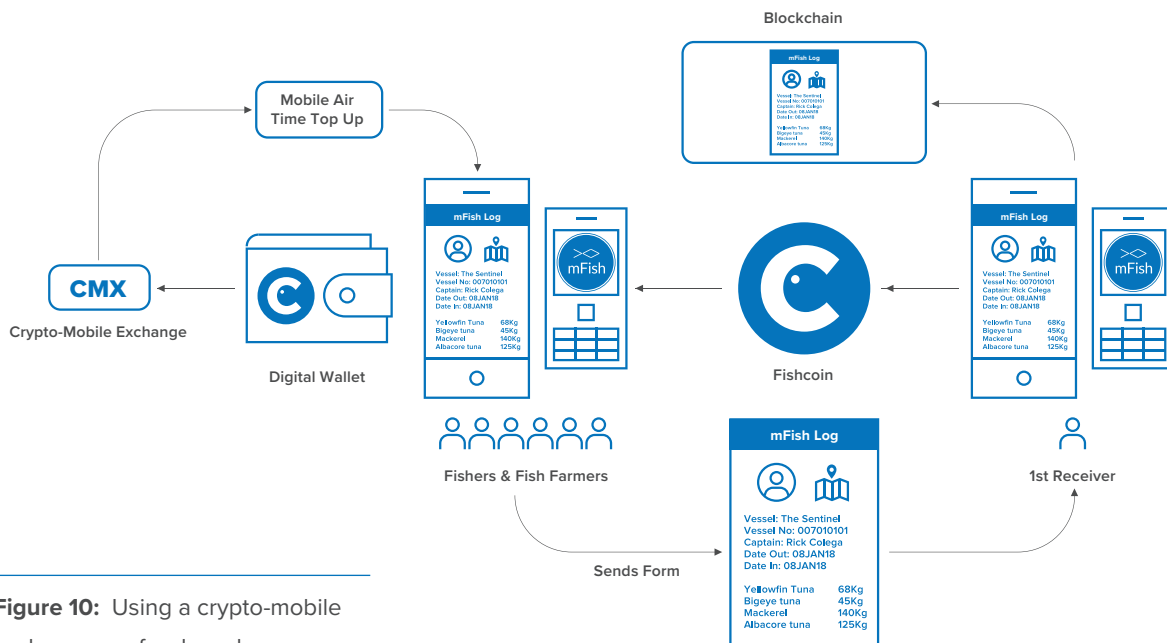

Figure 10: Using a crypto-mobile exchange seafood producers can be rewarded for data capture with mobile airtime top-ups.

The Solution

At least one crypto exchange, Spectrocoin, already allows for the exchange of crypto (BTC or ETH) for airtime top-ups. It is therefore possible to list Fishcoin on this and other, similar exchanges, but in addition we intend to create a specific crypto-mobile exchange ("Crypto-Mobile Exchange") system for Fishcoin using one of the many mobile airtime top-up APIs for adding airtime to pre-paid mobile plans. Eachmile is already partnering with one such provider, Transfer-To, but there are many other options with existing APIs for automatically topping up mobile numbers in more than 140 countries worldwide. In fact, these same APIs could also allow us to create a crypto/fiat (bank transfer) exchange, assuming the appropriate KYC is done with users. Our desire is that this will be the first of many dedicated crypto-mobile exchanges.

How Does This Benefit The Fishcoin Ecosystem?

Fishers and fish farmers are incentivized to capture data

More than 85% of the world's seafood is harvested in developing nations by small-scale seafood producers. These rural agriculture workers typically have lower levels of digital literacy and therefore are more likely to have reservations about the use of cryptocurrency. However, such workers are likely to be highly incentivized by redeemable mobile airtime, and may go to unusual lengths in order to reduce their cost of data, or earn more airtime through incentives from MNOs. By allowing producers to earn mobile airtime, which can be converted to data, in exchange for them logging KDEs for traceability for their harvest, we create an incentive for mass adoption and usage among our target users.

Mobile Network Operators are incentivized to promote Fishcoin

MNOs are eager and willing to promote third party products if it will allow them to increase their profitability from specific users in their network. The Eachmile team has been in discussions with multiple MNOs for this purpose. MNOs are also in a unique position to efficiently target users within their network at scale with specific promotions. For example, using their internal data and internal ad capabilities, an MNO can run a direct short message service (SMS) campaign to users who live along rural coastlines and / or areas that consistently come in and out of the network (e.g. fishers going out to sea).

This is aligned with other mobile for agriculture programs

For example, the GSMA has a dedicated agricultural program called mAgri which forges partnerships between mobile operators, technology providers, and agricultural organizations. By providing deep technical expertise to service providers, the GSMA's mAgri team supports scalable commercial mobile services that impact smallholder farmers and the agricultural industry at large. The mAgri team is constantly looking for opportunities to demonstrate the value MNOs can provide to the world's agricultural workers and they have already been in discussions with the Eachmile team about multiple initiatives.

Governments & NGOs are incentivized to collaborate with Fishcoin

Connecting Information and Communications Technology (ICT) tools with agriculture and thus improving the livelihoods of fishers and farmers overlaps with multiple United Nations Sustainable Development Goals. By providing these tools with minimal economic and technological barriers we create a powerful incentive for governments and multinational NGOs to incorporate the Fishcoin ecosystem into their existing and future programs for fisheries management, livelihood development and oceans conservation.

Appendix 3: IoT Sensor Potential for Fisheries and Aquaculture

We envision a coordinated linkage of IoT sensors that can confirm quality standards are being met in real-time, along with alerting supply chain stakeholders of potential failure at critical control points. Sensor data can be stored on the blockchain, thus making it accessible by other stakeholders in the supply chain. This represents an opportunity for the sensor owner or vendor to be rewarded with Fishcoin tokens as data is captured. In this case the owner of the seafood batch could be required to have Fishcoin tokens in their wallet in order to reward the sensor provider for capturing data about that batch of seafood. This in return can incentivize IoT sensor manufacturers to further develop their business model and equipment for the seafood supply chain.

On fishing boats, sensors can be placed on fishing gear, in fish holds, in and around equipment such as engines, enabling the collection of valuable data for tertiary actors in the ecosystem on not only fish quality and safety but to help improve efficiencies of the operation and thus reduce costs (Fig. 10). Furthermore, the data could be of value to those input providers that provide hardware and consumables, as well as those companies that provide components and ingredients to said providers, as well as analytics companies that can turn data into usable knowledge. Additionally, the costs of mobile air-time used in communications by the boat or by the crew could be offset through the exchange of Fishcoin tokens.
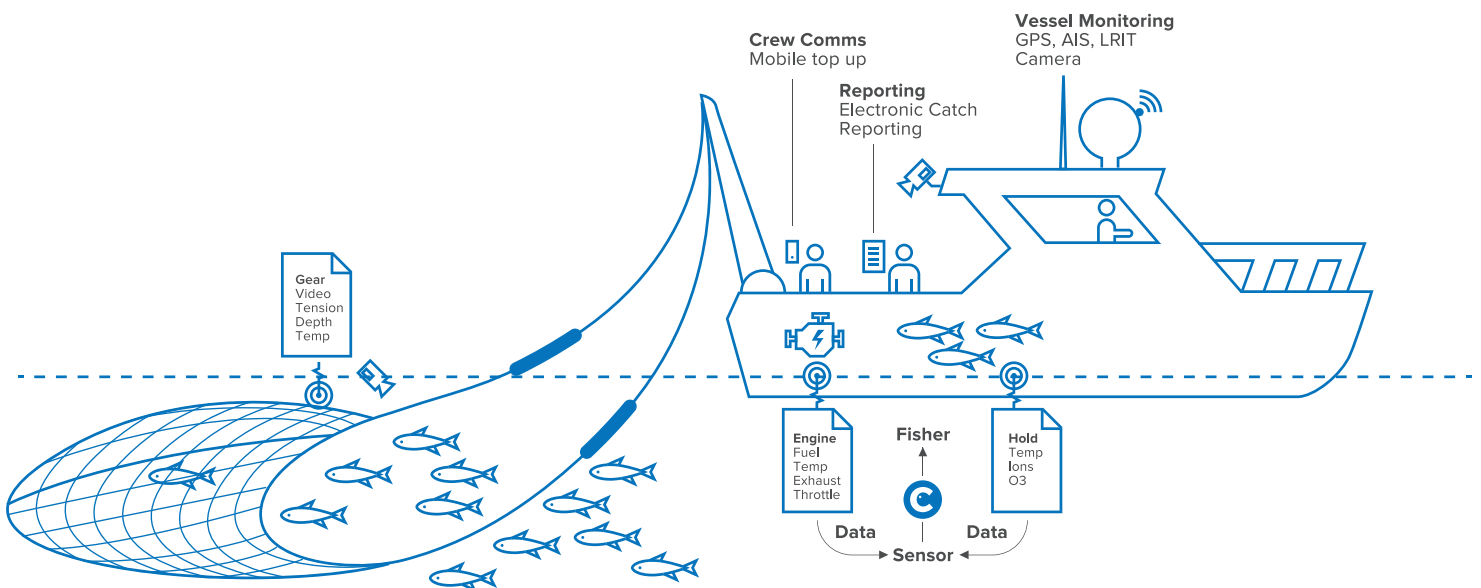

Figure 10: IoT sensors and secondary ecosystem actors accessing data through the supply chain via Fishcoin tokens.

Similarly, on fish farms, IoT sensor manufacturers or third parties can place sensors in and around the farms and on equipment to monitor farm performance, reduce costs, improve productivity and quality, as well as ensure compliance with regulations and third party certifications (Fig. 11). For example, feed manufacturers value data on the growth, health, survival, and quality of the fish produced on fish farms as this key information may enable them to improve the quality and performance of the feed products they are selling to the farmers.
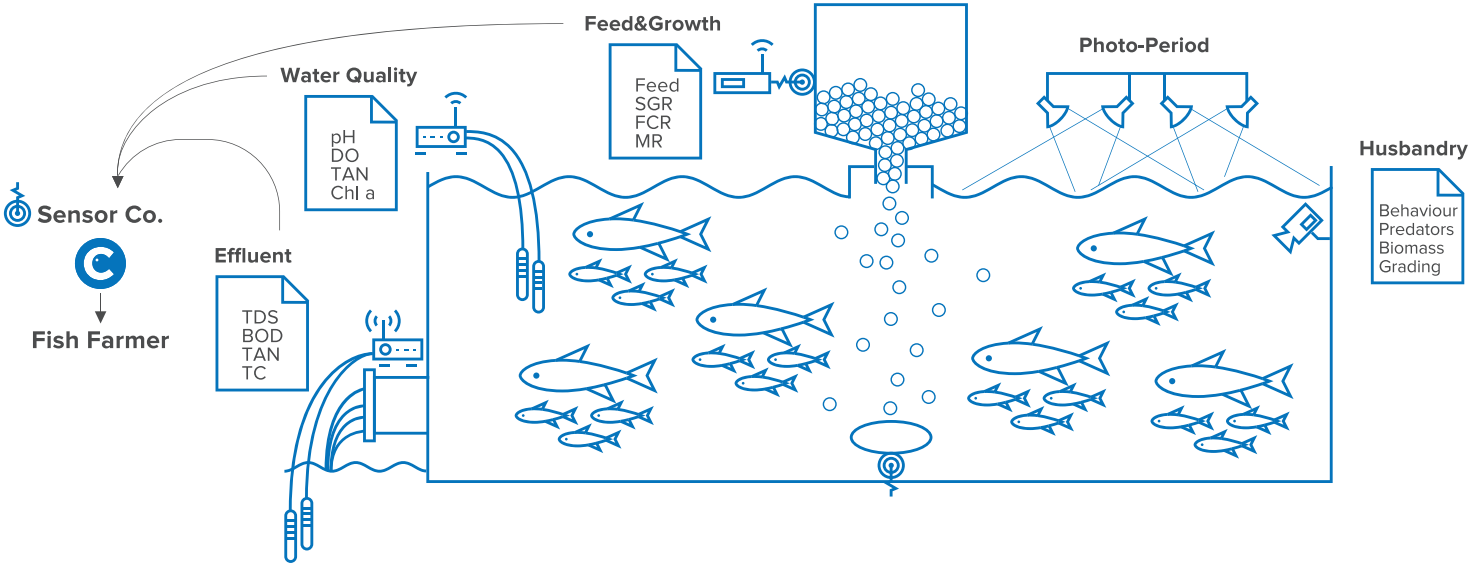

Figure 11: IoT sensors and secondary ecosystem actors accessing data through the supply chain via Fishcoin tokens.

References

[1] Authors Geoffrey G. Parker, Marshall W. Van Alstyne, and Sangeet Paul Choudary identify these four characteristics when describing industries that will be most prone to platform disruption in the coming years in their excellent book Platform Revolution: How Networked Markets Are Transforming the Economy — And How to Make Them Work for You (2016).

[2] Unless otherwise noted, all industry statistics stated in this business plan are taken from the 2016 United Nations Food & Agriculture Organization's Report: The State of World Fisheries and Aquaculture — **http://www.fao.org/3/a-i5555e.pdf**

[3] **http://www.iuufishing.noaa.gov/RecommendationsandActions/RECOMMENDATION1415/ FinalRuleTraceability.aspx**

[4] The Our Ocean conference is an annual invite-only event limited to dignitaries and business leaders from around the globe that are contributing to ocean conservation -- **https://ourocean2017.org/**

[5] **https://www.transfer-to.com/airtime**

[6] Brafman, O. & Beckstrom, R.A. 2006. The Starfish and the Spider: The Unstoppable Power of Leaderless Organizations. 235 pp. An exploration of the implications of the recent rise of decentralized organizations such as Grokster and YouTube.

Dedicated to making supply chains
more responsible and equitable
for the millions who harvest
the seafood we eat.