Assessment of Emerging Technologies and their suitability for MCS&E in coastal fisheries for the Pacific Community FAME Coastal Fisheries and Aquaculture Programme

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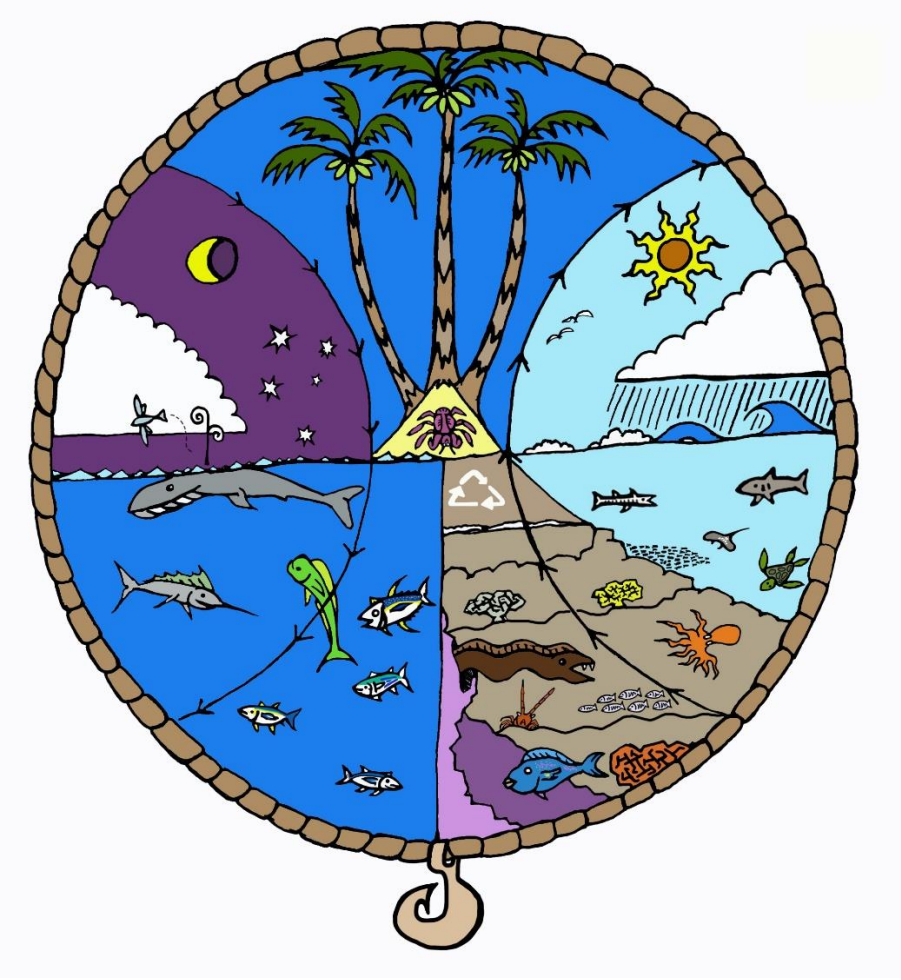

Executive Summary

This report is the result of a wide-ranging global review of over 100 companies and organisations, 75 direct consultations and nearly 200 tools and technologies that may have application in Pacific Islands coastal fisheries and aquaculture management and MCS. The purpose of the review is to *investigate the development of tools and systems to combat IUU fishing activities into coastal waters* to identify systems and equipment that may enhance Pacific Island Coastal Fisheries Officers efficiency and effectiveness. While acknowledging up front that every country and every situation is different and that there isn't a "one size fits all" solution, the hope is that this review will help to explain what the different tools and "tech" can do, what they cost, and what needs to be considered if you were to use them. It will also attempt to offer some suggestions or ideas for how the various tools and tech might work in the Pacific context.

It's important to acknowledge that the findings in this report may not apply to every Pacific Island Country and Territory in every context. All MCS solutions need to be tailored to the situation on the ground considering resources, capacity and the actual needs and circumstances. Given that, a number of tools and technologies did stand out to the author as having good potential for application in the Pacific Island context. A separate report based on this study was submitted to SPC recommending SPC to conduct trials of a number of these tools and technologies.

Fancy tools and technologies are not a panacea *for coastal MCS anywhere in the world, including the Pacific Islands. Effective MCS comes from suitably skilled and resourced Fisheries Officers working with a clear mandate and authority to regulate fisheries rules and regulations. This work is made much easier if the rules and regulations are based on good science, fisheries management and community involvement and awareness. If a good base can be achieved, all the other tools and technologies will be more effective.*

Below is a table listing the key tools and technologies considered by the author (in order of importance) to have the most potential impact and benefit for coastal fisheries management and MCS in the Pacific Islands. The appendix contains a listing of all the companies and organisations reviewed in this study.

Tool/technology	Proposed benefit
Baseline MCS tools and capacity for Coastal Fisheries Officers	With a solid foundation to work from, all of the other tools and technologies mentioned in this report will be more effective.
Regulator Apps	These systems can provide a risk based; intelligence led structure for coastal MCS. They can interface with virtually all of the sensor and other data created by the tools and technologies reviewed in this study.
Shore-based cameras	Cameras with the ability to recognise people and vessels are an inexpensive way to monitor ports, launch and landing sites. This data can be analysed to estimate fishing effort and access patterns.
Wildlife cameras	These cameras provide a similar benefit to the shore-based cameras but are highly mobile and discreet. Fisheries Officers can use them in different locations in remote areas.
Shore-based radar systems	These radar systems integrate with other sensors and cameras and can be deployed in remote locations such as Marine Protected Areas or other areas of interest. They can be used to establish usage patterns and well as enforcement interventions.

RFID for port monitoring	An inexpensive way to measure fishing effort with extra benefits of safety and traceability. This could be an easy step for monitoring vessels before proceeding down the VMS/AIS track.
Solar VMS/AIS vessel tracking	For regulators wanting to track artisanal fleets, there are now very compact, solar systems available. The key to implementation success will be to focus on the benefits of these systems for the fishers.
Acoustic sensors	If these hydrophones can be calibrated for a site and the data can be interpreted using artificial intelligence, they offer good potential to complement other shore-based monitoring systems.
USVs	While these solutions are quite expensive, they can function as highly mobile sensor systems that can be deployed virtually anywhere. They can serve to complement coastal MCS operations and can patrol very remote areas.
Other (not exactly MCS and not in any order)	Proposed benefit
Sonar FADs	These simple and inexpensive systems could be an easy way to promote fishing on inshore FADs and thereby help to reduce fishing pressure on other coastal species.
FishKit	This new platform looks to be a very easy to use and understand tool that can be used to engage with communities on coastal fisheries management and potential regulations.

Contents

Background

The development of robust Monitoring, Control, Surveillance and Enforcement (MCS&E or often just MCS) for coastal fisheries and aquaculture is a work in progress across much of the world, including in the Pacific Islands. Coastal fisheries and aquaculture are key contributors to the livelihoods and food security of many Pacific Islanders and they are also important for the economic and social well-being of their countries. Coastal MCS efforts in the Pacific Islands are often under resourced and/or have to compete for resources with Offshore MCS which is often given higher priority and resources due to the significant financial gains from access fees and fines for infringements. One way for coastal fisheries managers and officers to build MCS capacity is to work smarter and more effectively. This is where technology and tools have the potential to contribute to developing more robust coastal MCS.

SPC, with funding from the PEUMP Program, has asked the author[1] of this report to *investigate the development of tools and systems to combat IUU fishing activities into coastal waters*. This report is the result of a wide-ranging global review of over 100 companies and organisations and nearly 200 tools and technologies that may have application in Pacific Islands coastal fisheries and aquaculture management and MCS. A key focus of this work has been on identifying systems and equipment that may enhance Pacific Island Coastal Fisheries Officers efficiency and effectiveness.

It is important to acknowledge up front that every country and every situation is different and that there isn't a "one size fits all" solution. Rather, the MCS needs for any coastal fisheries or aquaculture situation needs to be evaluated on its own: What is the problem? What are you trying to achieve? How complex is this? What resources do you have to achieve this? Is the solution more costly than the problem?

The hope is that this review will help to explain what the different tools and "tech" can do, what they cost, and what needs to be considered if you were to use it. It will also attempt to offer some suggestions or ideas for how the various tools and tech might work in the Pacific context. This review will not recommend one company or solution over another due to the differences in context and needs of each situation. Simply put, there are too many variables. It will make broad recommendations for the tools and tech that show the most promise and it will list in the appendix, all the companies and organisations consulted in this review. Even though this list won't include every company and every tool or tech in the world, it should be a good starting point should you choose to investigate further.

A complementary report for SPC has been produced making recommendations for tools and technology that SPC can consider for trialling in select locations in the Pacific Islands. Those recommendations come from the same research that went into this report.

[1] Note from the author: I have a background in fisheries science, aquaculture, management, policy, and MCS. I'm relying on this cross-discipline experience and my understanding of fisheries administrations in the Pacific Islands to reach my conclusions. I wish to issue a disclaimer that these are my opinions which were formed from what I learned from the research and conversations during this review. I apologise if any element of my analysis isn't characterised perfectly. There was a lot of information to digest. This is my best effort to present my findings.

Methods

The methodology used to produce this report is summarised by step below:

1. The contract with the Terms of Reference for this work was signed on 7 October, 2021. Work began immediately.
2. Methodology for this review including categorisation of the tech/tools was developed and approved by SPC on 3 November.
    a. There were three broad categories that had a preliminary list of organisations and tools under each:
        i. Officer/Station Tech (use and return) - This is gear and equipment that may be available to Coastal MCS Officers to use individually or collectively from the station. It is gear that is typically used in the field and returns to the station with the Officer (i.e., not left in deployed in the field).
        ii. Remote Tech (deploy and retrieve) - This is gear and equipment that is typically deployed in the field and accessed or retrieved later either physically or remotely.
        iii. Other Tech - Technologies that can help coastal MCS but are not necessarily something you can hold in your hand.
3. The list of categories with a preliminary list of organisations and tools under each was circulated to each Pacific Island fisheries administration, all key regional agencies, NGO's and other key Pacific stakeholders with some interest or knowledge in the field. This was done in later November. Each stakeholder was asked to comment on the list and identify if anything was missing or should be included in the review. All suggestions were incorporated into the review. Note: The list of tech/tools under each is not exhaustive, rather, they serve as a representative sample. There will be more companies and organisations supplying these tools/techs than what are listed.
4. The desktop research on identified organisations and products was started in late November and continued into early February 2022. Over 100 companies and organisations and nearly 200 tools and technologies that may have application in Pacific Islands coastal fisheries and aquaculture management and MCS were reviewed. Over 75 of the companies and organisations were consulted virtually one on one to gain additional insights into how their tools/tech work. The reviews were conducted using the following assessment criteria as a guide:
    a. **Affordability** – Purchase and operating costs.
    b. **Operability in conditions** – Ruggedness, waterproof, battery/charge, etc.
    c. **Connectivity** – Cell, satellite, Bluetooth, Wi-Fi, VHF, UHF, etc.
    d. **Maintenance** – Do they require regular service? Can this be done locally or by a specialist?
    e. **Parts/Service** – How easy it is to access parts/service?
    f. **Training/Skills needed** – How hard is it to operate? Do you need special training?
    g. **Security** – Is it private, encrypted, or otherwise secure in any sense?
    h. **Legality** – Might there be legal issues re: the use of this product? Any evidentiary precedent?
5. Research findings for each type of tool or technology within each category were summarised. This included summarising the what the tool/tech is, the costs, operational considerations, and potential Pacific applications.
6. All of the findings were then compiled into the Results section of this report. For each category, the following was documented:
    a. Generally, a description of what the tool/tech is. How does it work? What can it do?

b. Cost considerations (range of purchase and operational costs).
c. Operational considerations. Ruggedness, connectivity, maintenance, skills needed etc.
d. Potential applications in Pacific coastal fisheries management and MCS.
e. Hot link to appendix directory of companies/products.

7. The rest of this report was completed based on the Results and was then submitted to SPC.
8. A separate report with recommendations for specific tools and technologies to consider trialling in or on behalf of the Pacific Islands was also produced and submitted to SPC.

Review Results

Officer/Station Technology (use and return)

1. Fisheries Officer field tools/equipment

1.1. Officer operational gear

Description:

Effective MCS comes from suitably skilled and resourced Fisheries Officers working with a clear mandate and authority to regulate fisheries rules and regulations. This work is made much easier if the rules and regulations are based on good science, fisheries management and community involvement and awareness. If a good base can be achieved, all the others tools and technologies will be more effective. There are some key gear and baseline tools and technology that could be considered as a minimum set of operational gear for a fisheries field officer. All of the other gear and technology discussed in this report are things that can be used in addition to this baseline gear to complete the Officers work. Some of the baseline MCS tools and capacity include the following:

1. **Key gear**
    a. Official uniform, hat and identification badges.
    b. Fisheries Officer reflective vest.
    c. Safety gear such as first aid and protection from the elements.
    d. Smart phone with good digital camera and suite of useful Apps.
    e. Two-way radio or satellite communicator if cellular is not available (reviewed in this study).
    f. Official notebook.
    g. Gauges and measures such as rulers, vernier callipers, tape measures and portable scales.
    h. Binoculars (reviewed in this study).
    i. Torch/flashlight.
    j. Multi-tool.
    k. Access to a quality DLSR camera with zoom lens if there is need to gather evidence from a distance (reviewed in this study).
2. **Key capacity**
    a. Fisheries Officer training (e.g., Cert 4/other).
    b. Specific training in the deployment and use of tech/tools (e.g., DSLR camera with zoom lens training for evidence gathering).
3. **Communication/awareness**
    a. Printed awareness raising materials re: fishing rules and regulations including posters, brochures, pamphlets, and other to distribute to communities and stakeholders.

b. Useful tools to distribute such as measuring devices (e.g., ruler stickers printed with fish photos and size limits).
c. Pre-prepared presentations to give to communities to raise awareness of the rules and regulations including web links to resources.

Cost considerations:

Most of this key gear is already known to all Pacific fisheries administrations. Some of the operational gear such as cameras, binoculars and communication devices are reviewed in the sections below.

Operational considerations:

A Fisheries Officer working in the field should have most if not all of the gear and equipment listed above. This will enable them to conduct official business in a safe and effective way for the communities they serve. Having these baseline tools and capacity will enable Fisheries Officers to better utilise the various other tools and technology reviewed in this study.

Potential Pacific applications:

Use of the above gear and equipment is really only needed for field operations. If Fisheries Officers are doing their MCS work from the office, they do not need most of this gear. As such, some of the gear could be shared or rotated amongst Officers if and when they work in the field.

1.2. Safety gear

Description:

Safety in the field is critical for Fisheries Officers as they work in a large variety of environments including remote areas, crowded areas such as markets and dangerous areas along coasts, lagoons and reefs. Safety gear can be described as items such as first aid kits, sun and eye protection (hats and sunglasses), puncture resistant (search) gloves, masks, hydration containers, radio/communication devices and Emergency Position Indicating Radio Beacon (EPIRB) or Personal Locator Beacons (PLB). The emergency grab bags distributed by SPC contain a personal locater beacon (PLB), strobe light, compact medical kit, a signalling mirror and whistle, a rescue laser and sea rescue streamer, a marine handheld VHF radio, a sea anchor, three manual inflatable lifejackets, a directional compass and two emergency thermal blankets. A number of EPIRBs and PLBs are covered in this review. They provide worldwide coverage, position location accuracy, a reliable transmitted signal, an encoded message that identifies the distressed vessel, and a faster response time for help if they are activated. Once the carrier of the EPIRB or PLB activates the device, it emits a distress signal on the 406 MHz frequency. The repeating SOS signal is detected by the COSPAS/SARSAT system of polar orbiting satellites. An alert is sent to the Mission Control Centre (MCC) via Local User Terminals. The MCC then notifies the registered Rescue Coordination Centre (RCC) nearest to the EPIRB/PLB location to dispatch applicable search and rescue resources.

Cost considerations:

EPIRBs range in cost between around US $215 - $650 each and PLBs range from about US $270 - $380 each.

Operational considerations:

The biggest difference between EPIRBs and PLBs is that EPIRBs are registered to a boat while PLBs are designed for use by an individual. EPIRBs are often mounted on the boat itself, while PLBs are usually worn on a PFD or

carried in a pocket or in a "emergency grab bag" (a bag of emergency gear you can grab in a hurry). Category I EPIRBs are designed to automatically release from their mounted position and activate when they become submerged, while Category II EPIRBs may be hard-mounted or carried in a bag and are released and activated manually. EPIRBs are larger than PLBs, usually have more battery life (they're required to have a minimum of 48 hours of activation time versus 24 hours for PLBs), and they always have a strobe light built in, while PLBs may or may not have a strobe light. The generally have 5+ years of battery life when on standby (not activated).

Potential Pacific applications:

An EPIRB should be considered basic safety equipment for any vessel venturing to sea. PLBs have an added potential safety benefit for Fisheries Officers in that they are registered to the person, not the vessel. They can also be used on land and are easily packed by the Fisheries Officer in their gear bag offering increased safety in the field.

Hotlink to appendix of suppliers

1.3. Communications

1.3.1. Smartphones (cellular/Wi-Fi enabled)

Description:

Smartphones and the features they bring such as communication, GPS, camera, video, voice recording and a host of other applications have enormous utility for Coastal Fisheries Officers. They are useful as a data and evidence gathering tool as well as an information resource if there is cellular data and/or wi-fi data connectivity sources.

Cost considerations:

Many of the useful apps and features come preloaded on the phones and additional apps are easily sourced online. Many useful apps are free and others are quite inexpensive. Android based systems are generally cheaper and more frequently used in the Pacific Islands that iOS (iPhones).

Operational considerations:

Given all the apps and features available on modern smart phones, they seem like they should be a requirement for any Fisheries Field Officer. Some of the key features and benefits for Officers include:

- **Communication** – cellular voice and messaging along with web enabled chat and communication platforms.
- **Safety** – the ability to communicate with each other and supervisors along with GPS location technology helps with Officer safety in the field.
- **Weather** – weather, wind and tide forecasting help with planning and executing patrols.
- **Navigation** – compass and map features can help with navigation and sharing locations (pins) with others.
- **Evidence collection** – phone, video and voice recording can all be used in evidence collection with the added benefit of time stamps and geolocation.
- **Data collection** – applications such as TAILS and other e-reporting apps can help with gathering needed fisheries management information.

- **Web** – the ability to access the internet in the field opens the possibility of accessing web enabled platforms such as vessel and person registries as well the ability to do general searches for information.

Potential Pacific applications: Smartphones are a multi tool that have eliminated the need for many other bits of gear that a Fisheries Officer may have carried before such as separate cameras/video, weather forecasts/tides, printed maps, digital voice recorders and data collection forms or systems. All of these and more are within a smartphone now.

1.3.2. Non cellular communication devices

Description:

Non cellular/Wi-fi connected devices such as Satellite phones and radios (VHF/UHF) can offer connectivity to the office, the authorities, or each other when operating in the field out of range of cellular connectivity.

Cost considerations:

Satellite phones range in cost from about one to a few thousand (AUD) to purchase. Satellite enabled communicators are cheaper ranging from a few hundred to more than a thousand (AUD) to purchase. VHF/UHF radios used by law enforcement are generally very expensive ranging from more than a thousand to over six thousand (AUD) per unit to purchase. The real cost in satellite phones and communicators is the cost of either being on the Iridium or Inmarsat network.

Operational considerations:

The satellite phones generally have over 24 hours of standby time on a charge and a few hours of talk time if needed. They are generally robust and water resistant, much like normal cell phones. Satellite enabled communicators have longer battery life and use less data to connect and message. VHF/UHF radios are robust with good battery life but will have limited utility without repeaters around the area as they function on line of sight. They may be suitable for Fisheries Officers if other local law enforcement agencies use them and the system can be shared.

Potential Pacific applications:

Satellite connected devices may be the only option in remote locations that do not have other connectivity. They are not likely to be cost efficient for regular communication for an Officer, but they can serve very well as safety devices and for sending/receiving limited information in remote areas. Having a small number of these devices at a station that can be deployed when Officers are working in remote locations would have great safety and operational benefits. VHF/UHF radio systems are likely too expensive an option unless the Fisheries agency can piggy back on existing police or military systems as setting up repeaters and system programming will likely be cost prohibitive.

Hotlink to appendix of suppliers

Additional Resources:

Digital Cameral World Review of Sat Phones https://www.digitalcameraworld.com/buying-guides/best-satellite-phones

VHF/UHF solutions https://firstsourcewireless.com/blogs/blog/police-walkie-talkies-vs-commercial-walkie-talkies-key-features-compared

1.4. Data/evidence collection

1.4.1. Manual gear

Description:

This includes core gear such as Official Notebooks, note pads, rulers, scales, callipers etc. that Officers use in the field. Most of this gear is covered in section 1.1 above.

Operational considerations:

Not reviewed in this study.

1.4.2. Tablet and laptop computers (for field notes, apps, data collection)

Description:

Portable laptop computers and handheld tablets. Laptop computers and tablets are fairly common so only a few ruggedized options were reviewed.

Cost considerations:

Some of the ruggedized tablets and computers reviewed in this study cost between US $416 - $2,399. This seems to be reasonable and in the range with other standard, not ruggedized machines.

Operational considerations:

Standard tablets and laptops can be semi protected for field work but ruggedized machines may be better suited for field work, especially in wet areas. Ruggedized tablets are a good option for field work. They have good battery life and are resistant to drops, water and general rougher use.

Potential Pacific applications:

Ruggedized computers and tablets seem to be worth the extra money if their primary use will be in the field, particularly in wet areas. They will give the user a bigger screen than a smart phone for collecting and entering data. If it is inefficient to collect this data on smaller smart phones, then these devices are worth utilizing.

Hotlink to appendix of suppliers

1.4.3. Camera and video

Description:

A good camera either as a point and shoot/smart phone camera and/or a quality DLSR camera with a zoom lens are very important equipment for a Fisheries Officer operating in the field. Photos (and video) are excellent for gathering intelligence and evidence. Every Fisheries Officer should have some sort of camera in the field, noting that for most applications the camera on their Smartphone will likely do most of what is needed.

Cost considerations:

High quality digital SLR cameras cost between US $417 - $1,499. Quality zoom lenses with zooms in the ranges of 50-300m can be found in the price range of US $439 and $1,645. Waterproof “GoPro” style camera/videos and 360° views can be purchased for around US $400.

Operational considerations:

If you assume Fisheries Officers have smart phone cameras, then smaller point and shoot cameras are redundant. DSLR cameras are useful for gathering intelligence and evidence when they have good zoom lenses that can be used at distance, noting the need for a trained operator to fully benefit from this tool (see below for expert camera advice for Fisheries Officers). Care needs to be taken as these cameras are pretty delicate and are not ruggedized equipment.

Potential Pacific applications:

A quality camera with a zoom lens could be considered baseline equipment for a Fisheries Field Officer that is tasked with gathering evidence. If this type of field work is not required, then simple point and shoot or smart phone cameras will likely be all that is required. It's worth noting that in order to fully realize the value of DSLR cameras with zoom lenses, the operators should receive specialized training. There may be other applications for the GoPro style cameras in that they are small and waterproof. These cameras could also potentially double as a kind of body or safety camera for officers in certain situations.

Hotlink to appendix of suppliers

Expert camera advice for Fisheries Officers

For a standard Fisheries Officer that may not have extensive camera skills, a point and shoot (auto) function may be all that is needed noting that modern smart phones will take an excellent photo in almost all conditions for close ups of accused, evidence and general location and context photos.

For a DSLR where good longer distance or technical surveillance use is required, a good mid-range Nikon, Cannon type body with a reasonable zoom capability like 70-300mm would be a good standard issue but really depends on main intended uses and environment it is expected to work in. The cameras don't like sand and they have a limit on distance from which you will take an effective photo. It is worth getting a screw on UV lens filter for any DSLR lenses.

Camera body is just as important as lens in SLR's for quality and functionality. As for zoom lenses, it all depends on what the officer wants to achieve. Is it distance? Is it close up evidentiary photos to prove a breach during an apprehension? Is it surveillance in any conditions where you have to play with manual settings to get the camera to capture what you want it to? If the officer is acting as a surveillance operative, the camera doesn't know what you are thinking and which part in the view finder you want it to focus on or meter the light, if the subject is moving and how quickly, what the ambient light is, any contrasts of light with the subject. Otherwise, you will take a lovely photo of the wharf on a nice sunny day except you can't make out the ID of the person standing in the wheelhouse of the boat in the shadow. Either that or the whole photo except for the twig from the bush just in front of you will be out of focus. You can get the camera to do amazing things in surveillance but it will need technical training and regular practice.

The only other thing to consider is the type of SD card. These DSLR's have the capability to dump very large photo files onto the card rapidly. A basic SD will not cut it or will significantly reduce certain functions like doing a burst of photos for as long as you hold the shutter release down. Unless you have a high quality or "Extreme" type SD card with high download speed, it slows the burst sequence down considerably as the file takes too long to dump onto a standard card before it will allow the camera to take the next shot in the burst. These extreme SD cards are more expensive but are a must for burst photos. An example of this is a drive-by of a subject location where you take a whole burst of photos up the driveway of a premises as you go past on the road without slowing down so you avoid attention. You will need as many frames in the burst as you can get for intel gathering and so you need the card to accept them without any pause.

1.4.4. Body cameras

Description:

Officer worn body cameras that can provide officer safety and evidence collection assistance.

Cost considerations:

There are few cheaper models on the market that cost in the range of US $130-$270 but they don't seem to be used by the serious law enforcement agencies. A GoPro camera can be adapted as a body camera for about US $40. Serious law enforcement body cameras used by police range from about US $1,000 to $1,300 each and there are additional costs depending on the level of connectivity and evidence gathering features you want. Many of these types of features incur monthly fees.

Operational considerations:

Body worn cameras can be excellent officer safety tools as well as a supplement to gathering evidence and conducting interviews. These cameras can also be used for training and mentoring, either through retrospective analysis or the live connection for on-the-spot advice.

Potential Pacific applications:

The higher end law enforcement body cameras are likely to be more than what Fisheries Officers need in the Pacific, given that much of the "law enforcement" comes from the Police in most places. There may be applications for the lower end camera systems to assist with interviews and gathering evidence in the field in places such as fish markets. They should not substitute for normal evidence collection methodologies that officers use in the field, but can supplement these methodologies with extra information. They can also serve to provide the officers with some additional security.

Hotlink to appendix of suppliers

1.4.5. Distance viewing devices

Description:

Handheld binoculars, image stabilised gyro binoculars, and spotting scopes for viewing targets at distance.

Cost considerations:

Quality binoculars can range in cost between US $50 - $600. Image stabilised gyro binoculars range from US $550 - $9000. Spotting scopes (often used for hunting but sometimes for viewing) range from US $175 - $1800.

Operational considerations:

Quality standard binoculars with 10x42 or 10x50 magnification are very useful for finding and observing activity in the field. It should be noted that the higher the magnification, the more need for them to be stabilized so you can see clearly without having the image shake. Gyroscopically stabilized binoculars are extremely useful when in a moving vehicle or vessel. They automatically stabilize the image so you can remain focused on the target you are viewing. Spotting scopes are mostly used for hunting, but could work like binoculars for officers.

Potential Pacific applications:

A good pair of binoculars could be considered basic equipment for an officer working in the field. Binoculars are extremely useful in observing fishing activity from a secure distance. Image stabilized binoculars are essential if the officers are conducting their field work from a moving vehicle or vessel. Normal binoculars are challenging to use in rough conditions.

Hotlink to appendix of suppliers

1.4.6. Other viewing devices

Description:

Night vision, infrared, and thermal types of viewers, typically used for seeing things in the dark or in low light situations.

Cost considerations:

Night vision goggles range in cost from US $200 - $500. Infrared (IR) viewers cost between US $140 - $400 and thermal viewers cost between US $600 - $5000.

Operational considerations:

Night vision goggles are helpful to see at night as the don't magnify what you are seeing. IR viewers use short wavelength infrared light to illuminate an area of interest. Some of the infrared energy is reflected back to the viewer and interpreted to generate an image. These viewers can magnify the image you are looking at like binoculars. Thermal viewers use mid- or long wavelength IR energy. Thermal imagers are passive, and only sense differences in heat. These heat signatures (usually black (cold) and white (hot)) are then displayed on a monitor. Because thermal imagers operate in longer infrared wavelength regions than active IR, they do not see reflected light, and are therefore not affected by oncoming headlights, smoke, haze, dust, etc. The range you can see depends on the model you buy but they can see a person at night 150-300 meters away.

Potential Pacific applications:

Night vision, IR and thermal viewers can be very useful for Fisheries Officers if they are working at night. They are especially useful for finding and seeing people on the water or on a reef at night. They can even detect heat signatures on items that may have been dropped or hidden.

Hotlink to appendix of suppliers

2. Unmanned surface vessels (USV) or autonomous surface vehicles (ASV)

Description:

Unmanned surface vessels that can carry out surveillance, patrols, and remote sensing for Fisheries Officers using a variety of sensing technologies as the payload. They operate on the surface of the water and do not require crew. Some require remote control and others operate with varying levels of autonomy. They can be any size, but are often smaller than normal vessels.

Cost considerations:

These solutions are quite expensive. Purchasing these USVs can range from US $40,000 - $250,000 with one full-service model costing US $2 million. Using them as a service can cost from US $2000 - $4000/day. Costs for using them may be able to be shared amongst other agencies for different purposes: Border/police security, Fisheries, Oceanographic measurements/science and others.

Operational considerations:

A number of these USVs can be deployed for very long periods of time due to operating on solar and/or wave propulsion technologies. The operability of these USVs depends on the types of sensors that you load them with which will affect the power usage. Most of them seem to be best suited to gathering oceanic/other data but some have surveillance capabilities. These are likely to be most effective when used with other assets such as vessel or aerial patrols if response capability is desired. There are a broad range of sensors that can be deployed on these assets. Some of the more relevant for fisheries MCS would be radar, LiDAR, optical/camera, hydrophones, radio signal detection, IR, and thermal. They will generally use satellite or radio connectivity back to base and data/images can also be stored on board and retrieved later. They may be most effective if deployed as a small fleet to cover large areas as then they can all be managed by one operator/command centre.

Potential Pacific applications:

Unmanned Surface Vessels (USVs) may have an application for coastal fisheries monitoring if they can be run in collaboration with other users to defray costs as well as in fleets so that operator costs can be minimized. They have long range capability and are relatively undetectable given their low profiles. Given their significant cost, they would also likely need to be deployed with other air/vessel assets at the same time to get the most benefit of their use. Another possible way to make them more cost effective could be to have a centralised flying squad of operator/maintenance technicians and a fleet of USVs that can move between PICTs. This would still not be cheap but could share the cost of operation between multiple PICTs and allow fisheries authorities to more effectively monitor remote coastal sites such as MPAs.

Hotlink to appendix of suppliers

3. Autonomous Underwater Vehicles (AUV)

Description:

Unmanned underwater vehicles/vessels that can carry out surveillance, patrols, and remote sensing for Fisheries Officers. They are essentially an autonomous underwater vehicle (AUV) that travels underwater without requiring input from an operator. AUVs constitute part of a larger group of undersea systems known as unmanned underwater vehicles, a classification that includes non-autonomous remotely operated underwater vehicles (ROVs) – controlled and powered from the surface by an operator/pilot via an umbilical or using remote control.

Cost considerations:

All the systems reviewed are quite expensive, in the range of US $250,000+. Some of the towable camera systems are cheaper, but may not serve a great purpose for MCS given they are being towed by a manned vessel.

Operational considerations:

They can operate for very long durations but need dedicated operators and deeper water to function effectively. The towable cameras can be useful for marine surveys.

Potential Pacific applications:

AUVs seem better suited for long range oceanic applications. They are expensive, require trained, dedicated operators and may not be compatible with shallower inshore areas. The appear to be too expensive and technical to work effectively in the coastal MCS context. They may have tuna applications given the ability of some of them to track tagged fish. The towable camera/sensor solutions could have applications in doing marine surveys.

Hotlink to appendix of suppliers

4. Unmanned aerial vehicles (UAV) or unmanned aerial systems (UAS)

Description:

Unmanned aerial vehicles (drones) that can carry out surveillance, patrols, and remote sensing for Fisheries Officers. It is essentially an aircraft without any human pilot, crew, or passengers on board. The flight of UAVs may operate under remote control by a human operator, as remotely-piloted aircraft (RPA), or with various

degrees of autonomy, such as autopilot assistance, up to fully autonomous aircraft that have no provision for human intervention.

Cost considerations:

Smaller multirotor UAVs can cost as little as hundreds up to a few thousand dollars. Costs vary depending on payload and duration of flights. Fixed wing and vertical take-off and landing (VTOL) UAVs are even more expensive, costing from US $30,000 up to hundreds of thousands to purchase.

Operational considerations:

The smaller multirotor UAV's can have camera and other sensors on board that can collect and send data if needed. Most of these seem to have flight times between 30-45 minutes. The fixed wing and VTOLs are larger and can carry more sensors and also have longer flight times. Flight durations seem to range from 120 minutes up to 10 hours at a time. Some of the UAV's can range a long distance from the operator but these are the more expensive UAVs. Some of the smaller UAVs can just collect information and others can send information back to the operator. A trained operator will be needed to use these UAVs effectively.

Potential Pacific applications:

The smaller multirotor UAVs may have value as a quick response tool for something that is reported or detected via other systems. Given their short flight durations and limited payloads, they may not be the best asset to deploy for searching for targets or activity. The larger UAVs with their longer flight durations and more payload may have applications for gathering scientific data and general usage patterns of vessels or people in remote areas. They are quite expensive and require specialist skills. Deploying other assets and sensors (see other sections of this report) may be a more cost-effective solution for coastal MCS purposes.

Hotlink to appendix of suppliers

5. Aerostats, Airships, and Balloon Technology

Description:

These are an extension or variation of drones. An aerostat is essentially a lighter-than-air aircraft (blimp) that gains its lift through the use of a buoyant gas, like helium. Aerostats include unpowered balloons and powered airships. They may be free-flying or tethered.

Cost considerations:

They range in price from US $22k plus sensors up to $100k+ for aerostats that may have application in Pacific coastal fisheries. They all need a regular supply of helium and it is unclear what local costs for this would be.

Operational considerations:

They can remain in the air for 12 hours to a week depending on payload and power requirements for sensors. They do have over the horizon capability due to being tethered to the ground and flying at an elevation of 200-300 meters up in the sky. They don't work great if the wind or weather is too strong. Another consideration is the need for regular service to add helium.

Potential Pacific applications:

Aerostats are interesting in that they are relatively passive and have over the horizon capability due to their altitude. The need for regular top ups of helium and service to equipment that need power, makes their use a bit limited in that they can't really be deployed in remote areas. Other sensors mounted to poles or on higher ground may be an easier solution given they don't require regular management and can be run on solar. A potential way to use an aerostat (if you have reasonable access to helium) could be to tow it behind vessels moving from one island or area to the next. If the aerostat is fitted with a pan/tilt camera and/or a radio frequency detector, they may have application as a detection tool. Data gathered could be used in real time or analysed later.

Hotlink to appendix of suppliers

Remote Technology (deploy and retrieve)

6. Vessel Monitoring Systems (VMS)

Description:

Vessel monitoring systems (VMS) are surveillance systems primarily used to monitor the location and movement of fishing vessels within an area. The systems use satellite and/or cellular based communications from onboard transceiver units. The transceiver units send position reports that include vessel identification, time, date, and location, and are mapped and displayed on the end user's computer screen.

Cost considerations:

Costs for VMS systems that would be suited for use on smaller, artisanal vessels vary between US $100-$1000 with most costing around $400-$800 and some up to $1,299 for the units. The monthly costs depend on satellite or cellular rates and the frequency of polling. Some suppliers indicate costs for this being as low as US $150 year up to about $1000/year per device.

Operational considerations:

There are now a number of reasonably priced solar units that are very easy to install. Most come preprogramed or can be connected via Bluetooth or Wi-Fi to be reconfigured later. Connectivity depends if the units are satellite (Iridium or Inmarsat) or cellular or a hybrid of both and on how often they transmit their location information. Most of them continue to record tracks if connection is lost, which can be synchronised when connected. Most of the units suitable for small artisanal vessels are solar/battery powered. The battery in most of these lasts 8-24 hours if there is no sun. Most are the units are fully sealed with no moving parts that require maintenance.

Potential Pacific applications:

There are a lot of small VMS and solar VMS units on the market now or in development that are targeting smaller artisanal vessels. Costs to purchase the devices doesn't seem to be a big barrier. Monthly cellular or satellite costs may be an issue for the longevity of these on small artisanal vessels that may not earn enough revenue to pay for this service, meaning the regulator will bear this burden. The simplicity of the solar units mean they can fit easily on virtually any vessel and don't require power. All this is good, but none of this is a particular incentive for artisanal fishers to place these units on their vessels. If the government has enough regulatory influence, this could be regulated but will still likely face some resistance from fishers. If regulatory influence is limited, uptake of regulated VMS on these small vessels may not work. There is great value for

fisheries managers to have these artisanal vessels on VMS as it can help them make management decisions relating to catch and effort coupled with other scientific and reporting inputs. **The key to success in implementing VMS on small scale artisanal vessels will be in figuring out what the value is for them as fishers and communities.** Some of the features discovered that may help to drive uptake of VMS are listed below, noting that there isn't one solution that has all of these features:

- **Safety features** – Does the unit have a panic button for emergencies that can alert authorities if needed?
- **Communication** – Does the unit allow for two-way messaging so a fisher can alert the shore if they are late or have other needs?
- **E-reporting** – Does the unit enable catch reporting over the satellite or cellular network?
- **Security** – Is this data encrypted and secure?
- **Alarms** – Does the unit make a noise or flash a light if a geofence (e.g., an MPA) is crossed or entered? Does it send a message to the administrator?
- **Connectivity** – Does the unit work on satellite and/or cellular? Can you connect to it via Bluetooth or Wi-Fi for uploading or downloading information? Does it collect data when it is not connected that can be synchronised later when it is connected?
- **Integration** – Does the unit connect to other sensors such as motor, hydraulics, oxygen or others?
- **Analytics** – Can fishers or their communities access the VMS information for safety, logistics, or fishing pattern/analysis purposes?
- **Navigation** – Can the unit be accessed via Bluetooth by the fisher's phone/tablet to be used for navigation purposes (like a plotter)?
- **Weather conditions** – Can the system give the fisher useful information on weather, wind, tides, currents, sea temperatures etc?

Hotlink to appendix of suppliers

7. Automatic Identification Systems (AIS)

Description:

Broadcast transponder system similar to VMS that operates on the VHF mobile maritime band. While these are generally used for larger vessels, there are a number of systems that can be used for smaller vessels.

Cost considerations:

The AIS units reviewed are in the range of US $300+ each depending on the add-on features and solar charging. Each coastal station/gateway is about US $1000-$2000 plus setup, computer and service. One of the systems reviewed has no ongoing costs for connection and the other that is integrated to other apps can costs US $7-$32/month per user.

Operational considerations:

They work on VHF radio signals which required line of sight for functionality. They generally locate the coastal station(s)/gateway(s) up high to cover the most area at sea. One of the systems can relay connection between other vessels on the system to extend the range and they both can relay signals between coastal stations/gateways. Range can be 50km or more out to sea. If the signal is lost, it will pick up again when the vessel comes into line-of-sight range. They also have panic buttons, two-way messaging, geofence alarms and

ability to Bluetooth connect for quasi plotter utility. One system has a traceability system built in the units. Access can be customized and for fishers, communities, regulators to see what they are authorised to see.

Potential Pacific applications:

This technology seems like a simple and inexpensive alternative to traditional VMS systems that need cell or satellite. If the coastal stations can be located around the island areas for maximum coverage, there is very little in running costs other than retrieving data from the coastal stations. The benefit of a simple solution for fishers that can alert them of geofences, send panic messages, send/receive other messages, and if it works as a quasi-plotter that fishers can use on the water and when they return, makes this an interesting solution. The traceability solution on one of the systems also has good potential for uptake by fishers in that it can code a fish or group of fish caught to a fisher and location.

Hotlink to appendix of suppliers

8. Radio Frequency Identification Systems (RFID)

Description:

RFID (radio frequency identification) is a form of wireless communication that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object, animal or person. Passive systems are often used for traceability applications but systems that use active, battery powered RFID tags operating at 433MHz with passive readers can track movement on objects (such as vessel) from distances of 400-600 m up to 2 km distance.

Cost considerations:

The active RFID system reviewed costs about US $1000 for the reader and about $500 per antennae. The battery powered tags that can last for 5 years cost in the range of $40 - $85 each if purchased in small quantities (dozens) and cost about half that if purchased in bulk (hundreds to thousands). Systems set up to track vessels may require multiple antennae depending on the area you are trying to pick up tag readings.

Operational considerations:

The active systems operating on 433 MHz have a reading range of 400-600 m up to 2 km and can even read up to 2m under water and through solid objects such as concrete. Each reader has 4 serial ports to which the antennae are connected. Multiple antennae are often used to focus the reading signal to certain places. The active tags can even be fitted with antennae if needed. The tags are preprogramed to transmit at a designated interval, contain a unique ID (that can be associated with a fisher) and can be loaded with up to 256kb more data if needed. When the tag is read it is given a time stamp and is added to the data set collected. This dataset can be output via CSV or JSON file formats. Antennae and reader systems could be set up at various locations to track movement of vessels. Data from the readers can be downloaded directly from the units or transmitted via cellular or satellite if needed.

Potential Pacific applications:

This type of system could be an inexpensive way to monitor fishing effort in various locations. Given the low purchase and operating costs, they could be used monitor how often and for how long vessels are out to sea. If antennae and readers are set up at other fishing locations such as on a FAD or focussed on a reef or area on the other side of an island/atoll, even more effort location could be collected. If this information were correlated

with port sampling information, estimates of catch and effort for these areas could be achievable. If GPS loggers were co-located with the tags mounted to the vessels, the tracks of the vessels could be downloaded and correlated to the reader information yielding a retrospective quasi-VMS system.

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Onboard Observation Technology (EM)

Description:

Electronic Monitoring is done with cameras onboard fishing vessels recording activity as crew members fish and haul in catches. The video is then stored on a hard drive for later analysis by fisheries managers ashore.

Operational considerations:

This analysis was not included in this review as there are many EM systems being trialled and used around the Pacific and the world. Once these cameras and systems are refined on the larger vessels, then it may be time to investigate their use in smaller vessels. The camera analysis for this study is focused on cameras Fisheries Officers might use or deploy, including shore-based camera monitoring systems (see Optical sensors).

9. Sonar buoys

Description:

The purse seine fleet depends on attaching GPS positioning buoys to their drifting FADs to improve efficiency. Some of these buoys have remote sonar or echo sounder capabilities with software and algorithms that provide users with predictions on biomass and species ratios of aggregated tuna schools. These buoys have also been used by coastal fishermen on anchored FADs to provide position and biomass estimates.

Cost considerations:

Solar powered sonar buoys cost between US $1000-$1400 each. Satellite connectivity charges cost between US $15-$25 per month.

Operational considerations:

These solar powered units take regular readings of biomass under buoy and can transmit condensed information once/day or more if desired. Some of them can even distinguish species under the buoy. Some also have other sensors that can read water current and temperature.

Potential Pacific applications:

These buoys have good potential utility on inshore FADs for a few reasons. They can alert the authority if it breaks free and since it is still transmitting, it can be recovered. The soundings can track the productivity of the FADs daily and over time. This can also be used by fishers so that fuel and effort can be saved, thus encouraging their use and can help to relieve pressure on reef fisheries. Authorities can use the soundings to better locate the FADs over time as well. At $180-$300/year to operate, this seems like a good value proposition for saving fuel and more effective catch for effort by coastal communities.

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10. Sensors

10.1. Optical sensors

Description:

Fixed Closed-circuit television (CCTV), networked and covert (wildlife) types of cameras that could be used for coastal MCS purposes.

Cost considerations:

There is a full spectrum of quality and prices for mounted cameras, predominantly coming from the security industry. Decent cameras suitable for coastal monitoring start at around US $1,500 and can be as much as $10,000-$20,000. Wildlife/trail cameras can cost around US $100-$200.

Operational considerations:

There are a number of robust cameras for shore-based monitoring and most can be run on solar power if needed. Most can send live images or store them for later review. A few have Artificial Intelligence (AI) built in to recognize vessels and can even send short messages if a vessel is detected. Some cameras have the ability to detect even in the dark and/or can detect via thermal images coupled with optical. The trail cameras are motion activated for when they take a photo or record video. They can have hard drives or SD cards that can be swapped or they can send data over cellular or satellite if that is needed. Some have the ability to send satellite or cellular short message if a vessel is detected which is pretty cheap. Most of the cameras will need some support for configuration and sighting and/or hiding them. Depending on if the camera has AI, some skills will be needed to review and interpret images.

Potential Pacific applications:

Surveillance cameras are everywhere now. There are many options to choose from. Trail or wildlife cameras are often used by MCS practitioners around the world to gather information at target locations. They can be hidden and are motion activated. Images can be retrieved at a later day and analysed. The next step up are fixed cameras. The kind of camera chosen depends on the site and what images you want to capture. You may need cameras that have strong zoom to see an area of interest or you may need one that works at night or uses thermal imaging to detect activity. Cameras that have AI processors incorporated in them can detect vessels or objects of interest and focus their recording on them. This information can be retrieved later, sent via cellular or satellite connection or short messages can be delivered indicating activity with the images to be retrieved later. I suggest that cameras can initially be used to understand access/use patterns in remote locations. This can give Fisheries Officers an idea of the amount of usage a particular area is getting and can even help to determine if there are patterns to this usage. For example, if it can be determined that there is a recurring time/day that the area is being accessed, this can give the Fisheries Officers and opportunity to target when they go there to investigate in person. Cameras can also serve as a deterrent to illegal activity.

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10.2. Acoustic sensors

Description:

Remotely deployed acoustic devices such as hydrophones. A hydrophone is a microphone designed to be used underwater for recording or listening to underwater sound.

Cost considerations:

The acoustic sensors range in cost from about US $3,500 - $10,000 each. Processing systems and hardware are extra and often require specialist skills, which can be quite expensive.

Operational considerations:

They can work well as data gathering devices. Small outboard motors can be detected at 10-15km distance and explosives can be detected at 50km distance. The challenge is in interpreting the data. This currently requires super specialist skills to interpret acoustic readings, but they are working on making this more automated and real time. CSIRO has an AI system that can do this automatically when it is calibrated to the location.

Potential Pacific applications:

Acoustic sensors could give valuable insights into use patterns in remote areas. Acoustic sensors linked to cameras or other sensors would be complementary. Once they are calibrated to the local area, the AI processor can determine if the sounds are vessels, explosives and potentially even spearfishing. This technology would be worth trialling (with CSIRO) to determine how well they can work to detect usage in areas like MPA's. Fisheries Officers can use this information to get an idea of the amount of usage a particular area is getting and can even help to determine if there are patterns to this usage. For example, if it can be determined that there is a recurring time/day that the area is being accessed, this can give the Fisheries Officers and opportunity to target when they go there to investigate in person.

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10.3. Water quality sensors

Description:

While water quality sensors are not really part of this review, some tools and technology did pop up that may have applications for Pacific Island fisheries administrations, particularly if they are charged with water quality monitoring. This could be used for compliance purposes in lagoons or in specific areas used for aquaculture.

Cost considerations:

The satellite based environmental sensing system could cost in the range of US $1,500-$10,000/month. LiDAR is US $8,000-$24,000 for purchase of the sensor.

Operational considerations:

A trial would be needed for the satellite/remote sensing system. If the satellite/remote sensing system can accurately measure algal blooms, nutrients, chlorophyll and other via satellite and perhaps with some ground sensors for calibration, this might be a cost-effective solution if it can cover a large area with more frequency that physical samples going to a lab. The LiDAR seems to be better for a mapping solution.

Potential Pacific applications:

The LiDAR sensors could have some application in sensing movement in a remote area like an MPA, but someone will need to interpret the results, making it perhaps not an ideal solution. There is also a chance it may have application in water quality monitoring in lagoons or aquaculture areas. This would need to be trialled. The satellite/remote sensing for water quality might be a cost-effective solution if it can cover a large area with

more frequency that physical samples going to a lab. A trial would be required to test the solution for results versus costs and to see if it can accurately measure algal blooms, nutrients, chlorophyll and other via satellite and perhaps some ground sensors for calibration.

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10.4. Radar technologies

Description:

Radar and high-frequency surface radar systems capable of detecting vessels, objects and movement from a long range that can be deployed at coastal locations such as Marine Protected Areas (MPAs) or other areas of interest. Radars are commonly used on larger vessels.

Cost considerations:

The radar based mixed systems cost in the range of US $60,000 - $100,000 depending on the additional sensors and power supply (solar) systems that you need. Annual operating costs may be around $5,000. The High Frequency (HF) surface wave radar systems cost US $100,000- $200,000 to procure and about US $20,000/year to operate.

Operational considerations:

The radar-based systems use off the shelf radars (e.g., Furuno) coupled with optical and thermal cameras. The systems have a processor on site that can focus the cameras to follow vessels detected by the radar. Depending how high the radar is situated, it can detect vessels from a few miles to over 10 miles offshore. The HF surface radar systems work best close to the water and can detect small moving vessels 12nm offshore and possibly up to 200nm offshore depending on the size of the vessel. All systems can work locally on a processor and hard drive. Information can be sent to the user using VHF if line of sight is possible or cellular of satellite connectivity if that is needed.

Potential Pacific applications:

The radar-based systems with commercially available components look to have good potential in the Pacific Islands and in fact are being trialled. They seem like good solutions for monitoring remote areas like MPAs. The information can be used to establish use patterns and well as enforcement actions if coupled with cameras and other sensors. HF surface radars are likely to expensive to be cost effective.

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10.5. Remote Sensing

Description:

Technologies such as satellite based Synthetic Aperture Radar (SAR) and Radio Frequency (RF) monitoring. Satellite based SAR is a form of radar that is used to create two-dimensional images or three-dimensional reconstructions of objects. It can show changes on the Earth's surface day and night and in any weather as opposed to optical sensors from satellites that can be obscured by cloud or lack of light. Space-based radio frequency (RF) detection systems can detect and characterize the passive electromagnetic signature of any ship (cooperative or not), anytime (day or night), anywhere on the globe, regardless of weather conditions.

Cost considerations:

RF detection from satellite is very expensive ranging from US $50,000-$80,000 per month for one pass per day. SAR images are priced by the area covered and the resolution.

- 5km x 5km at 25cm resolution can cost $1,850/image
- 4km x 4km at 50cm resolution can cost $750/image
- 4km x 4km at 1m resolution can cost $500/image
- Larger areas as various resolutions cost in the range of $1,000- $3,700/image
- Some providers have archive images for $300/image

Operational considerations:

One RF solution can cover 10 million km^2 VHF, 7 million km^2 L band, and 3.5 million km^2 X band signals in one pass. Another covers 400km x 400km per pass. They can pick up even burst signals from satellite devices and radar signatures. SAR can see at night and through clouds and weather but need a skilled operator to interpret the data. It detects metal better than wood and can be partially obscured in stormy sea conditions. For RF, there is a 3–10-hour delay from the scan to when you receive the analysis. SAR has an 8–24-hour delay from the scan to when you receive the analysis.

Potential Pacific applications:

RF detection from satellites is amazing in that it can detect virtually anything that is emitting a signal, but it is also very expensive and with the time delay in receiving the information, it may not be suitable for an MCS response. It could be useful for generating a snapshot of activity that could be cross verified by other sensing and patrol technologies. SAR seems to have better application for offshore detection of larger vessels. It may be worth testing SAR in conjunction with other technologies in use or being trialled. It may have some use/application for assisting in understanding access/use patterns at remote MPAs. The historical information could potentially be more valuable given the reduced cost. If there are other sources of information for usage/patterns in remote MPAs, SAR could help to validate some of this.

Hotlink to appendix of suppliers

11. Optical satellite imagery

Description:

Images of Earth collected by imaging satellites operated by governments and businesses around the world.

Cost considerations:

Tasked images covering about 20km at 1m to 50cm resolution cost from $300-$800/each. Historical images can be purchased for $15-$30/each and there are some free lower resolution images available as well.

Operational considerations:

High resolution images can be sourced to 30cm resolution which can see cars and people. Medium resolution of 1-3m can see changes, buildings, boats but no detail. All optical images can be obstructed by cloud cover. These satellite systems can take from 3-5 images per day, but the images are only good if not obstructed by cloud/other. Some providers have images back to 2017.

Potential Pacific applications:

There are free earth images available that come from the European Space Station and one of the providers in this review has a web portal where you can access lower resolution images for free. Given there is a lag from when a tasked image is taken and when you receive it, this technology may be more useful in retrospect. It could be possible to source the free and cheaper historical images available for a particular island location for use/pattern analysis. Another potential use for optical imagery is if it is coupled with other sensors and operations. There is one company that offers this type of service as a package, but it is not cheap at US $10k+ per year for an area).

Hotlink to appendix of suppliers

11.1. Light Detection and Ranging (LiDAR) and Visual Ranging and Detection (ViDAR)

Description:

LiDAR (Light Detection and Ranging) is a method for determining ranges by targeting an object with a laser and measuring the time for the reflected light to return to the receiver. ViDAR (which stands for Visual Detection and Ranging) is an Optical Radar that can autonomously detect small objects on the sea surface over very wide areas, by day and night, in conditions up to Sea State 6.

Cost considerations:

LiDAR sensors range from US $8,000-$24,000. ViDAR may cost $35,000 for a small system on a UAV up to $600,000 for a complete system in an aircraft. LiDAR will need some training and support for sensors and the software/analytics will need to come from elsewhere. ViDAR requires a live skilled operator.

Operational considerations:

LiDAR can be on a UAV or pole mounted. 360° sensors can see 50m-120m but sometimes up to 210m. Focussed sensors can detect in 300-600m range if mounted on aircraft. The sensors can be integrated with other sensors like cameras and GPS and what is produced is a spreadsheet of data that can be interpreted by software for images and analysis. This costs extra. ViDAR operates optically so it is unaffected by white caps and other effects that impact technology such as radar. It could be used on a coastal station or a UAV. The larger systems for aircraft may only have applications in oceanic fisheries due to cost. All ViDAR systems need a skilled operator.

Potential Pacific applications:

The LiDAR sensors could have some application in sensing movement in a remote area like an MPA, but someone will need to interpret the results. They may also have application in water quality monitoring in lagoons or aquaculture areas. ViDAR is an expensive solution that requires technical skill so is likely more suited to offshore aerial patrols. There may be coastal applications for the small UAV mounted system which could be good for use on a VTOL drone. Another outside the box application could be to mount these sensors to island hopper planes to return data, although this would operate better if a Fisheries Officer/technician was on board.

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Other Technology

12. Traceability technologies

Description:

RFID (radio frequency identification) is a form of wireless communication that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object, animal or person. RFID systems consists of three components: a scanning antenna, a reader and a transponder and there are generally two types of systems: Active RFID, where the RFID tag has its own power source, often a battery and passive RFID, where the RFID tag receives its power from the reading antenna, whose electromagnetic wave induces a current in the RFID tag's antenna.

Scale camera systems integrate a camera and scale for weighing a fish or a box of fish. These systems can be integrated into catch recording or traceability systems.

There are a number of different traceability systems available. Essentially traceability is the ability to access any part of or all information about a product throughout its supply chain cycle by using a system of recorded identifications. Traceability also relates to the ability to track and trace along the supply chain.

Incentive systems are built around a set of rewards and rules for their disbursement that are designed to influence future performance.

Cost considerations:

Passive RFID systems suitable for traceability cost around US $600-$800 for a fixed Gen2 reader that can interface with a computer. This will allow the reader to "write" information on to RFID tag. Passive RFID tags cost less than US $1 each.

The scale camera system reviewed is about US $1,800 for the hardware plus $90/month subscription but excludes the scale. The traceability systems are difficult to price as it depends on the numbers of users and complexity of the fishery. One vendor has a model of $3,250 for setup and then $3.50/user/month. One vendor has NFC cards that are preprogramed to track a fish or fish bins from catch to market. These cost $5 each and are reusable. The incentive system reviewed costs about $.01 per transaction. Ideally the cost to cover this is borne by buyer in the market, but might need to be covered by the authorities in the Pacific context.

Operational considerations:

Passive RFID systems can be set up to read tags in the 1-10 meter range and even closer (like a tap the card system) if that is needed. The readers are encased, waterproof and shock resistant and can be mounted on a vessel and/or at a landing site. The tags are uniquely coded with an ID and can receive time and location information from a reader when activated. A laptop connected to the reader can encode the tag with additional information such as species, weight, catch location etc. The security system only allows information to be written on to the tags once. A reader at a market or point of sale can access the information coded on the tag to see where, when and by who the fish was caught.

Scale cameras attach to an electric scale and uses serial output with an interface to a mobile phone. The Fisher logged into the system puts the fish or box of fish on scale and enters the species. The photo is linked to this information yielding fisher ID, date, amount, species and an image. The scale camera data goes online and is available to fishers and managers for management or traceability purposes.

App based traceability systems vary in how they are utilized. It seems the more effective ones are more driven by the market end of things rather than the fishers and regulators. They have potential to link individual fishers/catches to the end market if all parties participate. Traceability systems can work offline, but are better

when connected for market interaction. The data that needs to be sent is small so connectivity costs shouldn't be too much. For the solution where the NFC card follows the fish or fish bin, the only connectivity required is to tap the card to the unit to receive the information which auto uploads to the cloud when it gets to the gateway or connected unit. All the traceability systems will require training and human power to make the whole thing work. Fish need to be transported with good chain of custody for these types of systems to work.

Incentive systems have potential if there is a way to incentivize fishers to collect data, tag fish, make reports etc by giving them a type of bitcoin to redeem for real things (phone credit, fuel etc). They would need some training and agreement by all parties to work in that the fisher and buyer or government need agree what each transaction is worth in the specific type of bitcoins. Then the traceability information can be shared and utilized.

Potential Pacific applications:

Passive RFID systems could be used by fishers to code a fish or a bin of fish with their name, catch location, catch time etc. at the time of catch. The tag could again be scanned at a port or landing site which would record time and location. The tag could again be scanned at a market, hotel or other end user to see the history and movement of that fish or bin of fish. With the readers being less than US $1000 and tags costing less than US $1 each, this seems like an affordable, easy to use traceability system.

Scale systems could be used as part of a domestic catch certification system (domestic MSC) and could be useful at landing sites and/or markets. It may be a way to complement catch data recording.

Traceability systems seem to have a better chance of working if/when the market is willing to pay the premium. In the Pacific context, this could possible is some markets and with some hotel/resort buyers. It is unknown how effective this could be in the Pacific.

Incentive systems seem better positioned where there is a developed market for fish that can bear the cost and wants the traceability information. It could be a layer to a solution of incentivising fishers to report information. Perhaps the incentives could be redeemed as fuel/other or linked to fuel subsidy schemes.

Hotlink to appendix of suppliers

13. Truth in labelling

Description:

Identification technologies that can help to identify the presence of or species of seafood through the use of DNA technology.

Cost considerations:

The species identification technology reviewed should be market ready later in 2022, but cost estimates for a 4-test unit are US $1000 for the unit with each test costing approximately US $40-$50. Development of the 4 assay/testing system will cost about US $30,000 -$40,000 and $10k for each additional species added after that. The Ambient DNA detection methodology that will test for the presence of a species is estimated to cost around $50 for each test analysed in the laboratory.

Operational considerations:

For the species identification technology, once assays/test kit is set up, field use will be very easy. The user will only need to swab the specimen and insert into the unit for a reading. The level of detail of

species/genus/family depends on how it is set up. The ambient DNA approach uses ambient DNA floating around in the environment such as in an icebox or a ship hold. The mucus, blood, and tissue floating in the water is collected in a 50 ml vial which has a powdered reagent in it. The sample is sent to the lab for analysis and can subsequently identify all of the species that were in that hold since the last time they washed it out (e.g., species of special interest like sharks).

Potential Pacific applications:

Both of these technologies are in some stage of development but may some value in the future for science and MCS. They will both more likely have better application in higher end markets and species. There may also be future applications in aquaculture for detecting disease and/or certifying crops as disease free (using RNA virus technology).

Hotlink to appendix of suppliers

14. Community outreach/awareness

14.1. In person

Description:

This is focused on technology MCS or other Officers might use to engage with communities and stakeholders such as workshops, trainings and consultations. It is not focused on traditional materials used for outreach such as presentations, posters and printed materials, all of which are still highly effective.

Cost considerations:

The tool identified in this study is not likely to cost the user anything to use. There could be some costs associated with learning how to use it in a fishing community context as well as travel related costs to engage with fishing communities.

Operational considerations:

It is a suite of online facilitation tools that make it faster and easier to collaboratively design management measures (size limits, bag limits, gear restrictions) that are proven to work for the majority of small-scale fisheries. It focusses on the most applicable, intuitive, and trusted interventions like size limits and bag limits which helps make science-based decisions available to everyone. There are a number of steps in this process:

1. **Life history repository** – Sourcing biological information (life history) of target species is a critical first step in the process of designing effective management measures, yet accessing and using this information can require targeted expertise. To solve this problem, the system includes the world's first curated life history repository in order to crowdsource the expertise of top fisheries scientists. The tool provides scientists with access to a helpful online fisheries database as well as built-in guidance tools and smart algorithms to make it as easy as possible for them to add new species information so that non-experts can quickly advance past this common hurdle. This information can then be used by all toolkit users into the future.
2. **Ocean ruler** – Uses photos of species and analytics to measure the fish and to compare with reproductive data in the Life history repository. This data is used to optimize the size limit to ensure fish reproduce before being harvested, while helping the community meet their objectives for keeping food on the table.

3. **Size limit builder** – Users can evaluate different size limits in real time and visualize trade-offs between catch (Yield Per Recruit-YPR and Short-term Loss) and conservation (Spawning Potential Ratio-SPR) thus speeding up the decision-making process.
4. **Bag limit builder** - Illuminates trends in historical fishing behaviour using catch data in order to forecast impacts of different bag limits.
5. **Stock health tracker** - Monitors fishery performance and tracks changes in stock health by uploading new data as the system is used. It uses this data to focus on target fish maturity, optimal sizes and mega-spawner avoidance in catches.

Potential Pacific applications:

This system looks to be a useful tool for community engagement to raise awareness of over fishing consequences. It was developed by the NGO specifically for small scale fishing communities that often lack data and understanding of the implications of their catch. The online tools combined with a comprehensive set of engagement materials (in development) will be a product that can be used by fishing communities, NGO's and government extension agents and officers to better understand the implications of science-based management measures.

Hotlink to appendix of suppliers

14.2. Virtual

Description:

There is a list in the appendix of various smartphone and tablet apps that are commonly used by Fisheries Officers. It is not a complete list and the apps themselves haven't been reviewed. The list was compiled by speaking to a number of Fisheries Officers in Australia, New Zealand and the Pacific Islands to see what they have on their smart phones.

Hotlink to appendix of suppliers

14.3. Printed

Description:

While this is not technology in the sense of this review, it is very important. This category includes traditional awareness raising information such as signs, fliers, brochures and posters.

Potential Pacific applications:

These may be the most cost-effective tools in MCS for the Pacific. Effective MCS needs to be built on the back of education and awareness, which often need face to face interactions or printed and online materials to reference.

14.4. Usable tools

Description:

This includes physical tools/resources such as fish ID materials, rulers with size/species information and other things that can be left with stakeholders in communities. These were not reviewed but are still important.

Potential Pacific applications:

These may also be very cost effective for MCS. They are tools that can be given away that fishers can use and will also inform them of rules, limits and fish information. These tools could be as simple as fish ruler stickers that show pictures of fish species with their size/catch limit information. Handy measuring devices for shellfish and crustaceans can also help fishers know they are taking the right sized catch.

14.5. Reporting lines/Apps

Description:

These are technologies that can help report, identify or quantify information of interest to Coastal MCS Officers (e.g., phone/web reporting lines).

Cost considerations:

There are a number of commercial solutions for fisheries and other regulators. They are quite expensive, costing US $50,000 - $200,000 per year to operate with significant development and installation costs that can be in the range of $300,000+ depending on customisation needs. There are some other regulator apps developed by cooperatives of NGOs, donors and governments that are available free and as open-source systems. They were initially developed for rangers and wardens in Africa, but have expanded into marine patrol environments. While they are free, that doesn't exactly mean free as there would be costs associated with setup, configuration and customisation if needed.

There are also a number of more formal e-Reporting apps. These systems are primarily used in developed fisheries with strong regulation where they are mandated to e-Report. They can cost tens of thousands to procure and set up with ongoing costing models varying considerably. One system costs about US $500-$1000 per user per year with another system ranging from US $36,000-$240,000 per year for a fishery.

Additionally, there are a number of hybrid e-Reporting apps. These are developed with more of a focus on smaller artisanal fisheries and seek to add functionality that will benefit small scale fishers. Most of these are free and open-source with users needing to pay for the equipment and the connectivity. Some come as Software as a Service (SaaS) costing US$5-8/month per user.

Operational considerations:

The regulator apps help regulators manage the entire process of regulation including licensing, inspections, intelligence and risk-based analysis of compliance. Some of the strongest benefits to these types of systems are that they can work as a quasi-intelligence solution over time, and they can also help managers better target tasking of Fisheries Officers and can help them to understand where and how their staff are working. They can also interface with other sensors and apps that can collect data and information from other sources such as the public.

The formal e-Reporting apps are generally configured to the fishing regulations. They generally have reporting and analytics that suite the fisher, the regulator and even the public and markets. Many have traceability systems built into them.

Some of the hybrid e-Reporting apps that are regulator focussed are seemingly more effective if there are dedicated data collectors at landing sites. The others that are more fisher focused offer weather, fishing history, traceability and even expense tracking for the fishers. All of them work in offline modes with the more formal ones being connected full time via satellite or cellular, depending on local regulations.

Potential Pacific applications:

While some of the commercial, more formal e-Reporting apps are very good, uptake of e-Reporting apps in small scale artisanal fisheries will likely be challenging due to lack of incentives for fishers and regulations mandating their use including cost of the systems. There are a number of e-Reporting data collection apps such as SPC's TAILS that have the ability to collect quality catch and effort data. It appears that the successful systems around the world that do this end up training and/or paying data collectors to use the apps at fish landing sites. Some of the other apps that may have application in the Pacific are more fisher focussed offering benefits such as wind, swell and weather information; fishing history that can help the fisher become more efficient; traceability features that can help fishers sell their catch for more money; and expense tracking for the fishers that may be able to help them access credit or other financial services. The free open-sourced regulator apps have good potential for Pacific fisheries administrations as they can help regulators manage the entire process of regulation including licensing, inspections, intelligence and risk-based analysis of compliance. Some of the strongest benefits to these types of systems are that they can work as a quasi-intelligence solution over time, and they can also help managers better target tasking of Fisheries Officers and can help them to understand where and how their staff are working. They can also interface with other sensors and apps that can collect data and information from other sources such as the public.

Hotlink to appendix of suppliers

14.6. Data collection tools

Description:

Apps and technologies that can be used by Fisheries Officers, individuals and communities to collect data useful to Coastal MCS. This data can be for scientific, social, management and enforcement purposes. It depends what they are set up for and how people use them.

Cost considerations:

One system reviewed is free and the other is from US$169/month $429/month for unlimited users depending on functionality and the license.

Operational considerations:

The free system is connected to the free regulator app and can serve as a portal for the community to report activity and data via a mobile or web platform. The other system is highly configurable and easy to use for any number of data collection needs. It is used by many significant organisations worldwide. Both systems work offline and can sync when connection is available and both are open source and configurable by the user so should be relatively easy to maintain if you have programming skills available. Some training will likely be needed for both systems.

Potential Pacific applications:

The cloud based open-source system that operates on a subscription model is worth considering if the fisheries administration has data collection needs. It is purportedly very easy to use and very configurable which means it could be a valuable asset for collecting field information. The free system connected to the regulator app could serve as a valuable community reporting line for gathering information and intelligence from areas that Fisheries

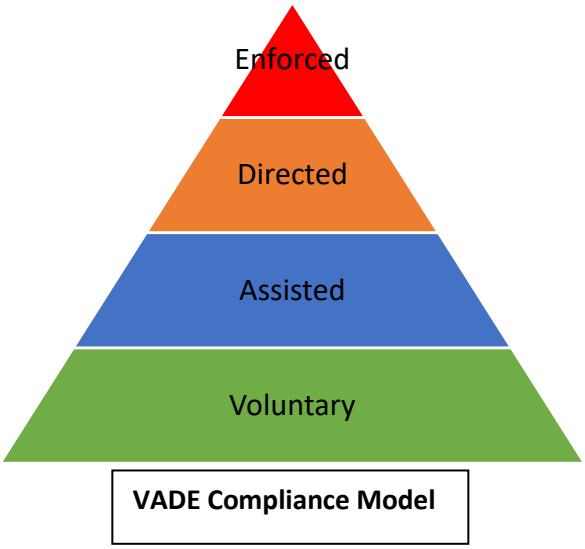
Officer cannot often access. It can also help communities to build up a record of issues occurring that can help them and regulators work on interventions to prevent these issues.

Hotlink to appendix of suppliers

Discussion

There is an amazing number of tools, technologies and solutions for various MCS challenges available around the world. Quite frankly, it's overwhelming. The key to utilising these solutions is to put them in perspective and to acknowledge up front that every country and every situation is different. There isn't a panacea or "one size fits all" solution for everything. To evaluate each situation, MCS practitioners need to consider a number of things:

- **What is the problem you are trying to solve?**
- **What are you trying to achieve by solving this problem?**
- **What is the complexity of the operating environment?**
- **What resources do you have available to achieve this?**
- **Is the proposed solution more costly than the problem itself?**



VADE Compliance Model

I suggest that the best way to utilise the various solutions reviewed in this study is to ensure that the foundation or base of MCS skills, experience and tools is strong. That way, the tools and technology can be utilised more effectively and efficiently, given that many of the solutions are not cheap. In addition to having a strong MCS foundation, it is also critical that those "being regulated" are aware of the rules and regulations. This can only come from strong engagement between the fisheries regulators and the communities they serve. This most often comes from "non-technical tools" such as face to face engagement, consultations, and provision of information to raise awareness of the rules and regulations. Readers may be aware of the VADE Compliance Model used in New Zealand and elsewhere. The engagement and awareness raising efforts are the foundation of the pyramid with regulatory information being easily accessible in the "voluntary" category and given freely to stakeholders in the "assisted" category. It's only when we get to the "directed" and "enforced" categories that the use of legal regulatory tools come into play. This review contains technical and some non-technical tools that support all levels of the VADE Compliance Model.

Given the above discussion about having a strong foundation for MCS work, it is very important that Fisheries Field Officers have the right gear to perform their work safely and effectively. This starts with uniforms and identification that show their authority to operate in this space. In the category of safety gear, beyond the usual first aid and protection from the element's types of gear, EPIRBs on vessels and PLBs for each field officer seem like a good idea. For a few hundred dollars each, all vessels and field officers could have very effective emergency location tools with them that will enhance their safety when working remotely and on the water. Communications technologies cross over from safety equipment into operational equipment. Depending on the terrain and connectivity, Fisheries Officers would benefit greatly from having a cellular phone (preferably a smart phone to harness other technologies reviewed in this study), a satellite phone or communicator or a radio to use while in the field. This gives them the ability to communicate with other authorities (e.g., Police and local

governments), their supervisors and others in the community while in the field. This could be considered baseline equipment for field work.

The more field oriented the officers are, the more they will need evidence gathering tools like official notebooks, gauges, cameras and viewing devices. Given that most smartphones now have high quality cameras capable of taking closer range photos, only officers collecting evidence from a distance have use for DSLR cameras with zoom lenses. These are important and effective tools for gathering evidence and proving offences. It should be noted that using zoom cameras effectively does take some training and practice. Other viewing devices such as binoculars, night vision, infrared and thermal vision scopes have utility for field officers in certain situations. This might be the type of gear that can be shared amongst a group of field officers that are surveying areas for suspicious or illegal activity. The need to observe at a distance or with limited light is a key operational ability for these officers. Body cameras are becoming increasingly popular for law enforcement in some countries and there are a number of pretty evolved systems on the market. I suggest that these higher end systems are not needed for Pacific coastal Fisheries Officers for most of their work, given that the police are often used for direct enforcement. There are a number of less expensive body camera systems and adaptations that may have good training and evidence gathering benefits.

From here we start to discuss other, nonessential tools and technologies that may be used by coastal Fisheries Officers. A number of autonomous or drone like tools were explored to see how they might enhance the effectiveness of field officers. Unmanned Surface Vessels (USVs) could be an interesting complement to other assets used by Fisheries Officers. Although they are quite expensive, they are relatively low profile, nearly undetectable and are capable of travelling long distances with little input from the command centre. They can hold a number of sensors and communications equipment that can relay information back to base. This could have applications in monitoring remote areas such as MPAs and could also complement other land, sea and air-based operations targeting particular areas. Given that one operator can command a large number of USVs, the area covered in traditional surveillance operations could be greatly increased with these tools. Autonomous Underwater Vehicles (AUVs) proved to be too expensive and restrictive given their need for deeper water and dedicated operators. Unmanned Aerial Vehicles (UAVs) have become quite popular with regulators, scientists and even hobbyists. There are a number of relatively inexpensive multirotor UAVs that can hold optical and other sensors, but they all seem to suffer from a lack of range and the need for an operator. Given the number of other systems and sensors reviewed in this report, UAVs seem like a better solution for quick response to something detected using another tool. The larger UAVs with their longer flight durations and more payload may have applications for gathering scientific data and general usage patterns of vessels or people in remote areas. They are quite expensive and require specialist skills. Deploying other land-based assets and sensors (see other sections of this report) may be a more cost-effective solution for coastal MCS purposes. Another variation on the drone theme are aerostats or balloons/blimps. They ended up being not that cheap and limited due to the need for regular servicing and helium to stay afloat. Their altitude which gives them pretty good over the horizon capability is their best attribute, but I suspect that well placed sensors on hills, in trees or up on poles would be more cost effective.

Another category or technology could be described as tools that can be deployed and retrieved or remotely accessed. There are a lot of small, easy to install and operate Vessel Monitoring Systems (VMS) and solar VMS units on the market now or in development that are targeting smaller artisanal vessels. Some of them run on marine VHF channels (AIS). Costs to purchase the devices doesn't seem to be a big barrier, although the monthly cellular or satellite costs may be a cost issue. Given the desire by many fisheries authorities to better

understand coastal catch and effort, these systems seem like a good way to go. The problem is in balancing the costs and incentives for use with their benefits. The key to success in implementing VMS on small scale artisanal vessels is in figuring out what the value is for the fishers and communities. Some of the features discovered that may help to drive uptake of VMS are listed below, noting that there isn't one solution that has all of these features:

- **Safety features** – Does the unit have a panic button for emergencies that can alert authorities if needed?
- **Communication** – Does the unit allow for two-way messaging so a fisher can alert the shore if they are late or have other needs?
- **E-reporting** – Does the unit enable catch reporting to be reported over the satellite or cellular network?
- **Security** – Is this data encrypted and secure?
- **Alarms** – Does the unit make a noise or flash a light if a geofence (e.g., a Marine Protected Area (MPA)) is crossed or entered? Does it send a message to the administrator?
- **Connectivity** – Does the unit work on satellite and/or cellular? Can you connect to it via Bluetooth or Wi-Fi for uploading or downloading information? Does it collect data when it is not connected to be synchronised later when it is connected?
- **Integration** – Does the unit connect to other sensors such as motor, hydraulics, oxygen or others?
- **Analytics** – Can fishers or their communities access the VMS information for safety, logistics, or fishing pattern/analysis purposes?
- **Navigation** – Can the unit be accessed via Bluetooth by the fisher's phone/tablet to be used for navigation purposes (like a plotter)?
- **Weather conditions** – Can the system give the fisher useful information on weather, wind, tides, currents, sea temperatures etc?

Sensor technologies have a wide field for potential applications in coastal MCS. There are a number of shore-based solutions for monitoring activity and usage in target areas. The most obvious and common is the optical sensor or camera. Two types of these cameras were reviewed. Trail or wildlife cameras are inexpensive and often used by MCS practitioners around the world to gather information at target locations. They can be hidden and are motion activated. Images can be retrieved at a later date and analysed by the officers. They are a "tried-and-true" way to understand who, what and when is accessing a particular place. The other type of cameras are fixed cameras. The kind of camera chosen depends on the site and what images you want to capture. Most, if not all of them can be setup to run on solar power. You may need cameras that have strong zoom to see an area of interest or you may need one that works at night or uses thermal imaging to detect activity. A number of the Cameras available have Artificial Intelligence (AI) and Machine Learning (ML) processors incorporated in them can detect vessels or objects of interest and focus their recording on them. The information can be retrieved later as with the wildlife cameras, sent via cellular or satellite connection or short messages can be delivered indicating activity with the images to be retrieved later. These cameras also can have a deterrence effect.

Another type of shore or water-based sensor is an acoustic sensor or hydrophone. While there are a number of reasonably priced acoustic sensors on the market, the hurdle to using them effectively is the need for a highly trained specialist to interpret the sounds. Acoustic sensors can give valuable insights into use patterns in remote areas. Acoustic sensors linked to cameras or other sensors would be complementary. Machine processing of the sound data is in development. Once these systems are calibrated to the local area, the AI

processor can determine if the sounds are vessels, explosives and potentially even spearfishing. This technology would be worth watching and trialling to determine how well they can work to detect usage of areas like MPA's. Fisheries Officers can use this information to get an idea of the amount of usage a particular area is getting and can even help to determine if there are patterns to this usage. For example, if it can be determined that there is a recurring time/day that the area is being accessed, this can give the Fisheries Officers an opportunity to target when they go there to investigate in person.

The radar-based systems with commercially available components look to have good potential in the Pacific Islands and in fact are being trialled/used in Hawaii, Palau, American Samoa and Tuvalu. They seem like good solutions for monitoring remote areas like MPAs as they are multisensory systems with radar detection (Furuno), FLIR Infrared (IR), AIS identification, camera and weather sensors. They have the ability to lock on to targets and record formation that can either be sent live, sent via short alert message and/or retrieved at a later date. The information can be used to establish use patterns and well as enforcement actions if coupled with cameras and other sensors.

RFID (radio frequency identification) sensors could be an inexpensive and relatively low-tech way of monitoring vessels, particularly if the antennae and readers can be located a key ports and launch/retrieve sites. While they won't track where a vessel went unless multiple reader/antennae systems are located around the fishing area, they can be paired with GPS logger that can show the vessel tracks later when downloaded. If the system counts boats as they move at a port or launch site, estimates of fishing effort can be made. Subsequent catch reporting or sampling could help to develop estimates of catch in areas that could be calculated with RFID sensor data as proxies for effort.

LiDAR (Light Detection and Ranging) and ViDAR (Visual Detection and Ranging) sensors are generally used on aircraft but could be used on a UAV or even on a high pole or hillside. Unfortunately, they are pretty expensive solutions that require either a skilled operator or special system to interpret the results. For this reason, they probably are not the best solutions for coastal fisheries MCS.

Another rapidly developing category is remote sensors that are based on satellites. There are quite a few earth imaging providers and costs are coming down. Given there is a lag from when a tasked image is taken and when you receive it, this technology may be more useful in retrospect. Satellite images are limited by cloud cover, making it not a guaranteed solution if it is deployed. It is possible to source the free and cheaper historical images available for a particular island location for use/pattern analysis. Another remote sensing technology is Synthetic Aperture Radar (SAR). SAR is a form of radar that is used to create two-dimensional images or three-dimensional reconstructions of objects. It can see at night and through clouds and weather but needs a skilled operator to interpret the data. It is also very expensive per image or pass making it not ideal for coastal fisheries monitoring. There is also another remote sensing technology called Radio Frequency (RF) monitoring. RF detection systems can detect and characterize the passive electromagnetic signature of any vessel (cooperative or not), anytime (day or night), anywhere on the globe, regardless of weather conditions. It can even pick up burst signals from satellite devices and radar signatures. It however is also even more expensive than SAR and such, not a good solution for coastal MCS. A problem with all of the remote sensing solutions is the time lag between when the image/reading is taken and when you, the regulator gets that information. That can be many hours or even a day later which makes these solutions perhaps better for historical analysis that for potential live or reactive interventions.

There are two other types of sensing technologies reviewed in this report even though they don't directly apply to coastal MCS. The first is the use of sonar buoys for inshore FADs. They have remote sonar or echo sounder capabilities with software and algorithms that provide users with predictions on biomass and species ratio of aggregated tuna schools. Given the focus of many coastal fisheries managers to relieve pressure on reef fisheries by encouraging the use of inshore FADs, these buoys have good potential for a few reasons. They can alert the authority if it breaks free and since it is still transmitting, it can be recovered. The soundings can track the productivity of the FADs daily and over time. This information can also be shared with fishers so that fuel and effort can be saved. Authorities can use the soundings to better locate the FADs over time as well. Another interesting sensing technology discovered is around remote sensing of water quality. This could be used for compliance purposes in lagoons or in specific areas used for aquaculture. The satellite/remote sensing for water quality might be a cost-effective solution if it can cover a large area with more frequency than physical samples going to a lab. A trial would be required to test the solution for results versus costs and to see if it can accurately measure algal blooms, nutrients, chlorophyll and other via satellite and perhaps with some ground sensors for calibration.

The last grouping of technologies includes traceability, and truth in labelling solutions, outreach and awareness tools, regulatory management, e-reporting and data collection apps. There are a number of different approaches to traceability. RFID and Near Field Communication (NFC) systems can be used for traceability. They can load select catch and fisher information on to a tag or card and into a system. The tag or card can then follow the fish or fish bin to processors or markets that will have access to the information. Once this process is complete, the tags and cards can be reset and reused. While this is more of a market driven desire, it can help Fisheries Officers to monitor compliance along the supply chain. Another layer to the traceability system could be with the use of scale cameras that are linked to the supply chain. These could be used as part of a domestic catch certification system and could be useful at landing sites and/or markets. It may be a way to complement catch data recording and verification. App based traceability systems vary in how they are utilized. It seems the more effective ones are driven by the market end of things rather than the fishers and regulators. They have potential to link individual fishers/catches to the end market if all parties participate. How effective these kinds of systems would be in the Pacific is unknown. There may be some niche markets where this could be useful. The last area of traceability reviewed is an add-on to existing systems. Incentive systems have potential if there is a way to incentivize fishers to collect data, tag fish, make reports etc by giving them a type of bitcoin to redeem for real things (phone credit, fuel etc). Incentive systems seem better positioned where there is a developed market for fish that can bear the cost and wants the traceability information. It could be a layer to a solution of incentivising fishers to report information. Perhaps the incentives could be redeemed as fuel or another cost associated directly with fishing.

An emerging field in truth-in-labelling is the use of DNA technologies to verify a species or existence of certain species. A species identification system was found that should be on the market later in 2022. It looks like it would be effective in identifying the exact species from a tissue sample, but will likely be too expensive for much utility in coastal fisheries MCS in the Pacific. The other technology tests for ambient DNA of species of interest in water samples and is less expensive but it requires specialist laboratory analysis. Both of these technologies are in some stage of development but may have some value in the future for science and MCS. They will both more likely have better application in higher markets and species. There may also be future applications in aquaculture for detecting disease and/or certifying crops as disease free (using RNA virus technology).

A system was found that looks to be a useful tool for community engagement to raise awareness of the consequences of over fishing. It was developed by an NGO specifically for small scale fishing communities that often lack data and understanding of the implications of their catch and can be used by fishing communities, NGO's and government extension agents and officers to better understand the implications of science-based management measures. It focusses on life history information of key species and then allows the community to use a camera with a reference object to measure the size of the species they catch. This is correlated to the life history information allowing the system to visually show the impacts of various size and bag limits on the current and future health of that local stock.

There are a number of different solutions that fall under the regulatory management and e-reporting category. While some of the commercial, more formal e-Reporting apps are very good, uptake of e-Reporting apps in small scale artisanal fisheries will likely be challenging due to lake of incentives for fishers and regulations mandating their use including cost of the systems. There are a number of e-Reporting data collection apps such as SPC's TAILS that have the ability to collect quality catch and effort data. It appears that the successful systems around the world that do this end up training and/or paying data collectors to use the apps at fish landing sites. Some of the other apps that may have application in the Pacific are more fisher focussed offering benefits such as wind, swell and weather information; fishing history that can help the fisher become more efficient; traceability features that can help fishers sell their catch for more money; and expense tracking for the fishers that may be able to help them access credit or other financial services.

There are regulator apps have good potential for Pacific fisheries administrations as they can help regulators manage the entire process of regulation including licensing, inspections, intelligence and risk-based analysis of compliance[2]. Some are quite sophisticated and expensive and some are free and open source. Some of the strongest benefits to these types of systems are that they can work as a quasi-intelligence solution over time, and they can also help managers better target tasking of Fisheries Officers and can help them to understand where and how their staff are working. They can also interface with other sensors and apps that can collect data and information from other sources such as the public.

Another type of reporting system is more along the lines of data collection systems that can be used by Fisheries Officers, individuals and communities to collect data useful to Coastal MCS. The cloud based open-source system that operates on a subscription model is worth considering if the fisheries administration has significant data collection needs. It is purportedly very easy to use and very configurable which means it could be a valuable asset for collecting field information. The free system connected to the regulator app could serve as a valuable community reporting line for gathering information and intelligence from areas that Fisheries Officers cannot often access. It can also help communities to build up a record of issues occurring that can help them and regulators work on interventions to prevent these issues.

[2] See below: Case Study – How the Victorian Fisheries Authority in Australia uses a intelligence-led, risk based approach to MCS

Case Study: How the Victorian Fisheries Authority in Australia uses an intelligence-led, risk-based approach to MCS.

The Victorian Fisheries Authority (VFA) manages the commercial, recreational and customary fisheries across the state of Victoria in Australia. The Education and Enforcement team within the VFA is the group responsible for MCS. This group is comprised of education team responsible for public outreach on awareness, understanding and acceptance of fisheries regulations, 69 uniformed Fisheries Officers located in 18 locations across the state monitoring and enforcing the regulations, a team of specialized Fisheries Investigators, and a team of Intelligence Officers along with various regional and state managers. Their outreach reaches thousands of stakeholders per year and last year in 2020-21, they conducted over 50,000 inspections detecting 1641 offenders.

The VFA adopted an intelligence-led, risk-based approach around 15 years ago which is also used by a number of fisheries and environmental enforcement agencies around the world. The intelligence-led evidenced based approach moves away from reactive compliance and seeks to apply tools appropriate to problems and to employ risk assessments that are meaningful, defensible and repeatable. This helps to reduce subjectivity and bias. These risk assessments are based on a combination of Bayesian quantitative modelling, innovative subjective analysis (Delphi methodology), bounded probability theory, and spatial analysis, rather than the traditional probability vs consequences risk matrices.

Each year the VFA uses all the data, risks, and intelligence identified over the year to strategically target their compliance actions moving forward. This is captured in an annual Compliance Strategic Assessment and Compliance Control Strategy that are developed to guide the years MCS work. This strategy is linked with other higher level organisational and government strategies and directives.

The annual cycle for this is divided into three sub-cycles: Strategic, Operational, and Tactical.

The "Strategic Cycle" starts with data and information collection over the previous year. This information comes from their centralised intelligence database that stores enhanced information from Officer submitted information reports along with tips and information about illegal fishing activity received from the public via a dedicated reporting telephone line. The Officers also document all their planned and ad-hoc compliance checks, inspections, advisories or surveillance using a web-based application which quantifies their MCS effort and results. The cycle also utilises information from their prosecutions/offences database along with any other data collected over the year including surveys, assessments and other environmental scans.

All of this information is analysed using their refined risk model described above. The result is the annual Compliance Strategic Assessment which recommends priorities for the coming year. These priorities endorsed by a State-wide Tasking & Coordination Group (STCG) which meets annually. The various units within the Enforcement Team list specific operational actions for each strategic priority along with other core business actions. This results in the Compliance Control Strategy. The actions in this strategy are delivered via regional and central staff coordinated by a State-wide Tactical Coordination Committee (STCC).

The "Operational Cycle" is comprised of Quarterly Tactical Assessment reports that include an analytical overview of compliance operations, highlights of any emerging issues, and documented progress against Compliance Control Strategy. These reports are summarised and presented by authors to the Operational Tasking & Coordination Group (OTCG) where progress and issues are discussed and then recorded for STCC action and/or follow up. This internal report is disseminated to relevant stakeholders within the VFA. Summary information is posted on VFA website

The "Tactical Cycle" is where the field work occurs. If/when a compliance action occurs and/or an Intelligence Report (IR) is generated, this information is recorded in one of the databases mentioned previously. In the case of IR's, they are enhanced by the Intelligence Team and disseminated back to Officers. Before they are dissemination, they are assessed by a Intelligence Assessment Panel (IAP) using a Complexity/Priority model. The IAP "refers" relevant IRs to a Fisheries Officer location or to the Investigation Team for action as a Preliminary Investigation (PI). Progress on these PI's is reported at monthly STCC meetings. Some PI's may develop into more formal Operations if the issue is significant enough. If this is the case, the Officer creates an Operation Plan for STCC approval and tasking and progress on the operation is reported at STCC monthly. All the information and results from routine compliance work, PI's and Operations is captured in their databases for consideration into next year's Strategic Assessment. From here the cycle starts again the next year.

Conclusion and Recommendations

Fancy tools and technologies are not a panacea *for coastal MCS anywhere in the world, including the Pacific Islands. Effective MCS comes from suitably skilled and resourced Fisheries Officers working with a clear mandate and authority to regulate fisheries rules and regulations. This work is made much easier if the rules and regulations are based on good science, fisheries management and community involvement and awareness. If a good base can be achieved, all the others tools and technologies will be more effective.*

It's important to acknowledge that the finding in this report may not apply to every Pacific Island and Territory in every context. All MCS solutions need to be tailored to the situation on the ground considering resources, capacity and the actual need and circumstances. In many instances a number of MCS solutions may need to be adopted and integrated together to maximise effectiveness and achieve the desired results. Given that, a number of tools and technologies did stand out to the author as having good potential for application in the Pacific Island context. A separate report based on this study was submitted to SPC recommending SPC to conduct trials of a number of these tools and technologies. It is recommended that anyone finding any of the tools and technologies identified in this study interesting and potentially useful for their situation, contact SPC to indicate interest in participating in a trial if possible. Obviously SPC will not have the resources to trial everything with everyone, but it can't hurt to ask. It's also entirely possible and appropriate for PICTs to trial any of the tools and technologies themselves if it looks like any of them will solve a need. Below is a table listing the key tools and technologies considered by the author (in order of importance) to have the most potential impact and benefit for coastal fisheries management and MCS in the Pacific Islands.

Tool/technology	Proposed benefit
Baseline MCS tools and capacity for Coastal Fisheries Officers	With a solid foundation to work from, all of the other tools and technologies mentioned in this report will be more effective.
Regulator Apps	These systems can provide a risk based; intelligence led structure for coastal MCS. They can interface and use virtually all of the sensor and other data created by the tools and technologies reviewed in this study.
Shore-based cameras	The cameras with the ability to recognise people and vessels are an inexpensive way to monitor ports, launch and landing sites. This data can be analysed to estimate fishing effort and access patterns.
Wildlife cameras	These cameras provide a similar benefit to the shore-based cameras but are highly mobile and discreet. Fisheries Officers can use them in different locations in remote areas.
Shore-based radar systems	These radar systems integrate with other sensors and can be deployed in remote locations such as Marine Protected Areas or other areas of interest. They can be used to establish use patterns and well as enforcement interventions.
RFID for port monitoring	An inexpensive way to measure fishing effort with extra benefit of safety and traceability. This could be an easy step for monitoring vessels before proceeding down the VMS/AIS track.
Solar VMS/AIS vessel tracking	For regulators wanting to track artisanal fleets, there are now very compact, solar systems available. The key to implementation success will be to focus on the benefits of these systems for the fishers.

Acoustic sensors	If these hydrophones can be calibrated for a site and the data can be interpreted using artificial intelligence, they offer good potential to complement other shore-based monitoring systems.
USVs	While these solutions are quite expensive, they can function as highly mobile sensor systems that can be deployed virtually anywhere. They can serve to complement coastal MCS operations and can patrol very remote areas.
Other (not exactly MCS and not in any order)	Proposed benefit
Sonar FADs	These simple and inexpensive systems could be an easy way to promote fishing on inshore FADs and thereby help to reduce fishing pressure on other coastal species.
FishKit	This new platform looks to be a very easy to use and understand tool that can be used to engage with communities on coastal fisheries management and potential regulations.

Listing of companies and website by category

Officer/Station Technology (use and return)

1. Fisheries Officer field tools/equipment

1.1. Officer operational gear

1.2. Safety gear

Company Name	Product Name/Model	Website	Estimated Price[3]
ACR	GlobalFix V4 EPIRB	https://www.acrartex.com/products/globalfix-v4-epirb-emergency-positioning-indicading-radio-beacon/	USD $510 - $610
Ocean Signal	Rescue Me EPIRB1	https://oceansignal.com/products/epirb1/	USD $470
McMurdo	SmartFind EPIRB	https://www.seasofsolutions.com/products/mcmurdo-smartfind-epirb-series/	USD $650
GME	MT600 EPIRB	https://www.gme.net.au/au/emergency-safety/mt600/	AUD $300
ACR	ResQLink	https://www.acrartex.com/product-category/marine/?swoof=1&pa_product=rescue-beacons&really_curr_tax=1170-product_cat	USD $330 - $380
Ocean Signal	Rescue Me PLB1	https://oceansignal.com/products/plb1/	USD $310
McMurdo	FastFind 220 PLB	https://www.seasofsolutions.com/products/mcmurdo-fastfind-220/	USD $275
GME	MT610G PLB	https://www.gme.net.au/au/emergency-safety/mt610g/	AUD $379

1.3. Communications

1.3.1. Smartphones (cellular/Wi-Fi enabled)

1.3.2. Non cellular communication devices

Company Name	Product Name/Model	Website	Estimated Price
Iridium	Iridium Extreme 9555	https://www.iridium.com/products/iridium-9555/	AUD $2,540
Iridium	Iridium Extreme 9575	https://www.iridium.com/products/iridium-extreme/	AUD $1,845
Inmarsat	IsatPhone 2	https://www.inmarsat.com/en/solutions-services/government/services/isatphone-2.html	AUD $999
Garmin	Garmin inReach Mini	https://www.garmin.com/en-US/p/592606	USD $350
Iridium	Iridium Go!	https://www.iridium.com/products/iridium-go/	AUD $1,145
Zoleo	Zoleo Satellite Communicator	https://www.zoleo.com/en-us/satellite-communicator/	AUD $295

[3] Prices shown are sourced from various websites. They are given as an indicator. Actual costs with tax and shipping will likely be different.

Garmin	Garmin Montana 750i	https://www.garmin.com/en-US/p/690986/pn/010-02347-00#overview	USD $800
Ground Control	RockSTAR Professional	https://www.groundcontrol.com/product/rockstar-global-satellite-messaging-tracking/	USD $999
Motorola	APX 6000 P25 portable radio	https://www.motorolasolutions.com/en_us/products/two-way-radios/project-25-radios/portable-radios/apx6000.html#tabproductinfo	USD $3000
L3Harris	XL-200P MULTIBAND PORTABLE RADIO	https://www.l3harris.com/all-capabilities/xl-200p-multiband-portable-radio	USD $4000
BK Technologies	KNG2 P25 Digital Portable Two-Way Radio	https://www.bktechnologies.com/product/kng2-portable-radio/	USD $3000
Cobra	Cobra MRF57B Marine VHF Radio	https://www.cobra.com/products/mrf57b	USD $180

Other resources:

- Digital Cameral World Review of Sat Phones https://www.digitalcameraworld.com/buying-guides/best-satellite-phones
- VHF/UHF solutions https://firstsourcewireless.com/blogs/blog/police-walkie-talkies-vs-commercial-walkie-talkies-key-features-compared

1.4. Data/evidence collection

1.4.1. Manual gear

1.4.2. Tablet and laptop computers (for field notes, apps, data collection)

Company Name	Product Name/Model	Website	Estimated Price (USD)
Samsung	Galaxy Tab Active 3 and Pro rugged tablets	https://www.samsung.com/us/business/mobile/tablets/galaxy-tab-active/	$416 $510
Handheld	Algiz RT8, 8X, 10X rugged tablets	https://www.handheldgroup.com/handheld-rugged-mobile-computers/rugged-tablets/	$2,399+
Handheld	Nautiz X9	https://www.handheldgroup.com/handheld-rugged-mobile-computers/rugged-handhelds/nautiz-x9/	$999+

1.4.3. Camera and video

Brand and model	Brief description	Estimated Price (USD)
Nikon D3500	**Type:** DSLR **Sensor:** APS-C **Megapixels:** 24.2MP **Lens mount:** Nikon F	$417-$1,114

	Screen: 3-inch fixed, 921,000 dots **Viewfinder:** Optical **Max video resolution:** Full HD **User level:** Beginner	
Olympus OM-D E-M10 Mark IV	**Type:** Mirrorless **Sensor:** Micro Four Thirds **Megapixels:** 20.3 **Lens mount:** MFT **Screen:** 3-inch 180-degree tilting touchscreen, 1,037k dots **Viewfinder:** EVF, 2,360k dots **Max shooting speed:** 8.7fps **Max video resolution:** 4K UHD **User level:** Beginner/intermediate	$599-$799
Fujifilm X-T200	**Type:** Mirrorless **Sensor:** APS-C **Megapixels:** 24.2MP **Lens mount:** Fujifilm X **Screen:** 3.5in vari-angle touchscreen, 2,760k dots **Viewfinder:** EVF, 2,360k dots **Max continuous shooting speed:** 8fps **Max video resolution:** 4K **User level:** Beginner/Intermediate	$599-$799
Canon EOS 90D	**Type:** DSLR **Sensor:** APS-C **Megapixels:** 32.5MP **Lens mount:** Canon EF-S **Screen:** 3.0in touch, pivot 1,040,000 dots **Viewfinder:** Pentaprism **Max burst speed:** 10fps **Max video resolution:** 4K **User level:** Enthusiast	$1,199-$1,499
Canon EF 70-300mm f/4-5.6 IS II USM	• High-speed autofocus for shooting stills and smooth, near-silent autofocus when shooting video are achieved by incorporating NANO USM technology. • New Lens Information Display shows focusing distance, focal length and shake amount • One UD Lens helps reduce chromatic aberration and delivers outstanding high-resolution and high-contrast results. • Image Stabilizer effect at up to 4* stops of shake correction helps capture sharp images • Circular aperture (9 blades) helps deliver beautiful, soft backgrounds. • Full-time manual focus allows manual focus adjustment while in AF Mode.	$439-$559
Sigma 70-200mm f/2.8 DG OS HSM | S	• EF-Mount Lens/Full-Frame Format • Aperture Range: f/2.8 to f/22 • Nine FLD Elements, One SLD Element	$1,299-$1,499

	• Super Multi-Layer Coating	
Nikon AF-P 70-300mm f/4.5-5.6E ED VR	• Capture sports, wildlife, concerts, landmarks and more with phenomenal clarity and precision • Maximum Angle of View (DX-format): 22°50', Minimum Angle of View (DX-format): 5°20', Maximum Angle of View (FX-format): 34°20', Minimum Angle of View (FX-format): 8°10'. Advanced Optics and telephoto field of view are great for still and HD video • Ultra-fast, near silent autofocus powered by a stepping motor (af-p) • Vr image stabilization ensures sharp photos, steady videos and enhances Low-light capabilities	$596-$781
Fujinon XF50-140mm F2.8 R LM OIS WR	• This multipurpose zoom lens is perfect for portraiture, sports, wildlife and landscape photography. • Focal length equivalent to 76-213mm. • Maximum aperture f2.8. • Dust, water and low temperature resistant. • Triple linear motor. • The world's top image stabilisation technology in its class.	$1,298-$1,599
Fujinon XF70-300mm F4-5.6 R LM OIS WR	• Internal focus system is driven by an ultra-fast linear motor, which achieves the necessary split-second levels of autofocus performance • Optical Image Stabilization (OIS) system provides up to 5.5 stops of correction • Dust- and moisture-resistant and can operate in temperatures as low as -10°C (14°F)	$799-$912
Panasonic DG Vario-Elmar 100-400mm f4-6.3 Asph Power OIS	• Micro Four Thirds System • 200-800mm (35mm Equivalent) • Aperture Range: f/4 to f/22 • 1 Aspherical ED, 1 UED and 2 ED Elements • High-Speed 240 fps AF, Focus Limiter • POWER O.I.S., Dual I.S. Compatibility • Rotating Tripod Collar & Built-In Hood • Weather-Resistant Construction • Rounded 9-Blade Diaphragm	$1,597-$1,645
GoPro Hero 10	All-out speed and ultimate ease, now in the most powerful GoPro ever. Powered by the revolutionary new GP2 processor, HERO10 Black shoots 5.3K video with double the frame rate, 23MP photos, enhanced low-light performance and game-changing HyperSmooth 4.0 video stabilization in all modes. On top of all that, HERO10 is cloud connected—so the moment you charge it, your footage is automatically uploaded to the cloud. • Includes free SD card and rechargeable battery • All-new GP2 processor makes this the most powerful GoPro ever • Unreal 5.3K60 + 4K120 video resolution + 23-megapixel photos	$399.98

	• Advanced HyperSmooth 4.0 video stabilization • Waterproof to 33ft + built tough • Automatically upload footage to the cloud when charging • TimeWarp 3.0, 8X Slo-Mo + tons of other features to nail any shot • Compatible with Quik app • Compatible with over 30 mounts + accessories	
GoPro Max	Experience total creative freedom with the most versatile 360 camera. You get 3 cameras in one: unreal spherical footage, HERO-style video and photos, and a vlogging powerhouse that's second to none. 360 capabilities deliver amazing panoramic photos and 360 Timelapse, too. Featuring unbreakable stabilization, premium audio from 6 mics, and waterproof design, this camera maximizes. • Shoot HERO mode or go with 360 mode for stunning 6K.[5] • Unbreakable stabilization from Max HyperSmooth • Waterproof to 16ft + built tough • Premium 360 + stereo audio from 6 mics • Vlog to the max with 1080p live streaming • Max TimeWarp, PowerPano, 4 digital lenses + so many other features to nail any shot • Compatible with Quik app • Compatible with over 30 mounts + accessories	$399.98
Sony Alpha 7 III - Full-frame Mirrorless Interchangeable Lens Camera	• Advanced 24.2MP Back-Illuminated 35mm Full-frame Image Sensor • 15-stop4 dynamic range, 14-bit uncompressed RAW4, ISO 50 to 204,800 • Up to 10fps1 Silent5 or Mechanical Shutter with AE/AF tracking • 693 phase-detection / 425 contrast AF points w/ 93% image coverage • Eye-AF with AF-C; Direct AF point 4-way multi-selector; touch AF • 4K2 HDR3 Movie w/ full pixel readout, no pixel binning or crop • Long-lasting Z battery for up to 710 images8 on a full charge • Secure and versatile dual media slots (1 SD card slot UHS-II compatible) • 5-axis in-body image stabilization, 5-step6 shutter speed advantage • SuperSpeed USB Type-C™ (USB 3.1 Gen 1 compatible) and Micro USB	$1,999.99

1.4.4. Body cameras

Company Name	Product Name/Model	Website

Axon	Axon Evidence	https://www.axon.com/products/axon-evidence
Axon	Axon Body 3	https://www.axon.com/products/axon-body-3
One Thing Cam	4G Body Worn Camera	https://www.onethingcam.com/4g-full-band-global-pass-ip68-protection-level-body-worn-camera-otc-c310-support-rtsp-rtmponvif28181-p00351p1.html
Reveal	D-Series Body Camera	https://www.revealmedia.com/products/d-series
BOBLOV	BOBLOV PD70 Wi-Fi Body Camera 1296P	https://www.amazon.com/BOBLOV-Wearable-Cameras-Recording-Enforce/dp/B0838X9TQH/ref=sr_1_3?keywords=Boblov%2BPD70%2B1296P%2BWi-Fi%2BBody%2BMounted%2BCamera&qid=1638576658&s=electronics&sr=1-3&th=1
Go Pro	Chesty (Camera accessory)	https://gopro.com/en/us/shop/mounts-accessories/chesty/AGCHM-001.html

1.4.5. Distance viewing devices

Company Name	Product Name/Model	Website	Estimated Price (USD)
Canon	Canon 18×50 Image Stabilization Binoculars	https://www.usa.canon.com/internet/portal/us/home/products/details/binoculars/is-binoculars/18-x-50-is-all-weather	$1,499
Canon	Canon 10×30 Image Stabilized Binoculars	https://www.usa.canon.com/internet/portal/us/home/products/details/binoculars/is-binoculars/10-x-30-is-ii	$550
Zeiss	ZEISS 20x60 S	https://www.zeiss.com/consumer-products/us/hunting/binoculars/specials/20x60-s.html	$9,123
Fujifilm	Fujinon Techno TS1440 14×40 Binoculars	https://www.fujifilm.com/us/en/consumer/binoculars/technostabi	$1,300
Vortex	CROSSFIRE® HD 10X42	https://vortexoptics.com/vortex-crossfire-hd-10x42-binoculars.html	$200
Steiner	T1042	https://www.steiner-optics.com/binoculars/tactical/t42-tactical-10x42	$590
Bushnell	POWERVIEW 10X50 BINOCULARS	https://www.bushnell.com/binoculars/powerview/powerview-10x50-binoculars/BU-131056.html	$50
Celestron	SKYMASTER 15X70MM PORRO BINOCULARS	https://www.celestron.com/products/skymaster-15x70mm-porro-binoculars	$120

Carson	3D Series 10x42mm High-Definition Waterproof Binocular, ED Glass	https://carson.com/td-042ed-carson-3d-series-binoculars/	$370
Leupold	MARK 4 12-40X60MM MIL DOT	https://www.leupold.com/mark-4-12-40x60mm-mil-dot-spotting-scope	$1800
Bushnell	Bushnell Legend T-Series 15-45x60mm Spotting Scope	https://www.bushnelloptics.com/bushnell-spotting-scopes-781545ed.html	$570
Barska	BARSKA 11-33x50mm WP Tactical Mil-Cross Rangefinding Reticle Spotting Scope	https://www.barska.com/11-33x50-wp-tactical-mil-dot-spotting-scope-barska.html	$175

1.4.6. Other viewing devices

Company Name	Product Name/Model	Website	Estimated Price (USD)
NightFox	NIGHTFOX SWIFT NIGHT VISION GOGGLES	https://nightfoxstore.com/products/nightfox-swift-night-vision-goggles	$200
J&K Outdoor Products	Nyte Vu Goggle N60	https://www.jkoutdoorproducts.com/product-page/nyte-vu-goggle	$475
Rexing	Rexing B1 Night Vision Goggles Binoculars	https://www.rexingusa.com/product/rexing-b1-black/	$160
NightFox	NIGHTFOX 110R NIGHT VISION BINOCULAR	https://nightfoxstore.com/products/nightfox-110r	$140
Bushnell	EQUINOX™ Z2 NIGHT	https://www.bushnell.com/more-products/equinox-z2-night-vision-6x50-monocular/BU-260250.html	$360

	VISION 6X50 MONOCULAR		
ATN	ATN OTS 4T 640 4-40X	https://www.atncorp.com/thermal-monocular-ots-4t-640-4-40x	$4000
Pulsar	AXION XM30S Thermal Imaging Scopes	https://pulsarnv.com/collections/axion	$2,200
Teledyne Flir	FLIR Scout TK and Scion PTM	https://www.flir.com/products/scout-tk/ https://www.flir.com/products/scion-ptm/?model=7TM-01-F350	$600 $2000-$5000

2. Unmanned surface vessels (USV) or autonomous surface vehicles (ASV)

Company Name	Product Name/Model	Website
X-Craft	Nemesis Class USV	https://www.x-craft.co.nz/nemesis-class.html
Ocius	Bluebottle USV	https://ocius.com.au/usv/#overview
Autonaut	Autonaut 3.5 and 5.0	https://www.autonautusv.com/
Autonomous Marine Systems Inc.	Datamaran Mark 7 and Mark 8	https://www.automarinesys.com/
Liquid Robotics	Wave Glider	https://www.liquid-robotics.com/wave-glider/overview/
Saildrone	Saildrone	https://www.saildrone.com/solutions/maritime-domain-awareness
ThayerMahan	SeaScout and Sea Picket, SeaWatch	https://www.thayermahan.com/systems/seawatch
L3 Harris	MARITIME AUTONOMOUS SYSTEMS	https://www.l3harris.com/all-capabilities/autonomous-systems

3. Autonomous Underwater Vehicles (AUV)

Company Name	Product Name/Model	Website
Teledyne Marine	Slocum G3 Glider	http://www.teledynemarine.com/o-glider?ProductLineID=14
Marine Applied Research & Exploration (MARE Group)	BATfish and Video Lander	https://www.maregroup.org/batfish.html

4. Unmanned aerial vehicles (UAV) or unmanned aerial systems (UAS)

Company Name	Product Name/Model	Website
X-Craft	Various – Fixed wing, Multirotor, Hybrid VTOL	https://www.x-craft.co.nz/aircraft.html
Anduril	Anduril Ghost 4 sUAS	https://www.anduril.com/ghost
Brinc	Lemur S	https://brincdrones.com/lemur-drone/

DJI	Matrice 300 RTK	https://www.dji.com/matrice-300?site=brandsite&from=nav
DJI	Mavic 2 Enterprise	https://www.dji.com/mavic-2-enterprise
DJI	Phantom 4 Pro v2	https://www.dji.com/phantom-4-pro-v2?site=brandsite&from=nav
DJI	Inspire 2 Drone	https://www.dji.com/inspire-2
Autel	EVO II DUAL 640T	https://www.autelrobotics.com/productdetail/4.html
Autel	Dragonfish fixed wing series	https://www.autelrobotics.com/productdetail/3.html
Sensefly	eBee drones	https://www.sensefly.com/drones/
Wingtra	WingtraOne Gen II	https://wingtra.com/mapping-drone-wingtraone/
Marine Instruments	M5D-Airfox	https://www.marineinstruments.es/products/stealthy-unmanned-aerial-vehicle/
Dove Air Technology	Dove Air Drone	https://doveair.org/our-doves/

5. Aerostats, Airships, and Balloon Technology

Company Name	Product Name/Model	Website
Aero Drum Ltd.	Tethered Aerostats	https://www.rc-zeppelin.com/aerostat-surveillance.html
Raven	Raven Aerostar's Tethered Aerostat Systems	https://ravenaerostar.com/products/tethered-aerostats
Drone Aviation Corp	WASP Aerostat	https://droneaviationcorp.com/
Elastec	Aerostat Systems	https://www.elastec.com/products/aerial-surveillance/

Remote Technology (deploy and retrieve)

6. Vessel Monitoring Systems (VMS)

Company Name	Product Name/Model	Website
AST	iVMS	https://www.theastgroup.com/uk/solutions/remote-asset-tracking-monitoring-control/ivms/
Blue Sky Network	Hawkeye 6300 and SkyRouter – Focussed on Iridium Edge Solar, Asset Pack and Skyrouter.	https://blueskynetwork.com/live-ship-tracking-communication-devices/ https://blueskynetwork.com/skyrouter/
Odaku	Odaku Marine GPS Receiver	http://www.odaku.in/
Orbcomm	ORBCOMM Vessel Monitoring System (VMS) and ST 6100 and new ST8100 coming in 2022	https://www.orbcomm.com/en/industries/maritime/vessel-tracking

Pelagic Data Systems	ultra-light Vessel Tracking System	https://www.pelagicdata.com/details#hardware
Satlink	Nano VMS	https://www.satlink.es/en/tracking-monitoring/nano-vms-for-traditional-fishing-boats/
Pinpoint Earth / SNAP IT	SolarVMS and e logbook	https://www.snapit.group/marine
Succorfish	SC2 Gen2 VMS	https://succorfish.com/product-suite/sc2-gen2/
Trackwell	VMS	https://www.trackwell.com/ https://vmsfisheries.com/
Blue Traker	BlueTraker iVMS Transponder and BlueTraker miniVMS Transponder	https://www.bluetraker.com/products/vms-for-fisheries/transponders/
Zunibal	Vessel Tracer Solar-powered inshore VMS	www.zunibal.com
Archipelago	Lime (Lite Integrated Monitoring Equipment)	https://www.archipelago.ca/products/lime
AssetLink	Asset Pack	https://assetlinkglobal.com/solutions/smart-maritime/commercial-fishing-fleet/

7. Automatic Identification Systems (AIS)

Company Name	Product Name/Model	Website
Weatherdock AG	Object tracking devices	https://www.easyais.com/en/vessel-tracking/
Futuristic Aviation and Maritime Enterprises, Inc. (FAME)	FAME Transponder	https://www.fameph.com/ https://www.seafdec-oceanspartnership.org/traceability-tools/fame/

8. Radio Frequency Identification Systems (RFID)

Company Name	Product Name/Model	Website
Sky RFID	Active 433MHz tags, reader with multiple antennae	https://skyrfid.com/

9. Onboard Observation Technology (EM)

10. Sonar Buoys

Company Name	Product Name/Model	Website
Satlink	Eco Buoy and Select Buoy	https://www.satlink.es/en/smart-buoys/satlink-eco-buoy/ https://www.satlink.es/en/smart-buoys/
Zunibal	satellite buoys	https://zunibal.com/en/products/
Marine Instruments	M3i+ echo sounder satellite buoy	https://www.marineinstruments.es/products/echo-sounder-satellite-buoy/

11. Sensors

11.1. Optical sensors

Company Name	Product Name/Model	Website
cvision.ai	ShoreSight	https://www.cvisionai.com/service/hardware-designs/
Shellcatch	Vessel Camera, Coastal Camera	https://web.shellcatch.com/welcome#/emonitoring
Mobotix	Move, Series 6, Series 7	https://www.mobotix.com/en/solutions/government
Excelsense	ToughEye-1700 and ToughEye-3100 self-cleaning cameras	https://www.excelsensetechnologies.com/
FLIR	FLIR M364c	https://www.flir.com/products/m364c/ https://youtu.be/Mzv3IVO8IMM
Camio	Camio box	https://camio.com/home

Wildlife Trail Camera Name[4]	Initial Assessment	Price[5]	Stills resolution	Video resolution	Video length	Data storage	Night vision	Audio recording	LCD	Power	Reason to buy	Reason to avoid
Bushnell Core DS No Glow	An ideal wildlife camera, with dual sensors and no glow	$219.99	30MP	1080p at 60fps	up to 60 seconds	Via SD or SDHC card, up to 32GB	Yes (up to 80ft)	Yes	Yes	8x AA batteries	Day and night sensors. No glow infrared lighting. 60fps video.	No wireless capability
Stealth Cam DS4K	The world's first 4K trail camera	$211.23	30MP	4K, 3840x2160 pixels	180 secs (30 secs with night vision)	Via SD or SDHC card, up to 32GB	Yes, via infrared	Yes	Yes	12x AA batteries	4K video resolution. 30 megapixel stills.	High resolution costs more. Requires 12 AA batteries (not included).
Spypoint Force-20 Trail Camera	This is a decent mid-range trail	$98.99	20MP	1280x720 pixels	not given	Via SD or SDHC card, up to 32GB	Yes (up to 8oft)	Yes	Yes	8x AA batteries	Inexpensive all-rounder. Suitable for beginners	Video not Full HD. 20MP shots generat

[4] Data sourced from https://www.digitalcameraworld.com/buying-guides/best-trail-cameras

[5] Estimated price from Amazon unless otherwise indicated

	camera option										and beyond.	ed from 3MP sensor.
Stealth Cam G42NG	Entry-level 10MP stills and HD video from an established brand	$122.79	10MP	1280x720 pixels	Up to 180 seconds (up to 30 secs with night vision)	Via SD or SDHC card, up to 32GB	Yes, via infrared	Yes	Yes	8x AA batteries	External power jack. External LCD status display.	Slower response time. 'Just' HD quality video.
Spypoint LINK-MICRO-LTE	This wireless trail camera comes with a pre-activated SIM card	$99.51	10MP	None	n/a	microSD, up to 32GB	No	No	No	8x AA batteries	Very affordable. Fast 0.5sec trigger speed.	No video recording. No night vision.
Bushnell Trophy Camera Essential E3	Best trail camera for those on a budget	$129.99	16MP	1280x720 pixels	up to 60 seconds	Via SD or SDHC card, up to 32GB	Yes, including Night Vision flash (12 to 30m range)	Yes	Yes, with B&W text display	8x AA batteries	30m (100ft) detection distance. Operates in -20°C to 60°C.	No wireless capability. No geo-tagging of images.
Spypoint Solar Dark	The best solar-powered trail camera	$199.99 (company direct)	12MP	1280x720 pixels	not given	Via SD or SDHC card, up to 32GB	Yes, via infrared	Yes	2-inch colour LCD	Solar, rechargeable lithium ion or 8x AA batteries	Solar powered. Super swift 0.07 sec trigger speed.	Solar power costs extra
Spypoint Link-S Trail Camera	The best trail camera with a cellular link-up	$169.99 (company direct)	12MP	1280x720 pixels	0-90 seconds	Via SD or SDHC card, up to 32GB	Yes, via low-glow LEDs	Yes	2-inch colour LCD	Solar, rechargeable lithium ion or 8x AA batteries	Sends images over 4G. Solar powered. SD card storage.	Cellular service costs monthly. Harder to find in UK.

Browning Defender	Best cellular trail camera for resolution and multi-camera plans	$119.99	20MP	1920 x 1080 pixels	120 secs	Via SD, SDHC or SDXC card, up to 512GB	Yes, via infrared	Yes	2in colour	16 AA Batteries	High-resolution camera. Large battery bay for long life. Data recording includes air pressure.	Videos can't be downloaded by cellular. Downloading full resolution for every image will push up monthly plan.
Bushnell Cellarer 20	Great cellular trail camera for the money	$99.99	20MP	1080p, 1920 x 1080 pixels	30 secs	Via SD or SDHC card, up to 32GB	Yes, via infrared	Yes	No, mono settings display only	12 x AA	Relatively high resolution. Shoots HD video clips.	Unsubtle design. Soon to be replaced with more expensive Cellarer 30 model.
Moultrie Wingscapes TimelapseCam Pro	Best timelapse trail camera for close-ups	$142.82	20MP	1080p	up to 90 seconds	Via SD or SDHC card, up to 32GB	Yes	Yes	Yes	8x AA (or AC adapter)	Can produce shallow-depth-of-field. Weather proof. Accessibly priced.	Firmware updates could be easier

* Estimated price on Amazon unless otherwise indicated and data sourced from https://www.digitalcameraworld.com/buying-guides/best-trail-cameras

11.2. Acoustic sensors

Company Name	Product Name/Model	Website
CSIRO	Hydrophones	https://research.csiro.au/iuu/case-studies/hydrophones/
Loggerhead Instruments	SNAP and LS1 AND LS2 FAMILY OF RECORDERS	https://www.loggerhead.com/acoustic-dataloggers-2
Ocean Instruments NZ	Soundtrap and dBWav Acoustic Analysis Software system	http://www.oceaninstruments.co.nz/

11.3. Water quality sensors

Company Name	Product Name/Model	Website

Gybe	Gybe ground sensors and remote sensing imagery	https://www.gybe.eco/product
Early Daily Analytics	Earth Daily	https://earthdaily.com/
Level Five Supplies	LiDAR	https://levelfivesupplies.com/product-category/lidar/

11.4. Radar technologies

Company Name	Product Name/Model	Website
Anthrocean	Marine Monitor (M2)	https://anthrocean.org/overfishing/marine-monitor/ https://protectedseas.net/marine-monitor-m2
Codar Ocean Sensors	SeaSonde Vessel Detection Software	http://www.codar.com/SeaSonde_Vessel_Detection_Software.shtml
TZ Coastal Monitoring/Nobeltec	TZ Coastal Monitoring software	https://www.coastalmonitoring.com/markets/marine-protected-areas https://mytimezero.com/

11.5. Remote Sensing

Company Name	Product Name/Model	Website
Hawkeye 360	Mission Space, RFGeo, RFGeo RAS, SEAker	https://www.he360.com/solutions/maritime-domain-awareness/
Unseen Labs	Maritime Surveillance Service	https://unseenlabs.space/our-product/
Iceye	Iceye SAR - Persistent Monitoring	https://www.iceye.com/persistent-monitoring/the-applications
Umbra Lab Inc.	SAR and RF Sensing	https://umbra.space/
Capella Space	SAR	https://www.capellaspace.com/data/why-sar/

12. Optical satellite imagery

Company Name	Product Name/Model	Website
Astraea	Earth AI	https://astraea.earth/
ImageSat International	Kingfisher - PERSISTENT MARITIME SURVEILLANCE	https://www.imagesatintl.com/home/data-analytics/kingfisher/
Planet	Planet Scope Monitoring and Sky Sat Monitoring	https://www.planet.com/products/monitoring/

12.1. Light Detection and Ranging (LiDAR) and Visual Ranging and Detection (ViDAR)

Company Name	Product Name/Model	Website
Level Five Supplies	LiDAR	https://levelfivesupplies.com/product-category/lidar/
Sentient Vision	ViDAR VMS Pods, Kestrel, ViDAR for UAS, Panoptes	https://www.sentientvision.com/products/vidar/

Other Technology

13. Traceability technologies

Company Name	Product Name/Model	Website
Sky RFID	Gen2 passive tags and readers	https://skyrfid.com/
Shellcatch	Scale Camera	https://web.shellcatch.com/welcome#/emonitoring
Plenumsoft	Nadir	http://plenumsoftmarina.com/en/
Abalobi ICT4Fisheries	Abalobi Fisher, Monitor, and Marketplace	http://abalobi.org/
Vericatch	Know Your Catch	https://knowyour.fish/
Fishcoin Project	Fishcoin	https://fishcoin.co/

14. Truth in labelling

Company Name	Product Name/Model	Website
Conservation X Labs	NABIT (Nucleic Acid Barcode Identification Tool)	https://conservationxlabs.com/nabit
CSIRO		Ambient DNA detection

15. Community outreach/awareness

15.1. In person

Company Name	Product Name/Model	Website
The Nature Conservancy (TNC)	FishKit	https://tnc-app-64a15f.ingress-florina.easywp.com/

15.2. Virtual

Smartphone and Tablet Apps Commonly Used by Fisheries Officers

Category	App/Utility Name	Description/Utility	Notes/Comments
Communication	Phone	Cellular/mobile phone	Key minimum gear for safety, communication and other applications. If no cell connection, may need either Wi-Fi, VHF radio or satellite phones

Communication	Messaging	Common text messaging application on most phones	Easy, low-cost communication
Communication	Email	Most smartphones have a range of email applications	Can be used to send and receive information while in the field, if connected to cellular or Wi-Fi
Communication	Facebook Messenger	Popular messaging app	Free if on Facebook and will link you easily with others on Facebook.
Communication	Google Meet	Common virtual meeting platform	Online talk and video meetings
Communication	Microsoft Teams	Common virtual meeting platform	Online talk and video meetings
Communication	Skype	Common virtual meeting and text communication platform	Online talk, messaging and video meetings
Communication	Slack	Messaging platform used by many organizations including SPC	Can be configured to communicate with specific people/groups on specific topics.
Communication	WhatsApp	Common virtual phone and text communication platform	Online talk, messaging and video meetings
Communication	Viber	Common virtual phone and text communication platform	Online talk, messaging and video meetings
Communication	Zoom	Common virtual meeting platform	Online talk and video meetings
Communication	Google Translate	Translates a number of languages from text or voice	Can be helpful if subject doesn't speak the same language at the Fisheries Officer. Works ok with typing or voice.
Data collection	On Board	SPC e-reporting for longline vessels	
Data collection	On Shore	SPC Port sampling App	
Data collection	TAILS	SPC small scale fisheries data collection	
Data collection	OLLO	SPC	
Evidence collection	Calculator	Common utility	
Evidence collection	Camera	Built in digital camera with zoom	Good for close up or distance with no detail. SLR with zoom lens better if detail/distance is needed. Photos geolocated and time stamped.

Evidence collection	Clock	time zones, timers, stopwatch	
Evidence collection	Google measure	uses camera to measure distance	Not perfectly accurate but good for estimates if you don't have a proper measuring device.
Evidence collection	OneNote	Note taking application common on the Microsoft Platform	Potentially a good way to store needed information in an organized manner. Also, can be used to take notes that can be filed and organized.
Evidence collection	PacFishID	SPC fish ID app	Free fish ID app.
Evidence collection	Video	Built in digital video with zoom	Good for evidence collection and visual notes.
Evidence collection	Voice Recording	Built in voice memos	Usually built in but a number of proprietary apps exist. Can be used to interview and take oral notes in the field
Navigation	Compass	Compass built into phone	
Navigation	Google Earth	Detailed satellite maps	
Navigation	Google Maps	Similar to Google Earth but built more for navigating	
Security	Find My	Locates your device if lost	
Security	Noonlight	Personal safety app	Panic button style
Social media	Facebook		Sharing photos, short videos and messages
Social media	Instagram		Sharing photos, short videos and messages
Weather	Pacific Tides	SPC app	Useful for planning patrols and operations around optimal times targeting activity.
Weather	Weather	A number of free weather apps exist	
Weather	Buoyweather	Marine weather apps for swell, wind, tide etc.	Good for knowing where fishing will or won't be occurring and coastal patrol planning.
Weather	Windy	Marine weather apps for swell, wind, tide etc.	Good for knowing where fishing will or won't be occurring and coastal patrol planning.
Weather	WillyWeather		Live wind
Web	Web browser	Generally, comes with the smartphone	Good for accessing internet information in the field if connected to cellular of Wi-Fi

15.3. Printed

15.4. Usable tools

15.5. Reporting lines/Apps

Company Name	Product Name/Model	Website
Fisheries New Zealand	SPECS	https://www.mpi.govt.nz/fishing-aquaculture/
AI2	Skylight and Earth Ranger	https://skylight.global/ https://www.earthranger.com/
SMART Partnership	SMART Platform	https://smartconservationtools.org/
Victorian Fisheries Authority	Fisheries Enforcement Net	https://vfa.vic.gov.au/
Objective RegWorks	RegWorks	https://www.objective.com.au/products/objective-regworks
Peskas Timor-Leste	Peskas	https://timor.peskas.org/
Shellcatch	Shellcatch eReporting	https://web.shellcatch.com/welcome#/ereporting
OurFish Ltd. and RARE – Fish Forever	OurFish app	https://play.google.com/store/apps/details?id=com.tellybug.fishapp&hl=en_US&gl=US https://rare.org/story/tracing-fish-and-finances/
Deckhand	Deckhand Pro	https://deckhandlogbook.com/product/
Electric Edge Systems	FACTS™ (Fishing Activity and Catch Tracking System)	https://www.fisheryfacts.com/
FINNZ	FINNZ Elements	https://www.finnz.com/products/fisheries-management-solution
Te Ohu Kaimoana	IkaNet	https://teohu.maori.nz/ikanet/
SPC	TAILS	https://oceanfish.spc.int/en/ofpsection/data-management/spc-members/dd/505-tails-application
Vericatch	FisheriesApp	https://vericatch.com/products/fisheriesapp/
PescaData	PescaData	https://pescadata.org/

15.6. Data collection tools

Company Name	Product Name/Model	Website
Conservify	Fieldkit	http://conservify.org/core-projects/fieldkit/
SMART	SMART Collect	https://impactsmart.azurewebsites.net/Download/SMART-Collect
Get ODK Inc	ODK Cloud	https://getodk.org/#features