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SUMMARY REPORT: SEAFOOD AND FISHERIES EMERGING TECHNOLOGIES (SAFET) CONFERENCE, 2019 - ILLUMINATING THE SUPPLY CHAIN

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Paper submitted by World Wide Fund for Nature (WWF)

SUMMARY REPORT:

SEAFOOD AND FISHERIES EMERGING TECHNOLOGIES (SAFET) CONFERENCE, 2019

Illuminating the Supply Chain

FEBRUARY 13-16, 2019. BANGKOK, THAILAND

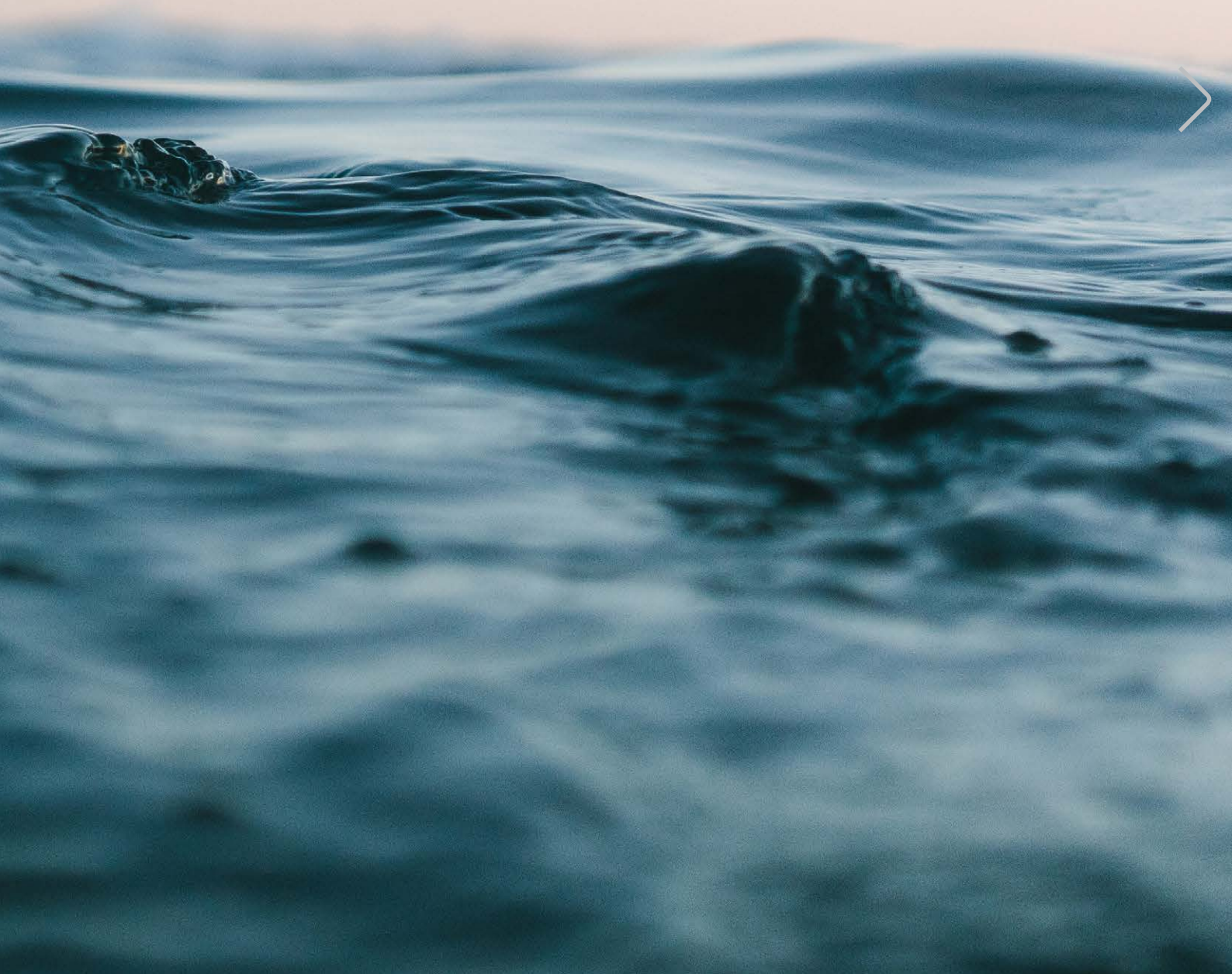
Summary Report for the Seafood and Fisheries Emerging Technologies (SAFET) Conference, 2019. Illuminating the Supply Chain

February 13-16, 2019. Bangkok, Thailand

DEVELOPED IN COLLABORATION WITH:

The World Wide Fund for Nature (WWF) has conducted similar conferences biennially since 2014, with a vision to explore emerging technologies that have the potential to transform the conservation and management of the world's fisheries.

While WWF led previous events, a broad coalition of industry, government, and non-government organizations (NGOs) came together to make the 2019 event the largest and most relevant to date.



Introduction

The 2019 Seafood and Fisheries Emerging Technologies (SAFET) Conference (formerly the Monitoring, Control, and Surveillance [MCS] Emerging Technologies Workshop) represents the first global conference where MCS and seafood supply chain practitioners from around the world were given the opportunity to explore and learn about the very latest technologies available for application in fisheries MCS and supply chain traceability.

By exploring emerging technologies as diverse as satellite remote sensing and unmanned surveillance vehicles, this conference created and strengthened new connections among technology, industry, and government specialists as well as helped identify current and future opportunities for the application of innovative technologies in seafood supply chain traceability and fisheries MCS contexts. Moreover, the event helped identify potential solutions to complex fisheries challenges by connecting technology providers with fisheries and seafood supply chain professionals in a forum intended to foster a mutual and global vision toward solving the conservation and management challenges global fisheries currently face.

The initial event held in Honiara, Solomon Islands, in 2014 had an ambitious vision to explore and discover emerging, and potentially disruptive, technologies that had the potential to be applied to the conservation and management of the world's fisheries. The second event held in Auckland, New Zealand, in 2016 expanded the scope of the original event and incorporated a theme of "Anything is Possible!"

Following the execution of these two successful events and based on feedback from previous participants, the organisers decided to include supply chain traceability as a discrete component, acknowledging the interconnected role of the seafood supply chain with MCS technologies.

Thus, the theme for the 2019 SAFET Conference was "Illuminating the Supply Chain," reflecting the recognition of the increasingly important role that the seafood supply chain plays in identifying and assisting actions related to investigations of illegal, unreported, and unregulated (IUU) fishing. As evidenced by the implementation of regulatory measures by the European Union, United States, and, soon, Japan, regulatory authorities have progressively viewed seafood supply chain traceability as an increasingly important tool in combatting IUU alongside other available MCS tools.

The SAFET Conference was scheduled and designed to precede and complement the International Monitoring Control and Surveillance Network's (IMCS Network) Global Fisheries Enforcement Training Workshop (GFETW; http://gfetw.org/).

Contents

The Conference

The SAFET Conference attracted over 240 registered participants from 40 different countries and 120 different institutions ranging from fishing companies to government to technology providers. A dramatic increase in participation reflects a growing interest in the use of technology to address challenges related to IUU and seafood supply chain traceability.

The Conference was held with the advice and support of Environmental Defence Fund (EDF), USAID, The Pew Charitable Trusts, The Nature Conservancy, Future of Fish, International Seafood Sustainability Foundation (ISSF) and Marine Instruments. The Pew Charitable Trusts and The Nature Conservancy provided Rhodium level sponsorship, ISSF at Platinum level and Marine Instruments at Gold level.

Specifically, the Conference focused on achieving the following outcomes:

1. Improve and clarify the understanding of the existing MCS and supply chain traceability environment.
2. Objectively review any emerging and advancing technologies that might contribute to less expensive and more efficient MCS and supply chain traceability.
3. Advance future implementation of innovative emerging technologies in MCS and supply chain traceability applications where appropriate.

Evolving from the two-day format of the previous workshops, WWF designed the SAFET Conference over 3 days with the first two days consisting of individual presentations and panel sessions followed by four separate workshops on the third day. Following the presentations of MCS practitioners and technology providers on day 1 and 2 of the conference, participants came together over the four workshop sessions on day 3 to help identify the right technologies for the right conditions to achieve an effective, efficient, and economical MCS programme. Additionally, as part of the conference scheduling, technology providers also had a substantial opportunity to present their technologies through vendor booths located in the foyer entrance to the main conference hall.

At the conclusion of the workshop, WWF requested that all participants reflect on the conference presentations, discussions and outcomes and submit answers to an online survey, with results from that survey are included in a summary as part of this report.

PRESENTATIONS

The presentations were conducted by MCS authorities and practitioners and covered topics including:

Understanding the Global Fisheries and Seafood Landscape

- Overview of Global Fisheries and the Seafood Supply Chain
- Understanding International Cooperative Efforts
- Basic Gaps in the MCS Framework
- Overview of Existing Technologies
- Basic Costs and Benefits of Existing Technologies Applications

Overview of Emerging Technologies

- Genetics, Biochemical Markers, and Spectrometry
- Electronic Monitoring
- Artificial Intelligence and Machine Learning
- Integrated Satellite Imaging & Tracking Technology
- Cryptocurrencies and Blockchain
- Data Management Solutions Technologies and Big Data Analytics
- Catch Documentation and Traceability Technologies

The presentations began with providing the vital insight into the current global fisheries and seafood supply chain including challenges and areas for improvement in both the governance framework and existing technologies. This provided vital context for which emerging technologies could be applied in fisheries MCS and seafood traceability.

By fully understanding the current status of fisheries MCS and seafood traceability, technology providers can better adapt their technologies to meet the needs and desires of MCS practitioners. This was followed by presentations given by technology experts regarding the capabilities and capacities of emerging technologies highlighting the barriers and opportunities for improving MCS of fisheries and/or seafood traceability.

PANELS

There were three panel sessions covering topics including:

Shared hurdles and common solutions – An honest discussion about eCDT

Panel Lead: Ms Traci Linder, Fishwise
Panel speakers: Stephani Mangunsong, MDPI; Farid Maruf, USAID; Kris Kastern, Abolobi

Course Change – Facilitating Adoption of Emerging Technology in the Supply Chain

Panel Lead: Mr Andy Kennedy, Global Dialogue for Seafood Traceability
Panel speakers: Benjamin So, 178 Degrees; Gena Morgan, GS1US; Miodrag Mitic, MSC

Weighing the Alternatives – Matching Technologies to Objectives and Capacities

Panel Lead: Mr Bubba Cook, WWF
Panel speakers: Tony Long, Global Fishing Watch; Meaghan Brosnan, WildAid; Deidre Duggan, MDPI

WORKSHOPS

There were four workshops on day three including:

Workshop 1: Electronic Monitoring

- Part 1: Cut to the Chase – Advances in Automating EM Video Review
- Part 2: Hard Drive Blues – Advances in Transmitting Video & Data from Vessel to Review Centre

Lead: The Nature Conservancy

Workshop 2: From Sea to Sky

Effective Implementation of Monitoring, Control, and Surveillance

Lead: Pew Environment Trust

Workshop 3: How Much?!

Small Scale Fisheries and Technology Finance Challenges

Lead: WWF

Workshop 4: From Bait to Plate

Designing Comprehensive and Integrated Technology Systems

Lead: USAID Oceans

Agenda

DAY 1: THURSDAY, 14 FEBRUARY 2019

08:00-08:30	Registration

Session 1: Introduction

08:30-09:00	Welcome – Department of Fisheries Thailand
09:00-09:10	Introduction Emcee: Overview of Event and Facilities
09:10-09:30	Opening Address Guest: Cdr Tony Long, Global Fishing Watch

Session 2: Understanding the Global Fisheries Industry and Seafood Supply Chain

09:30-10:10	*Overview of Global Fisheries and the Seafood Supply Chain* Presenter: Dr Lara Manarangi-Trott, WCPFC Presenter: Mr Eric Enno Tamm, ThisFish Inc
10:10-10:30	*Understanding International Cooperative Efforts* Presenter: Mr Daroomalingum Mauree, IOC/SWIOFC
10:30-10:50	*Basic Gaps in the MCS Framework* Presenter: Cdr Mark Young, Pew End Illegal Fishing
10:50-11:20	*Morning tea*
11:20-11:40	*Overview of Existing Technologies* Presenter: Mr Brett Alger, NOAA
11:40-12:00	*Basic Costs and Benefits of Existing Technologies Applications* Presenter: Mr Vivian Fernandes, Pacific Islands Forum Fisheries Agency
12:00-12:10	Summary and Discussion
12:10-13:00	*Lunch*

Session 3: Overview of Emerging Technologies

13:00-14:00	*Catch Documentation and Traceability Technologies* Presenter: Mr Julien Hawkins, Vericatch Presenter: Mr Jirawat Eauchai, Trinity Maritime Presenter: Mr Blake Harris, WWF Presenters: Mr Thira Rodchevid, Thailand Department of Fisheries Mr Bradley Soule, OceanMind
14:00-14:45	*PANEL: Shared hurdles and common solutions – An honest discussion about eCDT* Panel Lead: Ms Traci Linder, Fishwise
14:45-15:15	*Afternoon tea*
15:15-16:00	*Unmanned Surveillance Technologies* Presenter: Mr Gabriel Gomez, Marine Instruments Presenter: Mr Andrew Deary, Marine Management Organisation Presenter: Mr Yann Yvergniaux, Trygg Mat Tracking (TMT)
16:00-17:00	*Genetics, Biochemical Markers, and Spectrometry* Presenter: Dr Peter Grewe, CSIRO Presenter: Dr Olya Shatova, Oritain Presenter: Mr Steve Larkin, ImpactVision Presenter: Mr David Baisch, ConservationX Labs
17:00-17:45	*PANEL: Course Change – Facilitating Adoption of Emerging Technology in the Supply Chain* Panel Lead: Mr Andy Kennedy, Global Dialogue for Seafood Traceability
17:45-18:00	Discussion to identify key points raised, summarise and record key points
18:00	Adjourn
18:00-22:00	Welcome Function (Cocktails and Canapés)

DAY 2: FRIDAY, 15 FEBRUARY 2019

09:00-09:10	Brief Review and Recap of Day 1
09:10-09:30	Special Address: Ending Illegal Fishing Presenter: Cdr Peter Horn, Pew Ending Illegal Fishing Project

Session 4: Overview of Emerging Technologies (continued)

09:30-10:30	*Electronic Monitoring* Presenter: Mr Javier de la Cal, Satlink S.L. Presenter: Mr Christopher Cusack, EDF Presenter: Mr Jared Fuller, Saltwater Inc. Presenter: Ms Amanda Barney, Teem.Fish
10:30-11:00	*Morning tea*
11:00-12:00	*Artificial Intelligence and Machine Learning* Presenter: Mr Jeff Douglas, Integrated Monitoring Presenter: Ms Oihane Erdaide Goienetxe, Digital Observer Services Presenters: Mr Bundit Kullavanijaya, Thailand Department of Fisheries Ms Natalie Tellwright, OceanMind Presenter: Dr Manoj P Samuel, ICAR-Central Institute of Fisheries Technology, Kochi
12:00-13:00	*Lunch*
13:00-13:45	*Integrated Satellite Imaging & Tracking Technology* Presenter: Dr Christopher Elvidge, NOAA Presenter: Mr Paul Whitaker, KSAT – Kongsberg Satellite Services Presenter: Mrs Inès Guth, Collecté Localisation Satellites (CLS) Presenter: Mr Art Ramirez, ORBCOMM
14:00-15:00	*Cryptocurrencies and Blockchain* Presenter: Mr Anthony Orgill, IBM Food Trust Presenter: Mr Ken Katafono, TraSeable Presenter: Mr Guillaume Le Saint, Atato Co. Ltd. Presenter: Dr Alistair Douglas, Eachmile
15:00-15:30	*Afternoon tea*
15:30-16:00	*Data Management Solutions Technologies and Big Data Analytics* Presenter: Mr Alan Steele, CatchCompliance Presenter: Mr Chris Thomas, OpenSC
16:00-16:45	*PANEL: Weighing the Alternatives – Matching Technologies to Objectives and Capacities* Panel Lead: Mr Bubba Cook, WWF
16:45-17:00	Discussion to identify key points raised, summarise and record key points
17:00	Adjourn

DAY 3: SATURDAY, 16 FEBRUARY 2019

09:00-09:20	Brief Review and Recap of Day 2 and Intro to Workshops
Session 5:	**Workshops**
09:30-12:00	*Workshop 1: Electronic Monitoring* Lead: The Nature Conservancy Part 1: Cut to the Chase – Advances in Automating EM Video Review Part 2: Hard Drive Blues – Advances in Transmitting Video & Data from Vessel to Review Centre
09:30-12:00	*Workshop 2: From Sea to Sky* *– Effective Implementation of Monitoring, Control, and Surveillance* Lead: Pew
10:30-11:00	*Morning tea*
12:00-12:30	Workshops Report Back to Plenary
12:30-13:30	*Lunch*
13:30-16:00	*Workshop 3: How Much?!* *– Small Scale Fisheries and Technology Finance Challenges* Lead: WWF
13:30-16:00	*Workshop 4: From Bait to Plate* *– Designing Comprehensive and Integrated Technology Systems* Lead: USAID Oceans
14:30-15:00	*Afternoon tea*
16:00-16:30	Workshops Report Back to Plenary
16:30-16:45	Closing Statement
16:45	Adjourn

Discussion

DAY 1: *Thursday, 14 February 2019*

This section is intended to provide an overview of the major discussion points and themes of the presentations and provide a summary of the discussion that followed.*

SESSION 1: INTRODUCTION

CDR Tony Long of *Global Fishing Watch* delivered an opening address on four key areas that he believes are critical to consider and address. He opened by emphasizing that shared data is fundamental to successful Monitoring, Control and Surveillance and traceability. When discussing data requirements for managing global fisheries he stated

"If you can't measure it, you can't manage it. And you can't manage it, if no one has shared it."

He expressed concerns regarding incomplete or entirely missing landing data coupled with the fact that no reason remains for this to be the case given the potential for technology to develop the next generation of Vessel Monitoring Systems (VMS), e-logbooks, traceability and Electronic Monitoring (EM) that can make global data complete.

He also discussed the ability to connect transhipments to illegal fishing, highlighting the transnational nature of various crimes associated with the practice. CDR Long noted the exciting possibilities of DNA tests that can determine the genetic presence of fish in the water, for example the water in the hold of a transhipment vessel. He described how this new technology could identify possible discrepancies between what is reported and what has been held in the vessel, for example if sharks were retained that were not recorded.

SESSION 2: UNDERSTANDING THE GLOBAL FISHERIES INDUSTRY AND SEAFOOD SUPPLY CHAIN

OVERVIEW OF GLOBAL FISHERIES AND THE SEAFOOD SUPPLY CHAIN

Dr Lara Manarangi-Trott from *Western and Central Pacific Fisheries Commission (WCPFC)* provided a critical opening context around why "fish and fisheries are important". Dr Manarangi-Trott began by noting that 33.1% of fish stocks are currently fished at biologically unsustainable levels with 40.3 million people employed at capture fisheries. Importantly, Dr Manarangi-Trott highlighted the FAO definition of Responsible Fisheries; "The integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives."

** All presentations are located at: www.seafoodandfisheriesemergingtechnology.com/presentations*

Dr Manarangi-Trott then raised several key questions:

1. How do current fishing levels compare to maximum sustainable yield (MSY)?
2. How much reduction of fishing activities are required?
3. What rules and regulations are required to ensure objectives are achieved?
4. How do we enforce management measures? and
5. How do we track progress and adapt management?

Dr Manarangi-Trott highlighted that adequate and available data, stakeholder consultations, and technical expertise are crucial to answering these questions. She emphasised two areas with reference to data:

- Fisheries-based data encompassing the establishment of reference points, offloading records, port sampling, transhipping and observers notes; and
- Science-based data on fish and their environment, biological productivity and potential of stocks and environment.

She expressed that, to ensure this data is useful, fishers must submit daily catch logs and data to databases for analysis. She explained that independent data sources including VMS, inspections, observers and port samplers, along with emerging technologies, are facilitating a shift from paper reporting to electronic reporting and electronic monitoring. She described how data flows through to National Governments and then to Regional Fisheries Management Organisations (RFMO) acting as governing bodies that decide on fisheries management measures based on that data and existing policy.

Dr Manarangi-Trott explained that enforcement responsibilities largely remain with national authorities, but that the RFMO may establish regional MCS tools, "blacklist" vessels, VMS data sharing arrangements, and regional observer programmes. She also explained how the national fisheries authorities also have discrete responsibilities to manage fisheries, licenses and regulations.

Dr Manarangi-Trott emphasised that flag states are ultimately responsible for securing effective action to non-compliance/illegal activities with compliance monitoring schemes based on data provided by RFMO members. She noted that a centralized database maintained with standards-based data generation is an initiative of Western and Central Pacific Fisheries Commission (WCPFC). Dr Manarangi-Trott concluded by observing that emerging technologies could provide opportunities to enhance quality of fisheries data and information for better fisheries management decisions. For example, she noted that the Parties to the Nauru Agreement (PNA), a subregional fisheries management organisation, is considering a tracking system which allows for quicker and more efficient flows of data for real-time decision-making and shorter time lag to react.

Eric Enno Tamm from *ThisFish Inc* presented on the processing sector of the seafood industry and their data collection, monitoring and analysing app – Tally (Figure 1). He started by highlighting that with millions of harvesters and millions of end-buyers there becomes a bottleneck of data to analyse. Mr Enno Tamm provided a sector overview by explaining relative small-scale of the industry with only about 14% of companies possessing more than 100 employees.

Figure 1: ThisFish app -Tally' – allowing possessors to digitize, monitor and analyse data.

Mr Enno Tamm described the frequency of data collection from lowest to highest:

1. Quality Control Data
2. Production Data
3. Machine Data

He noted that the vast majority of companies that use Enterprise Resource Planning (ERP) have revenues over USD$40M with the cost of ERP software typically not fitting the scale of processing businesses.

Mr Enno Tamm emphasised that seafood processors are the most critical nodes in seafood supply chains for the following reasons:

1. There is an enormous volume of data but this is mostly tracked on paper. He stated, "Data, data everywhere but not a drop to sync!"
2. There is a data bottleneck of processors between harvest and retailers/end users
3. Technology drivers are traceability and drivers for internal efficiency

Mr Enno Tamm followed by giving an overview of the processing sector and explained why there will be greater sector adoption of technology. He stated that 43% of the sector are small scale processors with 59% in Asia.

He further noted that 70% of companies with over 100 employees are located in Asia, with 10% of those factories in Vietnam, collectively representing 80% of volume, which is the same for the tuna sector in Thailand.
Mr Enno Tamm continued by explaining that the sector is fragmented with thousands of species processed that are globally dispersed with processors in remote rural areas.

He described technology adoption challenges in the sector, which include quality control of data with very low automation and sampling. He further noted that some firms have developed Enterprise Resource Planning (ERP) software, but that it is adopted mostly in the US among companies with revenues of USD$50M with only 14% of those companies possessing revenues of over USD$10M.
He highlighted how this demonstrates that the cost of enterprise software does not fit the scale of most seafood businesses. Mr Enno Tamm noted that most ERPs are customized with unique code written for company needs, while the disaggregation of fish processing requires a higher level of customization that adds cost and complexity. Additionally, a mismatch between processes and software often exists, causing some to resort back to paper.

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Mr Enno Tamm highlighted the trends driving technology adoption with the most prominent being that technology costs going down making it more accessible and affordable for processing and harvesting sectors. "Smart factories" are trending with use of Internet of Things (IOT) sensors, Artificial Intelligence (AI) and Machine Learning (ML), and data visualizations incentivising high up-take from the seafood industry. The KPI in a processing factory is yield. He concluded by noting that raw material and process control factors influence yields, and therefore the question is "can we use machine learning algorithms to determine how to maximize yields" and a corresponding answer that traceability represents one management tool to track efficiency and yields.

"Data, data everywhere but not a drop to sync!"

UNDERSTANDING INTERNATIONAL COOPERATIVE EFFORTS

Mr Daroomalingum Mauree from *the Indian Ocean Commission (IOC) and Southwest Indian Ocean Fisheries Commission (SWIOFC)* presented on the "Regional Plan for Fisheries Surveillance in the South West Indian Ocean." Mr Mauree explained that the fundamentals of the IOC surveillance initiatives include:

- implementing a decentralized approach by strengthening national MCS capacities,
- sharing of national MCS (Human & Technical) assets for regional operations,
- cooperation beyond the IOC geographic delineation to enclose the SWIO basin and support sovereign rights and responsibilities of the Coastal States on their EEZ.

Mr Mauree explained the main objectives of the Regional Plan for Fisheries Surveillance include:

- building MCS capacity at national level,
- engaging joint patrol deployment (sea and air),
- supporting exchange of fisheries and MCS information (e.g. SIGMA, Regional VMS, AIS, SAR, STaRFISH),
- administrating the regional observers programme,
- facilitating coordination and cooperation activities among RFMOs (IOTC, SWIOFC) and associated programmes,
- supporting strategic alliance with regional MCS mechanisms (EFCA and SPFFA), sharing lessons learned and best practices with other aspirant regional MCS coordination centres (SADC, IGAD), and
- enhancing communication, awareness building and advocacies.

Mr Mauree concluded that efforts will continue to focus on, among other things, the institutionalization of the IOC Regional MCS Mechanism and sustain regional cooperation and supporting inter-regional, inter-agency and inter-governmental MCS cooperation, coordination and harmonisation processes with a view toward a more effective fight against IUU fishing at regional level.

BASIC GAPS IN THE REGIONAL MCS FRAMEWORK

Cdr Mark Young from *Pew Environment Trusts Ending Illegal Fishing Project,* provided an overview of the basic gaps in the MCS framework and started by explaining that MCS is essentially about compliance with fisheries management measures. Cdr Young noted that:

"The use of technology is dependent on the effectiveness of international and national policies supporting its use."

He discussed how information is captured through the MCS network and the subsequent mechanisms for sharing of data. He specifically noted that it is important to first understand for what purpose information is shared nationally, regionally, and globally, then you may ask how the information flows to the operators who need it and what data is needed to inform effective MCS. Cdr Young emphasised that information management systems need to be more connected and accessible.

Similarly, to Mr Enno Tamm, Cdr Young noted the rapid emergence of cost-effective technologies, but also added that it is important to target the right technologies to address specific risks. He highlighted such technologies as:

- electronic licensing,
- VMS,
- electronic reporting and monitoring; and
- catch documentation schemes.

Cdr Young also highlighted that seafood buyers must possess and understand the information they need to prevent illegally caught fish from entering global markets. He concluded that effective MCS is secured through a combination of technology and partnerships between law enforcement authorities, navies and coast guards, NGOs (e.g. GFW, Sea Shepherd), the seafood industry and markets, governing coalitions (e.g. FISH-I Africa, FFA), port state measures, and cooperative agreements (e.g. Niue Treaty, Djibouti Code of Conduct), which is ultimately supported through effective policy.

OVERVIEW OF EXISTING TECHNOLOGIES

Mr Brett Alger from *National Oceanic and Atmospheric Administration (NOAA)* presented on the basics of U.S. applications of technologies for MCS (Figure 2). He started by discussing VMS, which >4,000 vessels have on board, but highlights that this data is not publicly available and yet there are many uses of the data for enforcement purposes. Mr Alger then discussed the fisheries observer programmes, which have expanded into several regions where training and observer deployment takes place. He noted that much of this data is paper based, but that mobile and stationary tablet systems are making auto calculations, validation, and more real-time data acquisition possible.

Figure 2: NOAA electronic monitoring and machine learning.

He further added that NOAA is currently looking into barcoding and application-driven sampling (to randomize) data collection systems.

Mr Alger explained how vessels, processors, and dealers have historically worked with a paper-based system, and that many of the regional offices are adapting their processes to integrate new needs and technologies, including electronic reporting. Mr Alger highlighted the opportunities for putting data capture tools in the hands of fishers.

He also noted that challenges include difficulties standardizing (e.g. KDEs), collecting, and storing the data. Additionally, he noted increasing data collection from the recreational fishing community. However, he also explained that validating information from the private fishermen is difficult, as is ensuring they are reporting to begin with. Mr Alger discussed the application of electronic monitoring in US fisheries, including the data capture tools employed on the vessels. He explained that the Alaskan fisheries represent one of the most fully implemented programmes, while others are in pre-implementation or trial phases.

He described the basic EM systems to include a GPS unit, some cameras, a control box and gear sensors. However, he emphasised how it is still a largely manual process to get data from the vessel to the reviewers whereby an additional person must review the data. So, to make progress, he explained that we really need to expand the toolbox and automate the analysis.

Mr Alger explained the substantial technology implementation progress made in the US in 2019. He noted that NOAA is in the process of determining what policies and funding structure they are going to use (e.g. industry vs. government). He also noted that there are data access questions, uncertainties regarding video storage and retention requirements and standards, and necessary work to determine best practices for EM programs. Significantly, Mr Alger noted that NOAA is currently expanding the library of fish image information to be used by industry to make machine learning more effective in addition to hosting conferences and other meetings with technology providers and industry. He explained that NOAA has a 2019 Regional Implementation Plan that needs to be refreshed and updated with new 5-year goals and standards.

Mr Alger concluded by highlighting a key goal in the US is to put more tools in the hands of fishers and lower costs by the year 2024.

BASIC COSTS AND BENEFITS OF EXISTING TECHNOLOGIES APPLICATIONS

Mr Vivian Fernandes from *the Pacific Islands Forum Fisheries Agency (FFA)* presented on the costs and benefits of FFA's existing technologies applications. The FFA supports 17 Pacific Island Members, has 100 staff and an annual budget U.S. $25-30 million. He emphasised that the costs and benefits among technologies vary, but that VMS provides an applicable example of where the benefits have outweighed any costs over time. However, Mr Fernandes noted some challenges related to MCS application related to costs versus benefits including:

- lack of infrastructure,
- lack of capacity,
- complex multi-lateral agreements,
- challenges with integration of information management systems, and
- competing priorities & national interests.

He noted that the key focus should be to consolidate the use and analysis of existing data and technology as much as possible. He further emphasised technology as a tool that could, in some circumstances, reduce overall costs, but that there are multiple factors that must be considered. He noted that FFA maintained an interest in addressing specific cost-related aspects including:

- human capacity limitations,
- connectivity limitations, and
- scaling challenges going from national to regional.

Mr Fernandes concluded by reminding the audience to respect the systems in place in order to maximize the operations that you are dealing with.

Q&A SESSION:

The discussion following the presentations made apparent that markets and certifiers are increasingly asking for more detailed information, including mass balance reports, which provide assurance for legality of fish at the processor level. Additionally, an audience member pointed out that younger people are working in the fishing sector and processing facilities in Asia, creating an advantage given the younger generation's aptitude for new technology.

SESSION 3: OVERVIEW OF EMERGING TECHNOLOGIES

CATCH DOCUMENTATION AND TRACEABILITY TECHNOLOGIES

Mr Julien Hawkins from *Vericatch*, a company founded in 2006 by fishermen and technologists, presented on their technology solutions to support sustainable fisheries, including software technology and practices to support sustainable fisheries by applying tools that:

1. Digitally collect real catch data on boat and at the landing (empowering industry management of the fishery);
2. Use of that catch data to confirm real seafood traceability for the wider supply chain; and
3. Connect the retailers, restaurants and consumers with the verified story of where their seafood came from.

Mr Hawkins explained that the software platform for electronic reporting is modular and flexible enough to be configured for different types of fisheries, noting that they work with a range of users from artisanal fishing communities to full scale commercial fleets. He highlighted two tools which together help bring the value back to fisheries that use catch reporting; knowyour.fish (Figure 3) and FisheriesApp.

Figure 3: KNOWYOUR.FISH CatchID interface by Vericatch.

He described FisheriesApp as the flexible and quick to implement tool that brings in catch data, which includes a tablet or smartphone app that securely communicates fishing data with a robust database.

He noted that Vericatch can also add in data from GPS and other vessel-based systems adding as well as provide data to regulators in support of industry licenses, security and accountability of this data. Mr Hawkins explained that as fishery priorities change and reporting rules update, they have to keep the software constantly updated and easy to use. He further described how the application includes tools to manage across boats or the entire fishery for those people authorised to see the fishing data, which is valuable operationally to fishermen to both improve efficiency and be proactive to indicators of fishery stocks.

Mr Hawkins described KnowYour.Fish as the way Vericatch brings additional value back to industry. He noted that the supply chain increasingly demands verifiable data as to the origin of seafood and FisheriesApp provides real harvest information that may be attached electronically to KnowYour.Fish as it progresses through the supply chain by use of CatchIDs.

Mr Hawkins described how CatchIDs connect seafood in the supply chain back to the harvest event, but also to the path that seafood takes through the supply chain. He noted how, as a third party, sometimes in conjunction NGOs, the technology system provides those extra levels of verification to allow for detection of suspicious product shipment.

He explained how this feature is not only a platform for traceability but also an effective marketing tool to demonstrate responsible practices. He offered the example of groundfish in British Columbia, Canada, where the use of both FisheriesApp and KnowYour.Fish has increased the fisheries value by making it verifiably traceable.

In conclusion, Mr Hawkins highlighted that Vericatch's system is designed to be interoperable with other systems and data sources to produce integrated and data-rich supply chains, whilst keeping costs under control.

Mr Jirawat Eauchai from *Trinity Maritime* presented on their fishery information system and reporting framework using Odoo software (Figure 4). Odoo ERP is known to be very complete and extremely modular, with 8,000+ modules and features. He explained the valuable aspects of Odoo including;

- One need, one module
- Ready to use in 5 clicks
- Design your own application
- Extremely flexible
- Integrated system
- Friendly user interface
- Data integrated

Mr Eauchai explained that their product enhances electronic supply chain traceability by providing data processing and storage that supports GS1 seafood traceability requirements by recording variables such as the lot number, net weight, species code, species name, and compliant barcode GS1 datametrics barcode. Other key features that may be incorporated into the system include:

- Electronic Reporting Systems;
- Electronic Monitoring Systems;
- Crew Survey and Activity Records; and
- Vessel Monitoring Systems

Mr Blake Harris from *World Wide Fund for Nature (WWF)* presented on the E-Traceability System application – 'TOR'. He opened by comparing electronic and paper-based traceability systems whereby;

Paper-based traceability systems that are:

- Slow and labor intensive
- Reliant on random auditing to catch bad actors
- Confusion over documentation requirements
- Prone to fraud
- Length of time between incident and discovery
- Risk of data desynchronization

While electronic traceability systems allow for:

- Increased supply chain accountability
- Risk monitoring:
  - Food health and safety
  - Environmental
  - Social
- Increase confidence in compliance with regulatory requirements
- Increase efficiency of audits
- Connectivity for all actors

Figure 4 Odoo front and back end integration.

Mr Harris emphasized that each supply chain is different, and TOR was developed to be able to conform to those differences. He explained the software provides a blank slate where a new company or platform can pull the code for free and design the system to fit their supply chain including: supply chain length, types of users, roles, permissions, and data requirements for each user (Figure 5). He also described the ability of the system to allow quick easy capture, submission, and review of documents with a secure and shareable record of all transactions, noting the importance of this security feature to competitors that do not want to share information with others in their industry.

He further explained how TOR can capture confidential information, but only share it with those who need to see it. He described how the vast majority of actors in supply chains currently have smartphones with those device capabilities rapidly improving and data costs plummeting. He noted how the TOR app interface mimics social media apps for ease of use and has no requirements for software licenses or hardware beyond the phone.

Thus, he explained how this open source format and access ensures interoperability across and within supply chains and may be supplemented by the desktop portal that allows for document lists, document review, and a supply chain map.

Mr Harris also advocated TOR as a foundation for a secure blockchain solution that can be developed to comply with government regulations. He concluded by noting the app is currently being developed to ensure compliance with US Seafood Import Monitoring Program (US SIMP) and that it will be released in English, Thai, Bahasa, Telugu, and Spanish.

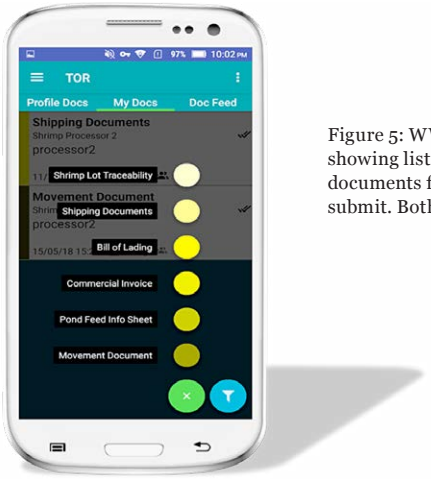


Figure 5: WWF's TOR interface showing list of required documents for the producer to submit. Both easily modified.

Mr Thira Rodchevid from *Thailand Department of Fisheries (DOF)* and *Mr Bradley Soule* from *OceanMind* presented together on the implementation of the Port State Measures Agreement (PSMA), which requires parties to exert greater controls on foreign-flagged fishing vessels requesting to enter their ports. They described the aim of the PSMA approach to reduce and eliminate IUU fish entering the world's markets. They described the Thailand Traceability system, the E-traceability system called Processing Statement Endorsement-linked PSM System (PPS), which is a new electronic traceability system that allows the competent authority to more efficiently trace and control imports from third party countries through chain of custody. This system includes components described as:

1. Electronic Port State Measures (e-PSM)
2. Fisheries Single Window (FSW)
3. Processing Statement Endorsement System (PSE)

Mr Rodchevid explained how these three systems are linked together. He further explained how this would enable Thailand to increase its capacity and capability to track and trace back from sea to plate. Mr Soule then presented on the three parts and the future plan of the collaboration between DOF and OceanMind regarding PSM implementation via the new tool Portstates.org.

Mr Soule explained how electronic traceability systems enable Thailand's traceability system to be complete. He explained how these are important innovations to increase the capacity and capability of DOF officials to control fish and fish products throughout chain of custody with the most important aspect of these systems is the support provided through the information exchange involving all stakeholders (i.e. private sector, intergovernmental agencies, and relevant states).

Mr Soule concluded by explaining how this system would greatly increase transparency and develop a complete traceability system that ensures no IUU fish enters the international supply chain through Thailand.

Q&A SESSION:

Some key themes highlighted in the discussion included:

- Data collection is universal;
- Cost is always an issue;
- Software changes over time and must systems must adapt accordingly; and
- Industry must be brought along.

Q: Does traceability increase the value of fish or is it that it reduces the potential cost of illegal product in the supply chain?

It does actually increase the value but not necessarily the cost of the product. It does give access to other markets that would not normally be available thereby increasing the value.

Q: Is the thai gov't collaorating in the region to share information on bad actors? Have you turned boats away?

Yes – we collaborate and are part of information sharing. We turned away 1 boat from Malaysia and we knew it was not licensed because of our collaboration with many in the region including Myanmar, Malaysia, etc.

Q: What is the incentive for fishers to use eCDT?

It's a tough question. Essentially you need a catalytic event to that may push uptake of eCDT systems. We do need incentives for fishers. Digital credibility is one option – eCDT means fishers could have collateral for insurance or loans.

PANEL: SHARED HURDLES AND COMMON SOLUTIONS - AN HONEST DISCUSSION ABOUT ECDT

Ms Traci Linder from *FishWise* moderated the first panel of the conference with panellists *Ms Stephani Mangunson* from *(MDPI), Mr Farid Maruf (USAID Oceans),* and *Mr Chris Kastern (Abalobi).* Ms Linder opened by delivering an introduction to the work of the Seafood Alliance for Legality and Traceability (SALT). She explained that SALT was created to bring cohesion to seafood initiatives around the globe and support collaboration for more sustainable seafood. She also described that one of the main activities of SALT is to support eCDT development, in which there are many lessons learned that can be adapted/modified for others.

Ms Mangunson offered the first presentation of the session on the Traceability Based Technology program (TBT) in Indonesia for small-scale fisheries.

Figure 6: Elements of Abalobi Fisher.

She opened by commenting that data collection and reporting requirements in Indonesia vary for small, medium and large-scale vessels and that the small-scale vessels main requirement is boat registration. She noted that larger vessels have more complicated requirements including more regulatory requirements and certificates to comply with such as fishing licenses, landing certificates, health certificates, and certificates of origin. Ms Mangunson explained how MDPI currently works with approximately 3000 fishermen, with about 900 of those fishermen part of a fair-trade initiative. She explained that the main challenges in implementation are the fishermens' level of education and connectivity.

She described that trackers for small-scale operators are not compulsory, but that MDPI is currently working with the government in order to understand the situation better and collect data. She noted that, at landing, data collection is done via integration of bookkeeping with traceability, suggesting that the processing plant will not have all customers' required data if they do not have a good traceability system in place. She further noted that MDPI engaged successfully with processing plants because the plants see direct benefits, especially on food safety. She also suggested that MDPI is currently exploring blockchain for data exchange within supply chains.

Ms Mangunson concluded with lessons learned, highlighting that:

- working with all individual fishermen requires trust;
- you need appropriate technology for circumstances; and
- users need to be involved in the design of the technology and not pushed towards adopting technology.

Mr Maruf presented on USAID Oceans work in the traceability space, noting the emphasis on working with local governments as one of the key beneficiaries of the project. He noted that USAID Oceans does not create technology and make people adopt it, rather its approach is to first look at where there are existing technology gaps along the supply chain and then work with private sector partners to fill those gaps by, for instance, building a supplier application. He explained how USAID Oceans are working with Socsksargen Federation of Fishing and Allied Industries, Inc. (SFFAII) and first mover companies in the Philippines and partnered with Philippines' Bureau of Fisheries and Aquatic Resources (BFAR).

Mr Maruf explained that in Indonesia USAID Oceans has employed a different approach than the Philippines, with the main challenge being interoperability, especially among government systems and private sector systems. He noted that the Indonesian government launched an e-logbook in October 2018 to capture KDEs targeting 10,000 boats over 10GT by the end of 2019. He further noted support offered by USAID Oceans to MDPI to link CDT data to fisheries management.

Mr Maruf described some of the at-sea capture technologies under trial including large-scale technologies such as 2-way VMS and fully integrated government e-logbooks as well as small-scale technologies such as Near Field Communication (NFC) cards and net mesh technology (for up to 50 km from shore) which is inexpensive.

He concluded by noting key takeaways including:

- Practitioners must build a strong business case for CDT to achieve scalability and sustainability; and
- More effort must be given to focus on and work to fill gaps in technology and process.

Mr Kastern provided a presentation describing Abalobi, a selection of apps including Abalobi Fisher (Figure 6), Abalobi Monitor, Abalobi Manager, Abalobi Co-Op, and Abalobi Market-Place. He described how the foundation of the ABALOBI app suite, Abalobi Fisher, provides a mechanism for fishers to co-produce knowledge, a personal logbook with analytics and sharing options, personal accounting, and integrated safety-at-sea features.

He explained how the system allows fishermen to track earnings and expenditure and links this to catch data, while noting how this feature can be used as proof of income allowing fishermen to secure a loan.

Mr Kastern concluded by explaining how the app suite was co-designed with fishers and therefore relevant to fishers.

Q&A SESSION:

Q: How do fishermen validate data that was input, especially when approaching banks for loans?

- A financial technology solution is still under development.
- Abalobi started because small-scale fishers have been marginalized and records have been experiencing a 2-year lag, so validation is not the biggest concern in this context. Abalobi aims to provide real-time data, matching the electronic version and paper form that has been submitted to the government.
- Safety is also a big concern. Small-scale fishers do not have resources to protect themselves and the app provides easy access to safety at sea information like weather and sea state.
- Transactions can act as digital credibility to show that transactions have happened and that businesses/trading partners can verify. There are movements in Indonesia regarding digital credibility as well.

Q: If we rely on fishermen only to provide data there can be misreporting. How do we approach this issue?

- Large-scale vessels have obligations and incentives to accurately report logbooks. Logbooks are usually accompanied by other paperwork and inspections. Despite this, misreporting can still happen, such as with catch location.

- However, the main problem of misreporting is with small-scale fishers. Verification is difficult. Ideally data collection should come from middlemen. In Indonesia, middlemen are spread out and only processors know whom these middlemen are. However, for small-scale fishers, if their catch is sent to processors and gets exported the data required will be as much as or more complicated than large-scale.

Q: What are the opportunities to further include gender consideration in CDT?

- Gender is a new consideration and trend in Indonesia. Most employees in processing facilities are women and middlemen's wives are often responsible for recording data. However, men remain predominant in at-sea activities.
- Human-centred design helps to integrate gender equity. Another opportunity is to have a supplier application integrated with fintech for women. Some ideas for fintech could be to incorporate mobile money (spending and saving) into traceability.
- Through the co-design process, Abalobi sees the following themes 1) climate change 2) community and 3) women's roles. Women's roles are largely unaccounted for and the platform aims to make them visible.

Q: How effective is a platform such as abalobi when fishermen are illiterate?

- Co-design is key. There are many ways the app can incorporate this including simple visual representation of key data, how to input data, data visualization of submitted data, different languages for different species, and tools that are relevant need to be co-designed

Figure 7: Marine Instrument's TunaDrone™.

UNMANNED SURVEILLANCE TECHNOLOGIES

Mr Gabriel Gomez from *Marine Instruments* presented on their TunaDrone (Figure 7), a technology initially conceived to support free school tuna fishing, but also promoted as a potential breakthrough in monitoring, control and surveillance. Mr Gomez explained that the motivation behind TunaDrone is to provide a robust and efficient tool for easy scanning and scouting flocks of birds and free schools of tuna. He described how it was designed from scratch with tuna fishermen in mind and represents a durable and reliable solution for intensive use. He further explained that, because the drone is in the sub 2kg category users have permission to operate without the need for certification, such as a remote pilot licence or a drone operators permit for the business.

Mr Gomez expounded on how the drone has fully automated launch, mission and recovery system, purpose made software for command & control, and allows for ease-of-use and safe operation. He explained that the key uses and advantages of TunaDrone include;

- Control of fishing sites on specific fishing activities: ship identification, entries & exits, time registry, type of gear, etc.
- Monitoring of fishing effort within protected marine reserves: ship identification, entries & exits, time registry, type of gear, etc.
- Addressing IUU fishing, sighting illegal fishing activities
- Surveillance of aquaculture production sites: red tide alerts, fattening installations, shellfish harvesting areas, etc.

Mr Andrew Deary from *Marine Management Organisation* presented on innovative technologies for surveillance across the UK Overseas Territories, in particular the Blue Belt Technology Roadmap Project. He described the technologies that are expected to be reviewed as part of the project including:

- Satellite surveillance;
- Unmanned aerial vehicles (UAVs);
- Passive acoustic monitoring;
- Unmanned marine surface vessels;
- Natural tags (such as genetic analysis);
- AIS monitoring/analysis;
- Ground/buoy based RADAR; and
- Argo floats.

He noted that the project would also address issues such as:

- Intelligence management;
- Data acquisition and management;
- Training; and
- Asset tasking.

We are looking for opportunities to operationally trial these technologies in order to better understand the operational readiness of these technologies, Mr Deary said.

So far, testing has focussed on satellite surveillance, UAVs, and passive acoustic monitoring. He discussed the drone trial partnership with a drone provider, particularly some of the challenges and questions which surfaced during the pilot including affordability, waterproofing, ability to operate in tropical maritime conditions, durability, battery life, training, maintenance requirements, and supporting legislation and guidance.

Mr Yann Yvergniaux from *Trygg Mat Tracking (TMT)* presented on FishGuard. He opened by stating how combining low-cost UAVs, fisheries data, and Artificial Intelligence, FishGuard is a drone-neutral initiative aiming to demonstrate that UAVs can become a key asset for systematic use in routine fisheries patrols and assist countries in finding the most appropriate and cost-efficient combination of MCS tools.

He explained that FishGuard operates along four steps:

1) Drones are equipped with autopilot, multiple sensors, and Artificial Intelligence;
2) The system is armed with current and historic parameters, vessel databases, and zoning information;
3) UAVs detect objects on the surface of the ocean, adapt their flight behaviour, assess risk and transmit situational reports to base, and
4) Authorities take enforcement actions and evidence is collected from the drone when retrieved

Mr Yvergniaux suggests FishGuard could be used to create a deterrence effect, target identified "hotspots" of illegal fishing activity, respond to live reports from fishers, scan a specific area where a vessel had reportedly "gone dark," scan a specific area to follow a lead, monitor EEZ boundaries and monitor restricted areas. He also described their pilot in the Seychelles whereby test flights and autonomous trials were scheduled for early to mid 2019. Mr Yvergniaux stated that next steps included securing funding for upscaling from pilot to full deployment, the setting-up of drone bases in other locations to allow for full EEZ coverage, trialling new drones to operate autonomously and simultaneously as a network, and grow the stakeholder group to include MPA managers, search and rescue, etc.

Q&A SESSION:

Q: Is there a trend for unmanned subsurface or surface surveillance?

Underwater surveillance is too difficult at this stage and has bandwidth issues. Surface vehicles are improving and we should see a larger role for them in the future.

Q: How do uavs operate? What determines the application?

The application of UAVs depends on the objectives you are trying to achieve. One place it has worked was in Guatemala where they used drones to monitor the closed season by not looking where suspects were fishing, but where they were processing the fish they caught – as people were catching illegal fish, drying it, and selling as something else. In the Guatemalan case, drones captured GPS, etc. to verify the location of the drying racks.

GENETICS, BIOCHEMICAL MARKERS, AND SPECTROMETRY

Dr Peter Grewe from *the Commonwealth Scientific and Industrial Research Organisation (CSIRO)* opened the session by promoting how genetic technology has advanced to a point where it can now offer a solution by providing fishery independent data. He explained that the technology now overcomes bias in fisheries data and that costs are now feasible for high throughput DNA analysis. Dr Grewe explained how his research, demonstrated through trials of protein gels, mtDNA, DNA microstats and SNPs (Single Nucleotide Polymorphism), could be used to determine species ID, provenance, and individual indicated SNPs (Figure 8).

Additionally, he described how abundance can be estimated through gene tagging and how stock structure information gained through that tagging can provide provenance information about fish.

Dr Grewe highlighted the practical application of species ID using mtDNA markers, including detection of species substitution that could be used to support truth in labelling and verification of catch documentation to identify IUU. He described how CSIROs gene tag technology permits sampling of 6 fish per minute in the factory with DNA extraction of 1200 fish per day in lab.

Dr Grewe concluded by noting that, in order to obtain broad scale coverage across any species requires effective integration of DNA approaches & broad scale genetic coverage and genetic marker validation, which demands collaboration with management agencies and member countries responsible for managing those species.

Dr Olya Shatova from *Oritain* followed with a presentation on their approach to using chemistry and statistics to prove the origin of various products to identify fraud and secure their customers' supply chains.

Technique	Species ID	Provenance	Individual
Protein Gels	Y	?	–
mtDNA	Y	Y	–
DNA Microsats	–	–	Y
SNPs	Y	Y	Y

Figure 8: Genetic analysis options and their ability to determine species ID, provenance and individual.

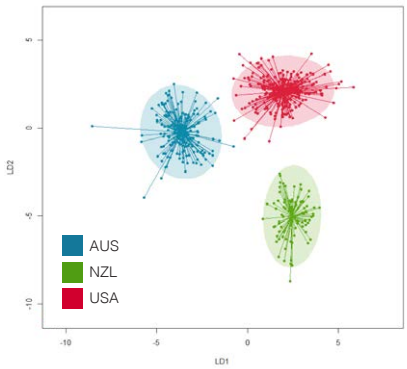


Figure 9: Oritain analysis indicating origins of salmon.

Dr Shatova explained how this method uses elements as chemical markers and mass spectrometry for analysis. She described how seafood products naturally absorb different levels of chemicals from their environment. Samples of the genuine product are taken to establish a baseline or 'fingerprint' that is stored in the Oritain database. She further explained how samples from the market can then be collected for testing to verify the claimed origin of the product and how this allows for on-pack certification and marketing opportunities that can be leveraged for consumers. Dr Shatova offered an example of analysis illustrating how salmon samples from different countries contrasted quite greatly in their biochemical structure (Figure 9) allowing for traceability to the country, region or farm even without packaging.

Mr Steve Larkin from *Impact Vision* presented on the companies' hyperspectral capabilities as it applies to the traceability of fish. Mr Larkin explained that every object has a spectral fingerprint that reveals information about the chemical nature of the product. Mr Larkin explained how ImpactVision works with suppliers to match the 'fingerprints' with specific quality parameters, for example fish freshness (i.e. a fresh fish does not reflect light in the same way as a frozen fish). He further described how the tool can then use machine learning tools to identify, classify, and understand the 'fingerprints' of food products, associating them with established quality parameters in a real-time and non-invasive way.

Mr Larkin explained that they are working toward creating the technology to be able to use your phone in the super market to get information from a hyperspectral image (Figure 10) as well as how the technology can reduce cost, risk, and fraud while increasing revenue. He concluded by suggesting that Impact Vision is seeking pilot partners interested in trialling the technology in different contexts and encouraged those interested to get in contact.

Figure 10: Impact Vision's idea for using a phone to determine freshness of a product by hyperspectral imaging.

Wildlife trade is the 4th largest illicit economy in the world.

Mr David Baisch at *Conservation X Labs* provided insight into DNA barcoding and the DNA tester Conservation X Labs has developed. Mr Baisch described the tool as something that could be used by anyone to address everything from seafood fraud to wildlife trafficking. He outlined that for DNA barcoding to be useful, tested, and trusted that diagnostics are a necessity. He further explained that the cost of DNA barcoding had previously presented a considerable hurdle, but one which Conservation X Labs hopes to address soon. Mr Baisch emphasised that "fancy technology" is not always needed to solve all problems. He explained that Conservation X Labs is making simple, low cost technology to answer important questions, such as a hand-held DNA scanner (Figure 11).

He explained that not only is the device low cost to purchase, on the order of hundreds rather than thousands of dollars, but also that each test is low cost to run on the order of a few dollars per sample rather than hundreds. Mr Baisch concluded by noting that by 2025 Conservation X Labs aims to scan species communities at 2,500 sites, expand their reference library to 2.5 million species, and involve one nation from every ecosystem biotype as it develops baselines across regions and species to support the genetic fingerprint technology.

Figure 11: Conservation X Lab's hand held DNA scanner.

On average, ~33 % of seafood products are mislabeled in the United States.

Q&A SESSION:

Q: Does processing of the fish inhibit the ability for DNA identification?

- The cooking process and processing can affect DNA identification, but there are ways to get around that.
- The more complex the processing, the more complex getting around the issues.
- Canned tuna and tuna preserved in lemon is incredibly difficult to test for DNA

Q: Can this technology be used for prosecution?

- It's not always permissible in a court, but can be. Genetic evidence has already been used in some cases, including seafood.

Q: How long does each test take?

- Sample to answer in 10-15 minutes for the Conservation X Labs device
- CSIRO low res test is about 2 hours but can be up to 2-3 days

Q: Some species are highly migratory, can this work for them?

- Biochemical signatures don't work very well with wild fisheries, especially highly migratory, but it is possible.

PANEL: COURSE CHANGE – FACILITATING ADOPTION OF EMERGING TECHNOLOGY IN THE SUPPLY CHAIN

Mr Andy Kennedy from *Global Dialogue for Seafood Traceability* led the panel discussing the adoption of emerging technology in the supply chain. Mr Kennedy discussed the importance of the establishment of interoperable standards for data exchange between multiple supply chain stakeholders. He unpacked the components of interoperability including: globally unique identifiers, standardized data carriers, readers for data collection and sharing, visibility event data standards (look up lists, master data, key data elements, CTE, file formats and validation protocols) and traceability data sharing technologies (block chain, email, etc.). He firmly emphasised, however, that data needs to be compatible among systems.

Mr Kennedy explained how, in an effort to address those compatibility concerns, the GDST has supported events such as hackathons and pilot projects to explore how this information can be used in real life. He described some of the outcomes of the recent hackathon preceding SAFET2019 that included such examples as Nemo, a bot based on a messaging app platform designed to guide a fisherman in submitting their data through an interactive user experience. Mr Kennedy concluded by addressing the issue of incentivizing data collection by describing a pilot that addressed challenges of how to verify catch area without divulging area.

Mr Benjamin So from *178 Degrees* presented on the King Salmon pilot, which provided data to trace the salmon from the main supplier from Mount Cook Alpine Salmon in New Zealand to Hong Kong.

Mr So explained that the Hong Kong market is highly competitive, so sustainable and fully traceable salmon was a competitive advantage. He described key lessons learned from this pilot that included:

- There was value in streamlining data flows and automating processes;
- A high-level commitment is absolutely necessary; and
- There is tangible value that extends from being traceable and sustainable.

Mr Miodrag Mitic from *the Marine Stewardship Council* presented on maintaining Chain of Custody (COC) standards for MSC, addressing integrity of the supply chain from fishery to point of sale. Mr Mitic highlighted that traceability is not chain of custody, creating a need for analytical testing methods. He explained how, at the very least, there needs to be a mass balance method calculation in real time. He further expressed that there is a desire to replace a once-a-year audit with a remote system that will follow the COC of each certificate holder with a mass-balance measure. Mr Mitic also identified some major risks in certification including:

- Counterfeit certificates;
- Product dilution with non-certified product mixed with certified products; and
- Substandard audits.

He discussed how tablets could allow digital uploading and reporting and that, eventually, data needs to be aggregated to allow for access worldwide. Mr Mitic also emphasised the need for a repository for all certificates for authentication and validation of expiry dates and highlighted the importance of not increasing the cost to certification holders as well as the need to obtain a balance between the cost and value.

He further noted that there needs to be more information provided to the consumer and suggested the use of the MSC platform as a means to communicate on quality of the product, food safety, traceability and sustainability. He suggested that an integrated process optimization should bring value to the process. To conclude, Mr Mitic calls for solution providers to develop mass balance calculation systems and analytical tests for product provenance.

Ms Gena Morgan from *GS1* presented the function of the global standards organization, which generates unique identifications for products for 2.5 million businesses across the world with a 112-member organisation federated across 120 countries. The GS1 standards include:

- Identifying – GS1 Identification Numbers: Companies, Products, Locations, Logistics, Assets, and Services;
- Capturing – GS1 data carriers: Barcodes and EPC®-enabled RFID; and
- Sharing – GS1 data exchange: Master Data, Transactional Data and Physical Event Data.

Ms Morgan described how this system addresses the consumers demand for greater traceability upstream. She further described how the GS1 focus includes Business-to-Business-to-Consumer (B2B2C) communication, data quality and data management, inventory efficiency, product and location identification, traceability, and safety. She discussed the emerging drivers and trends for traceability including interoperability, digital disruption, conversational commerce, unique ID, AI, and blockchain. Ms Morgan concluded by highlighting the importance of standards, which make interoperability possible (sharing unique ID is core through a common language), connected experiences possible (where, who what, when, and why), and transparency and trust possible.

Q&A SESSION:

Q: How does msc, mass balance and coc inter-relate?

Take for example the pelagic fishery in Norway, there are discrepancies with COC in the MSC certified fishery, yet there is nothing in the COC for auditors to check if the scale systems are approved or not.

We know that manipulation of scale systems is still happening and this could be solved through technology.

However, the MSC notes that this manipulation is difficult to detect because in an audit we just need to check if the manufacturer of the scale has a conformance document by a credible agency. Auditors are not competent to determine if scale has been manipulated.

Q: It seems as though if there is sound regulation and the private sector benefits, there is not a need for certification?

MSC is not intended to replace regulations, as evidenced by legality being a prerequisite for MSC certification. The better the regulatory framework and enforcement, the better for MSC certification. What's most important is to address IUU, but to what extent can certification address IUU? MSC is not a substitute for effective regulations and enforcement, but a strong complement to move everyone forward with a stick and carrot.

Discussion

DAY 2: *Friday, 15 February 2019*

SPECIAL ADDRESS: ENDING ILLEGAL FISHING

Cdr Peter Horn from *Pew Charitable Trusts* offered a special address and provided a perspective on the interest the British Royal Navy has in illegal fishing, noting that the oldest squadron in the Royal Navy is the fishery protection squadron. He emphasised how any of us can spend any time at sea and have a deep feeling for the ocean, and a deep respect for those who work on it. Cdr Horn then went on to explain the Ending Illegal Fishing Project and why it's relevant.

He noted the campaign is about changing behaviours, making sure that rules are in place, can be implemented and followed, and if ignored, those who break those rules will be prosecuted. He explained that the campaign is a cycle, starting with policy, moving to implementation and operations at sea, and moves back to policy. He noted how it starts with flag states, which are critically important, that register fishing vessels and are responsible for tracking and vessel identification information. He explained how flag states play a key role in sharing data and ensuring the data is used properly. Cdr Horn further explained the process how we put audits in place to ensure flag states are sharing the right information correctly.

Cdr Horn addressed the Cape Town Agreement (CTA), that addresses several shipboard requirements, and how fishing vessels are often exempt from naval merchant standards. He noted how the CTA would mandate that vessels under 20m must implement Automated Identification System (AIS) coverage as well as require coastal states to board offloading vessels to ensure crew safety and standards. He stated that MCS is next and technology is very important, but so is building capacity and capability within people. Cdr Horn recalled an operation with the US Navy, CUTLASS Express, which recently concluded and included work on IUU fishing. He emphasised the importance of transhipment reform and highlighted that Port State Measures must be implemented to support the vital associated audit trail and risk assessments.

He noted that industrial scale IUU fishing does not do it for their health, but rather for the money, and that we need to work with governments and financial institutions to find an effective solution. He discussed how achieving this goal is subject to engagement by multiple diverse stakeholders including those more focused on worker's conditions and rights as well as correct policies in the seafood supply chain. He noted that, for this reason, Pew engages and collaborates with diverse stakeholders such as RFMOs, IMO & FAO, Fish-I Africa, FFA, and the EU Coalition.

Cdr Horn concluded by emphasising that technology alone is not a silver bullet and partnerships and sharing knowledge and information are critical.

SESSION 4: OVERVIEW OF EMERGING TECHNOLOGIES (CONTINUED)

ELECTRONIC MONITORING

Mr Javier de la Cal from *Satlink S.L.* presented on improving observer coverage and sea using the SeaTube electronic monitoring system, which includes on board and onshore components. He described that on-board equipment to record fishing activities and obtain footage from catch, bycatch, gear, species, trans-shipments includes:

- Cameras;
- Monitor;
- Storage;
- Antenna; and
- GPS.

He described that the on-shore equipment to provide support, analyse video footage, create fishing reports and adapt to different regional requirements includes:

- SVM software and hardware; and
- "Dry" observers.

He explained how this system results in accurate fishing reports in a digital and tailor-made format based on irrefutable data. He noted that Satlink has worked with 65 purse seiners, 105 long liners, 13 supply vessels, 1 reefer and 90 trained observers to develop their system and service. Mr de la Cal concluded by promoting Satlink's technical standards that are based on affordability and performance.

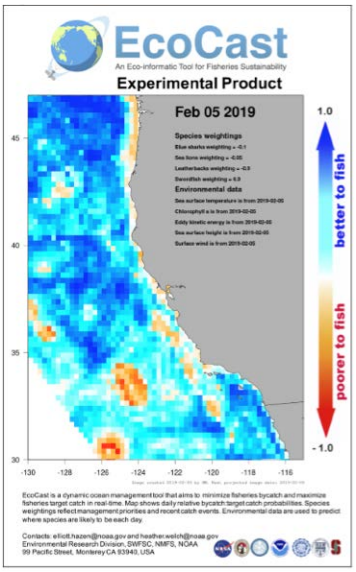


Figure 12: Environmental Defence Fund experimental product – Ecocast.

Mr Christopher Cusack from *Environmental Defence Fund* began by explaining that electronic monitoring programs are not scaling fast enough. He promoted that technological change reduces costs. He emphasised that AI potentially reduces data review costs and also allows for better identification of reviewable events, which will eventually be automated. He also noted how most EM currently involves manual removal of hard drives, but that costs of wireless communications are coming down driving an inevitable progression toward remote transmission of data.

Mr Cusack presented their experimental product called Ecocast (Figure 12). He discussed how the Ecocast program allows for better prediction of sensitive species and is improved with real-time analysis and communication that allows real-time bycatch hotspot mapping to support avoidance of those areas. AI and wireless communications potentially allow minimal requirements for fishermen input with Ecocast potentially enabling longer seasons and better revenue.

At current rates, only 1-2% of all large vessels will have EM in 10 years. In the best case, 12% of large vessels (>12m) will have EM.

Mr Cusack also highlighted that fishing vessels offer 'platforms of opportunity' for science with oceanographic sensors getting cheaper and data integrated at a finer resolution and broader scale than ever before, potentially allowing more accurate quota allocations leading to higher sustainable catches. He also promoted new market options for data, explaining that public data can generate >$3 trillion per year, noting the example where better data leading to more efficient route plotting and real-time decision making for shipping companies leads, in turn, to better prediction of events that affect aquaculture operations (low pH water, SST).

The Blue Economy is based on information.

Mr Jared Fuller from *Saltwater Inc.* addressed the challenge of data integration. He described Saltwater's role as an at-sea observer and EM service provider based in the United States. He explained that at Saltwater they believe that EM can play a critical role in validating sustainability and responsible sourcing claims by capturing video and sensor data at sea that can be used to document catch information as well as data on both labour and fishing practices. Mr Fuller then explained how Saltwater has developed a full EM solution where a shipboard EM system collects information to convey data including:

- Time, dates and locations of fishing activity;
- Fishing method;
- The location of catch-- both landed and discarded--which can include protected and endangered species; and
- Confirmation of compliance with relevant laws and regulations, such as those that restrict fishing in certain areas or have set quotas for certain constraining species.

He explained that the EM system links location information to video and gear position data, which provides much more robust evidence of when and where fishing takes place, and what is actually caught. He further described how they search for cost-effective strategies to integrate EM data with existing or new MCS data streams. He noted that Saltwater has developed open-source data review/analysis software that is designed to be adapted to meet the distinct data requirements of each client, whether that be a government interested in compliance monitoring or an industry trying to validate responsible sourcing claims. Mr Fuller explained how flexibility allows Saltwater to easily adjust and refine Key Data Elements (KDEs), and being Open Source facilitates interoperability between software platforms-when data standards are clearly defined.

He described how one challenge in the implementation of EM for MCS is the need to find cost-effective strategies to integrate EM data with existing or new MCS data streams. Three aspects of this challenge are:

- Defining KDEs – these are the pieces of information relevant to the program;
- Aligning KDEs – how do these pieces fit into the existing programs; and
- Ensuring the interoperability of technology or software systems to allow for the exchange of information.

"Having clear definitions for key data elements (KDEs) is critical."

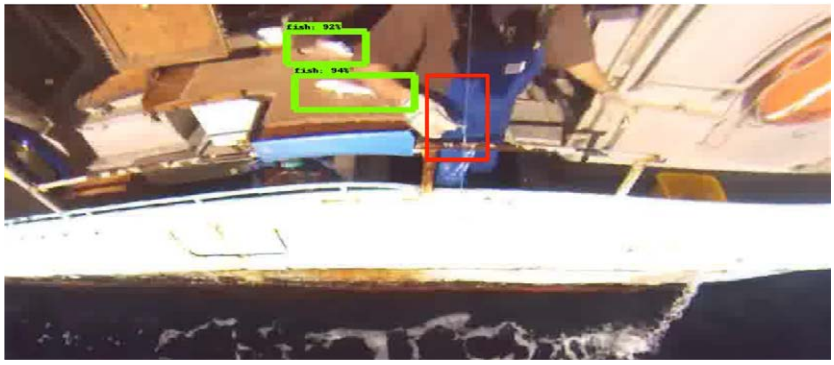


Figure 13: Artificial intelligence showing two green boxes which are fish and the thing in the red box is an "anomaly detection".

Mr Fuller then explained how Saltwater undertook pilot projects where EM was trialled on volunteer vessels in the mid-water trawl fleet in 2016-17, noting that the trials were meant to determine whether it could improve monitoring and address bycatch issue in the Atlantic herring and mackerel midwater trawl fisheries. He described that the key learning outcome of this pilot was that having clear definitions for KDEs is critical. He noted that the data was used to make the case that EM was an effective tool, resulting in its approval for use in this fishery by the governing body, The NE Fishery Management Council.

He pointed out that, during the midwater trawl project, the EM system captured video data of an incident of multiple marine mammal protection act violations, which resulted in prosecution and penalties to the responsible parties and would not have occurred had there not been an EM system on the vessel.

Miss Amanda Barney from *Teem.Fish* presented on EM 2.0, which she explained provides robust hardware capable of capturing high definition, high frame rate video analysing the video data with on-vessel AI (Figure 13).

She explained that this allows them to scale EM by reducing the amount of footage that is being transferred, stored and reviewed, which leads to:

- Transmission of targeted footage via cellular instead of hard drive swapping;
- Greater data integrity and security from the vessel to the reviewer;
- Significant cost reductions for review of selective EM data;
- Higher review efficiency, more vessels per reviewer;
- Up to 100% of fishing activity reviewed, currently in some fisheries this 2%; and
- Affordable and non-obtrusive systems on-board allowing fishermen to just fish.

She further explained that EM Systems (or AI Hubs) that have a review platform that include AI offer two advances:

- On vessel: ability to detect fishing activity so that video and sensor data can be transmitted remotely in reasonable sized chunks; and
- In the cloud: Ability to detect fish, and learn species, for much quicker video review and data analysis and deliver timely information for MCS and management purposes.

Q&A SESSION:

Q: What is the timing estimate for EM on boats?

The recent TNC/CEA Report on EM estimated less than 1000 large vessels have EM and at current growth rate an expectation of less than 6000 vessels annually.

With a best-case scenario we may see 12% (50,000 globally) in 10 years.

Q: Is there a need to consider scaling capacity to support equipment maintenance and failure?

We really need to scale technical capacity for this reason. At the moment, the capacity is just not there and we need more people. Anticipating the technology and scaling capacity internally is important to ensure enough staff to service equipment. The goal should be to build this consideration into the discussions from the start. EDF developed a guide to help address these scaling issues.

Q: Why is there currently such low numbers of use? Is it all cost? How much does it cost for large vessels?

There is not one clear answer as even a "ballpark estimate" depends on system design. However, the slow adoption and lack of scale is not because of costs only. You can demonstrate costs and benefits, but the pinch points indicate scaling as a major obstacle. TNC has a report that illustrates how the pinch points aren't the technology itself, but rather human resources and capacity and infrastructure.

Q: Review of the em footage is crucial. How far are we from fully automated systems so human review is not needed?

It is important to clearly define the objectives around analysis to determine the review needs and the time required. Your objectives will dictate the amount of review necessary and, in turn, the costs. In some fisheries, 100% automation is not the goal as they want to continue to use human observers to meet certain social objectives and there is some basis in "ground-truthing" automated data with human coverage. In that regard, an 80% automation level can be hugely beneficial.

Machine learning is often better than the human observer once the species database is robust enough and the algorithm has had the opportunity to learn the images.

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Mr Jeff Douglas from *Integrated Monitoring* presented case studies where they implemented EM and AI including Thailand Purse Seine, New England Groundfish, and Peruvian Anchoveta.

He noted that in the case of Thailand Purse Seine fishery, crew welfare was enhanced with labour monitoring and worker communications through:

Automated time & motion studies:

- Verifying Compliance with Labour Agreements,
- Ensuring Minimum Safe Crewing Standards,
- Validating Worker Hours, and
- Observing Crew Transfer Events.

And providing crew welfare services including:

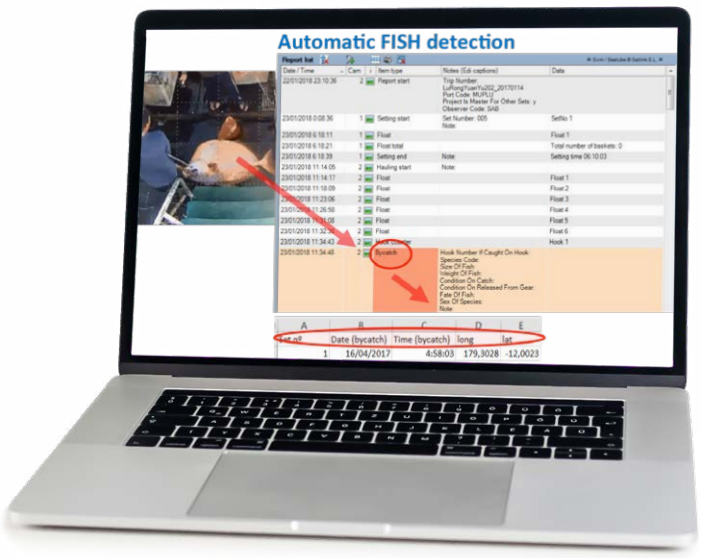
- Social media access,
- Web browsing,
- Safety violation reporting.

Mr Douglas then described how in the New England Groundfish fishery only 10% – 25% of trip time requires individual frame review, depending on the fishery.

He explained how variable frame rate and resolution reduces transmission and storage costs by 80% – 90%.

He further explained that Integrated Monitoring is currently developing an open source reference implementation and demonstration project in partnership with the National Fish and Wildlife Foundation (NFWF), NOAA, the Atlantic Coastal Cooperative Statistics Programme (ACCSP), and Gulf of Maine Research Institute (GMRI).

Figure 14: Digital Observer Services – application of machine learning to automatically detect fish.



Mr Douglas then discussed their work on the Peruvian Anchoveta fishery, which explored fleet management via real-time operational visibility and allowed for live video providing activity recognition including operational monitoring, crew safety (deck zone areas), fuel monitoring (theft prevention), and proper gear handling procedures.

Key takeaway messages from the presentation included:

- The enabling systems are mature and proven;
- Artificial Intelligence is integral to all system components;
- The use of open source, non-proprietary technologies is key;
- An integrated technology platform significantly reduces costs;
- New HTS (high-throughput) satellites and 5G cellular are coming; and
- Regulations must be flexible enough to facilitate new technologies.

Miss Oihane Erdaide Goienetxe represented Digital Observer Services (DOS) an independent fisheries consultancy and a certified EM service provider.

Miss Goienetxe emphasized the significance of machine learning.

She described how observers currently need to find and declare all the fishing events as well as catch/bycatch identification and that with machine learning the fish (Figure 14) and sets (Figure 15) are automatically identified and observers only need to determine the species.

In summary, Miss Goienetxe acknowledged that machine learning:

- Will help greatly reduce the time required by the observer in analysis;
- Is a cost-effective system;
- Will increase the coverage to collect data for all the gear types;
- Produces quality and refutable data; and
- Still requires further development to increase the accuracy of detections.

Mr Bundit Kullavanijaya from *Thai Department of Fisheries (DOF)* and *Ms Natalie Tellwright* from *OceanMind* jointly presented on machine learning work conducted on Thai VMS data. Mr Kullavanijaya explained how data is currently managed by the Coastal States and Member States Fisheries Monitoring Centres (FMC). He described how the system is programmed with simple alerts, such as when a vessel enters or exits an area or when a vessel fails to transmit for a specified time, but that manual identification of fishing activities is typically undertaken as well. He noted that the aim of the collaboration with OceanMind was to assist the DOF in identifying suspicious fishing vessel behaviour from VMS data deployed on Thai fishing and fishing support vessels and, therefore, focus their monitoring and investigative capacity on high-risk vessels, rather than the maintaining a manual process of monitoring all vessels all the time.

Ms Tellwright described how they developed a machine learning algorithm to detect fishing activity by a certain gear type, numbering 19 in total, used by Thai-domestic vessels. Ms Tellwright then described how they applied the relevant Thai regulations, such as closed areas and gear restrictions, to the fishing detection algorithm to identify non-compliant fishing activity. She described how non-compliant activities are displayed in the format of a feed of alerts to the DOF.

Ms Tellwright further explained how they used 3 years of historical VMS data from almost 6000 different vessels across all 19 gear types to develop their machine learning solution.

They concluded by addressing some of the future opportunities and challenges including:

- Tracking technologies produce a lot of data and machine learning provides a solution to sifting through tonnes of data by quickly identifying key elements of tracks to review;
- Opportunities for FMCs to quickly share alerts to other surveillance divisions, e.g. at-sea patrol and PIPO centres, and integrating alerts into the DOF VMS system;

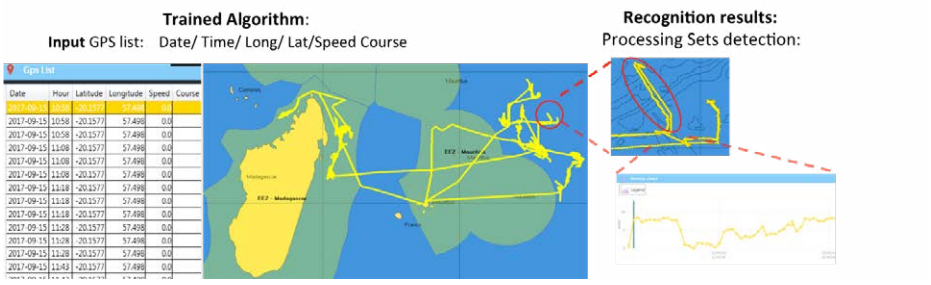


Figure 15: Digital Observer Services – application of machine learning to automatically detect gear setting.

- This data can be utilised for other fisheries management applications, such as when aggregated through time it can inform marine spatial planning;
- Risks identified for a vessel can be linked with traceability systems to support transparency in the supply chain;
- There are opportunities to increase scalability, such as using this on other positional datasets such as AIS or GSM-based VMS units with a cloud-based system allowing greater scalability and speed;
- The machine can be trained to identify other behaviours, such as 'fishing hours' and 'rest hours' to identify possible labour issues;
- Use ML alert to index other Electronic Monitoring such as CCTV;
- Challenges remain for using VMS data in legal prosecutions, which must be tied with other evidence so this is not a stand-alone solution; and
- ML needs to be met with effective enforcement and MCS capabilities on the ground.

Dr Manoj P Samuel from *ICAR* – The Central Institute of Fisheries Technology presented on the development of portable fish freshness assessment sensor based on digital image processing. He explained that parameters considered depicting the extent of freshness of fish including:

- Colour of fish eye, gill, skin, and fish eye through image analysis;
- Capacitance and conductivity of fish muscle; and
- pH of mouth fluid.

Figure 16: ICAR – the Central Institute of Fisheries Technology's handheld freshness sensor.

He explained that, out of these options, the most accurate trend was observed in eye colour.

Therefore, he described how the portable fish freshness sensor performs image processing of the fish eye, thereby assessing the quality of a fish in a user-friendly manner and providing real-time analysis of freshness of most of the fish species. He explained the technology is easy to use and convenient as a handheld portable sensor (Figure 16). He suggested that, while this project was focussed on product quality, the AI/ML developed in this context demonstrates how the technology can effectively learn, adapt, and accurately detect fish attributes in any context, such as species ID.

Dr Samuel concluded by discussing other inventions in the fisheries sector under development including:

- Energy and water use optimization in seafood industry;
- Automatic information system;
- Specimen collection and transport devices; and
- Live fish transport container.

Q&A SESSION;

Q: What is preventing broader development and uptake of AI and ML?

There are challenges with scaling EM tools related to cost and human capacity, but some of the speakers have shown how machine learning and other technological advances are helping.

Q: It seems like AI and ML could revolutionise EM. Is it really ready for application across all fisheries?

These tools are not silver bullets, and need to be adapted to the specific use cases and their users' needs. A lot of emphasis needs to be placed on collaboration between providers and their clients, but also the fisheries managers, scientists, and broader fishing community.

INTEGRATED SATELLITE IMAGING AND TRACKING TECHNOLOGY

Dr Christopher Elvidge from *the National Oceanic and Atmospheric Administration (NOAA)* offered a presentation on VIIRS (Visible Infrared Imaging Radiometer Suite) Boat Detection, which uses low light imaging data obtained via satellite scanning for lights out of the water and an algorithm developed to collate and report results (Figure 17). Dr Elvidge demonstrated the system by bringing up data results from the previous night in Google Earth, noting that the goal of the system is to have the information available by 6AM local time. He explained that the system does not do artificial holds, but will send alerts for detections that occur in closures or in MPA's or other restricted coastal waters, such as the cases for Indonesia, Philippines, and Thailand.

He expressed that there are also methods to cross match VMS and AIS with VIIRS boat detection and even show recurrent detections in the same areas, such as gas flares and offshore platforms. He also noted that, in the alternative, VIIRS can show the absence of vessel demonstrating zero detections in North Korean waters for the previous day.

Dr Elvidge demonstrated large clusters of vessels on the west coast of India as well as in the Indian Ocean and large amounts of previously unreported fishing vessels using lights in the Mediterranean. He suggested that one of the things they discovered over a year of analysis was linear features going from port to port, potentially indicating a passenger vessel.

He confirmed that alerts can be sent for individual zones of interest and identify "dark targets," such as in Asia where VIIRS detects vast more numbers of vessels than AIS or VMS.

Figure 17: NOAAs VIIRS boat detection.

He further noted that temporal records extending back to 2012, make it possible to monitor trends, outline fishing grounds, and assess the effectiveness of enforcement and management efforts. Dr Elvidge concluded by noting some limitations on the technology including:

- It only provides locations, date/time, and radiance;
- It provides no detailed metadata of AIS or VMS;
- Not all fishing boats are lit sufficiently for detection and some of the detected boats are not fishing boats;
- It is not possible to track individual boats through time;
- The current algorithm works best under low lunar luminance; and
- Detection thresholds rise under moonlit conditions.

Mr Paul Whitaker from *KSAT*, a commercial satellite centre providing access to satellites with headquarters based in Tromso, Norway, discussed their system, which allows them to communicate with a polar orbiting satellites with 140 remotely controlled antennas. He explained that as satellites are getting smaller the antennas are also able to get smaller with most areas of the world now covered. He further explained that as satellites are also becoming easier and cheaper to purchase and the barriers to launching satellites are getting lower.

He noted that in 2017, 249 commercial non-GEO satellites were launched in the US and 243 of those are on KSAT network. Mr Whitaker explained that most of KSATs business is around supporting people with satellites and a smaller part of the business associated with exploiting time sensitive data such as vessel detection, oil spills, ice detections, and wildfires.

He commented that, because KSAT can pull from different satellites, they can cover more area and correlate with other types of information like VMS. He noted that Norway is launching microSAR satellite designed for passive vessel section with high resolution and low tasking times that will be owned by the Norwegian government, but information will be made available to the global community.

Ms Ines Guth presented on *Collecte Localisation Satellites (CLS),* which is a 30-year old company with 750 people and 23 offices and is a subsidiary of the French space agency and the French marine research institute that specialises in satellite-based data collection and earth observation. She described the Hybrid Tracking Solution for small-scale fisheries, noting that the definition for “small scale” changes depending on country and region.

Ms Guth explained that CLS maintains 20,000 VMS systems with daily reporting to flag states, RFMO’s and Secretariats and introduced a new hybrid Satellite transponder (Figure 18), which she described as a seamless system with global coverage designed to be affordable and powered by a solar powered battery.

Figure 18: CLS’s hybrid satellite transponder.

Figure 19: OrbComm's MT 5000 Class B AIS+M2M small vessel tracking device.

Ms Guth emphasised the incentives for the fishermen to have this attached to the boat beyond simple vessel tracking, which include:

- Weather alerts;
- Navigation and mapping;
- Electronic forms for catch reports/notes; and
- Messaging.

Mr Art Ramirez from *OrbComm* presented on protecting the development of artisanal fisheries and ORBCOMM's portable satellite solutions. He concluded the session with a presentation starting with a story demonstrating the human factor where the Mexican government set up processing facilities to stop overfishing allowed under previous methods as well as add to the value chain. Mr Ramirez then described how they came to create a dual signal device for small-scale fishermen called MT 5000 (Figure 19) that transmits on AIS as well as on the ORBCOMM frequency. He described how the system could be used to send location reports every 10 minutes to a designated monitor who is usually a friend or relative. He also described how OrbComm has ground stations around the world, as well as devices that work on other networks. He further described the device as an AIS device with proven capability within OrbComm's 2.1 million assets deployed globally. He noted how the unit offers a comprehensive and cheaper solution for small fishing vessels with a battery lasts 5-6 days, simple and easy installation with no power or small motors to connect, and an easy operation with basic functions for power and alerts.

He pointed out that the device can even be worn using an arm band. Mr Ramirez concluded by noting that the device has desired flexibility in that location reports can be emailed or delivered to a platform.

Q&A SESSION;

Q: Dr Eldridge, we're starting to use viirs as a way to correlate vms. There are two areas that are difficult in the south atlantic. Will this be fixed?

There's an issue with an area over Rio, with an ion layer that creates fake lights that look like boats. We have a plan to develop an algorithm that will sort through those detections and discard if there's no evidence of having a glow at their base (coming from the atmosphere scatter). We think it will work but R&D is stalled out so we're looking for a sponsor so we can start that again. Another flaw occurs in the polar regions with the detection of sea ice, where we have an object that is very bright and reflective and moon light will reflect off the dark sea and look like a boat. That one is not "as crackable" but we know about it.

Q: CLS – Can fishing managers still receive information even if it's be switched off?

CLS responded, "Our transponder cannot be switched off and the only way it would turn off is if the battery is down." OrbComm responded:

"Most fishermen don't want to be tracked, but that's why we hit it from a safety angle, emphasising that you want to be tracked, so we can find you if you're in trouble."

CRYPTOCURRENCIES AND BLOCKCHAIN

Mr Anthony Orgill of *the IBM Food Trust* opened the session on cryptocurrencies and blockchain by emphasising that the consumer is the key driver for technology that can aid in transparency, quality and developing trust. He explained that the consumer wants transparency and more information, therefore the retailer demands transparency, and the regulator responds to these demands. He highlighted that there is a significant amount of big data available in the sector. He also suggested, however, that with more data comes more confusion. Mr Orgill referenced the confusion created for the consumer as more information is made available regarding their products, including mislabelling, that make it difficult for consumers to make choices. He suggested there is a need for end-to-end traceability, consistency, and standards.

Mr Orgill advocates that Blockchain presents a solution because it tracks stuff (people, things, products, seafood, ideas, docs, money) consistently and completely – end-to-end. He emphasised how Blockchain can be used to transfer title and ownership, enables secure transfer of any information, and allows for policies with clear and incorruptible standards and consistency.

He emphasised that Blockchain provides a "single source of truth" that cannot be tampered with, allowing little need for reconciliation and checking. Mr Orgill reinforced that large retail outlets are considerable drivers in technology, such as Walmart, which recently agreed to source all their green produce through Blockchain traceability. He concluded by playing a video clip featuring how Walmart demonstrated traceability back to the source, providing reliability and optimization of how food gets from farm to table, which means fresher food that is delivered faster and cheaper.

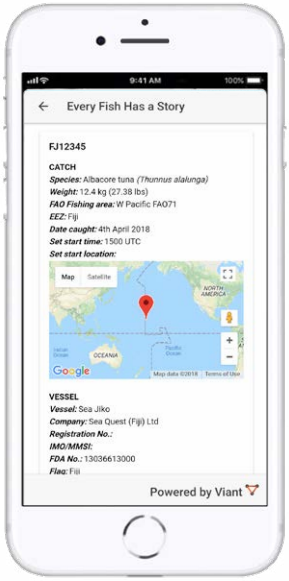


Figure 20: TraSeable Blockchain user interface app.

Mr Ken Katafono from *TraSeable*, a traceability tech company from Fiji, presented on traceability and catch documentation challenges in the Pacific and the potential solutions offered by Blockchain. He noted the need to provide affordable systems to all stakeholders in the supply chains. Mr Katafono described how they seek to provide affordable systems by utilising regional experience and building on existing solutions to provide local solutions for local problems.

He noted that his experience having worked for a Pacific Islands fisheries agency and recent traceability and catch documentation workshops helped him realize there are still many gaps, including good e-data systems. He explained that TraSeable recently started working with a consortium of interests including ConsenSys, Viant, Sea Quest Fiji Ltd, Sealand Processors Fiji Ltd, and WWF on the potential of Blockchain to provide full chain traceability. He described the project they had initiated in Fiji, which employed the supply chain product Viant, built by ConsenSys, which provided a full supply chain traceability scheme for a longline fishery. He noted that the system runs on an Ethereum platform that includes a user interface showing traceable data for end user (Figure 20).

Figure 21: Atato's Ethereum based cloud service to notarise records on Blockchain.

Mr Katafono emphasised the many lessons learned in this venture including:

- The need for good digital system foundation;
- It can be implemented cost-effectively;
- It requires trial and error;
- Automation through IoT devices and sensors is challenging;
- It is not a replacement for centralised databases; and
- You should only put data on the blockchain that you want to track to address demand for traceable products.

To conclude Mr Katafono identified the next steps for the project including a regular supply of blockchain-tracked tuna into NZ, an improved user interface (Figure 19), scaling up by onboarding more companies in Fiji, and planned expansion into the Pacific to include Pacific agriculture value chains as well as fish.

Mr Guillaume Le Saint from *Atato Co. Ltd.* based in Bangkok, Thailand, is a Blockchain provider and upgrades companies to Blockchain (Figure 21). Mr Le Saint explains that a lot of data often exists and is available, but that you need someone to help extract the complexity and extend your IT system to make it Blockchain ready. He noted that there is often no need to change existing IT systems, but rather extend it and plug a Blockchain module into existing IT systems.

He presented on the Pacifical Wild Tuna case study for which Atato improved traceability of their canned MSC COC. He described how the company had everything that was needed to trace the tuna and put on blockchain. He further described how information was independently audited to ensure data was correct, using Pacifical servers. He explained that Pacifical's existing data was put on Ethereum Blockchain and a user interface was developed via an app translating the data for the consumer. He described how they have worked with a Swiss retailer as the end user for traceable canned tuna. He noted that Atato started talks with Pacifical in May 2018, started work in September, and is due to deliver the first tuna can in March. Mr Le Saint concluded by noting that the Atato system can accommodate multiple sources of data if anyone is interested in extending their IT systems.

Dr Alistair Douglas from *Eachmile* presented on their project, Fishcoin (Figure 22). He opened by stating upfront the barriers to adoption of traceability systems, including interoperability challenges and that most designs are one up-one down, while a whole chain system exists leading questions regarding who pays for what, when, where, and how.

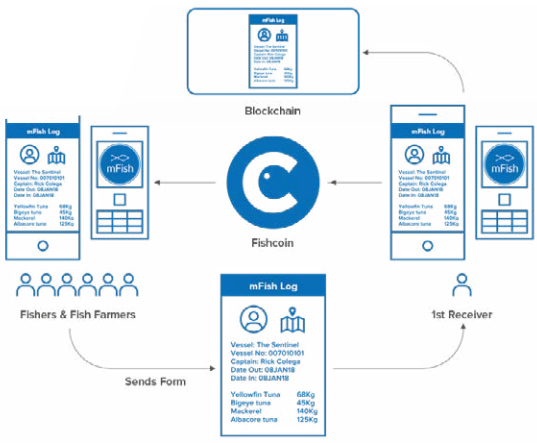


Figure 22: Description of Fishcoin platform and operation.

He noted how traceability systems can be difficult to use and expensive and that, unfortunately, most effort is targeted at large-scale fisheries with small-scale fisheries (90% of fisheries) and aquaculture getting left behind. He discussed incentives for small fisherman in subscribing to a traceability system, highlighting that smart phones are becoming more prevalent with many phones providing 2-G browsers with free access. He explained how Fishcoin combines a mechanism for data sharing, using Blockchain, with a scalable incentive (pre-paid mobile top-ups) using tokens, to incentivise data submission. He then explained how this incentive is meaningful to the millions of seafood producers around the globe from the large seafood producing nations.

Dr Douglas described Fishcoin as a user-pays system whereby with the market determines the value/cost of the data and presented on three case studies:

1. Transitioning to Rights Based Fisheries Management;
2. Protecting people; and
3. Incentivizing mark, release capture to maximise fishery returns.

In case one, fishermen are incentivised to provide anonymous and aggregated data, which is communicated to government where it can then be disaggregated and fishermen are identified and provided with tokens that have a discrete value. In case two, the Captain is rewarded for recording crew details and the crew are sent tokens or air-time top ups to call home. In case three, fishermen tag the fish and record information, which is then entered into Blockchain and sent to government database whereby the fishermen are paid per tag via tokens for providing data upon recapture.

Dr Douglas concluded by emphasising the absolute need for traceability stating:

"It's not mission impossible. It's mission critical and I am confident. Let's get to work!"

Q&A SESSION;

Q: WHAT INFO IS CHECKED IN AUDITS AND HOW IS IT VALIDATED?

Atato responded, "Quality Assurance people were sent to the factory to check products and documentation, which then report to Pacifical, who validate the data before it is recorded on the Blockchain."

Q: DATA IS BASED ON FACT. HOW DO YOU INTEGRATE VALIDATION IN YOUR PROCESS THAT ARE DOCUMENT-BASED, SUCH AS LICENSES?

There are multiple points of human validation and verification along the supply chain as it reaches the processor. All process will ultimately become digital in the near future before going on the Blockchain, which will be subject to automated verification and validation. Any information of value can be attached to a product through the Blockchain.

TraSeable responded, "In our case, for instance, the government authority released permits that could also be loaded on the Blockchain and could be transmitted downstream along with any other data. These documents can easily be scanned and put on Blockchain as we are currently doing with the Fisheries Ministry in Fiji."

Q: HOW DO WE INCLUDE THE REST OF THE SEAFOOD SECTOR?

Blockchain is not a quality verifier, but how you can trust the data is with respect to the fact that it can't be changed or modified over time, only appended, which leads to a permanent record. So, it is true that it is only as good as the veracity of the data, getting to the question of garbage in/garbage out. However, if you build incentive mechanisms, quality filters, and ensure data is accurate and verified through various verification and validation mechanisms, that, on top of the permanent record it provides, will ultimately incentivise against submitting false data because over time it could be discovered.

Q: WHAT IS COST PER TRANSACTION TO PUSH DATA TO BLOCKCHAIN?

IBM – At this time, the cost is largely borne by the retailer, who wants the data and has internal financial models on how to recover the cost. However, the business case is not always a cost case. For instance, it could be a matter of food safety or other risk management.

At the end of the day, cost is transaction basis, but it is specific as to who drives it and what objective is being met. Nonetheless, it needs to be solving a problem from the outset, otherwise it will fail, i.e. the Carrefour example.

Atato – For the Pacifical project, the cost of a container to go to Blockchain is 0.05% of the cost of a container. There is no upfront cost. As far as interoperability goes, there are many kinds of Blockchain. Ethereum is public, anyone can connect, and there is a standard for the data, which can accommodate GS1 standards. Admittedly, Ethereum has experienced challenges and they're doing upgrades.

At present, the cost of transactions is from 5 cents, but if scaled, can be 1/1000th of that cost.

DATA MANAGEMENT SOLUTIONS TECHNOLOGIES AND BIG DATA ANALYTICS

Mr Alan Steele of *CatchCompliance* presented on "Big Data and Why". He began by describing a project in the Philippines, a large processing state. He explained there is an enormous market for Tuna and the old, traditional way of recording information via pen and paper remains very prevalent, but that customers these days want more. He noted the increasing interest in predictive analytics, such as understanding what the price for the product might be next year. He described how, for tuna, tags were often used for traceability and the data from the tag was transferred by hand to an Excel spread sheet, making traceability seem like a time-consuming process and therefore not desirable. He emphasised that the US Seafood Import Monitoring Program (SIMP) has been driving the need for traceability.

Mr Steele explained how CatchCompliance developed The Catch Mobile App (Figure 23), a 2D barcode seen as the most effective way to collect data that allows five steps to get the history and data. He described that when the data is then put on a dashboard the fishers, pickers, and others involved in the supply chain get a payment history representing something valuable to them, which may serve as an incentive for them to adopt such a system.

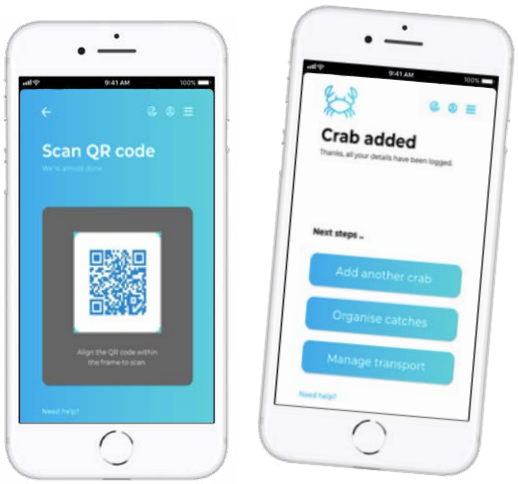


Figure 23: CatchCompliance – The Catch Mobile App.

He expounded on how this information might help them get a record of their earnings, which can be used in many situations to help them get loans. He also described how addressing some labour issues are also possible with the example of all crew getting their photos taken, included and uploaded with relevant labour data. He further described how all of these documents are uploaded and made available for the SIMP and eventually retailers. Mr Steele explained how he worked with WWF Philippines on collecting and managing catch documents for this project, which included 7500 fishers, emphasising the need for Big Data analytics and the tools it provides. He concluded by noting that the analytics model they employed ultimately produced a lower data collection cost and allowed for estimating predictive costs.

Mr Chris Thomas of *OpenSC*, a joint venture between WWF and Boston Consulting Group Digital Ventures, opened by explaining that there 15 key commodities that are controlled by approximately 75 companies globally. He noted that there are currently certification schemes among these commodities, but that none of these certifications currently exceed 20% of the total production of a particular commodity.

He then posed the question, "can these certification rates be accelerated and grown with new technologies?"

He explained growth in the sector takes three elements:

- Verified claims;
- Tracked products; and
- End-to-end and shared information with sustainable companies and customers.

He emphasized the importance of standards and gave praise to the Global Dialogue for Seafood Traceability for joining major companies together to develop these standards/ KDEs for seafood based on their own business experiences.

He noted the progress, especially related to reduced costs, specifically noting that 5 years ago fish tags were USD$5 whereas now they are USD$0.05.

Mr Thomas discussed a pilot conducted on with toothfish with Austral Fisheries where the process starts with a tag inserted into a fish that is used to verify that the fish was not taken from a closed area. He explained how from there the entire journey of the fish can be seen. He pointed out how even after a fillet is divided the tag is removed, the data is scanned, and the information associated with the original fish remains with each fillet by virtue of a sticker attached to each part of the whole fish. He emphasized the necessity to learn as you go and adjust and in this project they did approximately 20 iterations before the final, noting the critical importance that big data analytics played in refining the system.

PANEL: WEIGHING THE ALTERNATIVES - MATCHING TECHNOLOGIES TO OBJECTIVES AND CAPACITIES

Mr Bubba Cook from *WWF* led the panel on "Matching technologies to Objectives and Capacities" with *Cdr Tony Long* from *Global Fishing Watch, Mrs Meagan Brosnan* from *WildAid,* and *Dr Deirdre Duggan* from *MDPI*.

Cdr Tony Long opened by addressing the importance of transparency. He explained that law-abiding fishers are tracked easily and openly, demonstrating their compliance, while rogue operators stand out due to their patchy track record or suspicious behaviour. He noted how compliant fishers can be rewarded through faster, more efficient port entry and landings, while unauthorized vessels, and those that have a history of non-compliance, can be prioritized for inspection or even denied port entry. He emphasised that:

"By embracing transparency, nations have a more cost-effective way of monitoring vessels that puts the burden on fishers to demonstrate compliance, rather than on the country to prove illegality."

Cdr Long described how transparency can incentivize, recognize and reward honest fishers, while exposing, penalizing, and ultimately putting those who act outside the law out of business. He stated that transparency is not all information, it is only enough to make clear what has happened.

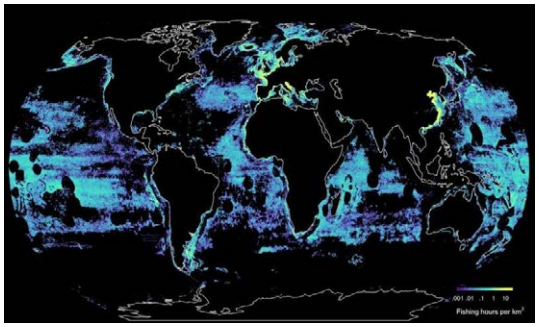


Figure 24: Global fishing activity, 2016.

He then highlighted the importance of sharing information, noting that most VMS systems are not publicly shared and that, before Indonesia made their VMS public, there was only a fraction of the data available. He explained how Global Fishing Watch is currently attempting to get 20 countries to make their VMS data public in the next four years.

He concluded by stating that transparency provides better MCS by driving compliance and that if countries publicly share their fishing vessel monitoring data, then we can create a more complete and connected picture of global fishing activity (Figure 24).

Mrs Meagan Brosnan opened by acknowledging that everyone in the room was working on building effective enforcement systems and WildAid helps connect technology to efforts that need it. Mrs Brosnan structured the presentation around the elements of a marine protection system (Figure 25). She explained that AIS can only be used to track fishing vessels if there are laws in place that require them. She noted challenges such as theft of sensor technology as an issue and that to combat such challenges involves engaging users and creating ownership in such implementations.

She emphasised that when you fundamentally involve the fishermen, then your technology will be used to their advantage. She highlighted that training and mentorship is key. She additionally highlighted that users need to be at least somewhat technology savvy and the right tool will vary depending on this ability to accept and understand the technology.

Figure 25: A complete marine protection system.

Mrs Brosnan stressed the importance of community engagement, training, and mentorship in the application and use of technology.

She further expounded on how maintenance of technology is important to consider with simple and less expensive generally being better, noting that system costs are an extremely important feature to fishermen. Mrs Brosnan concluded by emphasizing that technology needs to have the fundamental support of a complete enforcement system and consistent funding to ensure ongoing maintenance and commitment.

Dr Deirdre Duggan presented on the alternatives for small-scale fishermen and the efforts to use technology for improvements in small-scale fisheries. She stressed that individuals fishing on vessels 1 GT or less represent small-scale fishing in the Indonesian longline tuna fishery and that these fishermen are often overlooked in these types of discussions. She noted how these types of fisheries are remote, diffuse and create a "black hole" of information requiring more effort to illuminate small-scale fisheries and associated impacts.

She stated that the communities connect, communicate, and share what has worked for them and there is huge potential to train people and get them involved.

Dr Duggan emphasised that we should not want to hold fishers hostage with the amount of technology that we are expecting them to implement. She further emphasised that the manpower for implementing technology makes technology expensive and more difficult to scale as well because of the cost of maintenance.

She stressed the importance of thinking about and communicating the benefits for the fishermen, particularly beyond financial benefits. Like previous speakers, she emphasised that cost is an issue and stated there currently is no financing mechanism to get them involved, suggesting that a community premium fund could be a good model for this. Dr Duggan concluded by stressing the importance of considering how to efficiently access, analyse, and share information.

Q&A SESSION;

A general theme that opened discussion was that it is important to consider technology as a means to an end, not a silver bullet. Other themes included the need to emphasise incentives

Q: Who should pay and how?

Global Fishing Watch notes that they are free to access from philanthropic support, but that this funding model is not sustainable and they are working hard to drive it towards being funded by government.

MDPI suggested that the fishermen, especially small-scale fishers, should not be expected to pay for technology devices and that donors currently fund most initiatives. The return on investment that MDPI sees is further along the supply chain, but not so much benefitting the fishermen.

WildAid suggested that it is important to consider investment up front, noting that they have projects where tourists support it with park entry fees or through taxes from the government. She emphasised that it is important to be a part of the discourse early and often.

Panellists discussed how any technology is effectively rendered useless unless the fishermen actually want to use the technology.

The moderator pointed out that in any technology implementation costs can balloon very quickly because there is a view that if you buy it for one fisherman, the other fishermen are going to expect you to buy it for them as well. He suggested how the Pacific Islands Forum Fisheries Agency (FFA) looked at cost recovery and the "RainX Effect" where if the fishermen pay for the technology and fully understand it, then they have more reason to and actually do take care of it.

An audience member recommended that an "eyes wide open" approach is needed with any technology that considers all costs and benefits as well as relationship to other aspects of the fishery and supply chain.

MDPI generally discussed how it is all about incentives. At the end of the day, fishermen are businessmen and they must be able to see that the benefits outweigh the costs. Safety at sea, Market access – market certification and Digital credibility. Some work is happening in Indonesia around this.

An audience member pointed out that other incentives were very important in some cases, such as where vessel trackers can be accessed by family members and fishers spouses were able to keep track of their family members.

The moderator pointed out that alternative costs are often not considered in addition to the question of "who pays?" He cited the anecdotal example of Tuvalu, which is reported to spend as much as USD$20,000 annually to ship paper records to regional fisheries authorities.

Trygg Mat pointed out where their tracking efforts in West Africa have helped identify companies and vessels that are forging licensing and records.

MDPI suggested that if fishers knew that value was shared equitably across the supply chain, there might be much more uptake.

Discussion

DAY 3: *Saturday, 16 February 2019*

SESSION 5: WORKSHOPS

WORKSHOP 1: ELECTRONIC MONITORING

Lead: The Nature Conservancy

Part 1: Cut to the Chase – Advances in Automating EM Video Review

Part 2: Hard Drive Blues – Advances in Transmitting Video & Data from Vessel to Review Centre

PART 1: CUT TO THE CHASE - ADVANCES IN AUTOMATING EM VIDEO REVIEW

Mr Chris Rodley from *SnapIT* explained that their 2018 venture capital funding led to a boost in engagement in AI and went from 1 person to 6. He explained the need to streamline EM projects, illustrating that it is never to scale when watching 18,000 hours video each month for small 4 vessel fleet. He pointed out that SnapIT currently has 200 years of videos and other data. He stated that AI can let you see backwards across all footage, but that hydraulic sensors are problematic. He also stressed that 80% of progress in AI is in activity recognition, general classification, while 20% is measuring, grading, and speciation.

Mr Rodley described how they can monitor high frequency events (e.g., fish) and low frequency events (e.g., protected species) with a 360-degree camera and probability-based catch identification (98% certain that identifying occurrences of fish).

He noted, however, challenges of teaching a machine to identify something it has never seen before with low quality footage and suggested a training feedback loop that incorporates business as usual versus anomalies and less human intervention.

Mr Josh Wiersma from *Integrated Monitoring* presented on open source review software for the US Northeast Groundfish Programme, discussing the role of sensor speed and machine vision. He noted that they developed Chordata Alaska with NFWF funding and that it is compatible with 90% of existing EM file formats. He explained how this product divides a fishing trip into four main categories, which means that you don't have to pay a trained observer to watch hours of video where nothing happens. He suggested how AI can boost 10X review to 300X speed. He noted that the cost is USD$2-3 to run AI/ML on the comparable video to observer costs per day with lower scaled analysis to map/flag events while the observer does species ID. He noted the ability to choose an appropriate audit level that allows for interoperability across vendors and Critical Tracking Events.

He concluded by emphasising that the technology must be affordable to the fishing industry.

Mr Tomas Galan from *Satlink* stated that they have deployed~200 EM systems and that automation can reduce time as well as solve specific issues through an algorithm trained with a Big Data set (VMS, video footage, GPS, Date/time, Events) to create a Detector. He explained that EM needs a big dataset and Satlink has 50,000 labelled images in house. He explained that there is one algorithm for set start and set end and a second algorithm for detecting catch events. He concluded by emphasising that you must consider your expected output and what data is needed.

Mr Jacob Isaac-Lowry from *Flywire* explained their focus on developing and implementing at-sea verification systems at scale to serve fishers, as they are the closest people to the challenge. He described how product development at Toyota uses a production system to drive organizational change that is intended to be thoughtful and purposeful. He discussed how they complement machine work and human work. He further explained there is a 70-80% human labour requirement for end-to-end video review. Mr Isaac-Lowry concluded by describing how Flywire develops different training modules, which validates distribution and underpins live up-scale implementation.

Miss Amanda Barney from *TEEM.FISH* explained they have been using algorithms in trap fisheries for the past 7 years, which clips video to review for compliance issues post-harvest.

She described how they have 100% coverage with 24/7 videos and can review 100 hours fishing activity in 2-5 hours.

Miss Barney discussed the recreational fishing activity project in Canada that demonstrated that government estimates are underestimating effort levels. She described how the software matches up unique vessels and calculates time on water. She concluded by expressing support that software efficiencies for data analysis is an effective tool and, in a position, to do thoughtful experimentation with automation work.

Mr Howard McElderry from *Archipelago* Marine Research Ltd. stated that this is a people issue not a technology issue. He noted that there is not a strong mandate for independent monitoring and operational systems must be more efficient. He noted the sophisticated viewing platforms for reviewing footage and communications platform between systems, but suggested there are too many companies working in EM with no ownership or coordination. He stated that, while the technology is important, we also must consider how we use it and implement it. Mr McElderry highlighted that gathering information against the self-interest of the fishermen is a perverse incentive for fishermen to only show you what they want you to see. In conclusion, he noted that there must be some technology objectives that include the need to gather information on meta-data, camera black outs, and automation to detect vessel activity.

Discussion:

There is a need for optimization and efficiencies to be incorporated into automated machine imaging software, specifically to recognize when a camera is out using more traditional machine learning algorithms.

There needs to be a connection between innovation required in programs and the actual work. An AI package on a boat instead of in an office is of no use if there is no cell phone connection.

Some fishermen, like the crab fishermen referenced in one presentation, are not interested in EM systems, but want old systems with analog cameras. In those cases, the systems are present only for compliance, so we generally only need to know if systems are turned off. We can use non-video data heat maps of annual fishing area/effort for MPA negotiations.

EM can also be used to look at factory flow, where it has been used to understand differences in what machines do well versus what people do well. Machines are good at probabilistic inferences on patterns in data, but not as good at dealing with novel situations. For instance, Tesla's autopilot was found to be far from perfect where it could not distinguish a truck painted same colour as sky, but a human could clearly see it was truck.

Many of the EM developers are thankful for the automotive industry, which are using and developing software stacks designed for self-driving cars. This allows us to build off the shoulders of giants.

EMS position data can be used to infer or deduce what activities are happening on the vessel.

In terms of automation, we are increasingly able to use data for integration of reporting requirements, such as VMS and E-logs. We can already use images from videos determine gear being used, count hauls, and auto-populate forms.

Thus, we are beginning to solve some major misreporting issues. The challenge is to develop a programme that is cheap enough for fishermen. At ~1,000 boats globally with EM systems, that is not possible. We need to scale up the technology if we expect it to be affordable. Observer effect is demonstrated and we can get the cost for EM under $100 a day, which is cheaper than a human observer, which will provide other advantages such as improving stock assessment and managing quota systems.

We can already use machine learning for track analysis through remote sensing. However, partners sometimes have trouble understanding statistics, which may not always provide "all the truth," even if they provide "most of the truth." It's hard to communicate how misses or false positives affect the overall picture. For instance, there is a distinction between identifying "a fish" correctly 95% of time versus identifying "a yellowfin tuna" 95% of time, so there are two different challenges.

We still need human eyes auditing, which is where the loop and learning part comes in.

There is also a challenge with generating false positives and false negatives, but one provider notes that "we like false positives." If you are going to have a human validate 95% of detections, that sounds good, but it also needs to be verified with false positive and negative rates. You must have statistics used to develop and analyse a trip. Those statistics can use part of trip to explain another part through sub-sampling.

Most people are not friends with machines, so you must put "machine terms" into "human terms." There is no such thing as objective truth only agreement on what they say. VMS tracks provide an explanation, but you still must trust an expert for an explanation. The expert may not always be correct, but still represents the best access to the assumption of what is real or "true."

Machine learning tries to define a chain of "knowns" and each "known" has a statistical relationship. When you have lots of data, use t-test get closet to truth. More data points more accuracy with ML.

A lot of questions we are monitoring can be answered by statistics, but there are underlying biases. There are other monitoring questions that are deterministic.

Activity recognition, counting, and ID discards seem to be standing in the way of fully implementing EM. How far off from count and measure bycatch?

With groundfish, choke species in bycatch and discards can shut down seasons earlier than they would otherwise. Thus, there is a discrete need for species identification as well as counting and measuring discards. In the groundfish case, fishermen pass discards over a camera strip, which is a new behaviour on deck that they agreed to. We are looking to use automation to speed up review and facilitate full deck coverage to counter cheating on discards. We acknowledge the much cheaper costs of an observer programme using EM, but fish and species ID by camera is still the highest cost.

We need every fish on deck counted and we can describe afterwards. Also, we can address compliance issues and activities with a new algorithm for detection. We should focus on what we need to detect or not reduce the time at end. For instance, if we need 100% review for oil spills, then we will need to go back to the start.

There is currently work underway on discards, which should get to the last 20% and we don't need a highly skilled observer for basic activities.

PART 2: HARD DRIVE BLUES – ADVANCES IN TRANSMITTING VIDEO & DATA FROM VESSEL TO REVIEW CENTER

Mr Galan stated affirmatively that the equipment can do real time image and video. There needs to be a satellite on board to generate a minimum 2.5 Mbps for 12 hours per sea day and you need 4.8 Mbps for 6 h per sea day. This ramps up to 9.6 Mbps to do HD real time streaming per camera, which will need a bit rate slide of 200 kbps and 800 kbps. A hard disk drive (HDD) must accommodate 4 TB to support a time of 12 hours upload at 740 Mbps upload speed. For 12 TB you could achieve 1 week at 160 Mbps upload speed you secure the ability to do a pre-analysis on tracks, select interesting footage, record high-resolution images, and change FPS or resolution.

Global VSAT already exists with up to 4 Mbps capacity, while regional VSAT can accommodate up to 10Mbps. Meanwhile, shore-based fibre can support up to 400 Mbps. So, the question comes up as to where it makes sense to upload. If we have HDDs on island, it is possible to upload to the cloud via hardware such as Amazon Snow ball.

There are other options such as One Drive, hubiC, and Dropbox that can provide significant storage. However, privacy becomes an issue with videos in cloud.

Mr Wiersma explained that video review rates at Data Review Centre (DRC) is not fast enough for real time enforcement. He noted that wireless connectivity is now affordable and scalable for EM. He explained the challenges of magnetic HDDs, including that you need two to ensure there is a spare if one fails, they can be bulky, are sometimes incompatible, and result in high data storage costs.

However, recent positives include better solid state drives (SSDs) that are self-healing and more reliable, are USB plug and play compatible, and can hold more than to 500 GB data.

This means you can take to your home computer and upload with no need to have tech swap out HDDs.

At the moment, there is 4G wireless already available in Seychelles with 5G coming soon, which will reduce costs for uploading video by factor of 10. Furthermore, broadband satellite, which is becoming increasingly available, is capable of pulling up high-resolution images at a relatively low cost. He explained that it is not always necessary to record everything 24 hours in HD and some reduced FPS rates can be cost effective. He suggested that using AI to vary frame rate could reduce storage costs by 80-90%. He noted that increasingly government and fishermen will have direct access to the information. Mr Wiersma concluded by noting that wireless coverage will soon be available as much as 25 miles out to sea.

Mr Rodley discussed the EM implementation pilot in New Zealand from 2013-2014. He described how the first units did not allow for HDD swapping. There were 6 wireless stations around NZ collecting data with a 30 kilometre range on paper.

The system was designed using Amazon cloud storage to start transferring 2-4 km out in order to fully dump the data by the time the vessel was back to port. He described how the remote port placement of wireless gear on lamppost with server at base would allow a courier to collect data from server. He further noted how in the US they are using USB for data transfer with an IM model. He described how SSD have problems and that there is a point of failure with the units. Mr Rodley also confirmed that satellite communication is becoming more feasible, but is still not possible yet for small-scale fisheries.

He noted that there is value in considering cellular transmission in certain cases. Mr Rodley concluded that, as we trust AI more and are able to transmit interpreted data, it may be as little as 50 cents to transmit that data point.

Miss Barney described how they started service delivery when cloud storage was expensive, so they still use physical storage with vessels all coming to one place. She explained that we have to be careful how we portray older technologies that are still useable and they are not going to upgrade a fishery where existing technology is reliable and works. She noted how when weather drives everyone to port there is a large supply of data and video review becomes challenging at that pinch point. Miss Barney concluded by describing how they used the cloud to process information from 30-40 vessels at the same time with full delivery analysed data to government in 8 days.

Mr McElderry described how in 1992 they started with a VHS tape-based system they used to provide both sensor and imagery. He noted that in 1999, a 300 GB HDD became available, resulting in a new era in EM with dramatically increased capacity. He expressed how a design idea in a programme can create unintended behaviours.

He described the BC hook and line fishery, which required quick review due to regulations. Within 5 days the data was to be analysed, then go to 3 DRCs. He explained when they shifted to shipping HDDs there was a lot of legacy equipment to adjust to. He noted that in Alaska, southern Oceans, and Australia the failure rates are low on shipping HDDs. Mr McElderry suggested using a satellite communication staged approach with health statements and hourly synoptic reports that includes "VMS on steroids" position and activity as well as E-logbook and then sensor data. He concluded by emphasising that it all falls back to design process.

Mr Woodward enquired about money running out and efficiencies in the chain being important. He also asked about why some fishermen are happy with older systems. Miss Barney explained that, in BC crab systems, function, access to meta-data, and the fact that the federal government was happy seemed to be enough not to change. She emphasised that, "If it's not broken, don't fix it." She concluded that there is some reluctance to move to long-term stored data and that some of that reluctance comes from superstition.

Mr Woodward asked a direct yes or no question of the other speakers, "Do you envision a world where you decentralize reviewers? Mr McElderry said, "No, if you decouple the reviewers then the programme is lost." Mr Isaac-Lowry said, "Yes." Miss Barney said that species ID remains a problem, so "No." Mr Rodley said, "Yes." Mr Wiersma said, "Yes, and with open source review software." Mr Galan said, "Yes."

A participant raised the human rights and labour rights question. Mr Barney suggested it is possible to build capacity into an EM system to collect the necessary information, but that social scientists would be better placed to develop data review and metrics to be using to make decision on conditions/violations.

Mr Wiersma noted that he was working in Thailand with NGO labour rights, and the issues they want to know include number of hours worked and number crew on deck. He noted that facial recognition tech could help with this.

He also noted that wireless connectivity for crew was facilitating use cell phone for communications with family, which was helping with some of the crew rights issues.

A participant suggested that INMARSAT can transmit regardless of weather and there are developments at higher data rates and higher frequency K-band where your fail rate increases. Thus, it may become necessary to use K-band for broadband when there is no weather, but switch to L-band when there is weather.

Mr Galan suggested that you can transcode video to reduce file size and that L-band offers a good higher bandwidth. Noting that they had done a comparison with reduced resolution between Satellite versus HDD.

Mr Gomez suggested that Marine Instruments went to still images to reduce 10-20 times the amount of data saved and transmitted. He noted that for fisheries management you don't need high resolution video and as low as 1 FPS could suffice. He commented that for a longline trip of 9 months this could be 1 TB versus 10 and greater with a lower frame rate.

Mr Rodley noted that they started in 2012 with 1-5 FPS, but received feedback that it was not enough. Thus, they secured an 85% decrease in file size when they switched to video.

WORKSHOP 2: FROM SEA TO SKY – EFFECTIVE IMPLEMENTATION OF MONITORING, CONTROL, AND SURVEILLANCE

Lead: Pew Charitable Trusts

Workshop Goal:

The goal of this workshop included identifying:

- Best practice approaches to fisheries MCS;
- Whether existing or emerging technology solutions are appropriate or feasible in certain situations; and
- General barriers to implementation and integration of MCS technologies to address MCS challenges.

Overview:

The objective of the workshop was to gather providers and developers of emerging fisheries and seafood technology and end users of that technology to collaborate on ways to improve surveillance technology to better meet the diverse needs of the fishing and seafood community.

Outcomes:

What limitations exist with regards to technology?

- Different regions have different limitations.
- Cost will always be an issue but also availability and applicability of the available data.

Path to conviction and enforcement – technology can assist with:

- Risk assessment – vessels at risk, areas at risk
- Filling gaps in information – when enforcement is understaffed, technology can help with timeliness and information sharing.
- Legislation – technology can help inform better legislation and legislation should speak to emerging technological capabilities.

Impacts to legal fishing:

- Using technology to improve licensing and insurance to improve compliance.
- Market access is key to making sure fish that is bought by consumers is caught in a legal and sustainable and responsible way, so using traceability tools to track fish from bait to plate.
- Reporting mechanism like a “Trip Advisor” for fishing – where you can rate the behaviours of other fishers.

WORKSHOP 3: HOW MUCH?! – SMALL SCALE FISHERIES AND TECHNOLOGY FINANCE CHALLENGES

Mr Bubba Cook (WWF) moderated the session with support from *Ms Sarah Fagnani (WWF), Mr Michael Osmond (WWF),* and *Mr David Schorr (WWF).*

Workshop Goal:

The goal of this workshop was to identify finance challenges and barriers while exploring both practical and innovative approaches to support sustainable technology investment for small-scale fisheries (SSF).

Workshop Overview:

The intent of the workshop was to bring together technology providers and developers with practitioners to explore traditional as well as innovative finance tools and mechanisms to help support technology implementation and development. The workshop sought to take a pragmatic and realistic approach to funding mechanisms available to support technology implementation, specifically in small-scale fisheries (SSF) that are generally perceived as under-resourced.

Workshop Discussion:

Mr David Schorr opened the workshop by providing a presentation on one of the collective funding approaches proposed during the Seafood Alliance for Legality and Traceability (SALT) discussions that were held the previous week. The presentation provided a catalyst for discussion that followed, emphasising the theme that collective action taken together can achieve far more than each institution acting independently.

It also acknowledged that one of the first, and often most challenging obstacle, faced by fishery stakeholders in implementing a technology solution is the availability of initial capital to invest in the project.

The initial presentation and subsequent discussion was intended to identify the following key attributes of technology finance for SSF:

- Available and emerging technologies under consideration for SSF;
- Basic costs of those technologies generally perceived as the most effective priority technologies;
- Existing funding models and mechanisms available for SSF investment in technology; and
- Innovative and novel approaches to sustainable funding of technology for SSF.

The following discussion consisted of breakout groups assigned to generate a list of existing and potential funding resources. Once the breakout groups identified the various potential funding sources, the workshop leader facilitated discussion intended to further define objectives targeted at achieving other workshop goals.

BREAKOUT GROUP 1: SOURCE FUNDING OPTIONS

Many participants noted that the time allocated was too short to effectively address all the identified key attributes and the workshop organisers acknowledge that in the future a full day for some targeted workshop efforts would be necessary. The workshop organisers chose to focus on identifying, ranking, and categorising discrete funding sources according to specific criteria as a distinct outcome of the workshop.

The first Breakout Group discussions initially drew out the following potential sources for funding of technology implementation for SSF:

- International Institutions (World Bank, United Nations Food and Agriculture Organisation, etc.)
- Private Banks (HSBC, Citibank, etc.)
- Venture Capital Funding
- Private and Public Research Funding
- Private Foundations (Packard, Waitt, Vulcan, etc.)
- Crowdfunding
- Microfinance
- Cost Recovery
- Fines (Reinvestment of fines for violations back into compliance tools)
- Maritime Security Organisations (e.g. International Maritime Security [IMS])
- Individual Donors (Wealthy Benefactors)
- Cooperative/Association Organisations
- National Governments (including Fisheries, Conservation, or Foreign Affairs Departments)
- Industry Self-Funding
- Cryptocurrency (e.g. Fishcoin)
- In-Kind Donations (e.g. hardware donations)
- Rent-to-Own (Bank Investment supported through Loan Based Buyback)
- Impact Investors
- Community Organisations
- Corporate Social Responsibility Divisions of Private Companies
- Technology Companies (Google, Microsoft, etc.)

A facilitated discussion followed that considered some of the strengths and weaknesses of each of the proposed sources. Several key themes emerged such as the need for enough capital to start a project while also having a plan in place to ensure that the project is sustainable in the long term, including operation, maintenance, and upgrade costs. Many of the proposed funding sources failed to stand up within those themes. For instance, some discussed how international institutions often come in with sizeable amounts of capital investment funding, but that implementation flags after the funding runs out for a variety of reasons not to mention the excessively burdensome administrative and reporting requirements associated with large bureaucratic institutions.

The overarching theme, as is the case with so many other issues related to fisheries, is that there is no single "silver bullet" solution for funding technology projects for SSF.

BREAKOUT GROUP 2: SOURCE FUNDING FEASIBILITY RANKING

In Breakout Group 2, Groups were asked to review the individual sources of potential funding generated in the Breakout Group 1 session from the perspective of the end user (the fisher) and then assess three factors related to:

- Accessibility
- Scalability
- Administrative Burden

Most groups found the exercise very challenging, if not impossible, which is a clear indication of the complexity of the situation and how simply "throwing money at the problem" is not enough.

A weighted summary is provided below that attempts to encapsulate the responses from participants (scaled and normalised from lowest to highest or 1-3):

Funding Source	Accessibility	Scalability	Admin Burden
International Institutions (World Bank, United Nations Food and Agriculture Organisation, etc.)	1	1	2
Private Banks (HSBC, Citibank, etc.)	2	1	2
Venture Capital Funding	1	1	1
Private and Public Research Funding	1	0	1
Private Foundations (Packard, Waitt, Vulcan, etc.)	1	1	1
Crowdfunding	2	0	1
Microfinance	3	2	1
Cost Recovery	1	1	1
Fines (Reinvestment of fines for violations back into compliance tools)	0	0	1
Maritime Security Organisations (e.g. International Maritime Security [IMS])	1	1	0
Individual Donors (Wealthy Benefactors)	1	0	1
Cooperative/Association Organisations	2	2	1
National Governments (including Fisheries, Conservation, or Foreign Affairs Departments)	2	1	2
Industry Self-Funding	0	0	0
Cryptocurrency (e.g. Fishcoin)	1	1	0
In-Kind Donations (e.g. hardware donations)	1	0	1
Rent-to-Own (Bank Investment supported through Loan Based Buyback)	1	1	1
Impact Investors	0	0	1
Community Organisations	2	2	1
Corporate Social Responsibility Divisions of Private Companies	1	1	0
Technology Companies (Google, Microsoft, etc.)	1	1	1

One group noted, "All scores are severely dependent on the country and their particular circumstance." They further discussed how at their table were representatives of countries where government funding was substantial if not common, but that they could all think of places where nothing happens even if funding is applied. Overall, where the groups applied rankings they were not consistent and there appeared to be some confusion generated by differences in interpretation. However, there are some insights that can be gleaned from the information generated by the groups and placed into tables.

The most prominent conclusion that may be drawn from the group feedback is that no source of funding emerged as a clear winner with respect to application in a SSF context. However, there are a few that stood out with respect to the category of accessibility, which, possibly not surprisingly, are much closer to home and include community organisations, national government resources, private lenders, and even microfinance. Similarly, scalability had a comparable pattern. Conversely, and again probably not surprisingly, the large institutional lending agencies scored the highest with respect to administrative burden and the "strings attached to funding".

GENERAL CONCEPTS AND THEMES

Who, what, where, and why?

Discussion that followed the Breakout Groups among the participants was robust, with several raising concerns regarding the approach to the issue and suggesting a need to step back with a more measured and methodical approach to the problem.

There was general agreement that each case is specific and that fisheries, large or small, should not be seeking a technology solution for technology's sake, noting that in some cases the status quo might not only be the best option, but the only realistic option at this time due to constraints in infrastructure.

Thus, one participant suggested there were core questions in each application of technology in any fishery, much less SSFs, before proceeding with a pilot or implementation, including:

- What is it for?
- Where is it used?
- Why is it proposed for use? What problem is it solving?
- How much does it cost?
- Who benefits from it?

Once those questions are answered and there is an affirmative response to the need or desire for a technology solution, only then is it appropriate to move forward with developing a project and seeking funding.

Systematic Approach from the Bottom Up

Others raised questions regarding the "whack-a-mole" approach to individual challenges and even fishery applications of technology to those challenges, suggesting a more systematic approach to technology solutions was needed in order to ensure consistency. This raised the issue of the need for standards, such as those under development with the Global Dialogue on Seafood Traceability (GDST) and SALT. Related to these concerns, another participant raised the need for regional coordination of large institutions with respect to a lack of coordination among organisations leading to inefficiencies where multiple authorities unnecessarily "recreate the wheel."

The idea that *collective engagement* is necessary came up as a consistent theme. One participant noted that an individual goes nowhere by themselves and that engagement with a cooperative or association would be a more appropriate mechanism to build capacity in SSF for uptake of technology solutions to address an identified problem. Another participant emphasised that engagement needs to be participatory and bottom up, citing an example in South Africa where they started with grass roots engagement and 90% of their initial expenses were associated with education, outreach, and socialisation of the technology. An additional participant suggested that co-management represented a critical component of any successful implementation of policy or technology.

Scaling Investment versus Product

Another theme that emerged from several participants was in the form of a question, which was:

"Can you scale investment on a non-scalable product?"

The idea that a technology might not be scalable, but necessary, could have substantial impacts on the ability to secure investment in the technology. This idea becomes particularly more important where a return on investment might be expected either from the institution providing the initial funding or the end user expected to facilitate the expansion of the technology.

Communicating Shared Experience

An additional theme that emerged several times was embodied in a question raised by one participant, which was:

"How do we as a community share the stories of these projects?"

Several participants noted that the Seafood and Fisheries Emerging Technologies (SAFET) Conference represented a rare opportunity for participants to not only see what and where technologies are being employed, but also what resources stakeholders are tapping to support those initiatives. They expressed a need for a better network or mechanism to communicate the shared experience of similarly situated fisheries.

INCENTIVES!

The single most prominent theme that came out of the session involved the need to address the incentives of the fishermen to use a particular technology in order for any implementation to be successful. The facilitator noted that a full day workshop on this aspect alone would be useful, but supported discussion around how this might be achieved.

One participant suggested that SSF particularly are at the mercy of unscrupulous middlemen and that if a technology could be demonstrated that better empowered those SSF they would certainly be interested in using it. That participant further discussed the need to cut out middlemen who do not create monetary value or otherwise have a discrete role in logistics and how technology will play a role in creating the transparency necessary to expose middlemen who exploit fishers.

The end result would be using the technology to create "levelling" or "disintermediation" in the supply chain that ultimately accrues benefits to the fishermen that would otherwise be captured by middlemen.

Upon prompts for additional feedback on the subject of incentives, requesting participants to stretch their perception to consider novel methods to incentivise uptake of technologies by SSF, several participants suggested potential solutions such as fiduciary incentives like that provided by an insurance premium associated with an automotive "black box" that, by its use, creates a monetary award. For instance, a vessel that carries a particular technology, such as a satellite tracking unit, would be eligible for a discount on insurance, access to a market, or other benefit that otherwise wouldn't be available.

The facilitator noted the Cook Islands fuel subsidy incentive as another fiduciary incentive that resulted in a dramatic improvement in catch documentation for a relatively low investment barrier. Another participant suggested creating self-sovereign identity through new technologies where fishermen could create an immutable reputation they could base credit or access upon. This credit profile could facilitate direct access to data about the fishermen that could potentially disempower or eliminate middlemen while monetising data that could also support or facilitate microfinance.

CONCLUSIONS

- No funding source offers a silver bullet; throwing money at the problem won't solve it.
- Collective action and cross-pollination is imperative.
- Understanding and developing incentives for fishermen to use and care for the technology is critical.

WORKSHOP 4: FROM BAIT TO PLATE - DESIGNING COMPREHENSIVE AND INTEGRATED TECHNOLOGY SYSTEMS

PART 1 - GROUP DISCUSSION ON CHALLENGES

Group One – Cost Barriers to Adopting New Technology

- Barriers
  - Many types of costs –
    - Direct – Capital, Operation, Financing Costs
    - Indirect – higher taxes for more accurate reporting
  - Fairness – who is sharing the burden of the costs? The producers often bear the brunt of the cost, while the data recipients rarely pay. New technology is also not necessarily shared fairly with all actors in the supply chain (unfair advantages).
  - Transparency may come with being penalized – more incentives are needed to counteract
- Lowering of Barriers – offer more incentives (tie traditional industry subsidies to data creation)
- What brings value? VMS brings value to companies through fuel, fleet management that can make the expense of new technology worth it.

Group Two – Data Exchange and Interoperability

- How do you being to tackle all of the data points moving through a system?
  - Start with your stakeholders and all involved in the entire process
  - Once identified, look at each stakeholder's data inputs and outputs
  - Map out and visualize the system
  - Identify pain points and technological barriers
- Focus on the goals and objectives first, not the technology – technology it is the tool, not the complete solution

Group Three – Incentives to Input Data

- How can we incentivize fishers to input data, as the main inputter?
- Digital credibility – when data is digital, it is often viewed as more credible
- Defending fishing rights – with a historic record of who caught what where, fishers have more ground to stand on for claiming fishing grounds, etc.
- Social pressures – those that aren't helping the community are highlighted; international and regional pride is a strong incentive
- Historic, recorded information is helpful when applying for loans, investments
- Increased market access, prices

Group Four – Data Validation

- Data conformity vs. truth – how do you know what is being reported is true?
- Being able to cross-check sources is fundamental and enables multiple users (security, customs, etc.) to use data knowing that it is accurate

PART 2 - WHAT DO YOU PLAN TO DO AFTER SAFET?

- Implement cross actor humanization and interoperability. Pilot with Fishery and small-scale (SC) companies so that efforts are not duplicated and are harmonized. And continue to either support or host regulatory discussion to mandate CDT implementation (Marine Stewardship Council (MSC).
- Support small-scale fisheries to improve safety equipment.
- Bring traceability data to the consumers with QR or similar.
- Continue the design of the interoperability system and demonstrate the integration of Trafiz to another system (Trafiz/Altermyth).
- Push for necessary amendment to regulation (BAC 251) on CDT (SFFAII).
- Advocate for removal of tariff barriers for CDT compliant countries (SFFAII).
- Look at the introduced tools by technology that can help the eCDTs of Philippines in terms of data capture and validation.
- Help improve existing CDS and closely work with the EU and relevant stakeholders.
- Align policy and government implementation across sectors, business units and countries regarding understanding of what is a traceable product, its value and corresponding cost equivalent.
- Interrogate some of the contacts and their knowledge for traceability.
- Communicate to the whole organization the importance of CDT and its benefits.
- Promote and balance interest in data sharing and compliance. Do not penalize instead incentivize CDS. Try to be compliant and supporting implementation.
- Right technology should be adopted. User friendly and manageable.
- Look at trying to follow existing CDS projects for lessons learned, standards, and mistakes to avoid.
- Improve the incoming data in the traceability system with electronic devices.
- Run all transponders gateways to make the pilot a success (FAME).
- Continue to explore ways to extract greater value from data collected.
- Pay fishermen or small processors fixed and guaranteed premium until they see market do so – will seek project funds.
- Continue to collaborate with technology companies, government, NGOs on improved traceability.
- Develop business case for small/ medium vessels.
- Continue to support the implementation of BFAR's eCDTs by continuing engagements to member stakeholders in General Santos (Socsksargen Federation of Fishing and Allied Industries Inc.).

Survey Responses

The survey received a total of 64 responses. The survey consisted of 20 questions consisting of likert, multiple choice and open response.

Q1: Affilliation

Out of the 64 responses to the survey 63 people noted their affiliation. The largest affiliation group responding to this question were those in Government at 30%. Following this were Technology developers/providers (25%) and Non-governmental Organisations (21%). Academia made up the least of responses with 5% with those from the fishing industry and private business making up 11% and 8% respectively (Figure 26).

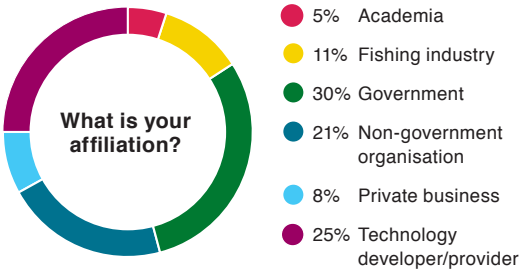


Figure 26 Responses to the survey question "What is your affiliation?"

Q2: How would you rate the conference website, venue, format and catering?

Question two asked respondents to rate their experience of the conference website, venue, format and catering. Due do having multiple lines of questioning there is no data regarding the number of responses to this question. The majority of responses rated the website, venue and format as good with the majority rating the catering and general event management as excellent. The results indicate the greatest room for improvement was regarding the website (Figure 27).

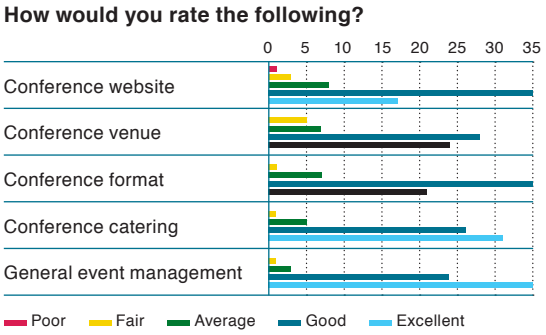


Figure 27 responses to the question "how would you rate the conference website, venue, format, catering and general event management?"

Q3: On a scale of 1 to 5 how would you rank the organisation of the conference?

All of the survey participants responded to this question with 56.3% of respondents ranking the organisation of the conference a 5, 37.5% ranked it a 4 and 6.3% ranking it a 3. No respondents ranked the organisation of the conference below three (Figure 28).

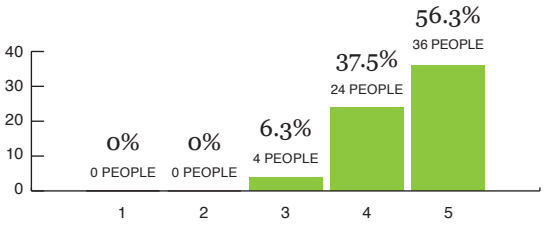


Figure 28 Responses to he questions " On a scale o f1 to 5 how would you rank the organisation of the conference"?

Those that answered 3 or less were asked, what they would recommend to improve the organisation of the conference. Four respondents answered this question. Two referred to better performing AV equipment and WIFI in the main conference hall. The other two suggested increased interaction between presenters and the audience. For example, reserving more time for questions and discussion.

Q4: On a scale of 1 to 5, how would you rank the content of the conference?

All of the survey participants responded to this question with 4 being the most common answer (53.1%), 40.6% ranked the content a 5 with 6.3% ranking the content a 3 (Figure 29)

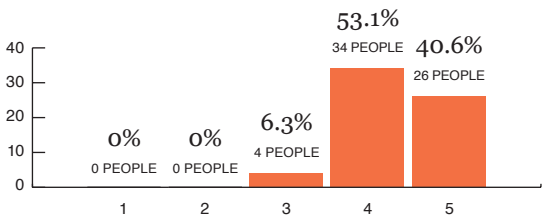


Figure 29 Responses to the question "On a scale of 1 to 5 how would you rank the content of the conference?"

Those that answered 3 or less were asked what they would recommend to improve the content of the conference. Five people responded to this question. Respondents suggested creating variety within each session, reducing promotional/sales content, include more fishers and to try not to avoid heavily focusing on one area (e.g. the Indian and Pacific Oceans) and "address other large fisheries regions such as European Union fisheries governed by the ruled of the common fisheries policy".

Q5: On a scale of 1 to 5 how you rank the execution of the conference?

Of the 64 respondents to the survey 62 answered this question. The majority of respondents ranked the execution of the conference at 4 (43.5%) and 5 (46.8%). A small percentage of 6.5% and 3.2% ranked the execution 3 and 2 respectively (Figure 30)

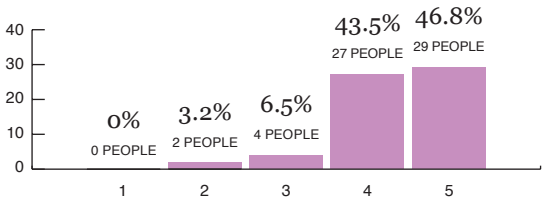


Figure 30 Responses to the question "On a scale of 1 to 5 how would you rank the execution of the conference"

Those that answered 3 or less were asked, what they would recommend to improve the execution of the conference. Six people responded with answers including improvements in technology issues, length and organisation of speaker sessions and a greater range of perspectives, for example, to include fisheries economists and retailers.

Q6: On the scale of 1 to 5, how would you rank the quality of the presentations?

Of the 64 respondents to the survey 62 answered this question. Just over half (53.2%) of the respondents ranked the quality of the presentations a 4 with 37.1% ranking them a 5. Ranking them a 3 were 9.7% of respondents (Figure 31).

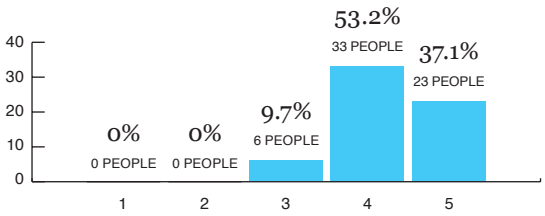


Figure 31 Responses to the question "On the scale of 1 to 5, how would you rank the quality of the presentations?"

Those that answered 3 or less were asked, what they would recommend to improve the quality of the presentations. There were 7 responses to this question. Respondents highlighted their frustration toward technology issues (e.g. clicker and projection) and the promotional slant of some presentations. Again, the format of the sessions was noted with ideas regarding creating opportunities for greater interaction between presenter, panel, and audience and the length of some sessions. Also, noted again was the scope of the presenters with a suggestion to include fishers, processes and/or retailers about how "how technology has given them confidence in their supply chain/operations."

Q7: On a scale of 1 to 5, how qould you rank the overall quality of the panel sessions?

A similar trend is observed for the quality of panel sessions. Of the 64 respondents to the survey 63 answered this question. The majority of respondents ranked the quality of the panels a 4 (60.3%) or 5 (31.7%). The panels were ranked a 3 by 7.9% of respondents (Figure 32).

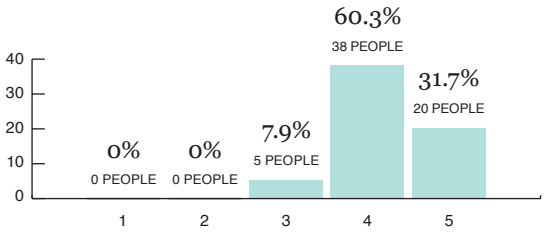


Figure 32 Responses to the question "On a scale of 1 to 5, how would you rank the quality of the panel sessions?"

Those that answered 3 or less were asked what they would recommend to improve the quality of the panels. There were 4 responses to this question. Of these there were suggestions regarding; time management of questions and answers and that the format could have been better executed. One suggested that smaller groups could have allowed for greater audience engagement and some panels didn't vary in format from the regular presentation sessions.

Q8: On a scale of 1 to 5, how would you rank the usefulness of the workshops on day 3?

Of the 64 respondents to the survey 61 answered this question. Half of the respondents ranked the usefulness of the workshops a 4 (50.8%) with 31.1% ranking them a 5. A greater portion of respondents (16.4%) than any other question in the survey ranked the workshops a 3 with 1.6% of respondents ranking them a 2 (Figure 33).

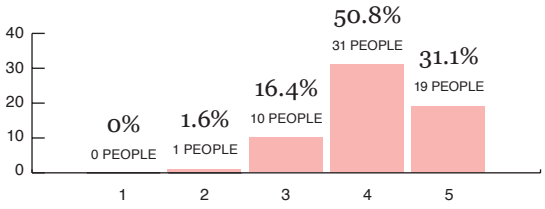


Figure 33 Responses to the questions" On a scale of 1 to 5, how would you rank the usefulness of the workshops of day 3?"

Those that answered 3 or less were asked, what they would recommend to improve the usefulness of the workshops. There were 11 responses to this question. The majority of these responses were regarding the facilitation and format of some of the workshops, which could have benefited from less "lecture style" and more interaction. Other comments included making each workshop longer and aligning them better with advertised descriptions.

Q9: On a scale of 1 to 5, how would you rank the performance of the organiser?

Of the 64 respondents to the survey 63 answered this question. The majority (73%) of respondents ranked the organiser as 5 with 25.4% ranking them a 4 and 1.6% giving a ranking of 3 (Figure 34).

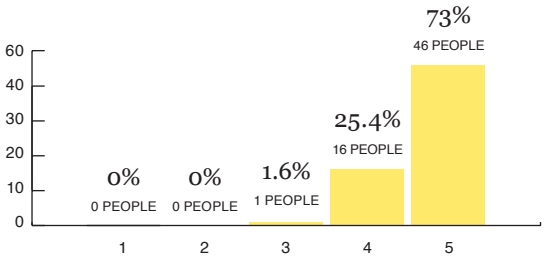


Figure 34 Responses to the question "On a scale of 1 to 5, how would you rank the performance of the organiser?

Those that answered 3 or less were asked, what they would recommend to improve performance of the organiser. There were 4 responses to this question with all but one congratulating the organiser. One respondent suggested increased energy from the organiser could have been beneficial.

Q10: On a scale of 1 to 5, with respect to overall quality and utility how would you rank the conference overall?

All survey respondents answered this question. Over half of respondents (53.1%) ranked the quality and utility of the conference a 5 with 42.2% ranking it a 4 and 4.7% giving it a ranking of 3 (Figure 35).

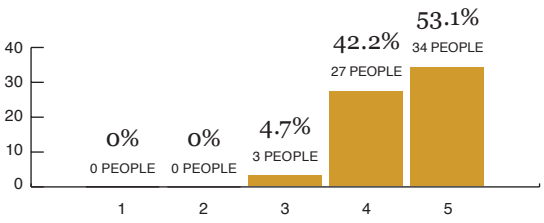


Figure 35 Reponses to the question "On a scale of 1 to 5, with respect to overall quality and utility, how would you rank the conference overall?"

Those that answered 3 or less were asked, what they would recommend to improve the quality and utility of the conference usefulness of the conference. There were 2 responses to this question that suggested less sales focused presentations, tighter schedule and more time to network, greater interaction with audience, and broadening the range of technologies discussed.

Q11: What subject from the day 1 presentations would you like to learn more about?

Of the 64 respondents to the survey 62 answered this question. Catch documentation and traceability systems was the most voted for subject from day one that respondents would like to learn more about (Figure 36). The least voted for topic was 'genetics, biomechanical markers and spectrometry (16.1%).

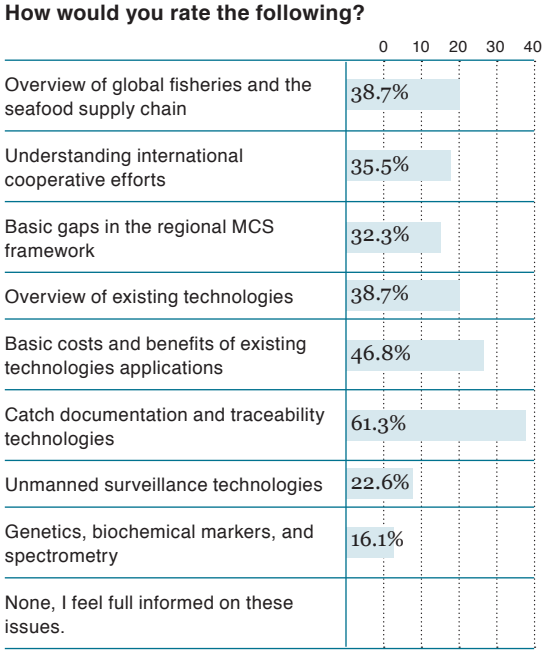


Figure 36 Responses to the question "What subject from the day 1 presentations would you like to learn more about?"

Q12: What subject from the day 2 presentations would you like to learn more about?

Of the 64 respondents to the survey 60 answered this question. The most voted for subject from day one that respondents would like to learn more about was 'Artificial intelligence and machine learning'. With 50% and 48.3% of respondents voting for 'Integrated satellite imaging and tracking technology' and 'Cryptocurrencies and Blockchain' respectively (Figure 37).

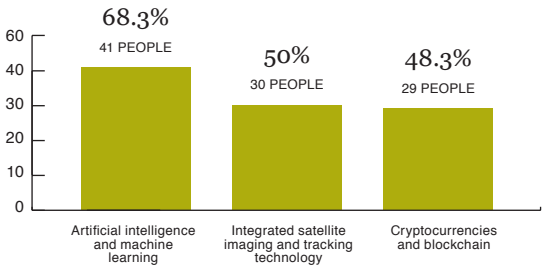


Figure 37 Responses to the question "What subject from the day 2 presentations would you like to learn more about?"

Q13: What subject from the panels would you like to learn more about?

Of the 64 respondents to the survey 57 answered this question. Responses to this question were fairly evenly spread across panel topics. Slightly more respondents (57.9%) voted for 'Course change – facilitating adoption of emerging technology in the supply chain' (Figure 38).

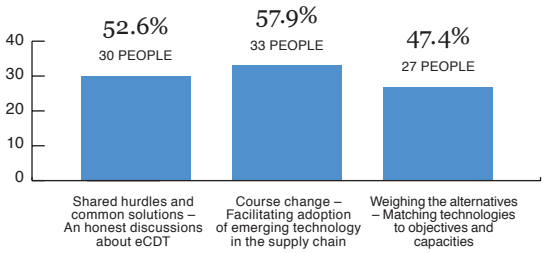


Figure 38 Responses to the question "What subject from the panels would you like to learn more about?"

Q14: What subject from the workshops would you like to learn more about?

Of the 64 respondents to the survey 60 answered this question. Responses for the question where respondents identified what subjects form the workshops they would like to learn more about had an upward trend from workshop 1 'Electronic monitoring' being the least voted for (33.3%) to 4 'Designing comprehensive and integrated technology systems' most being the most voted for by respondents (53.3%) (Figure 39).

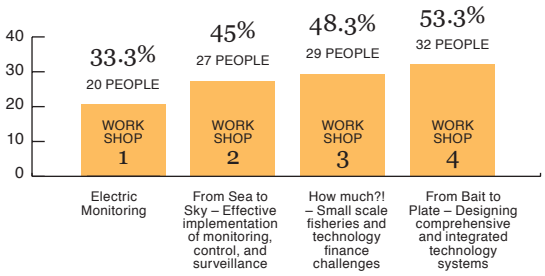


Figure 39 Responses to the question "What subject from the workshops would you like to learn more about?"

Q15: What technology was not included in the workshop that you would like to learn more about?

Of the 64 respondents 14 answered this question. Answers included:

- Open source software/standards in fisheries
- Hardware of e-monitoring, cameras, etc.
- Technology for stock assessments and management
- None – excellent spread of issues
- Undersea environmental sensing and commercial applications
- Data visualization technology for monitoring data and fisheries catch data
- 'Physical' technologies such as those that improve catch weighing.
- Electronic gadgets for small scale fisheries and seafood processing
- E-logbook solutions. Any cutting-edge ideas not covered by the generally available systems.
- Tracking a distant water fleet.
- Counterfeit prevention technologies that may be used with physical goods trade
- More on embedded sensors/IoT
- Use of AIS and cellular phone in artisanal fisheries for developing coastal states.

Q16: Please offer any additional comments regarding your perceptions of the safet conference

Of the 64 respondents 26 answered this question. Included in Table 1 below are concepts that were mentioned by more than 2 respondents. Of all the additional comments made by respondents regarding their perceptions of the SAFET Conference the most frequent was regarding the content (13).

While there was acknowledgement of the quality and variety of content, there were also suggestions of ensuring realistic, useful and adaptable technologies for small-scale fisheries and developing nations and to consider the social elements of such tasks. It was suggested that greater emphasis on small-scale fisheries and developing nations could have been beneficial.

There was also the suggestion to expand the scope of participants to include fishers themselves, purchasers and investors, developing government and bilateral aid agencies. Closely following this was the sentiment of a valuable and well-run conference (12). With 6 mentions, the timing and format of sessions was addressed including either too short or too long, the panel sessions lacked differentiation to the regular sessions and one of the workshops could have had greater interaction. Technology issues were also mentioned (4) including lack of WiFi in the main conference hall and presentation equipment.

Table 1 Responses to the question "please offer any additional comments regarding your perceptions of the SAFET Conference" in order of frequency.

Category	Number of responses mentioning category	Example quotes
Content	13	"Information and content from the conference can be linked to tangible outcomes."
		"Appropriate technologies for small scale fisheries may be given more emphasis."
		"Well designed but should adapt to emerging needs of developing nations in particular SIDS and small scale fisheries in developing countries."
		"Add more of a social nexus – relating to labour issues in the fishing industry and how that could play a role in traceability and event electronic monitoring."
		"The right blend of government, fisheries specialists, technology specialists etc."
		"Would love to bring the industry (fishing crews, etc.) to the conversation, as well as those with purchasing power and who would be subject to regulations/fines."
		"Conferences and conversations around fisheries technology across the globe need a bit more pragmatism, and perspective from the actual users, fishermen. It's hard to get them off the water and into windowless conference rooms, but we need their input."
		"Might have been good to have the fisherman voice, possibly sponsoring some fishermen from developing nations and encouraging others from developed nations to come."
Excellent conference	12	"An excellently run conference that was strategically planned and delivered to be inclusive for all relevant stakeholders."
		"Excellent content. Excellent facilitation. Great format!"
		"An excellently run conference that was strategically planned and delivered to be inclusive for all relevant stakeholders. This was particularly important as it meant that information and content from the conference can be linked to tangible outcomes. The organisation was seamless, and the networking opportunities integrated into the conference delivery in a very natural and enjoyable way."
Timing / format of sessions	6	"I felt the time allocated to some presentations was too short for the volume of information being imparted"
		"I applaud the decision to make the breaks long enough for participants to engage in those conversations during breaks"
		"Workshop 1 was not a workshop but another plenary session – this was a bit disappointing as the workshops are a great place to interact with others with the same interests and identify potential partnerships."
		"The difference between "panel" and regular speaker session was not always clear."
Technology issues	4	"Once over the IT problems it ran very smoothly."
		"Having free WiFi available at the venue would be appreciated."

Q17: Please describe a direct outcome or output from participating in the safet conference? (e.g. Deal negotiated, a new relationship formed, a new idea that has informed a new project)

Of the 64 respondents 37 answered this question. Included in Table 2 below are concepts that were mentioned by more than 2 respondents. The majority (25) of participants who answered this question noted the new relationships and networks formed from attending the conference. Twelve respondents identified new deals, collaborations and/or projects formed. Ten respondents claimed increased knowledge and understanding and 9 reported new ideas formed.

Table 2 Responses to the question "please describe a direct outcome or output from participating in the SAFET conference? (e.g. deal negotiated, a new relationship formed, a new idea that has informed a new project?"

Category	Number of responses mentioning category	Example quotes
New networks / relationships formed	25	"The conference gave me a great opportunity to meet and develop contacts with relevant experts and service providers." "Finding a potential new hire for our currently-open Scientist role." "I met a large number of new people from across the globe."
New deal, collaboration, project formed	12	"New relationships and contacts of at least three tech providers who are interested in trialling their technology with us." "Identified 2 possible channel partners and met 3-4 possible new customers."
Increased knowledge and understanding	10	"It was great to get a landscape of what technologies are already out there, and what roadblocks remain."
New idea formed	9	"Multiple new ideas to test and ground truth in our current processes." "I left with some general ideas about what I could do differently in the US." "New ideas on DNA usage as data verification tool."

Q18: Explain how you think one of the emerging or advancing technologies might fit into the current MCS or seafood supply chain infrastructure

Of the 64 respondents 26 answered this question. Included in Table 3 below are concepts that were mentioned by more than 2 respondents. Artificial intelligence and machine learning was the most frequently mentioned technology (8). Followed by electronic monitoring and reporting (5) and vessel tracking (3) (Table 3).

Table 3 Responses to the question "Explain how you think one of the emerging or advancing technologies might fit into the current MCS or seafood supply chain infrastructure?"

Category	Number of responses mentioning category	Example quotes
Artificial intelligence	8	"Advancements in artificial intelligence and automated review technologies will play an essential role in reviewing large quantities of data to indicate risks activities and potential non-compliance events."
		"AI for data stream analysis."
		"Adopting the machine learning technologies will help in … traceability issues in the large-scale fishing."
Electronic monitoring and reporting	5	"The introduction of electronic monitoring tools is critical for the enforcement of the landing obligation in Union (European) waters."
		"Electronic monitoring with AI is a developing technology that will completely transform the way fisheries management is done. It will allow for better engagement and value for the fisher as well."
Vessel tracking	3	"Tracking each vessel and where they are operating in order to get a picture of pattern of life for predictive analytics."

Q19: Briefly explain how you will use what you have learned in the safet conference

Of the 64 respondents 35 answered this question. Of these respondents 14 mentions that the knowledge they gathered from the conference would go directly into developing product and/or business strategy, 6 respondents discussed how it will help with or contribute to the forming of government policy/ fisheries management decision-making and 4 stated that they would use this knowledge to promote or share their new understanding of technologies and the role they play in MCS (Table 4).

Table 4 Responses to the question "Briefly explain how you will use what oyu have learned in the SAFET Conference?"

Category	Number of responses mentioning category	Example quotes
Product and strategy development	14	"It will help us figure out our future technology roadmap and where our R&D projects can support eCDT goals." "I will try to develop more regional specific and cost-effective technologies for MCS and fisheries supply chain in Indian perspective in line with the discussions and deliberations of the conference."
Developing government policy	6	"Bring in more perspectives when conducting policy work." "Bring out required policy changes and institutional innovations through the Indian Council of Agricultural Research and Department of Fisheries."
Knowledge sharing and advocating technology	4	"Influence policy and decision makers. Help create greater awareness of what technologies are available." "Promote the implementation of technologies for small scale fisheries and aerial surveillance."

Q20: If the safet conference were to be held again, what format would you like to see?

Of the 64 respondents 61 answered this question. Just under half (47%) of respondents liked the current format of the conference. However, 18%% agreed that they would like to see more exhibitors, 16% wanting more panel sessions, 13% more discussion/workshops and 6% more speakers (Figure 40).

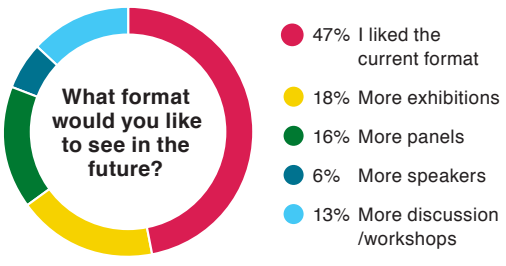


Figure 40 Responses to the question "If the SAFET Conference were to be held again, what format would you like to see?"

Conference Summary and Conclusions

The conference attracted over 240 registered participants from 40 different countries and 120 different institutions ranging from fishing companies to government to technology providers.

Technology and service providers received the unique opportunity once again to review and understand the challenges and opportunities facing MCS practitioners and seafood supply chain participants, while considering how their particular technologies might contribute to addressing some of those challenges.

In turn, MCS and seafood supply chain experts were given the opportunity to objectively review several emerging technologies as they might be applied in a fisheries or seafood supply chain context and assess their economic and practical viability. As a result, the desired objectives and outcomes identified for the SAFET Conference were largely achieved. The MCS and supply chain traceability environment was clarified, providing a base understanding that allowed for emerging technologies to be objectively reviewed and considered for possible contribution to advancing MCS and traceability of fisheries and seafood.

Responses from the electronic survey requesting feedback on the content, organisation, and outcomes of the conference were overwhelmingly positive.

WWF thanks those who provided comments regarding elements that they liked and areas for improvement.

Suggestions were made with regards to things such as format and content. Similar to previous events, the tangible outcomes for participants are continuously encouraging. Outcomes and outputs of the event include the development of partnerships or relationships between various technology providers and MCS practitioners with commitments to either pilot or implement technologies in an MCS context and improved product, policy and strategy development.

WWF again wishes to remark on the high degree of positive engagement, discussion, and commentary by all those who participated at the SAFET Conference in varying capacities. The extraordinary degree of professionalism and expertise of the presenters was motivating and inspiring. Moreover, the forum offered a unique opportunity for participants to consider the technologies and their potential both within and between the plenary sessions as well as in the exhibition sessions that encouraged an open and inquisitive dialogue.

Participants, either through the voluntary survey or independently, remarked positively upon the value of the event and strongly recommended repeating the event in the future.

The themes that follow are intended to capture a synopsis of the key takeaways from the discussions during the week as well as the workshops. They are not intended to be fully inclusive, but provide a snapshot of the highlights from the event.

BIG THEMES

COMPREHENSIVE APPROACH

First, a big theme expressed during the conference included that there is an increasing need to take a comprehensive approach to technology adoption and application. Some encouraged that we consider that structures already exist, for instance, for Food Safety where much of the information is captured. Likewise, others suggested that we have ISO certifications and GS1 protocols.

A general assumption that accompanies this approach included that we should always discuss these issues within the broader perspective of Maritime Security and Maritime Domain Awareness as well as Supply Chain Integrity and Traceability in an effort to bring disparate resources to bear in common objectives where possible. Lastly, participants identified that technology cannot and will not work in isolation and there must be the appropriate policy and regulatory environment in place to provide a foundation for technology implementation.

STANDARDS

Representatives from the Global Dialogue on Seafood Traceability, including the International Food Trust and GS1, emphasised the importance of standards for data capture, storage, transmission, and sharing. A participant noted that "It's hard for even the best marksman to hit a target if they are blindfolded and the target is moving." In a global business environment interoperability is critical so that systems may talk to each other. As one presenter noted:

- Standards Make Interoperability Possible
- Standards Make Connected Experiences Possible
- Standards Make Transparency and Trust Possible

INCENTIVES

A very clear and emphatic theme that arose is that we must create appropriate incentives for users, noting that no fisherman is going to be interested in adopting a technology unless you can demonstrate how and why they will benefit from it.

Several participants emphasised the need to place more effort into education and outreach with the end users – the fishermen themselves – to encourage adoption of appropriate technology.

Thus, we must find ways to explain and effectively communicate the benefits of any technology we wish them to use if we expect the data those tools generate to have any basis in reality.

OTHER KEY THEMES

Other key themes discussed or raised included:

- Technology is moving fast – Two years ago, hardly anyone outside the tech space was talking about Blockchain or Artificial Intelligence. Technology is moving far faster than the fishing industry or even the MCS community can keep up with.
- MCS and traceability is generally under-resourced – It will always be an arms race. The goal is to use technology to close the gap between the bridge of the purse seine vessel that looks like the starship enterprise and the MCS officer still using a pencil and pad of paper.
- Cost is a major barrier – Cost is and always has been an issue, especially for small scale fisheries.
- Legal and regulatory impediments – If you don't have the proper regulatory structure in place, it doesn't matter how good the evidence your new technology collects is.
- Collaboration is critical – Collaboration, information sharing, cross-pollination all contribute to ensuring a better product in the end.
- Integration is increasing – Integration and consolidation of technologies and even technology companies is increasing.
- The human dimension must be considered – You have to remember the people affected by the decisions to use a technology and the results of using such a technology.
- Build on existing systems rather than recreate them – Don't recreate the wheel if you don't have to.

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Abbreviations/Acronyms

AIS	Automated Identification System
BFAR	Philippines Bureau of Fisheries and Aquatic Resouces
CDS	Catch Documentation System
CSIRO	Commonwealth Scientific and Industrial Research Organisation
COC	Chain of Custody
DRC	Data Review Centre
eCDT	Electronic Catch Documentation and Traceability
EEZ	exclusive economic zone
EM	Electronic Monitoring
ER	Electronic Reporting
ERP	Enterprise Resource Planning
FAO	Food and Agriculture Organization of the United Nations
FFA	Pacific Islands Forum Fisheries Agency
FPS	Frames per Second
GDST	Global Dialogue on Seafood Traceability
HD	High Definition
HDD	Hard Disk Drive
IOC	Indian Ocean Commission
IMCS	International Monitoring, Control and Surveillance Network
IMO	International Maritime Organization
INTERPOL	International Criminal Police Organization
IOT	Internet of Things
IOTC	Indian Ocean Tuna Commission
IUU	Illegal, Unreported and Unregulated Fishing
MBPS	Megabytes per second
MCS	Monitoring, Control and Surveillance
MDPI	Masyarakat dan Perikanan Indonesia
ML	Machine Learning
MPA	Marine Protected Area
MSC	Marine Stewardship Council
MSY	Maximum Sustainable Yield
NOAA	National Oceanic and Atmospheric Administration
NFWF	National Fish and Wildlife Foundation
NGO	Non-governmental Organization
PSMA	FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing
RFMO	Regional Fisheries Management Organization
SALT	Seafood Alliance for Legality and Traceability
SAR	Synthetic Aperture Radar
SFFAII	Socsksargen Federation of Fishing and Allied Industries, Inc.
SIDS	Small Island Developing States
SSD	Solid State Drive
SSF	Small Scale Fisheries
SWIOFC	Southwest Indian Ocean Fisheries Commision
TB	Terabyte
TNC	The Nature Conservancy
UAV	Unmanned Aerial Vehicle
UNGA	United Nations General Assembly
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
USV	Unmanned Surveillance Vehicle
VDS	Vessel Days at Sea Programme
VIIRS	Visual Infrared Imaging Radiometer Suite
VMS	Vessel Monitoring System
VSAT	Very Small Aperture Terminal
WCPFC	Western and Central Pacific Fisheries Commission
WWF	World Wide Fund for Nature

"Technology is nothing. What's important is that you have a faith in people, that they're basically good and smart, and if you give them tools, they'll do wonderful things with them." STEVE JOBS