Building trust and equity in marine conservation and fisheries supply chain management with blockchain

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Abstract

This commentary explores how blockchain technology is being leveraged to improve marine conservation and fisheries supply chain management globally. In doing so, the paper considers the technical and political challenges of building trust and equity for various stakeholders. A blockchain is a smart electronic database, distributed to all users, immutably tracking every transaction that has ever taken place on the network. The blockchain is very difficult to hack, with no single point of authority to make mistakes and collapse the system. Automated consensus protocols enable data transmitted on the network to be verified and stored immutably, minimising the risk of data corruption to near-zero. Blockchain is being increasingly hyped for a range of services and industries, including transparent resourcing for marine conservation, reducing pollution from plastics, reducing slavery at sea, and sustainable fisheries management. Public distrust in some conservation operations, as well as in the provenance of seafood, is growing. Although some global marine conservation organisations and seafood producers have found practical solutions in disruptive technologies like blockchain, riding this wave will only prove worthwhile if coastal communities and artisanal fishers are on board and stand a chance of landing a fair share of the benefits.

1. Introduction

The UN Secretary-General's Special Envoy for the Ocean last year described the state of the world's oceans as worse than anything previously thought, with no easy solutions (Thomson, 2019). Due in part to increasing consumption of fish globally, the fraction of fish stocks that are within biologically sustainable levels continues to follow a decreasing trend, from 90% in 1974 to 67% in 2015 (FAO, 2018). As well as contributing to the global ecological crisis of overfishing and biodiversity depletion, Illegal, Unreported and Unregulated (IUU) fishing harms legitimate fishing activities and livelihoods, threatens food security, consolidates transnational crime, and undermines ongoing efforts to implement sustainable fisheries policies (Young, 2016). An estimated 24.9 million people are labouring under coercion in the global fishing industry (Vandergeest and Marschke, 2020). Catches are also impaired by marine litter such as waste plastics, added at a rate of around 8 million tonnes globally each year, as well as the unregulated disposal of waste materials at sea (Wilcox et al., 2016). Despite new regulatory mechanisms, consumer distrust in the provenance of seafood is growing (MSC, 2016).

To address these challenges, many global marine conservation organisations and seafood producers have found practical solutions in blockchain.

A blockchain is a smart database. Instead of being held centrally, this electronic database is distributed to all users, immutably tracking every transaction that has ever taken place on the network. The database is also very difficult to hack, with no single point of authority to make mistakes and collapse the system. An automated verification protocol enables data transmitted on a blockchain network to be stored immutably as cryptographically-secured 'blocks', strung together in a 'chain' (Howson, 2019). The cryptocurrency, Bitcoin, was the first application of blockchain, but cryptocurrencies are just one use for the technology. Some blockchains, like Ethereum, use algorithms to facilitate automated 'smart contracts'. These secure mechanisms for electronic collaboration are made possible through self-executing code eliminating the need for intermediaries to broker between transacting parties. Users do not need to trust each other because they can trust the authenticity of entries on a distributed ledger (Howson, 2019). Despite using the same peer-to-peer approach, many blockchain platforms bear little resemblance to cryptocurrencies in infrastructure or motives. Incentive tokens are not fundamental elements of blockchain. HyperLedger fabric, the technology behind IBM Food Trust, for instance, has no universal proprietary token operable across the fabric[1] (see Figure 1).

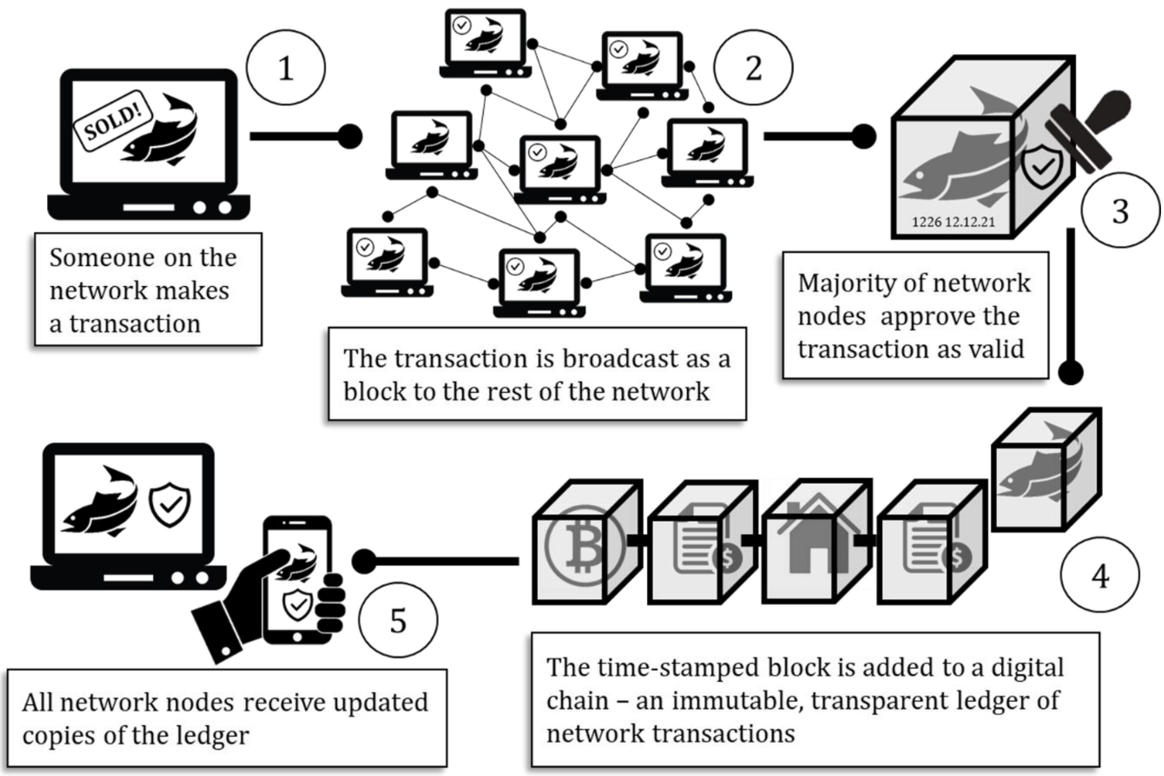

Figure 1. Typical mechanics of a blockchain transaction

[1] This may change with HyperLedger version 2.0, with the possible integration of an interoperable fabric token.

Unlike Bitcoin or Ethereum's transparent, public, open source and permission-free blockchain, IBM secures commercial advantages using a closed, permissioned alternative. Permissioned blockchain networks are accessible only to specified users. These distributed supply-chain platforms provide transparency and, sometimes, better data for decision making and sustainable management, without incentive payments via tokens. Similar platforms have been developed to enable, for example, more efficient and secure government record-keeping, transparent elections, and identity verification whilst maintaining people's anonymity.

Blockchain is providing digital infrastructure for a wide range of applications relevant to environmental sustainability. Uses for the technology include facilitating renewable energy grids, climate change mitigation, food production, e-waste monitoring, land registries, genetic resources, and sustainable supply chain management (Ahl et al, 2019; Bierbaum et al., 2020; Howson, 2019).

This commentary considers how blockchain technology is being leveraged for sustainable marine management, enabling new forms of resourcing and fundraising for healthy oceans as well as more transparent fish supply chains. The technical and political challenges for promoting greater equity between fisheries stakeholders in the Global South[2] and beyond are also explored. The commentary concludes by highlighting why blockchain-based marine management deserves appropriate scrutiny from critical scholars, with recommendations for future research and development.

2. Resourcing marine conservation with blockchain

Trust in conservation charities globally is falling (Prakash, 2019). A perceived lack of transparency, as well as frequent high-profile corruption, accounting and abuse scandals, continue to erode public confidence in the sector and fuel donor apathy (Brindle, 2019). Large conservation organisations face funding and operational restrictions in some jurisdictions due to their perceived radical intentions. For example, Greenpeace and Sea Shepherd in 2020 were listed in UK counter-terrorism guidance (Dodd and Grierson, 2020). Greenpeace India has also faced licence suspensions twice since 2015. As Talukdar (2019) explains, friction in the Global South between international combative environmental activism on the one hand, and local anxiety around economic development on the other, can cost an organisation its right to function. Compliance costs not only take up valuable resources; they also change the organisation's focus towards avoiding sanctions, as opposed to pursuing its conservation goals (Prakash, 2019).

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[2] The term Global South is used to refer to low and middle income countries located in Asia, Africa, Latin America and the Caribbean.

Blockchain platforms are being used to facilitate new forms of charitable giving internationally for conservation purposes, without the need for expensive financial services intermediaries and restrictive local scrutiny. Sea Shepherd promote their capacity to accept one-time donations of Bitcoin. Organisations such as BitGive and BitHope facilitate traceable transactions to conservation projects using widely circulated cryptocurrencies like Bitcoin and Ethereum. Despite the inherent contradiction of charitable giving to conservation projects using something as energy intensive[3] as Bitcoin, there are clear benefits for marine protection project implementers to receive funds in cryptocurrencies. The project can receive payments with full transparency. 'Frictional losses'– the necessity to share funds received with host governments, brokers, NGOs, or other intermediaries, are also avoided (Howson, 2019).

Blockchain-based resource mobilisation efforts for marine conservation are often creative. In partnership with conservation NGOs, a for-profit company, Axiom Zen created Honu, a sea turtle-inspired CryptoKitty. Honu was auctioned in 2018 to raise money for sea turtle conservation efforts in the Caribbean by supporting the Sea Shepherd Conservation Society in Antigua and Barbuda and Unite BVI and raised $25,000 (US). Honu is an example of a blockchain-based crypto-collectable digital asset, also known as an NFT (Non-Fungible Token). These digital artworks are near impossible to replicate, making the work scarce, and therefore collectible (see Figure 2).

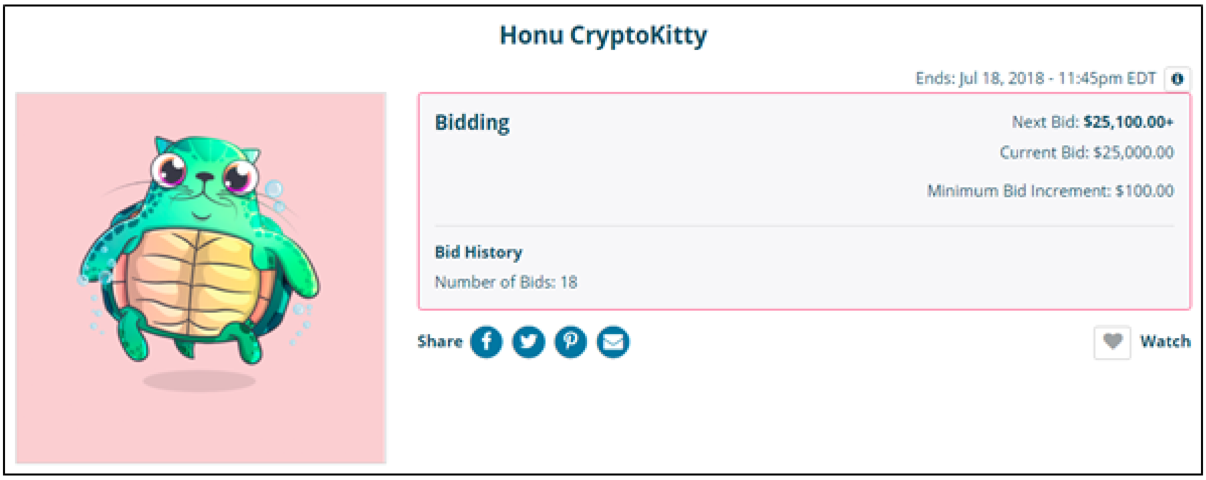

Figure 2: Honu the CryptoKitty – raising money for Sea Shepherd (Source: 32auctions.com)

Blockchain applications are proving especially useful in funding incentive payments for the protection and restoration of marine ecosystems. Companies like Singapore-based Generation Blue, in partnership with US money transmitter, RadPay, have recently developed a payment system using the

[3] Mora et al. (2018) estimates that the computer processing power needed for the Bitcoin network could result in a global temperature rise of 2°C by 2050. Others say such estimates are highly inflated, because Bitcoin production servers are usually located near cheap renewable energy sources, such as hydropower dams.

Ethereum ‘smart contract’ blockchain to fund marine conservation projects (Simmons, 2019). Radpay’s reward tokens, associated with consumers’ transactions on their payment network, are transmitted automatically to Worldview International Foundation’s Thor Heyerdahl mangrove restoration project in Myanmar. Vegetated marine ecosystems like Thor Heyerdahl sequester significantly more carbon than terrestrial landscapes, providing nursing grounds for fish, as well as flood protection and other social benefits (Macreadie et al., 2019). The Ether, the proprietary tokens used on the Ethereum blockchain, that are provided to the project can be used like any other unit of currency, or exchanged for fiat or crypto-currencies.

The various blockchain tokens described here are theoretically valuable as representations of the computer processing ‘work’ that went into their production, as well as their programmed scarcity, and their ability to act as a medium of exchange (Li and Wang, 2017). The value of the RadPay tokens are also derivative, literally derived from the value of the underlying avoided carbon emissions. However, as Büscher (2010) argues, the problem with producing ‘derivative nature’ in this way, is that landscapes (and seascapes), people and their livelihoods are marketed as ‘underlying assets’ for the ‘real’ source of value for market-based conservation. These underlying ‘assets’ become a fetishized abstraction of ‘nature’ (Nel, 2015; Howson et al., 2019). This fetishizing inevitably leads to an oversimplification of ecological complexity, embedding neoliberal ideologies and false solutions for environmental crisis (Matulis, 2015).

Blockchain-based incentive payments are also being used to incentivise waste collection and mitigate oceanic pollution caused by plastics. Plastic Bank, for example, is described by its technical partners, IBM (2019), as a secure asset-backed reward system to underpin the exchange of plastic waste for goods. The system works by enabling volumes of plastic brought to their dedicated recycling centres/grocery shops to be exchanged for blockchain tokens that can be used to buy consumer goods via a smart-phone app. Plastic Bank, a profit-making company, currently has operations in Indonesia, Philippines and Haiti (PlasticBank, 2019). The blockchain app enables real-time analysis of waste recovery data. As of 24th January 2020, the company claims to have collected 8,111,546.5 kg of plastic otherwise destined for the ocean.

It is impossible to know if the platform is meeting its stated objective to ‘turn off the tap to stop ocean plastics’, or rather, to reduce upstream production and disposal of plastic waste. The company promotes its global brand partners, which include Henkel, SC Johnson and Eat Natural. The upstream production sites of plastics originating from these partners are in Western Europe and North America. The platform risks maintaining pre-existing North-South waste flows and neo-colonial geographies of inequality (Furniss, 2015). The environmentally effective solution for these partners is obvious –

prevent excessive plastic pollution in communities by using alternatives to plastics. The cost-effective solution is more creative, and potentially disingenuous, requiring the ongoing externalisation of environmental costs. As SC Johnson's Chairman and CEO, Fisk Johnson, states, "We want to help recover plastic equal to the amount we put into the world, through innovative recycling and recovery programs. In this way we can neutralize our environmental impact and, at the same time, do some good in communities that have excessive plastic pollution." Other commercial ventures are using IBM's traceability platform to connect actors across supply chains and prove regulatory compliance.

3. Blockchain for sustainable fish supply chains

In some jurisdictions, recent legislation has made food companies liable for the working conditions behind the fish they sell and the traceability of catches (LeBaron and Rühmkorf, 2017). The California Transparency in Supply Chains Act (2010) requires large fishing companies to report their efforts to eradicate slavery and human trafficking from their supply chains. The Act also requires disclosure concerning supplier audits. The UK's Modern Slavery Act (2015) goes further, compelling large fishing companies to produce annual anti-slavery and human trafficking statements and report progress in ensuring human trafficking is not occurring anywhere in the fish supply chain (Lewis et al., 2017). The International Labour Organisation's (ILO) Work in Fishing Convention (2007) (C188) provides explicit guidance on safe labour conditions for fishing operations. The Convention puts responsibilities on vessel owners and skippers for ensuring the health and safety of crew. Crews must also be legally old enough to work, and provided rest, wages, food and medical care. Despite the development of these and other regulatory instruments for large fishing companies, according to some research, as much as one-third of seafood products in the US are not what the packaging suggests and are potentially dangerous to health (Barclay, 2013). Fraudulent supply-chain management is estimated to cost the global fishing industry between USD 10-23 billion each year, from prices being suppressed and from lost revenues. Research by the Marine Stewardship Council (MSC) suggests that 55% of the 16,000 seafood consumers they surveyed doubt the provenance of seafood they consume (MSC, 2016).

In response to compliance challenges, the National Fisheries Institute (NFI), which represents most large commercial seafood industry stakeholders in the US, has partnered with IBM Food Trust to develop a blockchain-based solution for their members' seafood supply chains. The commercially-funded initiative aims to increase efficiency, safety and consumer trust in associated members' brands. Carrefour supermarkets have also partnered with IBM Food Trust to develop a blockchain application enabling customers to access information concerning the origin of Spanish line-caught hake (FIS, 2019). Similarly, the US supermarket giant, Walmart is using the same technology for end-to-end traceability of shrimp sourced from Andhra Pradesh state in India (see Table 1).

Token / project	Developer	Blockchain	Established use case	Current Development Phase (as of Dec 2019)
Bumble Bee-SAP	Bumble Bee Foods	SAP Leonardo	Bumble Bee has used SAP's blockchain platform to track and collate supply chain data associated with its Anova yellowfin tuna products.	Initial pilot stage
FishCoin	Eachmile	Stellar	The Fishcoin enabled mFish application is a traceability solution based on blockchain technology that aims to incentivise data sharing across the fishing supply chain.	Initial pilot stage
Food Trust	IBM	HyperLedger	IBM's Food Trust is one of the highest profile traceability projects and includes brands such as Walmart, Sustainable Shrimp Partnership, Nestle, Unilever, and Carrefour. There are numerous other fish provenance projects using Food Trust fabric.	Active
OpenSC	WWF Australia, Boston Consulting and Nestle	OpenSC	The platform ensures products are ethically sourced. Consumers can scan a QR code to trace the source of fish and other products and their path through the supply chain. RFID tags are attached to fish with information stored on a blockchain. Additional data is recorded at each step on the supply chain, including storage temperature in transit.	Active
Pacifical-Atato	Gustav Gerig, Pacifical and Atato	Ethereum	The platform enables the traceability of Gustav Gerig's Marine Stewardship Council (MSC) certified canned and pouched Rosé tuna range under its Raimond Freres brand through the Ethereum blockchain.	Active
Provenance	Provenance, IPNLF and WWF	Ethereum	Provenance was one of the first blockchain supply chain platforms used to track and record catch data on a blockchain. The platform collates SMS messages from fishermen, and uses a system of RFID and QR tags.	Active
Tracey	WWF Philippines and UnionBank	Streamr	The Tracey app will be built on the Streamr blockchain. The data stream will be connected to Streamr Marketplace, where third parties can pay to access it. This revenue will then be transferred to fishers. UnionBank of the Philippines will provide Know Your Client (KYC) support for the app, a Peso stable coin and a digital wallet.	In early development
TraSEAble	TraSEAble, ConsenSys, WWF	Ethereum	TraSEAble blockchain-ready software-as-a-service (SaaS) platform enables collaboration between stakeholders and facilitates transparency by providing regulators with the means of verifying and validating end-to-end forward and backward traceability of fisheries.	Active
Trium	Consensys	Ethereum	Trium is an asset-tracking and supply chain modelling platform providing provenance solutions for fishing companies in the South Pacific region.	Active

Table 1: Examples of blockchain-based fish supply chain projects and their respective features

WWF-Australia and BCG Digital Ventures have launched a rival platform to IBM's, OpenSC, which uses blockchain to track individual fish along the supply chain to help consumers avoid illegal, environmentally-damaging or unethical caught fish. OpenSC uses a combination of vessel monitoring data, machine learning software, the Internet of Things (IoT) and blockchain technology to verify that fishing vessels have only fished in legal areas. This information is shared with consumers on a dedicated website. Working with Austral Fisheries, OpenSC has traced Patagonian toothfish from the point of catch in Antarctica to final customers in Asia, Europe and North America. There are multiple competing blockchain-based supply-chain platforms with similar associated use cases currently at various stages of development.

In 2016 supply-chain management business, Provenance, completed a six-month pilot project in partnership with the International Pole and Line Foundation (IPNLF). Using a system of Radio-Frequency Identification (RFID) tags and Near Field Communicator (NFC) devices, 'sustainably caught' tuna was traced from Indonesian fisheries to consumers in the UK using a distributed ledger on the Ethereum blockchain. The project aimed to show how the technology could guarantee catches that are compliant with legislation, including human rights laws, to reduce incidence of slavery at sea (see Figure 3).

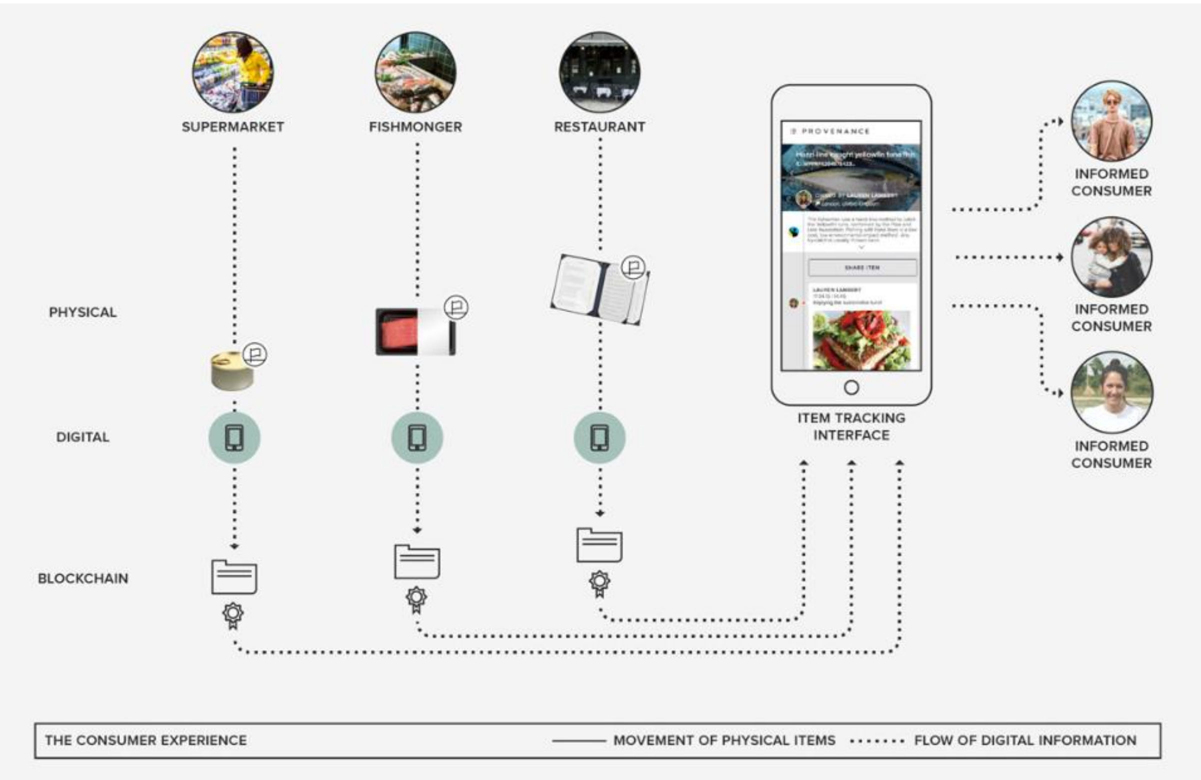

Figure 3: Provenance's blockchain-based supply chain solution (Source: Provenance)

Despite Provenance's focus on the Global South, on-boarding these platforms is expensive, placing them far out of reach for small-scale fishing companies. An additional challenge comes from ensuring the reliability of information entered onto the blockchain. While blockchain applications can collect data about the fish all the way from 'bait to the plate', they cannot guarantee that fish were caught how and where the data claims. The spatial data quality of smart phone GPS systems is easy to spoof

(Zhao and Zhang, 2019). Reliable tracking and monitoring of fish that are caught and processed is not possible with smart-phones and blockchain alone. Other peripheral sensors and trackers, known as oracles, could potentially help overcome this concern in permissioned networks. These oracles include internet of things (IoT) devices, remote sensors, and handheld DNA sequencers. The authenticity of data that is not native to the blockchain cannot be guaranteed at the point of registration – the 'garbage in, garbage out' (GIGO) problem. If supply chain data is entered incorrectly, either deliberately (by a bad actor) or mistakenly (due to human error), conflicts cannot easily be resolved without a trusted third party (Ito and O'Dair, 2019), which then begs the question – why use a blockchain at all?

Effective adoption of the technology faces a range of policy challenges including regulatory recognition and interoperability across jurisdictions. Allen et al. (2019) propose a regional high-level policy forum in the Asia-Pacific to coordinate issues such as open standards and regulatory compatibility. These forums may prove attractive to fishing outfits keen to prove their compliance. They are unlikely to attract the interest of fishers who operate illegally. Regulatory solutions are difficult to implement where fish are caught on the high seas – areas of ocean outside the jurisdiction of any state – or where catches are landed by artisanal fishers (DuBois and Zografos, 2012). In developing regions of Asia, Africa and Latin America, conflicts between fisheries stakeholders may also impact the abilities of authorities to regulate catches (Bavinck, 2005), whether using blockchain or otherwise.

4. Blockchain supply chains and artisanal fishers

According to the UN Conference on Trade and Development (UNCTAD) 96% of fishers around the world are artisanal or small-scale, and they account for around 35% of the fish caught worldwide (UNCTAD, 2017). Reducing consumption globally is necessary, but the fishing sector is a significant employer – fisheries and aquaculture support the livelihoods of nearly half a billion people across the world[13]. In Indonesia for example, the sector employs an estimated 6.4 million people directly. Fish accounts for 54.8% of animal protein consumed, whilst per capita, fish consumption in Indonesia is increasing, from 21 kg in 2003 to 33.9 kg in 2012 (Tran et al., 2017). Regulatory sticks exist for larger seafood companies to share data, meeting their legal obligations efficiently. Commercially viable platforms, such as Provenance and IBM Food Trust, are helping to ensure compliance, with consumer-driven incentives around brand promotion and trust. Adding demands for traceability and data sharing to small-scale artisanal fishers is a difficult proposition, especially where the benefits to be gained by individual fishers are unclear or where that data collation process comes at an unaffordable price, such as purchasing an IBM Food Trust product license.

Given the significance of artisanal practices to the fishing sector globally, to be successful, automated platforms must allow access for subsistence fishing communities. Fishcoin, a blockchain-based data-sharing platform, could prove useful here. The project aims to incentivise catch registration and data sharing by small-scale fishers in the Global South. In collaboration with the GSMA – a trade body representing the interests of mobile network operators worldwide – the Fishcoin platform incentivises individual fishers to share data on a shared ledger by offering tokens which can be exchanged for mobile phone credit. The approach shifts the economic burden to downstream consumers, such as hotels, restaurants and retailers, who benefit most from the increased traceability (FishCoin, 2019). Unlike many blockchain initiatives, Fishcoin is transparent and open source. It is not controlled by a central company. It incentivises data capture to enable better decision making by industry regulators, who at present have limited understanding of conditions below the water line. Blockchain projects like this are certainly not silver bullets for solving issues rooted in the overconsumption of fish globally. But, if marine ecosystems are improving while small-scale fishers are receiving a fair share of the benefits, then projects like this are a good start.

5. Conclusions

Marine conservation and global seafood production networks have a trust problem. For donors of charitable causes, pathways and impacts of funds are opaque. Conservation organisations struggle to meet transparency requirements and comply with national-level regulations while meeting their own goals that may prove at odds with the economic development interests of regulators. Concerns over the mislabelling of fish sold in supermarkets and restaurants is increasing (Black, 2019). Seafood producers are also struggling with consumer confidence issues, with claims of pervasive piracy at sea, slavery, abuse and suspicious deaths tainting the industry's performance (Urbina, 2019). This short commentary has considered how blockchain technology is being leveraged to mend these trust issues, enabling new forms of resourcing and fundraising for healthy oceans as well as more transparent fish supply chains. The challenges for these crypto-fixes are technical and political in nature. Challenges for promoting greater equity between fisheries stakeholders in the Global South will likely prove difficult where compliance attracts unaffordable costs. Regulatory forums may prove attractive to fishing outfits keen to prove their compliance. They are unlikely to attract the interest of fishers who operate illegally. Incentivising sustainable marine stewardship from artisanal fishing communities will require enabling equitable access to economic and other benefits. Blockchain technology is enabling larger companies to cost effectively protect their brand images. However, unless peripheral oracles are developed that are trust preserving, blockchain fixes for marine management will be subject to 'garbage in, garbage out'.

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