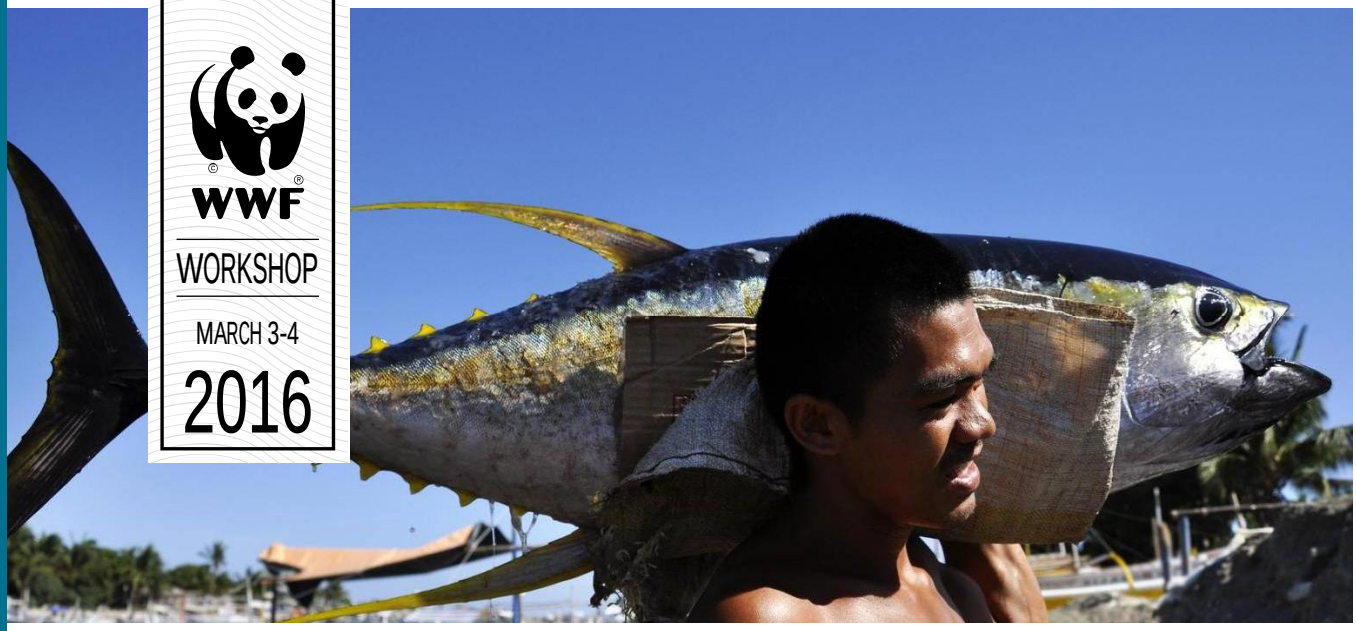

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WWF

WORKSHOP

MARCH 3-4

2016

MONITORING, CONTROL, AND SURVEILLANCE (MCS) EMERGING TECHNOLOGIES WORKSHOP

"ANYTHING IS POSSIBLE!"

FFA
PACIFIC ISLANDS
FORUM FISHERIES
AGENCY

Ministry for Primary Industries
Manatū Ahu Matua

ISSF INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

Summary Report

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Table of Contents

INTRODUCTION 5

THE WORKSHOP 6

AGENDA 7

DAY 1: THURSDAY, 3 MARCH 2016 7

DAY 2: FRIDAY, 4 MARCH 2016 9

SPECIAL GUEST SPEAKER 10

MR GRAEME MULLER, CEO, NEW ZEALAND TECHNOLOGY INDUSTRY ASSOCIATION 10

GUEST SPEAKERS 10

INTEGRATED SATELLITE IMAGING & TRACKING TECHNOLOGY 10

Mr Phill Proud, Manager, Speedcast Intl. Ltd. *10*

Abstract: Leading Comprehensive Connectivity in the 'Internet of Things' 10

Mr Yuval Magid, Manager, Windward Business Development *11*

Abstract: Transforming Oceans of Data into a Reliable, Validated Picture 11

Mr David J. Martin, VP, Global Services, exactEarth Ltd. *11*

Abstract: Real Time Satellite AIS + Small Vessel Tracking – Changing the game for cost effective Fisheries Management and Tracking 11

Mr Benjamin Querné, Regional Sales Manager, CLS *11*

Abstract: Real Time Satellite AIS + Small Vessel Tracking – Changing the game for cost effective 11

Mr Bradley Soule, Senior Fisheries Analyst, Satellite Applications Catapult *12*

Abstract: Cost-effective technology enablers in combatting IUU fishing: 'Eyes on the Seas' 12

Ms Lioba Struck, Project Manager, navama GmbH *13*

Abstract: Transparency and Traceability through Voluntary Satellite Tracking 13

ELECTRONIC MONITORING/FISH ID SOFTWARE 13

Mr Javier de la Cal, Sales Specialist, SATLINK, S.L. *13*

Abstract: Leading Electronic Monitoring into the Future 13

Mr Howard McElderry, M.Sc., VP Monitoring Technologies, Archipelago Marine Research *14*

Abstract: Electronic Monitoring Opportunities for Commercial Fisheries 14

Dr David Middleton, Chief Executive, Trident Systems LP *14*

Abstract: The Magic of Collaboration - Video Observation in New Zealand led by Fisheries Science and Benefitting All 14

Ms Nancy Munro, President, Saltwater Inc. *15*

Abstract: EM - Real World Technology 15

Jenq-Neng Hwang, Professor, Associate Chair for Global Affairs, Dept. of Electrical Engineering, University of Washington *15*

Abstract: Automated Image/Video Analyses for Fishery Science 15

INTEGRATED ELECTRONIC REPORTING 16

Dr. Amos Barkai, CEO, OLRAC SPS *16*

Abstract: The development of an integrated Electronic Monitoring (EM) and Reporting (ER) system to be used onboard commercial fishing boats 16

LASER IMAGING AND SCANNING SOLUTIONS 17

Mr Andrew Burrell, Global Survey, Ltd. *17*

Abstract: Cutting Edge Laser Scanning Tecnologies 17

CATCH DOCUMENTATION AND TRACEABILITY TECHNOLOGIES 17

Mr Mark Oates, Manager, Quick Access Computing Pty Ltd, Australia *17*

Abstract: Transparent Solutions for the Supply Chain 17

Mr Francisco Blaha, Fisheries Advisor and Consultant, FAO/FFA/SPC *18*

Abstract: The Keys to Unlock to Transparent Catch Documentation 18

Mr Alan Steele, CEO, Traceall Global Ltd. *18*

Abstract: Net to Plate Traceability Solutions 19

REMOTE VESSEL MONITORING AND CONTROL SYSTEMS 19
Mr Gabriel Gomez, CEO, Marine Instruments S.A., Spain *19*
Abstract: Inshore Vessel Monitoring System (iVMS), Watching Man Pro 19
RAPID ASSESSMENT GENETICS 19
Dr. Peter Grewe, Senior Research Scientist, CSIRO Atmosphere and Oceans *19*
Abstract: Low-Cost Species-Provenance-Individual Identification Delivered via High Throughput DNA 20
DATA MANAGEMENT SOLUTIONS TECHNOLOGIES/CLOUD COMPUTING 20
Mr Piers Harding, Solution Architect, Catalyst IT *20*
Abstract: Open Source, Open Standards, Open for Integration 20
THE STATE OF UNMANNED SURVEILLANCE TECHNOLOGIES 21
Mr Peter A Smith, Director of Strategy for Asia, Australia and Oceana, Textron Systems *21*
Abstract: The State of Unmanned Surveillance Technologies 21
UNMANNED AERIAL VEHICLES (UAVS) 22
Mr Jack Kormas, Managing Director, Aerosonde Pty. Ltd *22*
Abstract: Aerosonde Multi-Mission Civil And Military UAS 22
DISCUSSION 23
DAY 1: THURSDAY, 3 MARCH 2016 23
Session 1: Introduction *23*
Session 2: Understanding the Role of MCS Emerging Technologies *23*
Session 3: Overview of Emerging Technologies *25*
Integrated Satellite Imaging & Tracking Technology 25
Electronic Monitoring/Fish ID Software 28
PANEL: What technology could have the single largest impact on improving MCS? *31*
Key Points and Themes: *32*
DAY 2: FRIDAY, 4 MARCH 2016 33
Introduction 33
Session 4: Overview of Emerging Technologies *34*
Integrated Electronic Reporting 34
Laser Imaging and Scanning Solutions 34
Catch Documentation and Traceability Technologies 34
Remote Vessel Monitoring and Control Systems 36
Rapid Assessment Genetics 37
Data Management Solutions Technologies/Cloud Computing 37
The State of Unmanned Surveillance Technologies 38
Unmanned Aerial Vehicles (UAVs) 38
PANEL: What seems "possible" as opposed to what seems "practical"? *39*
Key Points and Themes: *40*
WORKSHOP SUMMARY OUTCOME 41
CONCLUSION 41
ACKNOWLEDGEMENTS 42
PARTICIPANTS 43
ABBREVIATIONS/ACRONYMS 49

Introduction

The genesis of the WWF Monitoring, Control, and Surveillance (MCS) Emerging Technologies Workshop began amidst informal discussions about monitoring and compliance challenges with several MCS practitioners at the September 2013 Technical and Compliance Committee (TCC) meeting of the Western and Central Pacific Fisheries Commission (WCPFC). All of these MCS practitioners acknowledged the inherent difficulty of monitoring and enforcing fishing regulations in large, industrial tuna fisheries over a vast expanse of ocean measuring millions of square kilometres. As the resource owners, they expressed interest in finding ways to ensure that not only the stocks be managed sustainably for the long-term benefit of their nations, but also that the revenues from the region's fisheries are fully captured and maintained by their nations. Many expressed concerns with illegal, unreported, and unregulated (IUU) fishing activities in the region that continue to undermine coastal states' efforts to ensure proper management of their fisheries.

Capture fisheries amount to approximately 87 million tonnes representing an estimated USD$129 billion in export value globally. The Western and Central Pacific tuna fisheries alone are conservatively worth approximately USD$6 billion a year in addition to being socially and culturally important to the Pacific Islands. These staggering figures, and the increasing threat that IUU fishing poses, served as the backdrop for this the discussions surrounding MCS Emerging Technologies. Subsequently, this led WWF to develop and conduct a workshop to review a variety of different technologies available to assist MCS practitioners in achieving their MCS goals. As WWF began to research the available and emerging technologies, it was stunned not only by the level of sophistication and rapid evolution of various technologies, but was also struck by how many technologies that had never been envisioned in fisheries MCS appeared to be developing rapidly for use in that context. Additionally, it quickly became clear that most of the MCS practitioners working in the field were also unaware of many of these new and developing technological tools that could ultimately revolutionise the way they do their jobs. Furthermore, upon contacting some of the technology developers and providers, many of them were unaware of the challenges that fisheries MCS faced that their technologies could help solve, much less the potential market it offered.

Therefore, WWF partnered with the Pacific Islands Forum Fisheries Agency (FFA) to conduct the 1st Monitoring, Control, and Surveillance (MCS) Emerging Technologies Workshop, which was held at FFA Regional Conference Centre in March 2014, in Honiara, Solomon Islands. WWF specifically sought to design the workshop to be more than just a "show and tell" for the technology and service providers. Thus, WWF carefully crafted the workshop in a way to get the participants to first think very carefully about the current MCS infrastructure: how it operates; where the gaps might be; where the expenses are; how they might economise the system. After careful consideration of the MCS baseline and some general goals and objectives, participants were encouraged to look at the available emerging technologies and how they might (or might not) help achieve those objectives in an efficient and effective way. The overarching goal of the workshop was to seek out and understand the MCS challenges and identify potential solutions offered by a few select emerging technologies. Although relatively small, this workshop for the first time brought technology providers and MCS practitioners together in a common forum where, in essence, the MCS practitioners could express their needs and gaps regarding MCS and the technology providers could offer potential solutions.

For the 1st MCS Emerging Technologies Workshop, WWF designed an agenda that on the first day reviewed important considerations and features of the current MCS infrastructure, considering that it was critical that the technology and service providers were in the room for this discussion so that they could understand the challenges faced by MCS practitioners and how their particular technology or service might play a role in meeting or resolving those challenges. Then, after reviewing the MCS infrastructure and challenges, on the second day the technology providers were given the opportunity to explain how their technologies might help the MCS experts in the room meet the needs and objectives they had discussed the previous day. In the end, the goal was to improve the understanding of how the technologies, both in their current state and how they are expected to evolve, might fit into the broader current MCS infrastructure and fisheries management regime. Survey responses following the workshop indicated that these goals and objectives were largely achieved.

Moreover, based on the overwhelmingly positive feedback and success of the 1st MCS Emerging Technologies Workshop, WWF determined that it would be beneficial to conduct a second, larger workshop in the near future, which is the subject of this report.

The Workshop

The 2nd MCS Emerging Technologies Workshop 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/), which brought in at least 200 MCS professionals from around the world.

The 2nd MCS Emerging Technologies Workshop was held with the advice and support of the Pacific Islands Forum Fisheries Agency (FFA; http://www.ffa.int/), an intergovernmental organization in the Pacific Islands region comprised of 17 member states that is responsible for strengthening national capacity and regional solidarity to ensure the sustainable management of the region's highly valuable tuna fisheries, the New Zealand Ministry of Primary Industries (MPI; https://www.mpi.govt.nz/), the International Seafood Sustainability Foundation (ISSF; http://iss-foundation.org/), and the Environmental Defense Fund (EDF; https://www.edf.org/).

Specifically, the workshop focused on achieving the following outcomes:

- Clarification and improved understanding of MCS objectives;
- Enhanced awareness of existing and emerging MCS technology tools within the context of a broader view of the existing MCS infrastructure;
- Better understanding of how current and emerging MCS technology tools and approaches might integrate to achieve a more efficient and effective comprehensive MCS infrastructure; and
- Improved comprehension of the potential applications and costs of emerging technologies within the context of the existing MCS infrastructure.

Much like the first workshop, WWF designed the second workshop as a two-phase event conducted over two days. Phase 1 consisted of presentations conducted by MCS authorities and practitioners including: a basic overview of MCS requirements; current MCS techniques and technology; current capabilities and limitations; and basic costs of MCS. Phase 1 provided crucial insight for the technology providers to fully understand the opportunities and challenges for the various technologies in the region. By fully understanding the current status of MCS in the region, technology providers can better adapt their technologies to meet the needs and desires of MCS practitioners in the region. Phase 2 consisted of presentations conducted by the technology providers to demonstrate the potential for each technology in an MCS context. Phase 2 allowed MCS practitioners to better understand the technology and consider its potential application in their respective contexts.

The workshop consisted of 7 primary elements covered over 2 days:

- Overview and review of the current state of MCS infrastructure;
- Understanding of the international legal and policy landscape;
- Basic gaps in the existing MCS framework;
- Overview of the current application of MCS technologies;
- Basic costs of MCS operations;
- Overview of the various emerging technologies; and
- Panel review designed to explore and critically challenge the implementation of various technologies.

Through the presentations of MCS practitioner experts on key MCS issues on the morning of Day 1 and the presentations of new technology providers on the afternoon of Day 1 and all day on Day 2, participants came together to help identify the right technologies for the right conditions to achieve an effective, efficient, and economical MCS programme. Additionally, as part of the workshop scheduling, WWF ensured that technology providers also had a substantial opportunity to present their technologies through vendor's booths located in an adjacent exhibition hall.

At the conclusion of the workshop, WWF requested that all participants reflect on the workshop presentations and outcomes and submit answers to an online survey.

Agenda

DAY 1: Thursday, 3 March 2016

08:00-08:45	Registration
Session 1:	Introduction
08:45-09:00	Whakatau: Maori Welcome Ceremony
09:00-09:15	Opening Address: Exponential Opportunities
	Guest: Graeme Muller, New Zealand Technology Industry Association (NZTIA)
Session 2:	Understanding the Role of MCS Emerging Technologies
09:15-09:30	a. Overview of Current MCS Infrastructure *i. What is MCS?* *ii. Existing Tools and Methods* *iii. Current Capacity*
09:30-09:45	b. Understanding International Cooperative Efforts *i. RFMO Management* *ii. Flag State Requirements* *iii. Port State Control* *iv. Global Record of Fishing Vessels* *v. Coordinated Surveillance Efforts*
09:45-10:00	c. Basic Gaps in the Regional MCS Framework
10:00-10:30	MORNING TEA
10:30-10:45	d. Overview of Current Application of MCS Technology *i. Electronic Reporting* *ii. Electronic Monitoring* *iii. Satellite Monitoring/Tracking* *iv. Patrol Boats/Aerial Surveillance*
10:45-11:00	e. Basic Costs of MCS Operations
11:00-11:15	f. Clarifying and Outlining Objectives *i. Clearly Identify Key MCS Objectives.* *ii. Identify and Refine Key Workshop Objectives*
11:15-11:30	g. Discussion and Summary
11:30-12:30	LUNCH
Session 3:	Overview of Emerging Technologies
12:30-14:15	Integrated Satellite Imaging & Tracking Technology
	Presenter: Mr Yuval Magid, Windward Business Development
	Presenter: Mr Dave Martin, exactEarth Ltd.
	Presenter: Mr Phil Proud, Speedcast Intl. Ltd.
	Presenter: Mr Guan Oon, Collecté Localisation Satellites (CLS)
	Presenter: Mr Bradley Soule, Satellite Applications Catapult

	Presenter: Ms Lioba Struck, navama GmbH
14:15-14:45	AFTERNOON TEA
14:45-16:15	Electronic Monitoring/Fish ID Software
	Presenter: Mr Javier de la Cal, Satlink S.L.
	Presenter: Mr Howard McElderry, Archipelago Marine Research Ltd.
	Presenter: Mr David Middleton, Trident Systems, LP
	Presenter: Ms Nancy Munro, Saltwater Inc.
	Presenter: Dr Jenq-Nenq Hwang, University of Washington
16:15-16:45	PANEL: MCS Professionals and Technology Providers
	Topic: What technology could have the single largest impact on improving MCS?
16:45-17:00	Discussion to identify key points raised, summarise and record key points
17:00	Adjourn
17:30-19:30	Welcome Function (Cocktails and Canapés)

DAY 2: Friday, 4 March 2016

09:00-09:10	Opening Address: The Evolution of Technology and Visions of the Future
09:10-09:20	Brief Review of Day 1
Session 4:	Overview of Emerging Technologies (continued)
09:20-09:40	Integrated Electronic Reporting
	Presenter: Dr Amos Barkai, OLRAC SPS
09:40-10:00	Laser Imaging and Scanning Solutions
	Presenter: Mr Andrew Burrell, Global Survey, Ltd.
10:00-10:30	MORNING TEA
10:30-11:30	Catch Documentation and Traceability Technologies
	Presenter: Mr Mark Oates, iFIMS
	Presenter: Mr Francisco Blaha, FAO/FFA
	Presenter: Mr Alan Steele, Traceall Global Limited
11:30-11:50	Remote Vessel Monitoring and Control Systems
	Presenter: Mr Gabriel Gomez, Marine Instruments S.A.
11:50-12:10	Rapid Assessment Genetics
	Presenter: Dr Peter Grewe, CSIRO
12:10-12:30	Data Management Solutions Technologies/Cloud Computing
	Presenter: Mr Piers Harding, Catalyst
12:30-14:00	LUNCH
14:00-14:20	The State of Unmanned Surveillance Technologies
	Presenter: Mr Peter Smith, Textron Systems
14:20-14:40	Unmanned Aerial Vehicles (UAVs)
	Presenter: Mr Jack Kormas, Aerosonde Pty. Ltd.
14:40-15:30	AFTERNOON TEA
15:30-16:00	PANEL: MCS Professionals
	Topic: What seems "possible" as opposed to what seems "practical"?
16:00-16:30	Discussion to identify key points raised, summarise and record key points
16:30	Adjourn

Special Guest Speaker

Mr Graeme Muller, CEO, New Zealand Technology Industry Association

Graeme is the Chief Executive of the New Zealand Technology Industry Association (NZTech), the national association representing organisations involved in the technology sector. This includes domestic and multi-national technology companies, high growth tech companies, emerging entrepreneurs, hi-tech manufacturers, educational facilities and government agencies.

Graeme is passionate about the impact that technology can make to the economy. He has a background in technology & business research, management consultancy and marketing across multiple sectors and geographies.

Prior to leading NZTech Graeme was the managing partner of Ecosystm, a New Zealand focused tech industry market analyst firm that worked to bring together the buyers and sellers of technology in engaging forums. Before returning to New Zealand to run Ecosystm, Graeme was based in Amsterdam and held the role of Managing Director of Europe, Middle East and Africa for IDC Insights, a global tech sector research and advisory firm. In this role he led a team of analysts and consultants that provided guidance on technology and business issues facing corporate leaders. Graeme spent a decade working in senior management roles for IDC including Managing Director of Northern Europe, Managing Director for the Pacific region and Country Manager for New Zealand.

Graeme has also worked in senior marketing roles for a tech subsidiary of Lion Nathan and for Pacific Pharmaceuticals. Initially trained as a pharmacist, Graeme has a Bachelor of Pharmacy from Otago University, a Post Graduate Diploma of Business (Marketing) from Auckland University and an MBA from Cass Business School, City University in London.

Guest Speakers

Integrated Satellite Imaging & Tracking Technology

Mr Phill Proud, Manager, Speedcast Intl. Ltd.

Phill is based in Sydney, working on sales engineering supporting the development of projects across the Pacific and globally. Phill has worked in various areas of satellite communications for over 7 years, building infrastructure and solutions around various platforms including: Inmarsat, Iridium, Thuraya, Maritime VSAT and MSS, C, Ku and Ka band land services.

Abstract: Leading Comprehensive Connectivity in the 'Internet of Things'

Publically listed on the ASX (SDA), SpeedCast is a rapidly growing company in all satellite communications sectors, including wholesale ISP, telco and reseller services, extensive global maritime services, government and NGO, Oil & Gas, Mining and Enterprise services.

Through extensive acquisitions and integration across the world SpeedCast has created a new global force in satellite communications, drawing from over 30 years' experience within the group. With proactive, 24/7 support and strong financials, SpeedCast is well positioned to support large, long-term projects.

As more devices become IP-enabled, the ability to both monitor and respond to data in real, or near real-time increases. This drives requirements for companies such as SpeedCast to provide new insights and data analysis opportunities to the scientific, NGO and enforcement communities.

SpeedCast is committed to supporting a growing demand for this 'Internet of Things' including the connectivity of devices outside traditional cellular and fixed wireless coverage both on land and at sea.

SpeedCast has partnered with premium suppliers and vendors of satellite airtime and hardware including Inmarsat, Iridium, Thuraya, O3b, IntelSat, Cobham Satcom, Faria Watchdog, Orbcomm and many more to bring the widest selection of leading edge technology platforms to meet our customers demanding requirements.

Mr Yuval Magid, Manager, Windward Business Development

Yuval leads Windward's business development team, deeply engaged in meeting with and understanding the unique needs of Windward's customers worldwide. Yuval is a former officer in the Israeli Navy, having spent eight years in a variety of operational and leadership roles. He holds a Bachelor's degree from Haifa University in Management, Maritime Studies and Political Science.

Abstract: Transforming Oceans of Data into a Reliable, Validated Picture

Windward is a specialized data company. Windward transforms the oceans of data available on ships, both vast and increasingly manipulated, into a reliable, validated picture of what is occurring at sea.

Constant and borderless fishing operations present a new set of complex challenges for today's fishing community, with significant economic, social and environmental implications.

Many MCS organizations have good data sources, and access to massive amounts of data. Technology is the key, however, to gaining a global perspective and making sense of the data.

In this presentation we will discuss the key role of visibility to effectively enforcing regulation, increasing compliance, and ensuring sustainability:

- Shifting from a local view to a global perspective, looking at the entire fishing ecosystem, well beyond local fishing grounds.
- Bringing an intelligence-driven approach to maritime data, providing a new level of visibility to MCS experts working in the complex and interconnected fishing ecosystem.

Mr David J. Martin, VP, Global Services, exactEarth Ltd.

David is currently VP, Global Services at exactEarth Ltd, a data services provider, which leverages advanced microsatellite technology to deliver solutions that enhance Maritime Domain Awareness. At exactEarth, Mr Martin oversees the Global Services and Sales functions. Mr Martin has extensive experience in the data services industry and is also an active member of the IALA and IEC AIS Technical Working Groups for the evolution of AIS standards and technical specifications.

Abstract: Real Time Satellite AIS + Small Vessel Tracking – Changing the game for cost effective Fisheries Management and Tracking

Satellite AIS continues to mature and provide global fisheries agencies with an effective and reliable method for tracking the world's fishing fleets. With the advent of real time satellite AIS tracking, combined with large scale deployments of cost effective tracking devices, it is now possible to track large artisanal fleets to provide the most complete picture of fishing activity on a global scale.

Mr Benjamin Querné, Regional Sales Manager, CLS

Benjamin is a sales manager & project manager for the Fisheries Department at CLS Headquarter in France. Mr Querné has been working in the space industry for 4 years and is dedicated to fisheries for more than two years. He was a pioneer in the creation of the first CLS Group subsidiary in Africa. He is now also supporting the CLS Australian office in Melbourne to follow the activity of the group in the Pacific area.

Abstract: Real Time Satellite AIS + Small Vessel Tracking – Changing the game for cost effective

CLS is a subsidiary of the French Space Agency and the French Ocean Research Institute and was established in 1986 and is based in Toulouse, France.

With almost 30 years operational experience and knowledge, CLS is considered a world leader of marine and maritime applications integrating all types of data ranging from vessel tracking, in situ measurements, ocean observation, ocean modelling and detection of maritime pollution and illegal, unreported and unregulated fishing where this is accomplished by being not only a service provider but also and system integrator utilizing multiple sources of satellite

derived data in the case of VMS, LRIT, SSAS, AIS (including coastal stations), oceanographic data (including in situ measurements), marine species tracking and synthetic aperture radar.

In the case of VMS and MCS; CLS is a MCSP, MTU vendor and a software service provider for Fisheries Monitoring Centers (FMC). The CLS FMC software is used by ICCAT, CCAMLR and over 20 fisheries administrations and flag state authorities and CLS VMS data is directly and securely accessible by authorized coastal and licensing states, RFMOs and regional secretariats (*e.g.* WCFPC and FFA).

Considering other CLS users from maritime surveillance and enforcement (civil and defense), fisheries and ocean research-scientific organizations together with decades of CLS expertise, this equates to CLS being uniquely placed with in-depth understanding of local, regional and international issues and challenges relating to the exploitation, conservation and management of marine resources where CLS has delivered several large scale integrated projects encompassing the entire process for the future protection of marine resources.

Mr Bradley Soule, Senior Fisheries Analyst, Satellite Applications Catapult

Brad is Senior Fisheries Analyst in the Ocean Sustainability Business Unit at the Satellite Applications Catapult. He acts as lead analyst on project 'Eyes on the Seas' - a joint initiative with the Pew Charitable Trusts.

Brad joined the U.S. Coast Guard as a teenager and upon commissioning as an Officer immediately started conducting law enforcement and search and rescue in the Bering Sea, home to some of the largest commercial fisheries in the world. He served in several Coast Guard regions on ships and directing fisheries enforcement operations from shore, including Alaska, Hawaii, and California. He was also the Deputy Chief of Fishery Enforcement and senior fishery watch officer at Coast Guard headquarters. He has a master's degree in fisheries management from the University of Washington in Seattle.

Brad also served as a Criminal Intelligence Officer at INTERPOL's General Secretariat where he helped set up the organization's nascent fisheries project, helping to coordinate operations, capacity building, and intelligence sharing and analysis on fisheries crime among INTERPOL's member countries.

Abstract: Cost-effective technology enablers in combatting IUU fishing: 'Eyes on the Seas'

Traditionally, efforts to clamp down on illegal fishing have relied on aircraft and patrol vessels, but they are often prohibitively expensive for even the richest nations. Monitoring economically critical fisheries and biologically important areas requires a new approach and 21st-century technology to support investigative efforts in port and at sea.

The Satellite Applications Catapult has partnered with The Pew Charitable Trusts to pioneer Project Eyes on the Seas, a cutting-edge technology platform that combines satellite monitoring and imagery data with other information, such as vessel databases and oceanographic data, to help analysts detect suspicious fishing activity.

What makes the system distinctive is that it combines advanced technologies for analysing and visualizing big data from multiple sources to monitor and identify specific activity around the globe for the review of fisheries analysts to produce actionable and useful intelligence.

The Eyes on the Seas system is designed to be a highly secure, cost-effective global fisheries monitoring tool, which provides information to governments to enable investigations, to monitor and detect illegal fishing, and to retailers and those in the seafood supply chains to assure the legality and provenance of their seafood.

Ms Lioba Struck, Project Manager, navama GmbH

Lioba coordinates all roll-outs and analytics for navama's natural resource protection projects since 2013. Combining her working experience in Africa and Asia with her background in conflict management she builds bridges in international projects between various project parties *e.g.* governments, NGOs and industry.

She holds a bachelor in Social Science (University of Applied Science, Munich) and a Double Master in Peace and Conflict Studies (Phillips University, Germany and University of Kent, UK). She is trained in Mediation and PRINCE II Project Management.

Lioba lives in Sheffield, United Kingdom and in her free time she likes to compete as a trail runner or do tricks on her BMX.

Abstract: Transparency and Traceability through Voluntary Satellite Tracking

navama has been analyzing AIS data for more than 4 years. They have developed sophisticated analytical tools and crosschecks to enable a profound understanding of satellite-data. Together with WWF, their aim is to make fishing operations transparent and to ensure that the seafood reaching markets is fully traceable to legal sources. The four key pillars of their initiative are:

TransparentSea.org, a tracking tool and data sharing platform that allows fisheries all over the world to voluntarily register with the system, and make their fishing activities transparent. www.transparentsea.org.

seeFish, a joint project of Luxspace, WWF, and navama funded by the European Space Agency (ESA) and German Aerospace (DLR), establishes a consumer friendly traceability system from catch to supermarket shelf. Consumers will be able to trace products back to the catch location, using smartphones and tablet PCs.

seeOcean Explorer is a web based analysis tool for marine geographic information and AIS/VMS/GSM tracks. It enables access to a big AIS satellite database with data about global AIS coverage, individual shared fishery tracks, marine protected areas, wind and waves, track patterns, ports, and economic data which can be combined and visualized to provide a holistic view of fishing operations.

smartTrack is a project in which WWF and navama test and install various vendor independent position tracking systems on artisanal vessels, supplied with solar power where necessary.

Electronic Monitoring/Fish ID Software

Mr Javier de la Cal, Sales Specialist, SATLINK, S.L.

Javier is the regional sales manager for the Asian and WCPO markets at Satlink S.L. His background includes a degree in Economics with two years of international exchanges in South Korea and the United States and experience in developing business relationships in Asia and the Pacific Islands region for two years. At Satlink, Javier specializes in sales, marketing and leading international projects of Electronic Monitoring for different types of fisheries including tuna purse seine and tuna long line.

Abstract: Leading Electronic Monitoring into the Future

Satlink S.L. is an international company, based in Spain with offices in Fiji, Seychelles, Vigo and Ecuador. With more than 20 years providing satellite solutions and with extensive experience in the fishing industry, Satlink has reached a leading position in the market and a well-known name based on the quality of its products and services. Among Satlink's wide portfolio where should be included VMS solutions and Satellite buoys for tuna fishing, Satlink has developed the "Satlink SeaTube" which is is a powerful electronic monitoring system designed to record and monitor the fishing activities onboard any vessel. The SeaTube system is fully configurable to address the requirements of fishery authorities and vessel owners. It is a great tool to prove the authenticity of fishing reports based on videos recorded with an automatic date/timestamp as a non removal watermark. Vessel surveillance and the capability to watch live video are other main features of the system. The SeaTube system consists of a number of HD cameras installed onboard, a Satlink video server (NAS/NVR), and a VMS system with preconfigured EEZs. Video of fishing operations is stored onboard in the Satlink SeaTube rack and encrypted. Videos are later extracted locally from the encrypted HDD for analysis ashore by the Observer Program with a Satlink View Manager analysis tool.

Mr Howard McElderry, M.Sc., VP Monitoring Technologies, Archipelago Marine Research

Howard has worked extensively in the field of commercial fisheries monitoring and analysis for nearly four decades. Since co-founding Archipelago Marine Research in 1978, Howard has played a key role in the development of onboard and shore-based fisheries monitoring programs, and led the development of the company's electronic monitoring (EM) programs and technology used around the world. While overseeing Archipelago's international fisheries monitoring projects, Howard works with government and industry to support sustainable seafood initiatives, develop fully documented fisheries, and help fishermen to improve efficiency, control costs, and remain competitive.

Abstract: Electronic Monitoring Opportunities for Commercial Fisheries

For 15 years, Archipelago has developed and deployed Electronic Monitoring (EM) technology in both high seas and coastal fisheries across a range of geographies, fishing gears, and monitoring objectives. Archipelago's EM technology integrates GPS, activity sensors, and video cameras to provide an accurate representation of key fishing activity at sea, similar to that provided by observers. To manage this data, Archipelago developed a software platform that helps land-based reviewers view sensor and image data, identify relevant events, and record their observations.

Although the technology is proven, designing and implementing an EM program can present some unique challenges. Using an iceberg analogy, the technology represents the visible, above-water portion—typically the focus of attention; meanwhile, the larger underwater portion (corresponding to program elements such as operational procedures, vessel crew obligations, and program infrastructure) is often neglected. These key design elements must be carefully tailored (based on fishery scope, program objectives, funding and more) to ensure the overall efficacy and cost-effectiveness of the monitoring program.

As an industry pioneer and experienced provider of both onboard observer services and electronic monitoring alternatives, Archipelago offers a complete 'end to end' technology solution, backed by a proven ability for developing effective, fully implemented EM programs.

Dr David Middleton, Chief Executive, Trident Systems LP

David has been Trident's Chief Executive since it was established in 2012. He was previously Chief Scientist for Seafood New Zealand, and its predecessor the New Zealand Seafood Industry Council.

Before moving to New Zealand, David was stock assessment scientist for the Falkland Islands Government and undertook research at the Universities of Minnesota and Strathclyde.

David leads Trident's mission to provide high quality fisheries research services in support of effective and efficient management of New Zealand fisheries, with the active involvement of the seafood industry.

Abstract: The Magic of Collaboration - Video Observation in New Zealand led by Fisheries Science and Benefitting All

When commercial fishers in New Zealand decided to install video observers on their vessels to achieve 24/7, year-round transparency they asked for help.

Trident Systems - a seafood industry research provider - was invited to facilitate the solution. This presented a perfect opportunity for scientists, innovators and government to step up.

Working with fishers is fast paced and demanding. The challenge was to develop a product that provided an integrated, multi-purpose vessel monitoring service. It had to be cost effective, competitive and capable of delivering robust data – plus fishers wanted to be involved all the way through the design process.

Our goal was to deliver a system that vessel owners could use to manage their fleet and, simultaneously, gather information that would feed into science programmes and meet statutory compliance requirements.

Government responded proactively by providing opportunities for trialling the technology to ensure it met their needs.

Today we have a pathway that allows fishers, fleets and government to incrementally invest in electronic monitoring and catch reporting. It's industry-based and supported by fishers.

Vessels are platforms for research. Data is encrypted and downloaded by WiFi. Smart phones allow managers to check on vessels. Government can monitor the vessel. Everyone wins.

Ms Nancy Munro, President, Saltwater Inc.

Nancy is the founder and President of Saltwater Inc., a U.S. company focused on the collection of high quality data on fisheries and oceans. Saltwater is one of the leading observer companies in the U.S. and is recognized as an innovator in the use of new technology and electronic monitoring for data collection. Nancy's commitment to finding practical and cost-effective EM solutions is reflected in Saltwater's development of open-source software and support for open standards for EM data collection and review. With a background in communications and business, Nancy has written extensively about marine and fishery issues. As Chair of the North Pacific Fishery Management Council's Advisory Panel and, currently, as a member of the NPFMC's Electronic Monitoring Work Group, she has also been active in the policy and regulatory processes surrounding fishery management. She holds a BA from UC Berkeley and an MBA from the University of Alaska.

Abstract: EM - Real World Technology

New technology offers promise to solve fishery monitoring issues, yet a big challenge is making the technology work in the real world. Saltwater Inc. is a US-based EM service provider and innovator in designing new EM solutions—from on-board equipment to data review software. Two of the biggest challenges we see are the logistics of implementation and data review. We are working to address both of these challenges, and will discuss our experiences and lessons to date.

The first large-scale implementation of EM in the U.S. was launched in 2015 in the Atlantic pelagic longline fleet. Saltwater was responsible for designing, building, and installing the EM systems on over 100 vessels in this fishery, and continues to provide upgrades and servicing. We will share lessons about system design, install logistics, and the provision of on-going support to a geographically dispersed fleet.

In collaboration with Chordata and Sea State, we are also developing open-source EM review software. In the Pacific Islands region, multiple EM projects are underway using EM systems provided by different vendors. Our software does not presuppose a particular onboard set up so it can be configured to work with different systems and modified to meet specific needs.

Jenq-Neng Hwang, Professor, Associate Chair for Global Affairs, Dept. of Electrical Engineering, University of Washington

Dr. Jenq-Neng Hwang received the BS and MS degrees, both in electrical engineering (EE) from the National Taiwan University, Taipei, Taiwan, in 1981 and 1983 separately. He then received his Ph.D. degree from the University of Southern California. In the summer of 1989, Dr. Hwang joined the Department of Electrical Engineering of the University of Washington in Seattle, where he has been promoted to Full Professor since 1999. He served as the Associate Chair for Research from 2011 to 2015 and is currently the Associate Chair for Global Affairs in the EE Department. He has written more than 300 journal, conference papers and book chapters in the areas of multimedia signal processing, and multimedia system integration and networking, including a textbook on "Multimedia Networking: from Theory to Practice," published by Cambridge University Press. Dr. Hwang has close working relationship with the industry on multimedia signal processing and multimedia networking.

Dr. Hwang received the 1995 IEEE Signal Processing Society's Best Journal Paper Award. He is a founding member of Multimedia Signal Processing Technical Committee of IEEE Signal Processing Society and was the Society's representative to IEEE Neural Network Council from 1996 to 2000. He is currently an advisory member of Multimedia Technical Committee (MMTC) of IEEE Communication Society and also a member of Multimedia Signal Processing (MMSP) and Internet of Things (IoT) of IEEE Signal Processing Society. He served as an associate editor for IEEE T-SP, T-NN, T-CSVT, IEEE T-IP, and IEEE Signal Processing Magazine, as well as an Editor for JISE, ETRI, JSPS, and IJDMB. He was the Program Co-Chair of ICASSP 1998 and ISCAS 2009, and is the Program Co-Chair for ICME 2016. Dr. Hwang is a fellow of IEEE since 2001.

Abstract: Automated Image/Video Analyses for Fishery Science

Fish abundance estimation, which often calls for the use of bottom and midwater trawls, is critically required for the commercially important fish populations in oceanography and fisheries science. A midwater Cam-trawl system, developed by Alaska Fisheries Science Center (AFSC) of National Oceanic and Atmospheric Administration (NOAA), is thus used to systematically conduct image/video-based surveys. The absence of the codend allows fish to pass unharmed to the environment after being sampled (captured by cameras). The captured video data, which provide much of the information that is typically collected from fish that are retained by traditional trawl methods, allow

automated detection, segmentation, tracking, counting, length/size measurement and species recognition. Moreover, as fisheries worldwide strive to produce a sustainable seafood supply, systematic monitoring of fish stocks is increasingly important and federal fisheries are increasingly incorporating electronic monitoring into fishery data collection. The goal of fisheries monitoring is to provide cost-effective solutions for collecting fishery dependent data which meets the needs of a range of scientific, management, and compliance objectives. One such effort is again made by the AFSC of NOAA to develop a live fish counting, length measurement and species recognition system, based on the data collected using a camera system located in on-board fish chutes. In this talk, I will talk about our recent developments on image/video analyses for both Cam-trawl and chute monitoring systems.

Integrated Electronic Reporting

Dr. Amos Barkai, CEO, OLRAC SPS

Dr. Amos Barkai is the co-founder and CEO of OLRAC SPS (www.olsps.com) a company founded in 1989. OLRAC SPS specializes in the implementation of sophisticated data management and quantitative and predictive analytic tools for different commercial sectors. OLRAC SPS won two prestigious IBM awards for its successful implementation of a number of complex data management software solutions. OLRAC SPS is also the developer of the Olrac electronic logbook software, an advanced system for the electronic collection, transmission and tracing of marine related data. The Olrac Software is now installed on over 500 vessels around the world. OLRAC SPS employs 34 highly qualified staff and has offices in South Africa, the UK and Portugal.

In this meeting Amos Barkai will present the Olrac/MI Electronic Reporting (ER) and Monitoring (EM) solution it developed together with Marine Instruments. In the Olrac/MI solution, data recorded and reported by the fisher are linked and synchronised with real time images captured by Marine Instruments cameras. This joint technology will force fishers to report their catch and operation very accurately and will allow enforcement agents to verify catch and effort reports sent by fishers.

Abstract: The development of an integrated Electronic Monitoring (EM) and Reporting (ER) system to be used onboard commercial fishing boats

Fisheries around the world are evolving toward greater collaboration and self-governance in response to directives for long-term sustainability, catch shares, cost recovery and environmentally responsible fishing. These drivers, together with enhanced data encoding and storage, satellite vessel tracking and on-board monitoring technologies, are enabling an international effort to receive and process credible and verifiable fisheries data supporting better management decision making. Three electronic (e) technologies are central to this quest: Vessel Tracking (VMS), Onboard Camera Monitoring (EM) and eLog Reporting (ER), in short eTMR. While the underlining technologies of the three eTMR components are different from each other they are nevertheless instrumental for practical and affordable fisheries management. Several initiatives have been underway in different countries. One example is a partnership between Olrac SPS (www.olsps.com), an International provider of eLog technology, with Marine Instruments (www.marineinstruments.es) a Spain based company which specializes in the development and manufacturing of marine electronics including vessel monitoring and tracking systems. Together Olrac-SPS and Marine-Instruments combined their forces and technologies in order to create one integrated eTMR solution. This eTMR solution incorporates the NOAA certified Olrac eLogbook technology with eEye “state of the art” on-board monitoring and vessel tracking systems to allow fishers and management authorities to cover all their compliance, commercial and scientific monitoring and reporting needs with a single integrated solution.

Laser Imaging and Scanning Solutions

Mr Andrew Burrell, Global Survey, Ltd.

Andy has managed to combine a lifelong thirst for knowledge with a strong interest in new technology.

After working for many years in asphalt crews, mostly whilst travelling across Australia before moving on to running level control systems on pavers whilst being trained in the field to utilise modern surveying equipment, Andy was driven pursue a degree in spatial science from University of Southern Queensland.

After a serious crush incident on site, Andy joined Leica Geosystems in Australia, where he could further pursue his strong interest in spatial technology. From initially selling total stations and Global Navigation Satellite Systems (GNSS) equipment, he gained further experience and expertise in automatic monitoring systems, UAVs, and, particularly, laser scanning. Andy has sold Leica Geosystems products for 10 years across Australia and New Zealand, mainly focussing on the terrestrial and mobile LIDAR product range.

Abstract: Cutting Edge Laser Scanning Tecnologies

The past 20 years or so have seen huge advances in spatial data capture instrumentation, software, and acceptance of the aforementioned. One of the most interesting and broadly utilised across many scopes is LIDAR which uses a laser to illuminate a target allowing the spatial position of that data to be captured, along with reflectivity information about the measured point.

Modern sensors capture this data upward of 1 million points per second from a static terrestrial position such as a tripod, a moving platform such as a road or rail vehicle, offshore from marine vessels and from airborne platforms. This method of data capture allows the end user to acquire amazingly high density, georeferenced, coloured spatial datasets of any site or structure, in a fraction of the time of any conventional method. Most airborne and some terrestrial solutions have the ability to receive multiple returns from a single laser pulse, allowing penetration of canopy and specialist bathymetric systems for LIDAR through water.

The resultant point clouds and imagery can be utilised for an unbelievable amount of scopes from the obvious terrain models, as-built surveys and volumetric computations, right through to cinematography and forensics.

This presentation will briefly discuss the technology, the different platforms, deliverables and techniques available to the broad array of industries, along with how the laser scanning solutions from Leica Geosystems might be able to add value to MCS operations.

Catch Documentation and Traceability Technologies

Mr Mark Oates, Manager, Quick Access Computing Pty Ltd, Australia

Mark possesses a background in Accounting and Electronic Data Management, IT Systems Management, and Training. Most recently, Mark has provided ongoing training and support on the Fisheries Information Management System (FIMS) to the Papua New Guinea National Fisheries Authority (NFA) and Parties to the Nauru Agreement (PNA) for over 5 years.

Quick Access Computing (QAC) maintains a highly intuitive, dynamic team committed to producing results through computing technology. QAC provides a full end-to-end service to clients that includes network administration, system administration, hardware support, operational support, software development, and data protection.

Abstract: Transparent Solutions for the Supply Chain

Port, Coastal and Processing States, have specific responsibilities to ensure that vessels only unload and tranship fish which have been legally caught, and that there is a mass balance system that avoids the potential for fish laundering along the value chain. This can be a very complex task over various countries jurisdictions with only paper records.

Near Real Time eReporting and eCDS FIMS were designed fit-for-purpose to facilitate eCDS processes. eCDS FIMS provides a web based platform for Flag States, Coastal States and Market States to work together to verify legality of the catch, provide unloading authorisation and ultimately a Flag State Authorised Catch Certificate. eCDS FIMS is then used to manage the movement of the Catch and to maintain the Mass Balance totals at the Catch Certificate level

and, as an outcome, also maintains country level Mass Balance. Access to the system has already been given to a number of Flag States by PICs to assist in meeting EU CDS needs, however eCDS FIMS will provide a convenient tool for many other countries as development and roll out continues.

Mr Francisco Blaha, Fisheries Advisor and Consultant, FAO/FFA/SPC

Francisco's experience ranges all across the fisheries sector since the 1980s, from a deckhand and later fisheries observer in the squid, hake and toothfish fleets in the South Atlantic, to longlining and purse seiners in the western pacific.

He worked his way up from a crewmember to a consultant for over 10 international organizations in more than 50 countries worldwide with a period in FAO Rome as a Fishery Officer gaining a MSc in Fisheries Science and another in Food Science along the way.

He has assisted industry and official institutions in a wide range of Fisheries areas, such as Applied Regulatory Compliance, Monitoring Control and Surveillance (MCS), EU IUU & SPS Market Access Requirements, Private Sector Support, Fisheries Research, Fisheries Information Management Systems.

Presently he is supporting the integration of MCS, Catch Certification and Fisheries Information Management Systems (FIMS) in the Pacific and leading FAO worldwide efforts on Catch Certification Technical Guidelines. He has published extensively on EU Market Access Issues and maintains an active blog on fisheries issues at www.franciscoblaha.info

Abstract: The Keys to Unlock to Transparent Catch Documentation

The importing markets have become more aware of the importance of legality and sustainability in fisheries. While assurances of sustainability are catered by private ecolabels, the assurances of legality in terms of market access requirements fall square on the authorities of the flag, coastal, port state and processing states along the value chain. Furthermore for fish to be legally caught in the WCPO it must be caught in compliance with coastal state licensing requirements and also regional, sub regional and commission measures, hence important compliance information over various countries jurisdictions must be available at the time of unloading or transhipping. To respond to this challenge, a Fish Unloading Authorization Code (UAC) and Fish Accountability system were developed. The concepts "combines" three basic elements; the requirements of Port State Measures Agreement (PSMA), a Key Data Element (KDE) needed to follow a landing through the value chain, and the basics of accountancy software.

Under PSMA, vessels have to seek advance approval to enter a port, and the information required is assessed as to whether or not to deny or grant entry. If an "authorization" is given, this is then "coded" as to be able to be reviewed, accounted and potentially crosschecked if it is deemed necessary later on. Hence the designed system uses the UAC as the tool for the initial KDE required traceability analysis along the value chain from landing to consumer, via a system akin to the used by the banking sector to account for transactions after a deposit. Furthermore, it sets the basic background of a Catch Documentation Scheme.

The system is presently being rolled out in some members countries members of FFA in stand alone form or imbedded under the iFIMS structure. Furthermore it has been acknowledged as one of eight recommendations by the WWF conveyed Expert Panel on Legal and Traceable Wild Fish Products in 2015.

Mr Alan Steele, CEO, Traceall Global Ltd.

A passionate entrepreneur, Alan has over 35 years' experience of working in start up businesses taking them from inception to a global player. Formerly an accountant, Alan has a varied career history spanning from fashion to electronics, IT to software.

As CEO of Traceall Global, Alan has built the business from a small software provider to a thriving enterprise providing Internet of Things (IOT) software solutions for the Food & Beverage, Marine, Retail, Oil & Gas, Logistics & Transport sectors.

Alan's knowledge and experience of business, fisheries, environment, sustainability and global supply chains has seen Traceall Global propelled to become the front-runner in fisheries tracking and traceability technologies globally. Seen as a visionary and an industry expert by partners such as WWF and by customers such as Coca-Cola he works with the European Union, Governments in Asia and with the American industry to bring state of the art technologies to combat IUU, slavery and unsustainable over fishing on the high seas.

Abstract: Net to Plate Traceability Solutions

Traceall Global is a UK based software solutions provider of global traceability solutions working with a variety of blue chip brands from different sectors across the globe and Governments. Using sophisticated software as a service (SaaS) solutions and state of the art sensor driven technologies, Traceall Global are able to track, trace and monitor a range of variables across increasingly complex supply chains and deliver business critical insights, Big Data and Analytics to their clients.

With over 20 year's industry experience, Traceall Global are passionate about the sustainability of our Oceans. From overfishing and biodiversity loss to mislabelling and food origin scandals, the need for fully auditable traceability software across the seafood industry has never been greater. Traceall Global has developed industry leading Net to Plate traceability solutions which are used in oceans across the globe to prevent IUU [Illegal, Unreported, Unregulated] fishing, drive sustainable and ethical practices, and deliver greater efficiencies to the fishing sector. Their solution has been adopted by WWF, the EU, UK Government, North Atlantic Inc. (leading US fish processor and its subsidiary Bali Seafood) and are currently working the Malaysian and Indonesian Governments on traceability and IUU.

Remote Vessel Monitoring and Control Systems

Mr Gabriel Gomez, CEO, Marine Instruments S.A., Spain

Gabriel is a professional with more than 10 years of experience in international business development with a strong focus on operations and technical-manufacturing management. He currently works as General Manager at Marine Instruments, a world leader in the development and manufacturing of technologically advanced electronic systems with special emphasis on high quality tracking and remote monitoring products for harsh marine environments and sustainable fishing. With a 25% average annual growth rate over the last five years, Marine Instruments is an innovation-driven company that has continuously outpaced the market.

Abstract: Inshore Vessel Monitoring System (iVMS), Watching Man Pro.

Marine Instruments has a solid experience in electronic and communications mainly for the fisheries sector. Designs and manufactures buoys for all kinds of fishing applications using the highest technology. Its portfolio includes satellite buoys for drifting FADs and radio buoys for longline fishing. It also includes monitoring systems for fishing vessels to help sustainability and to ensure the correct management of fishing activities on board. Systems such as Electronic Eye, a Remote Monitoring System based on still image capture to control fishing activities and Watching Man Pro, an inshore vessel monitoring system (VMS) to enable the control of fishing in restricted areas.

Rapid Assessment Genetics

Dr. Peter Grewe, Senior Research Scientist, CSIRO Atmosphere and Oceans

Peter is an applied marine scientist, with expertise in the molecular and population genetics focusing on genomics applications for fisheries management and aquaculture. He has more than twenty-five years' experience in marine research (from the tropics to the Arctic) and high seas tuna fisheries. While his main focus at the moment is population genetics of tropical tuna, he has a strong background in genomics applied to both integrated pest management and aquaculture species through active collaborations both nationally and internationally.

Peter currently works within CSIRO's Oceans and Atmosphere Flagship as a lead geneticist guiding research directions for a number of collaborative projects including Close-Kin Mark-Recapture of southern bluefin tuna (SBT), gene-tagging of SBT, population genetics of tropical tunas (yellowfin, bigeye, and skipjack). Peter's research team has also developed new approaches optimized for high throughput abundance monitoring of marine populations of highly migratory stocks and threatened species (*e.g.* tropical and temperate tuna and billfish as well as endangered species of sharks including white shark) and determining the provenance and chain of custody of fisheries and wildlife products. Using genomics based approaches to deliver fisheries independent assessment data helps to reduce negative impact of illegal unreported and unregulated (IUU) fishing and promotes sustainable fishing through better management practices.

Abstract: Low-Cost Species-Provenance-Individual Identification Delivered via High Throughput DNA

Technical advances in Next Gen Sequencing (NGS) platforms have opened up novel methods for extracting genetic data through DNA profiling that have revealed fine-scaled details of individuals and populations on unprecedented scales. Using southern bluefin and yellowfin tuna as model species CSIRO Oceans & Atmosphere has investigated NGS approaches and developed an integrated suite of tools and methods that span the three main components of genomic based testing: i) Tissue Sampling; ii) DNA Profiling; and iii) Data Analysis. Results demonstrate our tissue sampling tool can deliver a 10-20mg tissue biopsy that can be directly transferred to robotics handling for DNA extraction. Methods developed using NGS for DNA profiling and applied to three yellowfin tuna populations in the Western, Central and Eastern Pacific Ocean (Coral Sea, Tokelau, and Baja California, respectively) revealed strong population structure and demonstrated that individuals could be accurately assigned with a high confidence (close to 100%) to area of sampling origin. These results demonstrate the potential for using a single 'illegal, unreported and unregulated' (IUU) fishing.

Data Management Solutions Technologies/Cloud Computing

Mr Piers Harding, Solution Architect, Catalyst IT

Piers is an Open Source software advocate, and bee-keeper, with a particular interest in building the infrastructure behind Analytics. He has over 20 years in the IT industry ranging from:

- Architecture, and development of Data Analytics solutions including education, finance, and logistics industries.
- Architecture and development of web services.
- Implementing Enterprise Resource Planning (ERP) Systems, Applications & Products implementation (SAP) R/2 & R/3 in several leadership roles.

He is a respected contributor to the SAP Community Network for OpenSource integration, including developing the Open Source connectors for multiple platforms. His work has contributed solutions for clients ranging from Open University Australia and the New Zealand Ministry of Education to large scale multi-national implementations covering Telecommunications, Petro-chemical, Entertainment Industry, Pulp/Paper/Timber, Banking, Public and Education sector experience.

Abstract: Open Source, Open Standards, Open for Integration

Open Source technologies have long been the mainstay of the scientific and statistical computing fields, but in recent years there has been a convergence of open source technologies through out the computing stack. These changes have touched all layers of the Analytics solution from infrastructure to data product delivery, and places open source as a viable alternative to the commercial offerings.

This presentation will discuss these advances, and present a montage of tools and capabilities that can form the basis of any Analytics solution today - after all "Anything is Possible!".

The State of Unmanned Surveillance Technologies

Mr Peter A Smith, Director of Strategy for Asia, Australia and Oceana, Textron Systems

Peter has held senior management and board positions in manned and unmanned aerospace in Australia and internationally, including six years as a director of AUVSI (Association for Unmanned Vehicle Systems International) in Washington and five years as Vice President of AAUS (Australian Association for Unmanned Systems). He is currently the Director of Strategy for Asia, Australia and Oceania for Textron Systems.

Abstract: The State of Unmanned Surveillance Technologies

Since the last MCS Emerging Technologies conference in the Solomon Islands, there have been a series of interrelated developments which are rapidly enhancing the ability of unmanned air vehicle systems (UAS) to become an integral element of the monitoring, communications and safety aspects of national sovereignty in island and maritime nations. Because of Peter Smith's senior UAS industry roles and his membership of the board of both the Association for Unmanned Vehicle Systems International and the Australian Association for Unmanned Systems, he is able to provide a strategic overview of the state-of-the-art in these promising developments. Topics he will cover include:

- Border protection: Development of capabilities to, operate UAS independently or in conjunction with other air and sea assets to monitor suspected illegal incursions;
- Fisheries surveillance – Improvements in sensors and software to detect, track, identify and document illegal and unlicensed fishing, including small vessels;
- Extreme meteorology monitoring – Enhanced sensors for real time monitoring extreme weather including typhoons and cyclones;
- Surveying – Locally developed sensors and software to allow high resolution, three dimensional maps in near real time, including mapping potential areas of inundation when extreme weather events occur;
- Global Warming monitoring – ability to use these survey sensors to detect progressive changes in sea levels;
- Natural disaster assessment – rapid response capability to provide real time satellite imagery of damage to assist rescue efforts;
- Emergency communications – providing radio and mobile telephone communications when normal communication are knocked out.
- Search and Rescue – new software and sensor capabilities to detect small targets in difficult marine environments
- Communications monitoring – passively monitoring communications from suspect vessels
- Shipboard operations – operating autonomously from future Pacific Patrol Boats.
- Civil Certification – developments in civil certification regulations to simplify rapid response UAS operations.

Unmanned Aerial Vehicles (UAVs)

Mr Jack Kormas, Managing Director, Aerosonde Pty. Ltd.

As the Managing Director for Aerosonde Pty. Ltd., Jack is the Senior Executive Leader for all Australian operations of Aerosonde on behalf of Textron Systems. He is responsible for the management of the business in both the civilian and military domains, which includes Engineering research and development, manufacturing of the Aerosonde unmanned air vehicle, flight operations, training services programs and financial performance of the organisation. He has 27 years experience in the Aerospace and Defence industry.

Prior to joining Aerosonde, Jack has held senior roles at Rockwell Collins in Quality Management and was their Asia-Pacific Lean/Six Sigma Regional Manager. Jack was charged with providing quality management compliance to AS9100, ISO-9000 and to FAA, CASA and EASA safety standards. Additionally he provided training and direction to Rockwell Collins' avionics repair stations in the Asia-Pacific region in Lean Manufacturing and Six Sigma implementation and certification.

Prior to his time at Rockwell Collins, Jack worked for Boeing. In his 10 years at Boeing, he had a variety positions including Program Management, Spares Management, Manufacturing Process Improvement and Quality Management roles. He began his career at Hawker de Havilland in the Engineering Office supporting P3 Orion and F111 aircraft, progressing to airframe Manufacturing Quality Engineering.

Jack holds an Aerospace Engineering Bachelors Degree from RMIT University and a Masters of Business Administration – Technology Management from Latrobe University.

Abstract: Aerosonde Multi-Mission Civil And Military UAS

The Australia-develop Aerosonde unmanned air vehicle system (UAS) has become a world leader in civil and military roles particularly those involving a combination of long endurance, multiple payloads on a single flight, and the ability to operate covertly.

Weighing only 25 to 35 kg depending on the mission involved, the Aerosonde is easily handled by two people and the entire system including multiple aircraft, ground control station, communications, crew and spares can fit in a single van for rapid response operations. On a typical surveillance mission, the Aerosonde can operate with both daylight and night video, taking advantage of its ability to fly for up to 20 hours, either sending real time video back to multiple recipients or storing on board imagery of legally enforceable quality. Operations can be completely autonomous from takeoff to landing.

Using high-resolution still photography it has provided superior imagery for environmental scientists and for monitoring of environmental compliance in sensitive land and sea environments. Recently developed survey payloads allow rapid three-dimensional mapping of large areas to monitor erosion, pollution, sea level changes, and potential areas of inundation. Already known for its ability to undertake meteorology missions in extreme weather including hurricanes, it has added payloads to undertake initial assessment of natural disaster management and to provide emergency communications.

With its Australian-based and internationally experienced team, Aerosonde is capable of designing to exactly match customer needs as well as training customer flight operators, video operators and maintenance personnel. It also provides turnkey fee-for-service operations by its own crews who are experts at operating in remote Pacific environments.

> "Almost all of the emerging technologies discussed over the past two days have a place in the aspirational goal of improving regional MCS to ensure the future of the fishery. The biggest challenge will be to integrate all of these technologies with each other to fully realise their potential to make a difference." – Workshop Survey Respondent

Discussion

DAY 1: Thursday, 3 March 2016

This section will not restate all presentations in detail. It is intended only to encapsulate or distil some of the major points and themes as well as provide a summary of the discussion that followed. As indicated above, all presentations are located at: https://drive.google.com/open?id=0B79T78ZKDRNiUWFRWUxsdzhYWlk

Session 1: Introduction

Mr Graeme Muller of the New Zealand Technology Industry Association (NZTIA) gave an opening address on "Exponential Opportunities." Mr Muller emphasised that technology is rapidly advancing and that participants should not only consider what is out there now, but also what is quickly coming down the track. Referencing Moore's Law, he described how many emerging technologies are beginning to experience exponential growth, but because we are accustomed to recognise linear growth not exponential, we don't always recognise the potential of those emerging technologies. The MCS Emerging Technologies Workshop was funded by the Gordon and Betty Moore Foundation, making the discussion of Moore's Law particularly relevant.

Mr Muller noted that many of our presumed limitations are swiftly disappearing. For instance, he noted that 25% of global population had a smart phone in 2015 and that figure is expected to reach 50% by 2020, remarking that the average cell phone has more computing power than that used in all of the Apollo missions combined. Similarly, solar energy is also developing exponentially and following Moore's Law of increased capacity and declining cost, dropping from over USD$30/KWh in 1980 to less than USD$0.16/KWh today. He speculated that we should expect to have virtually unlimited information and free solar energy in the near future. Mr Muller further highlighted the variety of exciting and innovative technologies that were rapidly moving forward, ranging from 3D printed rockets capable of carrying a satellite payload into space for USD$77K where just 5 years ago the same task would cost USD5M!

He concluded by noting that emerging technologies have huge potential for fisheries MCS, but noted that we must remember that they are being used by those on both sides of the law.

Session 2: Understanding the Role of MCS Emerging Technologies

Bubba Cook from WWF, who also facilitated the workshop, gave an Overview of Current MCS Infrastructure. He defined key terms, outlined the forms various MCS tools take (paper-based, electronic, and manned surveillance), and emphasized the current huge technical and administrative burden imposed by unwieldy, inefficient, and out-dated paper-based systems. He also noted that current MCS capacity is overstretched, citing examples of one patrol vessel charged with monitoring 3.6 million square kilometres in Kiribati; or only three MCS staff charged with monitoring 1 million square kilometres in Tuvalu. He emphasised that, like many regions around the world, the Pacific region has very limited, overloaded resources to deal with huge ocean areas within a complicated legal and political 'seascape'. He highlighted that a fully functional observer programme, considered a foundational requirement for good fisheries management by many, of around 300 observers costs $1-5 million to run and at current levels is woefully under-resourced. Mr Cook pointed out that, given these limited resources, it's time to work smarter rather than harder, but that it might not be enough. He concluded by asking the rhetorical question "What is the future?" when considering MCS technologies and answered, "Anything is possible!"

Ana Taholo, the Assistant Compliance Manager for the Western and Central Pacific Fisheries Commission (WCPFC), offered a presentation on Understanding International Cooperative Efforts, which provided background on the complex responsibilities of the Regional Fisheries Management Organisation (RFMO) from the context of the WCPFC. The WCPFC, in place since 2004, is one of five tuna RFMOs covering the world's oceans. It is unique among RFMOs, as the convention area is predominantly developing coastal state Exclusive Economic Zones (EEZs), and 85% of tuna catch comes from EEZs.

Ms Taholo noted that the WCPFC Record of Fishing Vessels (RFV) contains around 5,600 vessels, with longline vessels representing about 60%, purse seine representing about 13%, and the remainder made up of troll or other gears. She also highlighted the illegal, unregulated and unreported (IUU) vessel "black list," which served to identify vessels affirmatively engaged in IUU fishing. Both the RFV and IUU lists are maintained on the WCPFC website. Ms Taholo also explained that the WCPFC maintained a vessel monitoring system (VMS) that covers high seas, and, at the request of member states, may cover their national waters. She noted that member states may also request VMS coverage of vessels that covers 100nm buffer zone beyond their EEZ. Ms Taholo also highlighted that, within the high seas of the WCPFC Convention Area, authorised inspection vessels are able to board and inspect other countries' fishing vessels.

Ms Taholo noted that current WCPFC initiatives include developing minimum standards for electronic reporting (ER) and electronic monitoring (EM), with standards recently adopted for ER and under development for EM. Lastly, she highlighted current discussions on Port State Measures (PSM), development of a Catch Documentation Scheme (CDS), and the development and review of the WCPFC Strategic Plan.

Peter Graham, MCS Policy Advisor, of the Pacific Islands Forum Fisheries Agency (FFA) outlined the Basic Gaps in the Regional MCS Framework. Mr Graham first explained the methodology of the gap analysis, which identified ten essential MCS components as fundamental for tuna fisheries including:

1. Licensing;
2. Vessel Monitoring System;
3. Observer Schemes;
4. Vessel Records and Authorisations to Fish;
5. Port Controls and Monitoring;
6. Prosecutions;
7. Boarding and Inspection and At Sea Patrols;
8. Data Management and MCS Coordina0on;
9. Aerial Surveillance; and
10. Legislation, Regulations and Management Plans.

He further explained how each component was assessed under a set 50 performance indicators and how FFA developed a compliance matrix using a traffic light system to score the various MCS components.

Mr Graham noted that data management gaps occur throughout essential MCS components and impact multiple aspects of MCS. Of particular note, he remarked that information is often not stored in a format that allows it to be easily analysed and cross verified. He pointed out that legislation in many island nations has not kept up with new developments and technologies and that, specifically, key flag and port states lack adequate legislation. Insufficient legislative tools include provisions enabling evidence to be used for prosecution or, for instance, prohibiting the landing of fish that has been illegally caught. He also noted that where there are sanctions available, they are often insufficient as a deterrence tool. Overall, Mr Graham emphasised that information management on the whole needs to be strengthened.

Mr Graham particularly noted that a big gap exists between the required FFA member state longline fishing target of 20% observer coverage and the level that is actually implemented, with most fleets struggling to meet even 5-10% coverage. He noted that this deficiency is driven in part due to broader challenges to the region's observer scheme, which includes high turnover of observers, poor working conditions on vessels, and a general lack of career opportunities.

Steve Masika, Surveillance Operations Assistant for the FFA Surveillance Centre, provided an overview of the Overview of Current Application of MCS Technology including human observers, E-Reporting, E-Monitoring, electronic surveillance, at-sea boarding and inspection, and manned aerial surveillance. Mr Masika generally covered a description of the currently available MCS technology and systems, the costs and logistics associated with their application, and general timing and delivery outputs associated with each technology or system.

Mr Masika noted that a fully operational observer programme is currently in place in the WCPFC region, with observers recording fishing effort and catch information, compliance, pollution issues and other vessels/aircraft sighted. He also noted the disparities in coverage as well as that timeframes in data transfer can range from days or weeks, to several months for data to reach the region's science providers, emphasising that data entry and sharing remains a major challenge.

Mr Masika remarked that there are several electronic reporting (ER) initiatives in the Pacific including a variety of electronic systems at various stages of being trialled or implemented.

He also observed that several Electronic monitoring (EM) trials had also been conducted in the Pacific, including one in 2015 in the Solomon Islands.

Mr Masika offered a brief overview of electronic surveillance technologies currently in use, including the FFA and WCPFC Vessel Monitoring System (VMS) and Automated Identification System (AIS) which is currently required for larger vessels but increasingly used by smaller vessels. He noted that these tools feed into the Regional Surveillance Picture (RSP) a Google Earth-based system maintained and operated by FFA. Using that system the FFA overlays

surveillance information where vessels may be categorised according to level of risk and, in turn, priorities for MCS efforts such as boarding and inspection.

Mr Masika briefly covered the FFA at sea boarding and inspection frameworks, which includes the Pacific Patrol Boat (PPB) Scheme, Niue Treaty Agreement, the US shiprider program, and WCPFC high seas boarding and inspection .

Mr Masika briefly summarised current applications of manned aerial surveillance in the region, which ranges among small cheap aircraft, leased aircraft, and military aircraft. He noted that each approach has various pros and cons with small aircraft for instance possessing good flexibility and dedicated time, but more basic equipment and images than that available from military aircraft.

Peter Graham returned to the stage to offer an overview of the Basic Costs of MCS Operations in the Western and Central Pacific. He emphasised the vast scale of the region (30 million square km, not including Australia and NZ) and huge fishing effort (1,227 vessels on the FFA register alone in Feb 2016) creates a substantial burden on resources. This, in turn, results in a monumental MCS task which, at this time, is facilitated in part by human observer coverage (100% observer coverage on purse seiners, lower levels on longliners and fish carriers), VMS satellite monitoring consisting of polling data on a 1, 2 or 4-hourly basis from purse seine, longline, and carrier vessels, respectively. He outlined the substantial costs of the VMS system, at-sea patrol missions, aerial surveillance and the observer programmes, which cumulatively is conservatively on the order of tens of millions of US dollars annually.

To conclude the morning sessions, Bubba Cook offered a presentation on Clarifying and Outlining Objectives for both MCS generally and for the workshop. In summary, he asked participants to:

- Keep the goals and objectives in mind during the workshop.
- Consider the improvement of MCS systems on a holistic basis.
- Think about the emerging and advancing technologies critically and objectively with respect to the current MCS infrastructure.
- Consider the MCS tools currently available and in use as well as the capacity, capability, and the legal framework to support the existing MCS infrastructure, and then contemplate the potential for emerging technologies.

Discussion

A participant requested clarification about the difference in vessel numbers on the FFA and WCPFC registers (approx. 1,500 vessels and 5,000 respectively). The response was that the discrepancy is based on the area of application in that the FFA registry deals with in-zone fishing in Pacific Island Country (PIC) EEZs, while the WCPFC registry deals with both with vessels fishing in-zone and on the high seas.

Several participants remarked on the value of a global fishing vessel register, based on UVI (unique vessel identifier) or IMO numbers. Participants referenced efforts within the Pacific region to expand IMO number coverage to this end. Participants also emphasised that vessel registers should also include information on beneficial ownership of fishing vessels, noting that "people that commit crimes, not ships."

> "The various solutions proposed here could help many organizations approach many topics, but the problem would always be the same: 'Can everyone approach the issue in a way that saves time and money TOGETHER?' The best approach might be a collective one." – Workshop Survey Respondent

A few participants raised the issue of the human dimension of new technology. They stressed the need to consider what makes a group receptive to being monitored, and why some are more willing than others. Alternatively, they noted a need for human involvement in MCS even with emerging technologies, *e.g.* video reviewers, drone operators, IT specialists. From a military perspective, a participant observed that the need for human resources doesn't change, but the skillsets do. For instance, a pilot might not be in an actual aircraft, but in a remotely located control centre. Thus, "unmanned aircraft" is a misnomer because there are still human jobs involved.

Participants noted that MCS traditionally involves a lot of time-consuming work. Thus, rather than asking how technology may replace humans, the better question presented might be, "Can we more effectively use technology to identify data of interest for human review and decision-making.

Session 3: Overview of Emerging Technologies

Integrated Satellite Imaging & Tracking Technology

Mr Yuval Magid of Windward Business Development offered a presentation of Windward's business approach, which incorporates a multi-source intelligence approach that incorporates satellite information. Mr Magid presented Windward as a maritime specialized data company, analysing data to bring visibility to marine

stakeholders. He noted increasing concern about ocean sustainability as a driver for their approach, noting that MCS professionals will ultimately be the ones who will make the difference. He pointed out that fisheries data is relatively abundant, but that raw data needs to be transformed into action. He described how Windward contributes to a solution by generating a maritime data platform, which aggregates over 100 million data points per day. Thereby, Windward can create "vessel stories" for all ocean-going vessels worldwide.

Mr Magid described the intelligence driven approach: (1) Take speed/location data from two vessels; (2) apply the proximity test (high proximity); (3) apply the duration test (more than 3 hours); and (4) identify that the vessels are engaged in ship-to-ship activity.

Windward's methodology generally consists of the following steps:

1. Targeting vessels of interest: Interrogate basic data (flag, vessel type, licenses, activities, *etc.*) For instance, look at foreign vessels with expired licenses or that have undertaken ship-to-ship activity without landing in local port.
2. Investigating: Building the vessel stories. Put together those stories – *e.g.* two fish carriers meeting on EEZ borders, not using direct routes.
3. Action: Plan inspections of both vessels and share information with other agencies.

Mr Dave Martin of exactEarth Ltd presented on Real Time Satellite AIS + Small Vessel Tracking. Mr Martin announced that second generation real time satellite AIS is being launched in 2016 for completion in 2018. He pointed out specifically that AIS was originally intended for collision avoidance and, at least initially, mandated for larger vessels, but is increasingly being taken up more broadly by vessels of all sizes. He noted the original design for AIS was ship-to-shore and ship-to-ship, but satellite AIS gives much greater visibility beyond coastal areas. He reported that ExactEarth sees 20,000+ fishing vessels (out of 4 million) and that the new second generation platform should enable a global revisit time of less than one second.

Mr Martin highlighted a new low-cost satellite based tracking for small vessels through Advanced class-B Satellite Enabled AIS (ABSEA). The system is basically a low-cost identifier to enable tracking of small vessels through AIS. He noted that the use of this technology could effectively remove "dark targets" from the broader picture. He also noted that the units provide distress signal capability. Mr Martin remarked that the new system is currently being trialled on over 50 vessels from small-scale fleets of various developing countries. He concluded by citing the additional community benefits offered by the technology including local job creation, community engagement, improved fishing practices.

Mr Phil Proud of Speedcast Intl. Ltd offered a presentation on an Introduction to SpeedCast and Satellite Technologies. Mr Proud gave a brief overview of Speedcast as a Hong Kong-based technology company established in 1985 and working in over 60 countries providing telecommunications, network management, maritime communications and infrastructure and equipment. He highlighted Speedcast's role as a global network and satellite communications provider to remote businesses and communities, emphasising that they are not aligned with any single satellite provider. Provide high speed broadband *e.g.* for accessing tablet data on vessels coming into Port Moresby. Operate SeaCast maritime solutions using Ku-band and C-band. Offer both IP (internet protocol) based services and message store/forward based services with both Inmarsat and iridium systems.

Mr Guan Oon of Collecté Localisation Satellites (CLS) provided an overview of the products, services, and applications that CLS has to offer for MCS Solutions. He noted that CLS has a 30-year history, with clients around the globe. Mr Oon highlighted products and applications offered by CLS including: (1) vessel location and data collection; (2) satellite oceanography and radar surveillance; and (3) maritime communications; (4) VMS hardware; and (5) ocean data monitoring (satellite and *in situ*).

As a specific example, Mr Oon described the MOVIMAR system operated in Vietnam, providing VMS for around 3,000 vessels as well as providing weather alerts. He also noted CLS' engagement in Indonesia with the INDESO system, which uses satellite technology to manage marine resources and combat illegal fishing and pollution. In conclusion, Mr Oon emphasised that CLS' general goals for MCS are to sell, integrate, partner, participate, transfer, build, and protect & solve.

Mr Bradley Soule of Satellite Applications Catapult outlined Project Eyes on the Seas, a collaboration between UK Government R&D Catapult initiative and Pew Charitable Trusts to build capacity to support MCS activities for developing nations and risk management for the seafood supply chain. He further remarked that Project Eyes on the Seas combines expert fisheries analysis with productivity enhancing technology to give analytical support and capacity building.

Mr Soule emphasised that the critical information to combine is location, time, behaviour, and identity using data from multiple sources to successfully use remote sensing and other sources of data for successful MCS operations. He

noted that remote sensing technologies still require investigation at the end of the day. For example, data may indicates vessels coming together and a satellite image my infer transhipment, but authorities still cannot see fish being transferred. Thus, despite the promise and utility of satellite information, Mr Soule insisted that the satellite technologies can only provide the context for follow up including: where and when; identity information; what is inferred from the satellite information; and what further investigation is required.

In summary, Mr Soule described Project Eyes on the Sea as an equation: Expert Fisheries and Enforcement Analysts + Productivity Enhancing Technology = Analytical Support and Capacity Building. He further explained that Project Eyes on the Seas' expert analysis provides support to governments, authorities and supply chains to deliver credible, actionable insights into fishing activities. He added that in future they intend to provide capacity building and in-country training to leverage Eyes on the Seas directly.

Ms Lioba Struck of outlined the focus of navama GmbH on using technology to support and develop Technology for Nature to ensure better nature protection in marine management. navama GmbH specialises in software development and data analysis, taking AIS current and historic data and correlating with other data including oceanographic, protected areas, and other environmental data. For example, Ms Struck explained how in one case they use an algorithm to identify licensed vessels fishing within protected areas, while in another case they correlate AIS/VMS data with satellite tagged whales to avoid collisions. She noted that navama offered four primary products or services including:

- transparentSea.org - Fisheries voluntarily share their AIS, VMS, GPS tracks to promote the good behavior and to reduce IUU risk.
- seeFish - Tracking from catch to plate to ensure premium certification processes and increase consumer trust in sustainable managed fish products with modern technology.
- smartTrack - Low cost, low maintenance, robust fishery vessel tracking devices for improved sustainable management of small scale fisheries (50% of world fishery fleet, high need in developing countries.
- seeOcean - Monitor and visualize fishery impact on marine resources worldwide for a fair, sustainable and open management of public owned nature resources.

Ms Struck concluded by explaining how navama can help through: (1) data analysis (fishery data, geoinformation, remote sensing); (2) technology consulting; (3) personalized solutions for individual challenges; and (4) a focus on innovation and technology development.

Discussion:

A participant pointed out that we now have the computing capacity to make this large amount and complex degree of information usable. These days most mapping systems can easily integrate data from different sources.

A participant asked about the potential of subsurface monitoring using satellite technology tools. Several other participants explained that some of the LandSat (US government publicly available satellite information) data crosses over into marine environment and can provide some information on such things as bathymetry and chlorophyll concentration. These participants noted that there are a few other optical satellite companies/networks doing similar work.

> "The secret is in the sauce, such as how we are able to merge the information coming from all the different technologies and methods and then use intelligent "data digestion" to take effective actions and decisions." – Workshop Survey Respondent

A participant noted the need to be targeted in data collection activities and consider the bandwidth required to support the display platforms from some of these products. Windward responded that the data packets used account for about 1MB of data under the Windward system. navama noted that their system works on smart phone and that a 3G network is adequate.

Another participant noted that data providers and companies need to be flexible in tailoring packages to local needs and limited infrastructure, emphasising the challenge many of these technologies face in light of remote locations. A provider responded that flexibility, in some cases, has meant driving across a border with data on a USB to send data. Another participant emphasised that the ability to work in an offline mode is also useful and should be considered when developing these platforms. Another participant emphasised that while people like to see flashy displays, often a system can be operational and work well in the form of a simple spreadsheet.

A participant remarked that removing dark targets requires not only preventing vessels from switching off tracking units, but also requiring more than one system to cross check and validate. This participant noted that MCS authorities should use fused capability of at least two systems (*e.g.* AIS report and satellite image), so that discrepancies may be identified and prioritised. This participant noted that, from a vessel perspective, all vessels

should have VMS as well as AIS. He noted that MCS authorities should also look at other aspects, such as where a ship disappears and where it reappears and enforcement can then work to fill in the blanks. This participant noted that for all the criticism of the shortcomings of AIS, only 1% of all AIS reports are deliberately misreporting position, but noted that there are also "half-dark" targets that are reporting while sending an invalid position that could be either a malfunction or intentional misreporting.

Key Points and Themes:

- Data is abundant and available! MCS requires sorting through the vast amount of data and then prioritising and profiling the data to take action.
- Solutions, potentially through technology, are needed to address bottlenecks (*e.g.* broadband allowing data submission before port call)
- There is a discrete need to remove dark targets including solutions for small vessel monitoring, improved use of AIS through uptake and reduction of switch-offs, and improvements in voluntary or mandatory position reporting.
- Developing vessel "stories" or "pictures" by providing information/context and identifying where further investigation is required.
- There is an inherent need for "flexibility". MCS practitioners must weight complexity vs. simplicity as well as identify and address the weakest link in a system (*e.g.* bandwidth)

Electronic Monitoring/Fish ID Software

Mr Javier de la Cal provided a presentation on Technology to support long-term Sustainable Fisheries through the Electronic Observer System, Satlink SeaTube. Mr de la Cal offered an overview of Satlink's operations, describing that they provide equipment and solutions, mostly designed in-house, for maritime (mostly tuna), land, and aviation sectors. He noted that Satlink's SeaTube brings together data on fishing activities (location, catch volume, composition, bycatch *etc.*) in an integrated platform. He also noted that the Satlink system complements observer programmes to improve transparency and traceability. Mr de la Cal described that their System has the following features:

- Up to 8 cameras operating simultaneously.
- Full time coverage 24/7.
- Valid, true and encrypted information.
- High storage and capacity with easily accessible information.
- Real-time information with alarm operation.
- Real and accurate data.

Mr de la Cal explained how the Digital Observer Service (DOS) provides "dry" observers an effective platform for reviewing video, providing trip reports, and other functions at-sea observers normally perform. He noted that the Satlink DOS is approved by Lloyd's Register of Quality Assurance to the ISO 9001:2008 standards and that the system is currently in trials in several Pacific countries.

Mr de la Cal noted the features of their system, including synchronised camera views, filters to identify important data, observer notes alongside data, and a mapping feature for points of interest. He further noted that these tools could be used to determine catch composition and even conduct size measurements. He described the pros and cons between human and electronic observation, but noted the two systems are quite comparable.

Mr de la Cal concluded by emphasising that Satlink E-Monitoring solution provides independent, verifiable, real and accurate information about the fishing activity that can:

- Increase actual observer programs coverage;
- Provide a cost effective solution;
- Provide a fully transparent system that can guarantee full documented catch and a traceable chain of custody; and
- Prove robust certifications systems.

Mr Howard McElderry of Archipelago Marine Research Ltd presented on Electronic Monitoring Opportunities for Commercial Fisheries offered by Archipelago. He noted Archipelago's long history in observer services, having been established in 1978, and that they now have a global reach with offices in Canada and Australia. Mr McElderry remarked on Archipelago's focus on environmental services, observer programmes, and, particularly, EM. He noted Archipelago's efforts to design and develop full EM programmes, with more than 30 pilot projects worldwide and 7 fully implemented programmes with over 600 camera systems deployed worldwide where they provide cameras, gear sensors and an analysis platform.

Mr McElderry remarked on the vital features of Archipelago's system including that it:

- is autonomous;
- is reliable;
- is tamper-evident;
- has multiple camera/sensor inputs;
- has continuous recording plus recording triggers;
- has high data storage capacity; and
- has strong data security.

He remarked that you need both context imagery, which offers an overall indication of activity, but also need control points where detailed identification and measurements can be taken.

Mr McElderry emphasised that technology is just the tip of the iceberg and does not function in isolation. He noted that the unseen parts of the iceberg are the EM services (the work behind the system) and vessel obligations (what the owner/crew must do to make EM work on board).

Mr McElderry explained why MCS practitioners should consider EM because it:

- provides very comprehensive fishery data;
- is well suited to a wide variety of fishing vessels and monitoring objectives;
- is often lower in cost and more scalable than human observer programs; and
- supports supports industry initiatives such as fishery certification and seafood traceability.

Mr McElderry concluded by emphasising Archipelago's long experience and expertise in implementing the EM technology in diverse situations.

Dr David Middleton of Trident Systems, in a presentation titled The Magic of Collaboration, emphasised that a key element in electronic monitoring is to build strong relationships with:

- the fishers on the water;
- the technology funders;
- the science community;
- the government agencies; and
- the eNGO community.

Through an anecdote using "Rain-X", a product used to keep glass clean, he noted the need to be aware of the weak points of a system because no matter how good the cameras are, if the lenses are dirty the video quality is going to be low. Thus, he emphasised that collaboration is at least as important as the technology itself.

Dr Middleton noted that Trident was established in 2012 as an initiative of NZ fishing companies with three goals in mind:

- Efficient data collection for fisheries management;
- Realising greater value from fisheries data; and
- Evaluating management procedures for lower information stocks.

He remarked how the industry wanted a solution to challenges in achieving these goals that did not cost a fortune. Trident offered an innovative solution that brought two key innovations to the table: (1) full-hemisphere cameras that

allow retrospective pan and zoom in the recorded footage; and (2) a proposal to build on the developing high speed networks in New Zealand to better manage "hands free" the large amounts of footage generated from vessels utilising cameras 24/7, 365 days of the year.

Dr Middleton described the "FishEye" system, which ultimately intends to do away with manual downloads, provide fully encrypted secure footage, connect to smart phone apps for real time viewing by vessel managers, and allow multiple people to view the data from different sites.

The FishEye system builds on a basic VMS system like "Legos", adding cameras and other environmental data collection as needed and desired. He noted that the aim of the system is to deliver data once and deliver it accurately, with the underlying goal to use that data to inform fisheries management while providing feedback to fishers in different areas about their performance relative to their peers and allowing improvements to be identified.

Dr Middleton pointed out that Trident's product is not just as an MCS tool for government agencies, but it is also a fleet management tool for the industry, a marketing tool for transparency, and even a way for families at home to follow their loved ones at sea. He also noted that FishEye technology delivers transparency as everyone is viewing the same data and also noted the rigorous policies and service agreements around data access and use supporting the system.

Ms Nancy Munro of Saltwater Inc offered a presentation titled Observer Services and Electronic Monitoring describing Saltwater's work on EM and perspectives on the bigger picture of EM. She pointed out that Saltwater's goal is to develop cost-effective solutions for real-world problems. However, she noted that a major challenge is presented with making EM technology work in the field.

Ms Munro noted that the Atlantic pelagic longline fleet (100+ vessels) represented the first EM programme in the US for the pelagic longline fishery, with the objective to validate catch accounting and monitor bluefin tuna bycatch. She remarked how the project was initially met with resistance from the industry and concerns about exposing bad behaviour on board. She emphasised that collaboration with the government agency and the industry was vital to agree to the scope of the work as well as to make refinements to the operation of the system in order to meet a deployment deadline of June 1, 2015. She cited an instance of collaboration with the industry whereby the law only required monitoring retrieval, so the parties agreed to eliminate monitoring of deployment, making it cheaper and more accepted.

Ms Munro emphasised that because operational EM is a legal requirement to fish in the Atlantic pelagic fleet, they needed a resilient and reliable system. She also noted that feedback to skipper if system is not operating as well as 24/7 support technicians to resolve on board problems with remote support constituted important aspects. She made a specific distinction of the need for "Tamper evident" vs "tamper proof" units, citing that "a completely locked box prevents vessel skippers from resolving problems with units."

Ms Munro remarked that distilling data to identify events of interest represents a big challenge. She noted that important approaches to make EM more successful include open specifications for on board EM systems, and collaborative open source software for data review. This makes systems more cost effective, flexible, compatible, and adaptable. She concluded with remarks that open source review software encourages collaboration, innovation and integration of systems and allows for future improvements to be easily incorporated.

Dr Jenq-Neng Hwang of the University of Washington provided a presentation on Automated Image/Video Analyses for Fishery Science, which focused on camera technology to potentially automate species identification and even measurement. He gave a description of how fish abundance estimation is traditionally done by trawl survey and the fish do not survive. Thus, managers sought a video survey system that uses a stereo camera system which would not only count fish, but also conduct size measurements and species ID automatically while allowing fish to pass unharmed after sampling. Dr Hwang noted challenges with data uncertainty, including that generated by low image quality or non-lateral and curved body fish. He also noted the large volume of video data as presenting a challenge. He claimed, however, that despite challenges, the system offered 88% accuracy compared to human observation and can give near real-time results.

Dr Hwang described how the system used 75 dimensions to identify species, achieving a level of 90% accuracy, increased to 93% accuracy with computer learning (automatic identification of key features). Furthermore, he remarked on advances that allowed for accurate length measurement even for fish that are bent with a corresponding very low error rate. Additionally, he identified that additional tools and methods exist that can narrow down species identification, but can stop at "partial detection" when confidence level is too low, for example recording a fish as being one of 3 species. If necessary, managers could then apply a long-term average to partial identifications.

Dr Hwang's presentation indicated that the image recognition is advancing rapidly and could become an important integrated tool for EM systems.

Discussion:

A participant asked if EM could detect purse seiners shooting the net and opening the purse to release undersized fish? They further questioned whether some of these sensors also record what is on the vessel's sonar, or their sonar buoy? Collaboration in EM requires discussion about catch handling protocols that vessels must follow when they are being EM monitored.

Integrating systems – once some equipment is on board, many more possibilities open up. Focus on fisheries data initially, but ecosystem approach makes much more environmental data useful.

Infrared sensor data with motion detection enables human behaviour to be detected without violating privacy/identifying individual.

EM can record seabird bycatch, but species identification is critical to population-level science. Identification is done after the fact – protocol agreed to allow this, *e.g.* crew member holding the bird up in front of the camera.

PANEL: What technology could have the single largest impact on improving MCS?

CMDR Gavin Baker, Yuval Magid, Amos Barkai, Jonathan Peacey, Colin Williams

In an opening statement, a panellist noted that it is frustrating that the driver of technological innovation seems to be an attempt to try and convert human tasks into technology rather than recognising the technology as a potential "game-changer" and re-thinking the scope to put people first rather than the technology. He noted that the objective of implementing technology should be to manage the fishery in real-time and implement daily management decisions. He further noted that this would, in turn, facilitate enforcement action in real-time. He stressed the importance of bring technological tools to the "coalface," by supplying those tools to the people who will ultimately take enforcement action.

Another panellist noted that much of the technology is both available and mature for implementation, but the real issue remains creating a step change in discourse and attitude to transparency. He remarked that if we desire this transparency we must be willing to reward it and not just use the transparency as a potential weapon. He stressed that if NGOs continually pillory industry for mistakes, they will inherently create resistance to transparency.

One panellist stressed that there is no silver bullet, but that the answer lies in the room. He stressed the importance of collaboration to bring us to 'one version of the truth,' where good information leads to good science and, ultimately, good management. He noted that, in NZ and the broader Pacific, fisheries management can get highly politicized, and this, unfortunately, can outweigh the good information.

Another panellist re-emphasised that the human factor is critical. He noted that when implementing something new, you must consider what you already have – especially the existing human resources – and how the people involved will deal with the new system or technology. He stressed that MCS practitioners and mangers must look at ways to augment what we already have and leverage what exists with new technology, rather than look at replacing current resources.

One panellist remarked that the fishing industry is very keen to improve and that visibility of what happens at sea is critical in doing that. He noted that the industry accepts there are areas where improvement is needed and stressed that industry is willing to partner with others to make those necessary improvements.

> "Widespread acceptance of transparency in fishing operations (data provision; VMS, video monitoring, *etc.*) will result in more effective and less expensive MCS than the non-cooperative compliance model." – Workshop Survey Respondent

An audience participant noted the importance of demonstrating benefits of these technologies to the industry. He cited the northeast U.S. scallop fishery, which is shut down upon reaching a certain bycatch level of yellowtail flounder, regardless of the amount of scallop quota remaining to the fisherman. He noted that rather than seeing the real-time bycatch information as a "stick," it was important to explain and better frame the benefit, which consisted of the return real-time information to the fleet as to where bycatch is occurring so they can avoid those areas and keep the fishery open.

A panellist asked a rhetorical question of "Is there a fundamental difference between an industry in a country prioritizing fishery reputation versus countries prioritizing a protein source for its population?" He noted that a company wants to be best in the world, whereas a local fisherman on the water generally just wants to be accepted by community and have their profession respected. He questioned how this dynamic applies to distant water fleets, where there is a big disconnect of the fishing community from the fishing grounds.

A panellist responded to the question that, if we intend to address these challenges, some of the countries in the distant water fishing chamber of Western and Central Pacific Fisheries Commission (WCPFC) must be convinced of the benefits. He noted that the distant water fleet industry representatives can play an important role in persuading their governments to accept such technology and monitoring.

Another panellist noted the urgency of addressing MCS challenges, citing the experience of Grand Banks cod fishery, where a lack of these tools led to a collapse of one of the most important fisheries on the planet. He stressed a fear that managers and MCS practitioners are going to lose control of the Pacific tuna fishery with the same result. He strongly emphasised the need to get the wider global community involved in and aware of the level of risk to the Pacific tuna fishery.

The facilitator remarked that in the WCPFC there is absolute and overt political resistance to implementing some of these technology tools. He noted there are some promising signs of progress, with a couple of countries showing initiative, but that, overall, some policymakers at the meetings are clearly opposed to any solution out of what appears to be principle and no rational argument. He noted that it is striking that the leaders in technology development (*e.g.* Taiwan, China) seem to be the ones most resistant to imposing these technology tools on their fishing fleets. He cited the strong irony in their position, but suggested that this aspect might present an opportunity.

An audience participant remarked that, although there is no silver bullet, we must not allow this to create a barrier to potential solutions offered by combined and integrated approaches. He stated that the approach to proposed solutions should not be "it doesn't work," but rather "how can we make it work?"

Another audience participant asked how these technologies might be applied to care for the several million square kilometres of marine protected areas (MPAs) in the Pacific region. A panellist responded that vessels fishing in unauthorised areas are one of the priorities of FFA MCS efforts, with VMS and other satellite tools being a critical component. He noted that local small-scale vessels or "dark vessels" are challenges, but that technology to address those components will further help protect MPAs.

A panellist observed that not everything with MCS does or has to happen quickly. He noted that it often takes enforcement officers years to gather evidence and build a case. However, he noted that by looking beyond your own area of interest and across borders it is possible to improve data and serve a greater purpose. He further emphasised the importance of building a profile and understanding what is happening at a regional level, which, in turn, helps locally as well.

An audience participant remarked that most fishers do not work to optimize their *catch*, but rather to optimize their *profit*. Thus, he noted that if technology allows fishers to increase their profitability without increasing their catch this that this could present a huge motivation. He emphasised that humans are ultimately driven by economics.

In conclusion, a panellist noted the FFA as a model because it is a "coalition of the willing" to address regional fisheries challenges as a unified effort under the Niue Treaty, which emphasises the importance of collaboration and data sharing. He noted the special arrangement which allows MCS practitioners in the FFA region to use enforcement resources where and when they are needed due to this agreed cooperation and collaboration. He noted specifically the importance of being able to use one country's patrol boat to enter another country's EEZ and enforce its laws, which magnifies the impact of limited resources and serves as a force multiplier and that tech resources can be used in the same way.

Key Points and Themes:

- MCS is currently under resourced in many cases.
- Technology is moving fast and we are simply not keeping up. However, we may not have to if we can continue to do our jobs well with the resources currently at our disposal.
- Technology is available, but we should not just pursue technology for its own sake. We must keep in mind MCS objectives.
- Acceptance of technology represents a critical element. The industry must see the positive incentives of the technology.
- There is no silver bullet, but it will take multiple technologies and policy changes. A well-formed policy and regulatory framework will be critical to the effectiveness of technologies.
- We must not focus only on the bad guys but also look at the good guys. It is equally important to emphasise the positive rather than negative and create appropriate correlated incentives.
- Eco-labelling has limited value because the burden of proof is unworkable or misapplied, leading to a lack of credibility in some cases.

- The pinnacle of MCS is to achieve voluntary compliance. Things like the ISSF Proactive Vessel Register, while not perfect, show promise.
- The initial reaction to new technology is often resistance to the release of what was once very secure and private information, but in many new technology applications more open information and resource sharing is ultimately viewed as a a positive (*i.e.* Uber, AirBnB, Facebook, *etc.*) Once there is a shift to sharing and collaboration, and acceptance of that shift, resources are more efficiently and effectively shared rather than isolated in "silos."
- One of the underlying issues growing in prominence is the increased desire for transparency and traceability associated with the supply chain that includes the appalling condition of some vessels, slave labour, illegal fishing, and general criminality at sea which must be addressed.
- Governments and RFMOs should develop regional standards for various technologies.
- Collaboration and agreed protocols with fishers is as important as the technology itself.
- EM presents a particularly powerful tool for verification and validation of catches.
- An open source approach could enhance the exponential development of EM by encouraging collaboration, making systems more compatible, and making them more easily built upon.
- Managers and MCS practitioners must consider the "human component," acknowledging the need to consider the people in the system, the various incentives (good and bad) associated with the technology, and how they accept/interact with the technology.
- We must consider building on and augmenting existing systems versus rethinking systems from the ground up (*i.e.* trying to imagine a new system that more effectively and efficiently uses human capacity rather than replacing a human with technology).

DAY 2: Friday, 4 March 2016

Introduction

Bubba Cook from WWF, started the morning with a presentation on The Evolution of Technology and Visions for the Future

Mr Cook introduced the presentation by noting that the presentation and the event overall was meant to inspire and encourage participants to think creatively about solutions to MCS challenges through the use of technology, but with a caution that while anything may be possible it might not always be practical.

He briefly described the theory of "diffusion of innovations," which seeks to explain how, why, and at what rate new ideas and technology spread through cultures. Using a graph, he described how any technology relies heavily on human capital and requires wide adoption to become self-sustaining upon reaching a "critical mass" of adoption. Next, Mr Cook described the "5 Stages of Technology Adoption": Knowledge > Persuasion > Decision > Implementation > Confirmation

Mr Cook then explained the "Technology Hype Cycle" through the use of a graph, which seeks to explain how some technologies evolve over time before showing how, when you bring the two graphs together, they offer some interesting observations of how technology evolves that should be considered by participants. He emphasised that the success of any technology depends on developers getting past the hype phase and responding to the needs and feedback of innovators and early adopters to make it work, then getting to a stage where there are more developers and second and third generation products.

He noted the key drivers for MCS technology, which include economic security, food security, social and cultural resilience, improved stewardship and subsequent economic returns, and the conservation of our shared ocean heritage. He challenged participants to consider some of the barriers to technology adoption, which include a lack of vision, drive, resources, institutional will, political will, or other factors.

In conclusion, he emphasised that industry must engage intently in the early stages of innovation as a critical element, pointing out that industry must join the early adopters (the innovators), and not become the "laggards" struggling at great expense to keep up with a changing environment.

Session 4: Overview of Emerging Technologies

Integrated Electronic Reporting

Dr Amos Barkai of OLRAC SPS presented on the The Development of Integrated Monitoring, Tracking and Reporting Technology as a Single, Cost Effective Solution for all Fishing Vessel Compliance Requirements. He expressed that fisheries are moving to a greater level of collaboration and self-regulation, influenced by sustainability, catch shares, cost recovery and environmental responsibility, which is driving a quest of practical and affordable means to collect credible and verifiable fisheries data.

Dr Barkai pointed out how current systems incorporate VMS (old, limited capacity and expensive), cameras (new, but not widely used yet), eLog (widely used in some regions but not others), but that those systems are not fully integrated with each information source functioning and treated as a separate system. Additionally, Dr Barkai explained that, for these non-integrated systems, objectives are often not well defined and only a small fraction of the collected data is even being used. He further explained that fishers often do not see the benefits of the technologies and often fail to even have access to the data of their own operations while only seeing the high costs of the tools.

Dr Barkai proposed that, rather than look at a wholly new technology, to assess the current available technology and offer an integrated technical solution through the product known as the eTMR. He described the modular, plug and play systems that are integrated, yet independent, and form the platform of the eTMR. He explained how the system incorporates:

- EM using eEye cameras (rapid action still cameras for high resolution at lower memory/cost);
- ER using OLRAC Dynamic Data Logger (Olrac DDL) providing eLog plus fleet level management; and
- A web-based fleet management platform using Olrac Dynamic Data Manager (Olrac DDM).

Dr Barkai noted the importance of using an "Audit Model" under which fishermen are required to submit honest reports, but where data is only scrutinised through an audit approach facilitated by random checks and investigation of discrepancies or suspicions.

Laser Imaging and Scanning Solutions

Mr Andrew Burrell of Global Survey presented on Laser Scanning & Imaging Solutions for High Density Spatial Data Capture. Mr Burrell encouraged participants to consider technology solutions broadly and stressed that it is important to step back and consider ways to use different technologies to address problems. He emphasised this point through a quote:

"If I had asked what people wanted, they would've said 'faster horses.'" Henry Ford

Mr Burrell talked about potential applications of LIDAR (light detection and ranging) technology, which takes integrated measurements to capture three-dimensional data and has terrestrial, mobile, and airborne applications. He also described potential applications of near infrared or multi-spectrum imaging, which possesses incredibly high resolution and can define characteristics that other imaging cannot. He also described how these laser and imaging systems can be fitted to aquatic and aerial drones to support mapping and other useful applications.

Mr Burrell noted several potential MCS applications for these technologies, including:

- Documenting vessels and volumetric data (*i.e.* identify false walls, hold volume, or hidden compartments)
- Forensic/incident scene analysis
- Measure areas, such as shorelines, to record and identify changes over time
- Fish species identification (*i.e.* a laser point cloud more accurate than basic image)
- Scanning a net as it is hauled and calculate catch volume

He concluded by noting the "art of the possible" in finding ways to use laser scanning and imaging technologies to achieve MCS goals, suggesting that there are many applications that can be considered.

Catch Documentation and Traceability Technologies

Mr Francisco Blaha presented on the Unloading Authorization Code and Mass Balance Tracking Programme originated from the FFA DevFISHII project in response to EU yellow cards issued to Pacific countries for IUU non-cooperation. Mr Blaha noted that fish does not become IUU during processing, rather it is either caught or landed illegally. He then described how this concept mixes Port State Measures and traceability systems to come to an integrated solution.

Mr Blaha used the analogy of an iceberg to describe a catch documentation scheme (CDS), with a catch certificate representing just the tip and only a piece of paper. He pointed out the issues with consistency, accuracy, and format that form the tip, but beneath the surface are catch accountancy (*i.e.* Port State Measures: observers, boarding and inspection, e-logsheets, *etc.*) and catch legality (*i.e.* MCS: laws, agreements, regulations, *etc.*).

He described the basis of an in-country catch accountancy system:

- Port Arrival Notification: Considers the details of cargo, VMS tracks, *et cetera* and defines the risk category (Vessel Compliance Index) of the vessels while allocating a Unloading Authorisation Code - UAC.
- Arrival and Offloading Inspection: Based on the arrival notification category the frequency target is established (25%, 75% or 100%) and the depth of inspection, including local and regional requirements.
- Processing Establishments: Participants establish a Mass Balance exercise (fish declared in, fish in stock, fish out) and UAC tracing.
- Export permits: Sales and exports accompanied by Catch Certificates (CC) that link back to UAC(s)

Mr Blaha then explained how the system worked both intra-country as well as inter-country, to facilitate traceability and transparency facilitated by a common identifier, the UAC, that follows the product throughout the supply chain. He note how tuna will often travel through several countries and that inter-country traceability relies on each country having a functional in-country system. He concluded with another poignant quote illustrating how more or better technology might not necessarily be the answer:

"We are stuck with technology when what we really want is just stuff that works" – Douglas Adams

Mr Mark Oates of iFIMS presented on the Integrated Fisheries Information Management System eCDS. He noted that FIMS is used by PNG and PNA for a wide range of their management systems. He further described how the iFIMS system currently used by purse seine and longline industry to report to governments on their fisheries activities. He then discussed how eCDS FIMS is a new separate system used by several Pacific Island Countries for the purpose of meeting EU transparency requirements. He noted that eCDS FIMS is provided to all nations fishing in PNA waters.

Mr Oates emphasised that eCDS FIMS will continue to be enhanced to provide a "fit for purpose" platform that can be made to communicate to regional authorities in a prescribed format or that the system may perhaps be provided as a trial platform for the regional authorities to oversee and audit the eCDS whist in its infancy.

Relating to the iFIMS eCDS, Mr Oates noted that the EU CDS requires:

- Legality of harvest (Logsheets, licensing, VMS et)
- Fish accountability (Mass balance elements)
- Certificate completeness and accuracy

Mr Oates pointed out that the existing system is retrospective, since a request for EU catch certification may come months after landing. This process results in CDS officers chasing back through historic records and balances. In contrast, he noted that the iFIMS eCDS issues an electronic Catch Certificate (eCC) at the time it is most easily verified, which is at the time of landing or transhipment. He expressed that industry wanted this system to make the process smoother, suggesting that using catch certificates and trade certificates allows for simple traceability through the system at whatever stage the EU CC is requested. Thus, he described how these other certificates all link back to original eCC. He also noted how the system integrates automatically, with the national FIMS is still the system used domestically, but it automatically updates to eCDS FIMS.

Mr Oates concluded his presentation by suggesting that other countries and regional authorities can access eCDS FIMS to produce EU CCs.

Mr Alan Steele of Traceall Global Limited presented on Sustainable Fishing Technology Solutions related to traceability. Mr Steele described his company's origin in traceability of fish and combatting illegal fishing, which is now even applied to combatting human trafficking. He cited statistics describing up to 43% of catch in Indian Ocean and 34% in the Western and Central Pacific as illegal, with 1 in 4 fish caught in Africa being illegal. He further noted that each year $10-24 billion worth of fish caught illegally. He described Traceall's solutions to include:

- Greater Control
- Quality Standards & Auditability
- Combats IUU

- Improved Fisheries Management
- Real time monitoring
- Control Human Trafficking

Mr Steele described the sea observer system, an on-board camera surveillance system that automatically calculates catch and links to an eLogbook. He described how the system incorporates touch screen controls and simple graphics, making the system accessible to even the illiterate. He noted that most fishers are able to estimate the weight of their catch to within 4%.

Mr Steele noted that the cost of development and deployment of these technologies are relatively high. Thus, he suggested that fishermen will not be the parties necessarily interested in buying these technologies or that a government mandate would be effective in forcing the implementation. He suggested that, when you consider illegal fishing impacts and factor such issues as fuel transfer, drug trafficking, human trafficking, and other illegalities that the incentive to monitor vessel activities rests with fleet owners.

Mr Steele noted recent work to develop an electronic CDS in Indonesia, which is also expanding to human rights issues including photographs and tax numbers of fishermen, which provides records and empowers fishermen to avoid being exploited by buyers. He concluded by emphasising that these technologies can be applied in small scale as well as large scale fisheries.

Discussion:

A participant asked where potential weaknesses might exist in more automated systems. He cited cases in even developed countries where laws have been systematically abused and expressed concern that, as fishery information systems are automated, we might be creating systems that can be abused or manipulated with loopholes. A presenter responded that in some cases clients have asked for a system in advance to test it and try to find ways around system boundaries. In one case, the presenter noted that he has specifically hired a graduate student for the sole purpose of trying to hack the system as a way to test the robustness of the system.

> "A key answer, in the context of Pacific fisheries, seemed to be that personnel capacity limits what is practical." – Workshop Survey Respondent

Another participant commented that there is a need to have an accounting/audit approach in all these technologies, with validation and verification at multiple levels. This participant stressed the need of one person checking another's work, specifically noting that even EM will not avoid need for observers on board.

A participant noted Indonesia's regulation against fishing in spawning areas for some species as a conservation measure to avoid small sized fish and maintain fish stocks. She questioned whether these technologies might offer or allow for visibility of who might be fishing in these spawning areas. A presenter responded affirmatively that the technologies could easily be adapted to meet that objective.

Remote Vessel Monitoring and Control Systems

Mr Gabriel Gómez of Marine Instruments outlined the Watching Man Pro, which could have applications for monitoring small-scale inshore fishing vessels.

Mr Gómez explained that Marine Instruments specialises in instruments for fishing, scientific buoys, security and tracking. He then described the Watching Man Pro system, which is a tracking system initially designed for pleasure yachts. He explained how the technology incorporates multiple sensors to detect things such as entry to the vessel, water in bilge, power on board, or an alarm if vessel leaves an area. He noted how this information was then distributed via cloud to the smart phone of the owner.

Mr Gómez provided a practical example of where the Watching Man Pro was developed as a system to track vessels entering Os Minarzos marine reserve (established by fishing association and NGOs after the Prestige oil spil environmental disaster). He discussed how the system uses GSM as opposed to satellite communication making the system less expensive and more publicly available. He described how the location, route, and time of all vessels operating in the area are tracked. Mr Gómez noted a unique feature in that the fisher, through a simple set of light indicators and audible alarms, is informed via the on-board system whether they are in the authorised fishing area (green), inside protected area (blue), or inside the prohibited area or in excess of a time limit (red and alarm).

He noted that the system also provides data to authorities for enforcement, science and management. He also noted future plans to add features such as sensors on fishing gear to see where it is deployed as well as crew safety alarms. Mr Gómez added that drones and unmanned surface vehicles could be queued and deployed upon a signal indicating illegal fishing or safety alert. He concluded by suggesting that the platform could also be configured to gather other data or evidence and even take environmental measurements.

Rapid Assessment Genetics

Dr Peter Grewe of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) presented on Fishery Independent Monitoring and Assessment for International Fisheries using Rapid Assessment Genetics. Dr Grewe emphasised that fishery independent data has many discrete advantages, not the least of which is that it is not impacted by changes in fishing efforts nor affected by bias or manipulation. He further noted that high-speed DNA analysis represents a cost effective and feasible solution for some of the challenges facing sustainable fisheries management, including addressing IUU.

Dr Grewe presented a case study in where these genetic techniques had been used for Southern bluefin tuna. He described how the stock had been fished down to 3-5% of its historic biomass and proper management was hindered by uncertainty of catches and variable recruitment. He pointed out how they had developed a new technique to count fish and assess population referred to as a "close kin abundance estimate." The estimate relied on the fact that each fish has two parents and that juvenile genetic profiles could be traced to adults.

Dr Grewe described how they analysed the genetics of juveniles and adults to measure the number of parent/offspring matches. He noted that a six-year peer reviewed study found 2.5 times more fish than previously assessed and reduced uncertainty as a result of the technology.

He then noted how the technology has potential applications for tackling IUU and misreporting through species ID in the field, provenance of fish populations, individual ID, and product tracking. He emphasised that it is possible to genetically differentiate yellowfin tuna between Western and Eastern Pacific populations or even differentiate between Coral Sea and Tokelau yellowfin tuna.

Dr Grewe stressed that further genetic assessment of stocks are necessary to facilitate species ID and provenance, which would, in turn, expose IUU and increase sustainable yields as well as improve consumer confidence. He concluded by noting that the technology allows for a global scope of application, and is even strengthened by better global coverage, but that collaboration and data sharing is vital.

Discussion:

A participant asked if the new system could be deployed by observers while on a vessel and at what cost. The presenter responded that the cost of equipment is approximately $1,000 for species ID, but that more detailed data would require more expensive equipment. The presenter noted that he envisaged the equivalent of a barcode, which would consist of a DNA plug sample by the observer as part of their report. That sample could then be used for identification down to individual fish. He also pointed out that the speed of processing influences cost and that they could currently process 20,000 fish in 3-4 weeks.

Another participant asked if the technology could also be used for shark species identification, which is currently a big issue in the Pacific. The presenter responded affirmatively.

Data Management Solutions Technologies/Cloud Computing

Mr Piers Harding of Catalyst offered a presentation The Convergence of Open Source for Analytics, which looked at open source solutions for data management and analysis challenges. Mr Harding discussed advantages of open source and open standards to reduce licensing and maintenance costs, avoid vendor lock-in, give the freedom to alter and share, and exchange data. He explained how this can energise innovation by reducing barriers to entry or change and allowing users to mix and match tools to best suit their needs. He explained how, as "big data" emerged, companies were faced with a decision to either go to existing providers and purchase a license to handle their data analysis needs or develop their own in-house solutions. He then described how efforts to develop in-house solutions matured and were ultimately released as open source platforms, which, in turn, stimulated adoption, innovation, and further development (*e.g.* visualization tools).

Mr Harding offered an analogous example of data management for schools in New Zealand. He noted how, similar to fisheries, there are thousands of institutions in NZ, with none in the business of IT, but all with IT requirements. He then explained how providing open standards and open source solutions allowed collaboration to meet common needs such as student identification and IT services. He suggested that open source platforms could offer a way to get around bottlenecks in the Pacific MCS information management system through remote cloud management of data rather than transfer of raw data or even analysis of the data from one side of the Pacific to the other.

He noted that open source platforms provide a set of discrete tools that:

- are flexible, powerful, and highly interoperable
- simultaneously fit a distributed and centralised productivity model
- allow mixing and matching based on requirements and resources available

- offer a low barrier to entry allowing a company to try, succeed, or fail quickly and allow for reassessment if necessary

Mr Harding concluded by emphasising that open source is unique in that some systems available only charge for resources used.

The State of Unmanned Surveillance Technologies

Mr Peter Smith of Textron Systems presented A Survey of Advances in MCS & Related Applications of UAS. Mr Smith noted the recent proliferation of civil UAS operators with over 3,300 civil UAS operators approved in the USA, and over 300 in Australia. He recommended that participants consider UAS not as an isolated technology, but as a toolbox that can perform a wide range of MCS tasks ranging from small UAS hovering over boarding parties to medium or large UAS on long duration covert surveillance recording legally enforceable data without detection.

Mr Smith pointed out the recent advancements sensors that allow smaller UAS to now undertake multiple roles in a single mission such as video, infrared, and radio/phone relay listening devices. He emphasised the possibility of cost sharing among multiple agencies with multi-purpose missions in mind, noting, for instance, that fisheries monitoring could be incorporating with environmental surveying or other data collection efforts. He also stressed the possibility of multinational sharing of UAS resources, which seems very possible under FFA's subregional structure.

Mr Smith described the full range of UAS tools, from nano (16 grams, 20 mins duration, $50,000 per unit and primarily for covert military use) through multi-rotors, fixed-wing, large and very large UAS. He cited one potential example of an MCS application using consumer multi-rotor drones ($1,000 - $2,500 per unit) above a fishing vessel to provide an aerial view of the vessel during a boarding and inspection operations. H also emphasised that, in wider surveillance considerations, UAS tools can support targeted investigation of dark targets and "hot spots."

Mr Smith noted that current technology can provide long endurance (shore based) or medium endurance (on board) operations. He discussed the ability of UAS technology to monitor sanctuaries against fishing, pollution, and also conduct abundance estimates and environmental surveys. He noted the additional search and rescue applications as well as natural disaster assessment and assistance features as well, clarifying that some UAS systems are able to fly in storm conditions in addition to surveying outlying areas while also providing a radio relay for communications.

He stressed that national airspace access represents an issue that regulatory authorities need to work together to properly address. He noted that a key technical advancement is 'sense and avoid' capability for that provides additional safety against collisions. He also noted that long-range deployment beyond line of slight is currently restricted by most governments.

Mr Smith acknowledged that UAS technology is experiencing a similarly exponential growth in advancement described with other technologies and related to Moore's Law. He described how UAS are becoming increasingly more relevant for enhanced maritime detection beyond normal human eyesight, with new advanced sensors that could expand search area 80 times the current capability. He concluded by emphasising that parallel technology development (*e.g.* reduced size/weight of sensor hardware, more compact satcom units) is rapidly expanding options for UAS.

Unmanned Aerial Vehicles (UAVs)

Mr Jack Kormas of Aerosonde presented on the Aerosonde Multi-mission Civil and Military UAS System. Mr Kormas noted that Aerosonde is Australian company now owned by Textron Systems in the U.S., but that Aerosonde independently holds many records, including the first transatlantic flight, longest continuous flight, and even arctic operations. He noted that mission performance would be different for each application, expressing that the key to success is reliability, and that reliability is largely engine dependent. He discussed Aerosonde's approach to using a range of engines to suit a particular mission and that the maximum take off weight of their UAS is up to 36kg with a 6.7kg payload capacity. He noted that this configuration would allow for mission endurance of 14+ hours at a speed of 65 knots and range of ~500km.

Mr Kormas described a system comprised of a body, engine, modular payload bays (allowing multi-mission capabilities), Expeditionary Ground Control Station, launch, and recovery. He noted that the system could carry a variety of payloads including video, infrared, transponder, anti-collision, high definition stills, LIDAR, and AIS relay.

Mr Kormas spoke about the trial that Aerosonde conducted in Palau in 2013. He described developing systems to extend range via handover to patrol vessel in a "hub and spoke" system that would allow an expanded range. He also stressed the need to consider important features when selecting a UAS, such as a desire to remain covert. He described some of the Palau detections that occurred in the trial, including illegal fishing vessels, small vessels, FADs, small-scale infrastructure, and infrared imagery.

Of particular note, Mr Kormas noted significant technology advances coming in 2016 including the development of VIDAR, a computer vision scanning tool capable of covering an extended search and detecting small objects in the water such as small/fast boats, helicopters, whales, and even a personal flotation device. He noted the further ability to use manual zoom to achieve a closer view of VIDAR imagery as well as its ability to use real time video from anywhere in the EEZ "storyboard," collected at 5 frames per second to offer real-time control of data channels.

Mr Kormas concluded by emphasising that UAS are very rapidly becoming an efficient and feasible technology for MCS purposes.

Discussion:

A participant asked about the potential of Synthetic Aperture Radar (SAR) to be used with UAS. The participant noted a concern with use of small UAV's ability to do actual 'search' missions rather than 'confirmation' missions. He expressed a need to be able to look for dark targets by surveying wide area, potentially through UAS technology, and asked how far we might be from operational SAR in a UAV of the size presented by Aerosonde. The presenter noted that SAR units are becoming increasingly available for use on UAS with the SAR units coming down in size and UAS capacity close to being able to carry it effectively as payload.

Another participant noted that for the purposes of MCS, he was more interested in a broad search area than in stealth capabilities. The presenter responded that the new VIDAR technology offers an 80 times greater search area and additional sensors can also search for all sorts of signals (*i.e.* radar, phone signal, *etc.*) which can "light up" dark targets even if they are not transmitting other signals such as AIS or VMS.

A participant noted that the UAV technology still seems to be prohibitively expensive. The presenter responded that buying a UAV and providing commensurate training for large operational staff is not the only option, noting that they also offer a leasing service where an operations team comes to the customer and provides the data needed. The presenter clarified that even just a one-man team could be provided in addition to training local staff to cover many of the roles for the operation of the UAS.

PANEL: What seems "possible" as opposed to what seems "practical"?

Losaline Koloa Lotoahea, Peter Graham, Pete Southen, Matt Merrifield

One of the panellists initiated the discussion explaining how often, at least in a Pacific context, there can be a lure of new technology without a full understanding of the hidden costs, such as training and maintenance, which can lead to products ultimately not achieving their full potential and promise.

Another panellist responded that there simply should not be any hidden costs. Costs should be very clear upfront and vendors should be very clear in making their proposals. He noted, however, that there may also be opportunity costs due to limited resources and personnel, and this also needs to be considered by countries when considering any new technology.

Another panellist emphasised some difficulties facing small island developing states like Tonga, which need to utilise limited resources in the most effective way. She expressed that developing countries with limited resources need a very clear cost analysis, including all associated economic, personnel and maintenance costs, in order to make any new technologies a reality.

> "I believe the MCS practitioners should be telling the industry what technology needs to be developed or improved, based on their needs to improve MCS gaps in the Pacific." – Workshop Survey Respondent

An audience participant noted that it would be useful to more clearly communicate who is the *beneficiary* and who is the *payer* for these technologies and systems. He suggested that large retailers and processors should be the ones willing to pay for the system, not developing country governments with limited budgets. He stressed that, from the perspective of a tech start up company, a potential customer base of 20-odd governments is not a huge market, while fleet managers or seafood traders present a much broader opportunity as a potential customer base.

Another audience participant enthusiastically expressed a view of huge opportunities among the presentations, including: the use of small, multi-rotor drones to complement at-sea boarding; backpack laser units to map out vessels during grid search; and big data analysis tools to analyse the data. He also noted how electronic reporting in near real time is already useful in reducing "creative accounting" opportunities.

A panellist expressed that using opportunities to streamline efforts can help use resources efficiently, such as using EM running in conjunction with VMS. He also noted that it seems necessary to maintain an ability to incorporate new technologies into existing systems.

Another panellist reminded participants that we must keep the ultimate purpose in mind when adopting new technologies, and remember there is a human element to using the technology. He pointed out that an on board human observer may actually pick up more details and provide more evidence that EM by physically being on board.

A participant followed that they believe that technology is not designed to reduce manpower, but to empower the people using it to apply brainpower at the appropriate higher level. In other words, he suggested that mundane elements such as scanning or data entry may be automated so personnel can focus on tasks requiring judgement, decision-making and prioritization, which, in turn, allows them to recognise and respond to discrepancies.

Another participant concurred that the issue is not necessarily a matter of eliminating jobs, but that the MCS workload can be made more efficient and effective, with improved working conditions. He expressed that we need to ensure training happening in the right areas, such as data analysis and programming, and ask ourselves whether we are keeping up.

A panellist acknowledged that, at a systems level, there may be many synergies between the various new technologies and that authorities should be willing to capitalise on those potential synergies, stressing that continued effort must be placed on identifying potential opportunities for technology. He added that Pacific Island nations can stand together more strongly even if each may have individual needs. He further added that it would be beneficial for technology industry experts to start to coordinate and find synergies that they can present to small nations for consideration.

An audience participant noted that a major constraint for PICs is internet access and reliability. He pointed out the continuing need of many PICs to apply the question "how much bandwidth will it require?" to every technology considered. He stressed this aspect also has major cost implications when bandwidth is so limited and expensive, adding that even just a consistent and reliable power source can be a barrier.

An audience participant responded that the tech industry needs to prove the value of technology for specific customers, emphasising that the burden of proof is on the tech industry to understand the specific challenges and limitations, and to work through trial stage to proof of concept. He stressed that the technology industry needs to hear more about the problems and specific challenges faced by governments to provide better tailored solutions.

A panellist stressed that tech is a tool, but can also be a liability. He noted that if evidence gathered by technology is not usable in court, it is not valuable. He noted that it is also important to note that where there is a development in technology there will be a corresponding effort to exploit or counter the new technology or system. He suggested that with each and every technology application we must diligently identify potential loopholes or gaps as part of product/system testing phase and that, with respect to technology, it is a bit of an "arms race".

An audience participant remarked that there well may be many potential 'silver bullet' technologies, but they still sit within a bigger system that must be considered. He expressed that MCS practitioners and regulatory authorities require a mind-set shift about what we do with the information and how we apply it to the issues we confront.

Another audience participant expressed that MCS practitioners must use a risk assessment and cost/benefit approach to prioritize and choose between technologies available. He noted that it all comes back to the objectives we are trying to achieve, with a big question consisting of what level of compliance we might be happy with. He added that objectives for MCS and science requirements might differ significantly.

In closing, a panellist noted that opportunities to have dialogue between MCS practitioners and technology industries are extremely valuable. He stressed that steps forward can include a greater understanding of the technologies, further discussion and refinements, pilot projects, and more. He noted the value in the workshop and the ability to have presentations and contact details available following the meeting to digest and share what was presented at the meeting and continue these conversations.

Key Points and Themes:

- Moore's law applies to most, if not all, technologies. Advancements are progressing at a rapid pace.
- Although technologies are advancing rapidly, MCS practitioners must consider basic issues such as technical, logistical, and financial capacity with respect to whether it is appropriate to apply the technologies.
- Pairing up technology advances happening in parallel is resulting in even greater advances – *e.g.* UAV developments and increasingly smaller/higher capability payload such as VIDAR.
- Open source platforms can help standardise systems, enable innovation and make systems more flexible, allowing for easily tailored solutions to be developed for countries facing similar-but-not-identical challenges.
- Efficiency must be improved by removing unnecessary burdens from the system, such as moving computing instead of moving data and reducing or eliminating duplication of data gathering (*i.e.* GPS system in several devices on board).
- Partnership and integration is needed and desired among tech providers, countries, NGOs, and industry leaders to best develop and implement emerging technologies.

Workshop Summary Outcome

Once again, technology and service providers received the unique opportunity to review and understand the challenges and opportunities facing MCS practitioners while considering how their particular technologies might contribute to addressing some of those challenges. In turn, MCS experts were given the opportunity to objectively review several emerging technologies as they might be applied in a fisheries MCS context and assess their economic and practical viability. As a result, the desired objectives and outcomes identified on Day 1 were largely achieved by the workshop. Participants looked critically at the technologies presented and how they might apply in an MCS context, acknowledging that, while "anything is possible," some technologies still are not quite practical or achievable even if they are advancing rapidly. However, at least two of the discrete technologies, electronic monitoring and electronic reporting, were identified as available and ripe for implementation and expansion in fisheries around the world.

A very encouraging outcome from the workshop included the development of at least four discrete partnerships or relationships between various technology providers and MCS practitioners during the event, with commitments to either pilot or implement technologies in an MCS context as a direct result of the event.

An electronic survey was sent out following the workshop requesting feedback on the content, organisation, and outcomes of the workshop. Responses to that survey were overwhelmingly positive. The results of the survey and some of the recommendations will be included in a separate document available to event participants.

Several overarching informational needs were identified by participants as necessary to move forward implementation of some of the emerging technologies. Most of these needs are identical to those previously identified including:

- A comprehensive MCS gap analysis;
- Basic cost estimates for each technology that are context specific;
- An objective and comprehensive cost/benefits analysis of each of the current MCS measures as compared to the emerging technologies;
- A needs assessment reviewing the IT requirements of individual countries necessary to support emerging technologies;
- A broad analysis of applications of various emerging technologies for MCS activities globally; and
- Big Data remains a critical technology advancement that should be explored.

Conclusion

WWF again wishes to remark on the high degree of positive engagement, discussion, and commentary by all participants at the MCS Emerging Technologies Workshop. The extraordinary degree of professionalism and expertise of the presenters was fantastic. 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. Most participants, either through the voluntary survey or independently, remarked positively upon the value of the event and strongly recommended repeating the event on a larger scale in the future.

One workshop survey respondent encapsulated the overall conclusion from the event quite well in the quote that follows.

> "There is no silver bullet to solve the issues and challenges of improving regional MCS capacity and capabilities. There are, however, many emerging technologies that, when they are brought together offer the potential to substantially improve regional MCS. The key will be to bring all of the participating nations/organisation/companies to a level of agreement that empowers the region to take the actions necessary to ensure the enduring viability of the Pacific Tuna fishery." – Workshop Survey Respondent

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Abbreviations/Acronyms

ABNJ - areas beyond national jurisdiction

AFMA - Australian Fisheries Management Authority

ALDFG - abandoned, lost or otherwise discarded fishing gear

ASV - Autonomous Surface Vehicle

BMP - Best Management Practice

CDS - Catch Documentation System

CSIRO - Commonwealth Scientific and Industrial Research Organisation

CCAMLR - Commission for the Conservation of Antarctic Marine Living Resources

CCSBT - Convention on the Conservation of Southern Bluefin Tuna

CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora

CMS - Convention on Migratory Species

Code - Code of Conduct for Responsible Fisheries

COFI - FAO Committee on Fisheries

CSO - civil society organization

EAF - ecosystem approach to fisheries

EEZ - exclusive economic zone

FAO - Food and Agriculture Organization of the United Nations

FIMS - Fisheries Information Management System

FFA - Pacific Islands Forum Fisheries Agency

GDP - gross domestic product

GEF - Global Environment Facility

Global Record - Comprehensive Global Record of Fishing Vessels, Refrigerated Transport Vessels, and Supply Vessels

IATTC - Inter-American Tropical Tuna Commission

IMCS - International Monitoring, Control and Surveillance Network

IMO - International Maritime Organization

INTERPOL - International Criminal Police Organization

IOTC - Indian Ocean Tuna Commission

IPOA - international plan of action

IPOA–IUU - International Plan of Action to Prevent, Deter and Eliminate IUU Fishing

IPOA–Sharks - International Plan of Action for the Conservation and Management of Sharks

ITLOS - International Tribunal for the Law of the Sea

IUCN - International Union for Conservation of Nature

IUU - Illegal, Unreported and Unregulated Fishing

LOA - length overall

MCS - Monitoring, Control and Surveillance

MOU - memorandum of understanding

MPA - marine protected area

MSY - maximum sustainable yield

NGO - Non-governmental Organization

NPOA - National Plan of Action

PNA - Parties to the Nauru Agreement

PICS - Pacific Island Countries

PSMA - FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing

RFMO - Regional Fisheries Management Organization

RPOA - Regional Plan of Action

SIDS - Small Island Developing States

TAC - total allowable catch

UAV - Unmanned Aerial Vehicle

UAS - Unmanned Aerial Systems

UNGA - United Nations General Assembly

UNEP - United Nations Environment Programme

UVI - unique vessel identifier

USV – Unmanned Surveillance Vehicle

VDS - Vessel Days at Sea Programme

VMS - Vessel Monitoring System

WCPFC - Western and Central Pacific Fisheries Commission

Our Smart Fishing Vision and Goals:

Vision: The world's oceans are healthy, well-managed and full of life, providing valuable resources for the welfare of humanity.

2020 Goals: The responsible management and trade of four key fishery populations results in recovering and resilient marine eco-systems, improved livelihoods for coastal communities and strengthened food security for the Planet.

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