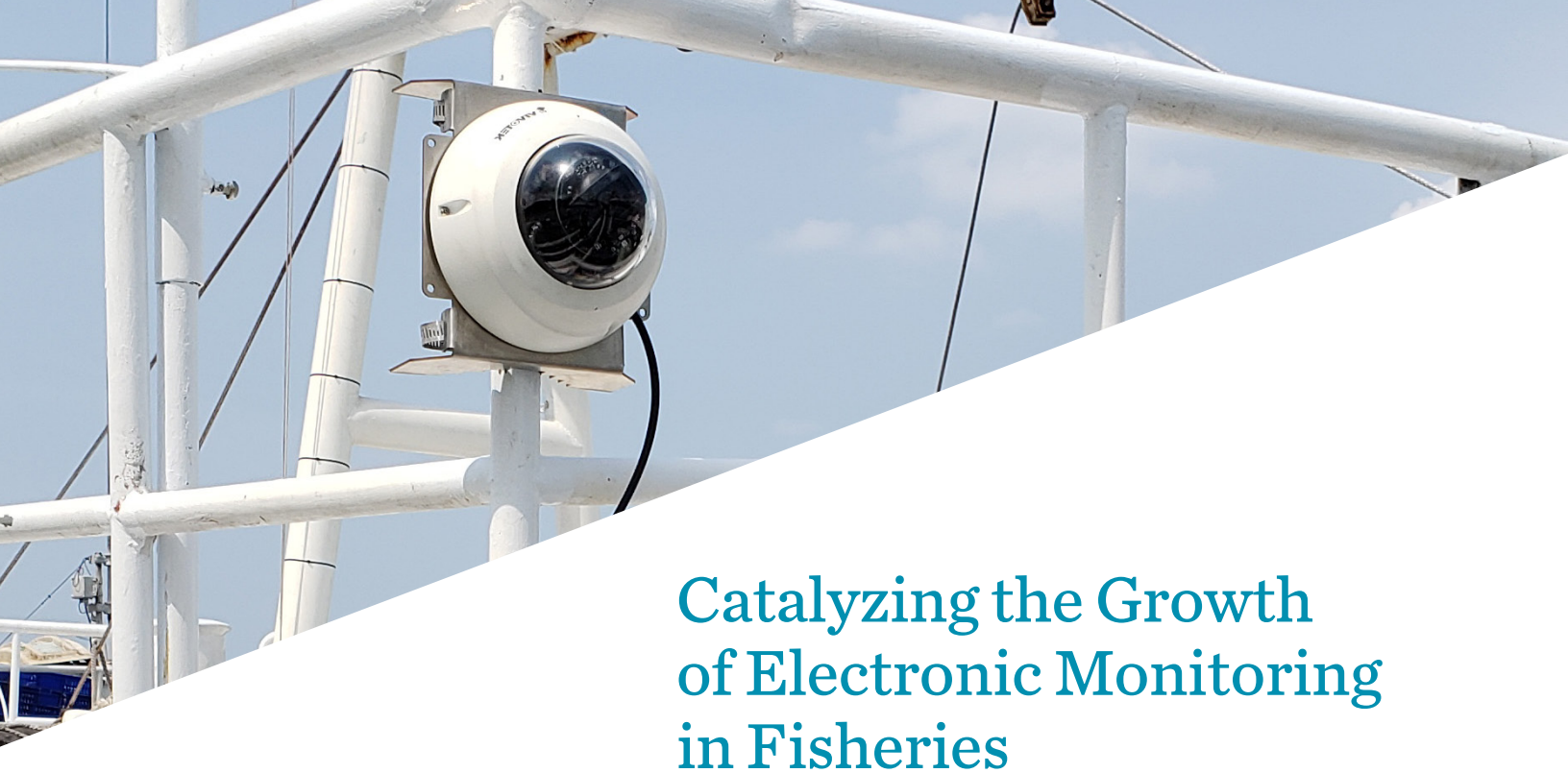

Catalyzing the Growth of Electronic Monitoring in Fisheries

PROGRESS UPDATE
AUGUST 2020

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CEA CONSULTING

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CONTENTS

ACRONYMS

AFMA – Australia Fisheries Management Authority
AI – Artificial intelligence
ANABAC – National Association of Tuna Freezer Vessel Shipowners
ABNJ – Areas beyond national jurisdiction
CAB - Certified assessment bodies
CEA – CEA Consulting
EFCA – European Fisheries Control Agency
EFP – Exempted fishing permit
EM – Electronic monitoring
ETP – Endangered, threatened, and protected
FAD – Fish aggregating device
FIP – Fishery improvement project
FSM – Federated States of Micronesia
GMRI – The Gulf of Maine Research Institute
HaV – Swedish Agency for Marine and Water Management
HMS – Highly migratory species
IATTC – Inter-American Tropical Tuna Commission
ICCAT – International Commission for the Conservation of Atlantic Tunas
ICES – International Council for the Exploration of the Sea
IOTC – Indian Ocean Tuna Commission
ISSF - International Seafood Sustainability Foundation
IUU – Illegal, unreported, and unregulated
MARPOL - International Convention for the Prevention of Pollution from Ships
MMPA – Marine Mammal Protection Act
MSC – Marine Stewardship Council
NGO – Non-governmental organization
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
OEM – Original equipment manufacturer
OPAGAC – Organización de Productores de Atún Congelado
PNA – Parties to the Narau Agreement
PRIs – Program-related investments
PSMFC – Pacific States Marine Fishery Council
R&D – Research and development
REM – Remote electronic monitoring
RFMOs – Regional fisheries management organizations
RFQs – Request for quotation
SeaBOS – Seafood Business for Ocean Stewardship
SIMP – Seafood Import Monitoring Program
SPC – Pacific Community
TAC – Total allowable catch
TNC – The Nature Conservancy
VMS – Vessel monitoring systems
WCPFC – Western and Central Pacific Fisheries Commission
WCPO – Western and Central Pacific Ocean
WGTIFD – Working Group on Technology Integration for Fishery-Dependent Data

ABOUT THIS REPORT

In 2018, The Nature Conservancy (TNC) and CEA Consulting (CEA) released the report, "Catalyzing the Growth of Electronic Monitoring in Fisheries." The report highlighted that many of the world's fisheries lack accurate data about what is happening on the water. Even in fisheries with human observers, low coverage rates, basic human limitations that prevent viewing everything happening onboard, and even threats and bribery can limit data quality. The result is that fishery managers do not have the information they need to get the rules of the game right and ensure compliance with regulations. Electronic monitoring (EM), which is an integrated system of onboard cameras and sensors to record fishing activity and extract data, has proven to be an effective tool to help solve this challenge and deliver the granular on-the-water data necessary for effective fisheries management at scale.

The 2018 report highlighted that, although growth of EM has historically been slow, it was at an inflection point and poised for more rapid growth. The report presented several recommendations to catalyze EM growth. It has been 18 months since we presented this investment blueprint. This progress update report revisits the original recommendations, assesses the progress and new innovations that have been made, identifies key remaining barriers, and updates the investment blueprint based on what has changed or been learned over the last year and a half.

More than 30 EM experts representing nonprofits, foundations, regulators, seafood companies, and EM service providers were interviewed as a part of this project, and their perspectives have been invaluable in synthesizing the current state of EM and collating an updated set of recommendations for advancing the tool. These perspectives have been supplemented with a review of the EM literature. We hope the findings in this report will spur further conversations about the role of EM in improving fisheries management and delivering value to the seafood industry, and help build alignment within the fisheries stakeholder community around how best to advance this tool.

This analysis was commissioned by TNC and prepared in collaboration with CEA. CEA takes accountability for any errors or omissions in this report, and welcomes constructive feedback from readers by email: electronicmonitoring@ceaconsulting.com.

KYDD POLLOCK / THE NATURE CONSERVANCY

Updated Key Findings and Recommendations

The Case for Electronic Monitoring

Every day, millions of fishing vessels ply the oceans to harvest seafood that helps feed the world's almost eight billion people. Fisheries managers have the enormous challenge of protecting the productivity and biodiversity of the oceans while also safeguarding the livelihoods of the millions of people who work along the seafood value chain. To sustainably manage fisheries, managers must be able to collect high-quality data on the state of the fishery and ensure compliance with regulations.

Managers have historically relied on a variety of tools to collect this data (e.g., logbooks, human observers, dockside monitoring, at-sea patrols), but these tools often cover a limited portion of fishing activity, are subject to bias or misreporting, and can be expensive and imprecise. Facing severe data limits, most fishery managers lack the basic information they need to get the rules of the game right and ensure that fishers are playing by them. Managers have been chronically underinvesting in good fisheries data, and as a result are putting their fisheries at risk. The result is, all too often, ecological and economic decline. The World Bank estimates annual losses of $83 billion USD in global fisheries from insufficient management, accompanied by a gradual decline in the health of fish stocks and the marine environment.[1]

Onboard EM camera, Seychelles.
Photo: Kydd Pollock / The Nature Conservancy

Several emerging tools (e.g., Wave Gliders, Global Fishing Watch) are proving effective at enhancing marine domain awareness—a manager's ability to understand who is out on the water, where they are, and what they are doing. This information can be critical to management needs such as understanding overall fishing effort, ensuring fishers adhere to no-take marine protected areas (MPAs) and identifying illegal at-sea vessel rendezvous. But for many fisheries, there is a need for more granular data about activities on board vessels to get a reasonable picture of resource health and fleet compliance, especially in fisheries with strong incentives to misreport catch, discards, or interactions with endangered, threatened, and protected (ETP) species. EM can help fill this gap.

EM is an integrated system of onboard cameras and sensors that record fishing activity and extract data. It is a powerful tool that can provide the detailed information fishery managers need to solve their data and compliance challenges. EM can also enable more targeted, cost-efficient management strategies (e.g., targeted sanctions, bycatch cap and trade systems) and create opportunities for seafood industry stakeholders to drive improvements in their operations and demonstrate legality and sustainability to the seafood marketplace.[2] For many fisheries, EM can be more reliable, cost-effective, and readily scaled to cover 100 percent of fishing activity than human observers or other monitoring tools.

1. World Bank Group, "The Sunken Billions Revisited: Progress and Challenges in Global Marine Fisheries," 2017, https://openknowledge.worldbank.org/bitstream/handle/10986/24056/9781464809194.pdf
2. Philip Christiani et al., "Precision Fisheries: Navigating a Sea of Troubles with Advanced Analytics" (McKinsey & Company, 2019), https://www.mckinsey.com/~/media/McKinsey/Industries/Agriculture/Our%20Insights/Precision%20fisheries%20Navigating%20a%20sea%20of%20troubles%20with%20advanced%20analytics/Precision-fisheries-Navigating-a-sea-of-troubles-with-advanced-analytics-vF.ashx

On Driving More Rapid EM Growth

In the two decades since the first EM pilots, use of the tool has grown steadily, if slowly. There are now approximately 1,500 EM systems deployed worldwide. While EM has proven effective for meeting a variety of monitoring functions at scale, EM adoption has been slow relative to monitoring needs for the world's almost 400,000 industrial and semi-industrial fishing vessels.[3,4] The reality is that EM has been a regulatory-driven tool, and regulatory changes in fisheries are often, by design, long processes which require the support of many different stakeholders.

Historically, EM has been implemented in fisheries in which the costs of existing monitoring programs, including the impacts of limited accountability, outweigh the costs of an EM program (Box 1).[5] For example, in fisheries where:

- Unreported discards are driving managers to consider major constraints on fishing effort to protect the health of choke stocks[6]
- Interactions with ETP species could constrain or shut down a fishery
- A lack of accountability threatens access to markets with sustainability or fair labor demands
- Existing human observer programs are high-cost and logistically challenging

Although growth of EM has historically been quite slow, the tool appears to be at a critical point in its development and poised for much wider adoption. Fisheries are facing increasing regulatory and market pressure to improve data and accountability for their operations at sea. Climate change is increasing the need for more timely and verifiable data. At the same time, growing experience with program design and implementation is increasing confidence that EM can help meet this demand for improved fisheries monitoring.

Seafood for export, Republic of the Marshall Islands.
Photo: Kydd Pollock / The Nature Conservancy

BOX 1

The British Columbia Area A Dungeness Crab Fishery

The British Columbia Dungeness crab fishery implemented the world's first EM program. It is an example of how the economic impacts from a lack of accountability on the water can drive a fishery to implement EM.

In the late 1990s, a significant increase in fishing effort was escalating competition between fishers. With limited monitoring in place, this led to widespread incidences of gear theft, sabotage, and hauling other fishers' traps. Some estimates put the annual cost of this illegal activity at $100,000 CDN per fisher.

In response to the crisis, the regulator proposed implementing a trap limit for each vessel, but the industry recognized there was no means of enforcement. Ultimately, the industry turned to Archipelago Marine Research to develop and pilot an EM program that could ensure compliance with trap limits. The program helped limit fishing effort and the illegal activity that was costing the fishery millions of dollars. According to some in the industry, the cost of the EM equipment paid for itself after just one year due to reductions in gear theft and increased harvests.

3. United Nations Food and Agriculture Organization. "The State of World Fisheries and Aquaculture 2018 – Meeting the sustainable development goals." Rome. (2018)
4. Semi-industrial and industrial is used to mean motorized vessels >12m in length. EM may not be suitable for all vessels in this category and may also be suitable for some smaller vessels.
5. Archipelago Marine Research. "Monitoring the Area A Crab Fishery." https://www.archipelago.ca/case-studies/area-a-crab-fishery/. Accessed April, 2020.
6. A choke species is a term used to describe a species with a low quota that can cause a vessel to stop fishing even if they still have quota for other species. ICES, "Choke Species." In Other Words. http://www.ices.dk/news-and-events/Blogs/Inotherwords/Lists/Posts/Post.aspx?ID=13. Accessed May, 2020.

However, there are several barriers preventing EM from scaling (Box 2). Consumer demand for sustainable seafood, is unlikely to drive EM adoption at scale as it is primarily limited to Northern European and North American markets. Even in those markets, consumers lack the information and bandwidth to choose products that are produced with comprehensive on-the-water monitoring. EM service providers may be underinvesting in government outreach and research and development (R&D) of new technologies such as artificial intelligence (AI), due to the small market size, risk, and the possibility that their investments will be appropriated by others in the field. Regulators are resource constrained, risk averse, and lack curated information to implement EM with confidence. Finally, industry still sees EM as primarily a compliance tool with clear costs and few or uncertain benefits.

These barriers can be overcome. Targeted philanthropic and public investment can:

- Amplify market demand for EM.
- Support technology innovation and operational improvements that reduce EM costs and improve functionality.
- Provide technical support to regulators to de-risk, reduce the cost, and speed up EM program implementation.
- Develop private sector incentives for adoption and promote industry leadership in EM program design.

These investments can reduce uncertainty and change the cost-benefit calculus so that regulators and industry can say "yes" to EM.

BOX 2

Market Barriers Limiting the Growth of EM

Barriers to Government Demand for EM

Fishery management decisions require a thorough assessment of the costs, benefits, and risks of implementation. But regulators considering EM for the first time have a lot of uncertainty, which can bias them towards inaction. More specifically:

- **Governments may lack clarity about the scale of the current problem**. In most cases, EM is being considered in fisheries that do not have strong on-the-water monitoring. Therefore, regulators often lack a clear picture of the problem they are trying to address and its impact.
- **Will EM solve the problem and at what cost?** Although EM has been around for more than two decades, newly implementing regions are often uncertain about whether it will solve their monitoring challenges and at what cost. They may also be concerned about building the capacity and skills needed to successfully implement an EM program and how EM may impact current monitoring programs.

Barriers to Responsible Consumer Demand

Sustainable seafood demand has grown markedly in the last 15 years and has pushed the seafood industry to adopt better practices. But there are several barriers that limit consumers' ability to make responsible purchasing decisions, which has limited retailer and food service industry demands for EM in their supply chains. Some barriers to responsible consumer demand include:

- **Bounded Responsibility**: Faced with a slew of environmental and social issues, consumers cannot be aware of or expend the energy to be engaged with all of them.
- **Question of Impact**: Even when consumers care about sustainable seafood, they may not believe that their consumption decision will make a difference.
- **Information Overload**: Even when a consumer believes strongly in an issue, making the right choice requires huge investment. Confronted with a flood of marketing and information, consumers often resort to heuristics, which may lead to purchasing decisions that do not reflect their desired intentions.

Barriers to EM Provider Investment

With a small and slowly growing market, individual EM providers may be under-investing in activities such as government outreach and R&D that could lift the entire EM market.

Barriers to Industry Support for EM

In most cases, industry views EM primarily as a compliance mechanism that will constrain their fishing operations and cost them money. For industry, the potential benefits of EM are often uncertain or not well understood. In addition, industry may have concerns about privacy, data management, and operational impacts on their business (e.g., catch handling requirements, hard drive exchange, interruptions because of inoperable systems).

Summary of Progress
Against 2018 Recommendations

In 2018, TNC and CEA released the report, "Catalyzing the Growth of Electronic Monitoring in Fisheries." The report presented an investment blueprint for driving more rapid adoption of EM. There has been noteworthy progress on most of the 2018 recommendations, and nearly all are still relevant opportunities. But investment has not been large enough nor development fast enough to put EM on track to break out of a business-as-usual growth scenario. A summary of progress during the last 18 months against the original recommendations follows. The recommendation updates are organized into four broad categories:

- **Increase Demand for EM**
- **Reduce the Cost of EM**
- **Provide Technical Support to Regulators**
- **Promote Industry Leadership**

Progress Increasing Demand for EM

Since 2018, EM pilots have demonstrated the capability of the tool to fill critical science and compliance data gaps.

Reports and studies continue to show that absent on-the-water monitoring, most fisheries managers do not have the information they need to meet sustainable management objectives. Overharvesting of yellowfin tuna in the Indian Ocean, the death of a Kiribati observer, and the risk of a ramp up in illegal activity following Covid-19-induced reductions in monitoring are just a few of the recent examples of the need for stronger at-sea monitoring. At the same time, new EM trials and programs are demonstrating that the tool can provide the granular data about what is happening at sea, which is fundamental to effective fisheries management. For example, new EM studies in the Pacific Islands and Australia have demonstrated significant underreporting of catch, especially for ETP species. While there is no comprehensive listing of EM projects, we have identified at least 16 new EM trials or programs in the last 18 months which cover approximately 250 vessels. These new trials and programs are further demonstrating the capabilities of EM to fill critical fishery data gaps.

Growing confidence in EM is underpinning commitments to improve on-the-water monitoring.

The last couple of years have seen several high-profile commitments to improve monitoring and implement EM. These include commitments from industry (e.g., Thai Union, Luen Thai Fishing Venture), governments (e.g., New Zealand, Chile, Federated States of Micronesia (FSM)), and from regional fisheries management organizations (RFMOs). Ensuring that these commitments are met and continuing to demonstrate EM across a representative set of fisheries and regions will open the space for stronger accountability on the water and EM growth.

EM is being used to demonstrate sustainability in the marketplace, but market-based drivers for EM need to be amplified.

Market-based sustainability initiatives (e.g., eco-certifications, fishery improvement projects (FIPs), traceability solutions) and import regulations have provided incentive for some fisheries to adopt EM (e.g., Mauritius Longline Tuna, Chilean Hake, Scottish Scallops, Maldives Pole and Line Tuna). But many fisheries can meet the market's bar for sustainability without robust monitoring in place. Strengthening data adequacy requirements of the Marine Stewardship Council (MSC) standard and exerting more pressure on retailers, foodservice, and branded seafood companies to drive monitoring

Luen Thai Fishing Venture, Republic of the Marshall Islands. Photo: Kydd Pollock / The Nature Conservancy

improvements in their supply chain are needed to create stronger market incentives for EM.

New proof points are emerging about the benefits to industry from improved management enabled by EM, but the link to enhanced economic outcomes needs to be strengthened.

Examples are emerging about EM supporting more efficient and flexible fisheries management such as increasing individual target and bycatch quotas, potentially scaling back time and area closures in the United States Atlantic Highly Migratory Species (HMS) fishery, and enabling gear flexibility in the Scottish scallop fishery. While some fisheries see some market pull for verifiable monitoring, generally industry still views EM primarily as a compliance tool with few benefits. The link between EM, efficient fisheries management, and improved economics for fishing fleets needs to be strengthened and clearly demonstrated to accelerate EM growth.

New use cases for EM in areas such as labor and transshipment are emerging, but are still in the development and testing phase.

There is strong market demand for using EM to monitor both labor practices and transshipment activities. Progress is being made on both these fronts,

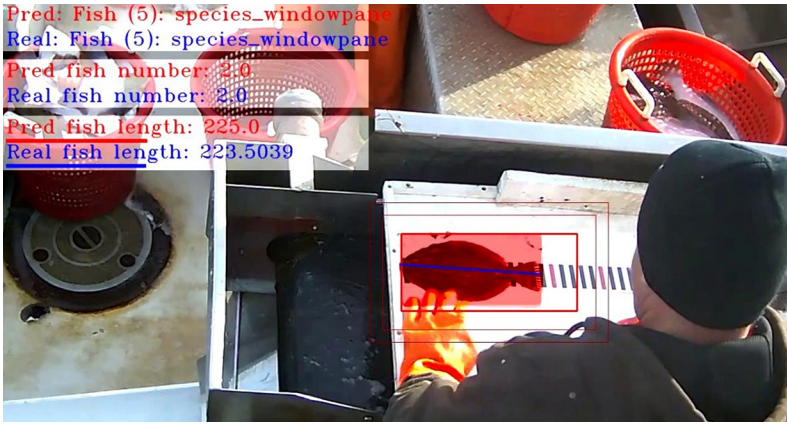
Tunago 51. Photo: Kydd Pollock / The Nature Conservancy

including on-the-water testing of transshipment monitoring as a part of the Tunago FIP. This trial showed that EM could verify transshipment events and the reported volume of fish moved, and ensure that there were no illegal activities occurring. The EM system in this trial operated continuously for over one year at sea. While progress has been a bit slower on labor monitoring, there have been extensive conversations between environmental and labor rights groups that have set the stage for on-the-water demonstrations. More investment is needed to advance these new use cases for EM so they are ready for the wider market.

Progress Reducing the Costs of EM

There have been great strides in artificial intelligence (AI) development, but it has not yet delivered tangible performance benefits or cost savings.

Video review costs often make up the lion's share of EM program costs and there is enormous interest among EM customers to speed up or fully automate this process with AI. Although incentives for EM service providers are not fully aligned with AI development since they often get paid per hour of video review, significant progress has been made in the last 18 months. This includes the development of Fishnet.AI, a library of 100,000 tagged EM images to support AI development. There have also been several proof of concept demonstrations of models trained specifically for fisheries (e.g., National Oceanic and Atmospheric Administration (NOAA) and the University of Washington's collaboration on species identification and length measurements in multispecies fisheries, development of quick screening tools to ID important events, length measurement assistance in New England).



Length measurement using AI, Rhode Island. Photo: Ayla Fox / The Nature Conservancy

EM service providers' experience with implementing AI has been uneven. A small segment (e.g., Satlink, Integrated Monitoring, SnapIT) have AI as part of their marketing and service offerings, and all of the EM service providers acknowledge the potential, but AI has not made the leap to product-ready solutions delivering obvious functionality improvements that deliver cost savings to customers. The two biggest challenges to address are (1) providing high quality labeled data to eliminate the cold start[7] problem for model development, and (2) operationalizing AI models within existing EM service provider workflows, software, and general technology stack (e.g., smart cameras, cloud). Getting over this hurdle will require more investment, deep technical support, and strategies to de-risk development for EM service providers and their partners.

While the market waits for product-ready AI, innovations to achieve program objectives at lower cost continue to advance.

Recent research has explored what share of video needs to be reviewed to meet overall program objectives. For example, research in New England is finding that increasing random review rates beyond 20 percent yields limited improvements in the accuracy of discard estimates for most species in a multispecies fishery. This work is being complemented by investigations of risk-based auditing approaches that can further focus video review resources on the highest-risk fishing vessels or activities. These efforts are essential to drive down video review costs in the near term until AI progresses to the point that it unlocks cost-effective review of large volumes of video.

Onboard Satlink system, Republic of the Marshall Islands. Photo: Lucas Bonetti

New mechanisms for driving efficient delivery of EM programs are being explored, but still need to be evaluated.

Performance-based standards, third-party contracting, industry-driven multi-provider program structures, and "EM as a Service" are all being actively explored as ways to make it easier for stakeholders to say "yes" to EM. Multiple providers are supplying systems for Chile's industrial fleet, new trials have been structured under "EM as a Service" contracts, and FSM is rolling out scalable EM performance standards for pelagic longline fisheries. These approaches are designed to reduce government capacity requirements, reduce transaction costs, maximize industry flexibility, create incentives for EM provider hardware and software improvement, and drive efficient program development and delivery, but they have yet to be widely tested. Proving the effectiveness of these models should be a near-term priority for the field.

EM service providers have developed lower cost EM systems targeted to smaller vessels, but little progress has been made reducing hardware cost for systems on larger vessels.

Although typically a smaller share of overall program costs than video review and data management, the hardware costs of EM systems are a concern for industry and governments alike. The 2018 report set a target of driving hardware cost reductions of 50 percent by 2021. Several companies are releasing lower cost EM systems designed for smaller vessels (e.g., Anchor Lab's Lite system, Satlink's SeaTube Nano, Saltwater), but there is no evidence that the hardware costs of systems for larger vessels are coming down significantly. Continuing to push for hardware cost reductions will be helpful, but ultimately, meaningful price reductions will come through growing the size of the EM market and realizing economies of scale.

7. The cold start problem refers to the issue that software is unable to make accurate inferences about events for which it has not collected sufficient information.

Progress Providing Technical Support to Regulators and Promoting Industry Leadership

A diverse assortment of working groups, conferences, and informal exchanges have taken place to share learnings and best practices.

The 2018 report recommended the creation of a global expert working group that could be deployed to provide curated guidance to regions on the EM learning curve. While a global working group has not been developed, the International Council for the Exploration of the Seas (ICES) formed the Working Group on Technology Integration for Fishery-Dependent Data (WGTIFD) for the North Atlantic. The group includes a mix of regulators, non-governmental organizations (NGOs), service providers, and academics who are tasked with providing advice to the community on electronic tools and applications that support fisheries-dependent data collection, including EM. The group held one meeting in 2019—its second has been delayed due to Covid-19—but could serve as a model for disseminating expert advice on EM. In addition, numerous EM conferences have taken place in the last 18 months, as well as collaborations between agencies (e.g., NOAA and the European Fisheries Control Agency (EFCA)), in which the latest developments and best practices for EM program design have been shared.

EM training, Solomon Islands.
Photo: Kydd Pollock / The Nature Conservancy

EM training. Photo: The Nature Conservancy

Summary of Progress
Against 2018 EM Growth Scenarios

In 2018, we put forth a handful of possible scenarios for EM development over the next 10 years. These ranged from a baseline scenario in which we estimated EM would grow to cover approximately 6,000 vessels, to a scenario in which the vision for EM was realized and was deployed on over 50,000 vessels (see Appendix A). The dialogue around EM has evolved in the last year and a half. As one EM provider said, "It has been a positive year. We have been involved with EM since 2012 and we definitely see a change in mindsets, especially among fishing companies and fisheries managers."

But the trajectory of EM adoption needs to be bent much further to deliver on its potential to provide granular data that can underpin science-based management for the world's fisheries on a timescale that aligns with the accelerating threats from overfishing and climate change. Covid-19 disruptions to existing monitoring programs have also highlighted vulnerabilities in these programs and the ability of EM to provide continual coverage when human observers are unable to do so.

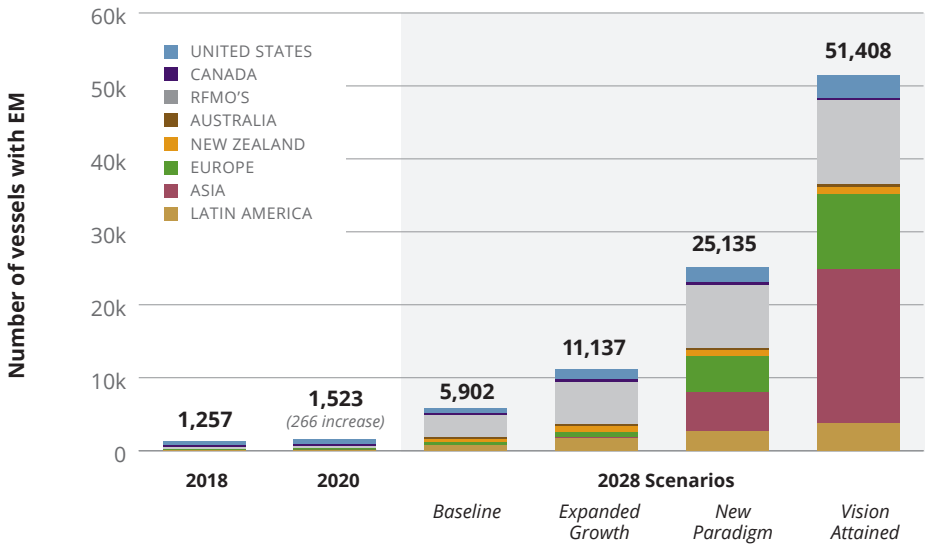
Based on EM deployments in the last 18 months, the world is still squarely in the baseline trajectory scenario. While there is no global database of EM systems, we estimate that about 250 additional systems have been deployed since the end of 2018 (Figure 1). The next few years may prove critical for scaling up the growth of EM in line with the expanded growth scenario. Serious deliberations or early implementations are underway for large programs such as the longline fleet operating in the Western and Central Pacific Fisheries Commission (WCPFC) Convention Area, Seychelles' longline and purse seine fleets, New Zealand's inshore and offshore fisheries, the Chilean semi-industrial fleet, North and Baltic Sea fisheries in Europe, Scotland's scallop fishery, the Maldives pole and line tuna fleet, and others. These fisheries represent well over 1,000 vessels that could have EM systems installed in the next couple of years. (See the section EM Developments Around the World for a summary of EM progress by country/region.)

Bending the curve on EM adoption will require greater leadership from governments and the fishing industry, accelerated product development from EM providers, additional effort from the NGO community to drive demand for increased accountability in fisheries and to provide support for EM programs, and targeted public and philanthropic investment. The seafood retail and foodservice industries will also need to amplify pressure on, and partnership with, their suppliers to ensure their commitments to sustainable seafood are driving change on the water.

FIGURE 1

Growth of EM systems from 2018 to 2020 and future scenarios for EM in 2028

The number of EM systems are estimated based on literature review and expert interviews. Numbers are approximate and may not be comprehensive.



Updated Near-Term Recommendations
for Advancing EM

The 2018 report put forward a series of near-term recommendations for advancing EM. The following is an updated set of priority near-term investments to catalyze the growth of EM. These updated recommendations reflect the progress and lessons learned since the release of the original report

The recommendations are organized thematically in four main groups: Markets, Policy, Technology, and On the Water. These updated recommendations aim to accelerate the growth of EM by building demand for EM, reducing the cost of EM, supporting regulators, and promoting industry leadership.

TABLE 1. Taxonomy of Updated Recommendations and their Primary Objectives

		BUILD DEMAND	REDUCE COSTS	SUPPORT REGULATORS	PROMOTE INDUSTRY LEADERSHIP
Markets	*Amplify pressure on retailers for on-the-water monitoring*	✓			
	Strengthen data adequacy requirements of the MSC standard	✓			
	Ensure traceability efforts incorporate EM	✓			
	Secure commitments to 100 percent on-the-water monitored seafood products	✓			✓
	Support pre-competitive collaboration among EM providers	✓	✓		
	Coordinate buyers into bulk procurements	✓	✓		✓
Policy	*Secure EM policy commitments with credible implementation plans across a range of fishery archetypes*	✓			
	Test and validate lower video review rates and more efficient video review methods, including risk-based approaches		✓		
	Develop scalable performance-based standards		✓	✓	
	Promote "EM as a Service" contracts		✓		
	Advocate for more flexible or targeted management measures enabled by EM	✓			✓
	Build and support EM expert working groups			✓	✓
Technology	*Support AI development to drive more efficient video review and analysis*		✓		
	Develop on-vessel AI for "near real-time" data	✓	✓		
On the Water	*Demonstrate EM across a range of fishery archetypes*	✓	✓	✓	
	Demonstrate new use cases for EM (e.g., labor and transshipment)	✓			

Markets

Amplify market incentives for EM adoption.

Market incentives have been insufficient to drive EM adoption at scale. The following activities should be supported to ratchet up market demand for EM.

- **Increase pressure on retailers for on-the-water monitoring**. Most of the largest retailers in the US and EU have made commitments to sustainable seafood, yet unsustainably harvested products and poor labor standards are still present in their supply chains. Simply put, without EM most retailers cannot have confidence that seafood products on their shelves were caught legally, sustainably, and without labor abuses. A stronger carrot and stick approach is needed to expose these practices and to demand that retailers' sustainable seafood commitments be matched by real improvements and accountability on the water.
- **Strengthen data adequacy requirements of the MSC standard**. MSC provides no data adequacy guidance to assessors. Not only does this weaken incentives for fishers to adopt EM, but, paradoxically, it may even create a disincentive to collect robust on-the-water data. Support should be provided to NGOs to engage in the MSC standard revision process that is currently underway to ensure that robust, risk-based data adequacy requirements are integrated into the standard to increase confidence that data feeding into the assessments accurately reflect fishery impacts.
- **Ensure traceability efforts incorporate EM.** There are numerous ongoing traceability efforts, but many are just dock-to-plate systems that do not provide certainty that the product was harvested sustainably, legally, and with fair labor practices. Support is needed to bring EM experts into these dialogs and ensure that they are building true catch-to-plate solutions.
- **Secure commitments to 100 percent on-the-water monitored seafood products**. Several companies have been driving and making commitments to EM in their supply chains (e.g., Thai Union). These efforts should be supported and amplified with a goal of securing initial commitments to 100 percent on-the-water monitored seafood products from major seafood, foodservice, or retail companies.

Support pre-competitive collaboration among EM providers.

Growing the EM market will require coordinated investment to overcome the challenges of building awareness of the tool and its capabilities, and developing technologies that will improve the level of service and reduce the costs of EM programs. Due to the small EM market size and risk associated with these activities, individual EM providers are unlikely to solve these challenges on their own. Thus, support should be provided to develop an industry association to pursue pre-competitive collaboration that will lift the entire EM market, including:

- Government outreach and education
- Coordinated technology development (e.g., AI)
- Development of interoperability and performance standards

Policy

Drive improved video-review efficiency.

Improving the efficiency of video review offers the best near-term opportunity for cost reductions. Support is needed to:

- **Test and validate lower video review rates and more efficient video review methods**. Several fully implemented programs have low video review rates (e.g., 10 percent), but many newer trials and programs are still operating with 100 percent video review as they develop baseline information. Investment is needed to test and validate methods that can allow these programs to review a lower percentage of footage while still meeting program objectives. Additionally, implementing measures that improve the efficiency of review (e.g., high speed review, software assistance tools) can also drive near-term cost reductions.
- **Develop and test risk-based review methods**. The granular data of EM can allow for more targeted use of video review resources on the highest-risk operations. Investment is needed to develop and validate these risk-based approaches and to coordinate with other industries (e.g., casino gaming) that may have risk-based approaches to share with the fishing industry.

Confirm that new program and contract structures drive cost reductions and service improvements.

Reducing the cost and improving the efficiency of program delivery is imperative for EM growth. The following

models have the potential to drive cost reductions and level of service improvements and should be tested and validated:

- **Develop scalable performance-based EM standards.** Performance-based standards define a minimum set of system and service delivery standards for an EM program. Performance-based standards facilitate moving governments out of the role of EM program delivery to validating that EM providers are meeting their level-of-service requirements. While it may be desirable and efficient in some cases for governments to execute a broader set of program operations (e.g., video review and analysis), in other cases contracting with third-party providers may reduce costs, improve service, and help overcome government capacity constraints. By defining a minimum level of performance, scalable performance standards can also unlock multi-provider supply and bulk procurement bidding processes which can drive more competition among EM service providers, and also give them the flexibility and incentive to meet program requirements in the most efficient way.
- **Test "EM as Service" contracts.** Traditional EM contracts, which pay service providers per hour of review time, do not align their incentives with driving program efficiencies. "EM as a Service" contracts, which pay service providers a fixed amount if they meet specified performance standards, create strong incentives to improve the efficiency of program delivery. They also provide buyers with more stable and potentially lower pricing.

Advocate for more flexible or targeted management measures enabled by EM.

With 100 percent on-the-water monitoring, EM can unlock more flexible or targeted management measures such as individual quotas, rollback of time and areas closures, targeted sanctions, or uncertainty buffers. These types of measures should be supported to strengthen the link between EM and improved economic outcomes for industry.

Support existing and develop new expert working groups to provide technical assistance.

There is an abundance of information about EM, but what regulators really need are world-class experts who can provide them with curated information and consultation on program design options. Multi-stakeholder working groups consisting of regulators, fishers, NGOs, EM service providers, and scientists could provide detailed, high-quality, on-demand guidance for EM program development. The efforts of existing working groups, such as the WGTIFD, should be amplified and could serve as a model for other regional expert working groups.

Technology

Move AI from proof of concept to a market-ready technology.

Streamlining video review is the biggest opportunity for reducing program costs and AI development is the key to unlocking much of this potential. To foster AI development, investment is needed to:

- **Continue to build and support image libraries.** Fishnet.AI, a training data library with 100,000 images, is a huge and foundational step for AI development. But many more accurately labeled images are needed to facilitate AI development across different fishery types. As more libraries come online, they should be encouraged to share tagged images to prevent balkanization.
- **Support and de-risk AI development.** EM providers may not have the resources, expertise, or risk tolerance to drive rapid AI development and integrate it into their product flow. Providing world-class AI engineers (e.g., Amazon Web Services, productOps), and resources to de-risk AI development will help speed development.
- **Support the development of on-vessel AI for "near-real-time" data.** Near-term application of AI is likely to happen in review centers after transmitting video from vessels. But the future of AI lies in on-vessel processing of video to identify relevant video clips or convert video into processed data for "near real-time" offloading. Support is needed to develop onboard AI applications and video compression that will enable more real-time analysis of fishing activity and more efficient data transfer.
- **Tie market demand to model development.** Retailer supply chains could be a powerful driver of the development of specialized models that deliver sustainability metrics at the vessel level. Smarter processing of vessel data could deliver information on various sustainability metrics like bycatch, transshipments, International Convention for the Prevention of Pollution from Ships (MARPOL), and human rights violations. Pilots with large-scale retailers are necessary to move this forward.

Demonstrate the functionality of EM for new use cases.

There is significant demand for new use cases for EM. Over the next 18 months, investments should be made to:

- **Test EM on the water for monitoring labor practices and integrate EM into a holistic fair labor platform.** Demand is growing for on-the-water monitoring that can reduce the risk of poor labor practices in seafood supply chains, including unsafe working conditions for observers and crew. Investments should be made to test and demonstrate EM for this use case and ensure it will not have any unintended consequences for the people it is meant to safeguard. In parallel, EM needs to be integrated into a holistic fair labor platform that comprehensively addresses seafood labor issues.
- **Implement a larger-scale transshipment pilot.** A proof of concept trial on a reefer has demonstrated EM's capability for verifying transshipments. There is increasing interest in applying EM for this function, and this has only grown with the Covid-19-induced suspension of at-sea observers. A larger-scale pilot should be supported that can test and inform the design of a fully implemented EM program to support transshipment monitoring.

Demonstrate EM on the water across a representative set of fisheries and governance archetypes.

The EM market is still in its early stages of development. For EM to transition into a growth stage, EM programs need to demonstrate success at scale across a variety of fishery archetypes (e.g., gear types, governance context, monitoring objectives) (Table 2). These demonstrations will provide a blueprint for other fisheries to follow that will unlock demand, decrease the friction of setting up new programs, and reduce the scale of external support required to get new EM programs up and running. Below, we present a selection of near-term on-the-water investment priorities organized by geography to prove EM's capability to improve monitoring and accountability at scale in a variety of fishery archetypes (Table 2).

TABLE 2. Typology of Priority Regions/Fisheries for EM Development by Governance Level and Status of EM Development
(Specific recommendations for the regions/fisheries in blue have been elaborated in this report.)

GOVERNANCE LEVEL:	STATUS OF EM DEVELOPMENT: STUCK IN AN ACCOUNTABILITY TRAP	ON THE LEARNING CURVE	EM IS ESTABLISHED
LOW/MIXED	N/A	**WCPO tuna** **Other tuna fisheries**	N/A
MEDIUM	N/A	**Chile** **Peru**	N/A
HIGH	**European Union** **New England groundfish**	**New Zealand** **Scotland** **England**	**United States** **Australia** **Canada**

New England Groundfish

TYPE: HIGH GOVERNANCE, STUCK IN AN ACCOUNTABILITY TRAP

The New England Groundfish fishery has struggled with a lack of accountability on the water and unreported discarding of choke species. A lot of heavy lifting has been done to advocate for better accountability and to demonstrate EM's potential to meet the fishery's monitoring needs. Now is the time to push these efforts over the line. As a part of the Amendment 23 process, which will set at-sea monitoring requirements for the fishery, the New England Fishery Management Council has identified 100 percent at-sea monitoring with the option of using EM to meet a portion of this requirement as its preferred alternative. A final decision is expected soon with implementation possibly happening in May 2021. Continued effort is needed to push EM across the line, including:

- **Advocate for full accountability and the use of EM through the Amendment 23 process.** The lack of a requirement for comprehensive on-the-water monitoring is the primary barrier to EM in the region. Stakeholders should make a final push to make sure the preferred alternative for Amendment 23 is adopted and brings full accountability to the fishery.
- **Lower video review rates to bring down program cost.** Reducing program costs will be essential for program durability, and a combination of research and on-the-water pilots should determine the minimum video review rate that can still meet program objectives of validating vessels' reported discards.
- **Develop AI concepts and integrate them into workflows.** New England has been a hub for the development of AI, and investment should continue for these efforts. Monitoring discards in a multispecies fishery presents some complex challenges for AI development, but also great opportunities to drive cost reductions.

European Union

TYPE: HIGH GOVERNANCE, STUCK IN AN ACCOUNTABILITY TRAP

The EU is in a standoff over the landing obligation. Industry sees the regulation as an existential threat to its survival and has firmly dug in its heels. At the same time, regulators are trying to find a way to enforce the landing obligation with many concluding that EM is the only way to ensure compliance. There appear to be three general scenarios for how this will play out:

- **Industry fends off implementation.** Industry continues to fend off implementation of the landings obligation which will likely have negative impacts on the health of fish stocks and the long-term economic prospects for the fishing industry. This will also increase the risk of several fisheries losing their MSC certification.
- **Government mandates EM implementation.** Government mandates the implementation of EM to enforce the landings obligation with no concessions made to industry. This causes significant near-term economic pain for industry and serious implementation and political challenges.
- **Industry and government reach a grand bargain.** Industry and government reach a grand bargain in which both sides make concessions. There will be sacrifices on both sides, but the result is a compromise that addresses the challenge of controlling unreported discards to ensure fisheries are managed sustainably while addressing the economic concerns of industry.

Completing a grand bargain will not be easy, but the following investments can help push towards a compromise that includes EM.

- **Support Northern European leadership.** In the last few months, Denmark and Sweden have made commitments to push ahead with EM. Providing on-the-water support, technical guidance, and endorsements of these efforts can make them a success and pull the EU forward.
- **Cultivate industry partners.** Bringing private-sector partners to the table to shape EM implementation will be essential to reduce political and practical friction. This is an opportunity for leading industry members to shape EM programs and incentives (e.g., quota top-ups) which will provide them benefits relative to less cooperative industry peers.
- **Create a credible MSC threat.** A large portion of MSC certified fish come from Europe, and with the lack of implementation of the landing obligation some of this supply could be at risk of losing certification. Highlighting the threat of decertification while also pushing for stronger risk-based data requirements in the MSC standard can ratchet up pressure to advance EM and to reach a broader agreement on the landing obligation.

New Zealand

TYPE: HIGH GOVERNANCE, ON THE EM LEARNING CURVE

New Zealand passed legislation in 2017 to require EM for all commercial fishing vessels, which could cover up to approximately 1,000 vessels. A change of administration and fishing industry concerns put the rollout on hold, but it is now back in motion with a mandatory regulated 20-vessel program up and running. The focus has shifted from EM as an objective to EM as a tool to meet monitoring objectives, and a more collaborative dialog has developed among stakeholders.

- **Support on-the-water projects and facilitate industry dialog.** The next eighteen months should focus on addressing some of the main challenges to further adoption of EM in New Zealand, including cost and privacy concerns. Bringing in organizations with international EM expertise to provide on-the-water support and technical guidance can help work through design options and facilitate dialog between stakeholders to address these challenges and chart a shared pathway forward.

United States

TYPE: HIGH GOVERNANCE, EM IS ESTABLISHED

The United States is the world's leader with eight fully implemented programs and 11 pilots/pre-implementation programs in process, which cover almost 600 vessels. Philanthropic efforts in the US should focus on pushing the leading edge of EM development and resolving some of the more challenging issues, including:

- **Create a model for efficient, sustainably funded EM programs.** With numerous EM programs, government budget and capacity constraints, and industry concerns about cost; a durable model for financing programs and bringing down costs needs to be established. This includes pushing performance-based standards, validating a third-party provider contracted program in the West Coast, and developing data management policies
- **Integrate EM data into science.** EM data is primarily used for compliance functions, but it has enormous potential to improve fisheries science. Research should explore the use of EM data for fisheries science and understand how these new data streams can be integrated to reduce the cost or improve the accuracy of fishery assessments.
- **Implement more efficient management measures enabled by EM.** Some EM programs are reaching a level of maturity where data should enable more flexible management. Selectively rolling back input controls or applying more targeted sanctions (e.g., spatial closures, gear restrictions) are logical first steps, but efforts should also explore a long-term vision for how EM data can support more dynamic and flexible fisheries management, which will become even more relevant with increasing climate-induced volatility.
- **Test new use cases for EM.** EM should continue to be tested for new fisheries and use cases. For example, expanding the testing of EM in the for-hire sector would be a big step forward for bringing stronger accountability to the recreational sector.

Onboard EM system, Rhode Island.
Photo: Ayla Fox / The Nature Conservancy

Chile's Semi-industrial Fleet

TYPE: MEDIUM GOVERNANCE, ON THE EM LEARNING CURVE

Chile is already moving ahead with implementation of EM for its industrial fleet with one hundred installations completed as of early 2020. In 2022 the country is scheduled to implement EM for its semi-industrial fleet, which would bring EM to hundreds of additional fishing vessels. This could be one of the largest EM programs in the world and would demonstrate the applicability and scalability of EM in a moderate governance context. The following activities can support a successful rollout of EM for Chile's semi-industrial fleet:

- **Support on-the-water pilots.** Chile will learn a lot through the implementation of EM on its industrial fleets, but the semi-industrial fleets will present some different challenges (e.g., different fisheries, locations, boat configurations, monitoring needs). Developing on-the-water pilots in representative sectors of semi-industrial fisheries can help collect baseline data, identify challenges, and inform program design in advance of moving towards widespread implementation.
- **Validate performance-based standards and third-party EM service provision.** The Chilean government is handling video review for its industrial vessel EM program, but a different program structure might be better suited to the semi-industrial fleet given the large number of vessels. This is an opportunity to test a third-party delivery model in which EM service providers would be responsible for hardware installation, service, video transmission, review, and the delivery of analyzed data to the government that meets minimum performance standards. The third-party contracting model could be a more scalable approach for EM program delivery, but it needs to be tested to validate whether it improves the efficiency of program development and delivery, and this model should be considered for Chile's semi-industrial fleet.

Peru Anchoveta

TYPE: MEDIUM GOVERNANCE, ON THE EM LEARNING CURVE

EM could be well-suited to monitor interactions with marine mammals, seabirds, and bycatch of juveniles, which are the primary concerns in the fishery. As of early 2020 a few large anchoveta vessels had EM systems installed, driven by the companies themselves.[8] The artisanal fleet is also largely unmonitored, and EM could provide a pathway to full fleet coverage. Effort in Peru should:

- **Find industry entry-points for industrial anchoveta.** Progress on EM for the industrial anchoveta fleet is likely to be driven from the bottom up, and investments should be made to develop on-the-water pilots in collaboration with leading companies.
- **Pilot EM in the artisanal anchoveta fleet.** The artisanal anchoveta fleet has been largely unmonitored, but a FIP is advancing human observers for a portion of the fleet. Human observers will be difficult to scale widely across the fishery and so EM should be piloted as an option for moving towards full on-the-water monitoring for the artisanal fleet.

Western and Central Pacific Ocean Tuna

TYPE: LOW/MIXED GOVERNANCE, ON THE EM LEARNING CURVE

EM has progressed markedly in the last few years in the Western and Central Pacific Ocean (WCPO). It has moved from basic trials to a point where regional bodies are pushing for EM programs and trying to influence their design and structure. The region's longline tuna fishery is set to be the first large-scale implementation of EM in a low/mixed governance region. Covid-19-induced monitoring gaps are also strengthening the case for EM for purse seine vessels and improved transshipment monitoring. The following priorities can help support successful development of EM in the region:

- **Support early adopting countries and industry partners.** A handful of countries (e.g., the Federated States of Micronesia (FSM), Solomon Islands) and industry partners (e.g., Thai Union, Bumblebee, Luen Thai Fishing Venture) are current leaders for advancing EM in the region. These groups are providing the bottom-up pressure that is driving the regional EM conversation. Investments should continue to support these groups so that their EM work can continue to drive towards broader EM adoption in the region.

8. Confidential interview

- **Advocate for a 100 percent monitoring requirement in longline fisheries.** EM is now a proven technology for monitoring tuna fisheries and with just over 2,000 longline vessels operating in the region with less than five percent observer coverage, the time is right to start pushing for 100 percent monitoring requirements for the longline fleet. Discussions are progressing at the regional level to push EM adoption to address this long-standing monitoring gap.
- **Advocate for EM as a complement to human observer coverage for purse seine fisheries.** Covid-19 has highlighted an additional weakness of human observer programs. This is creating stronger calls for EM, which should be leveraged to advocate for EM in purse seine fisheries as a complement to human observers that protects observer safety, reduces bycatch mortality and improves overall science and compliance monitoring and data collection.
- **Amplify market pressure.** Some tuna industry members are getting ahead of the EM curve to reduce risk in their supply chain. But market pressure needs to be amplified if it is going to push tuna fisheries more broadly towards EM. More pressure needs to be placed on retailers that exposes the risks and unsustainable practices in their tuna supply chains, which will create incentive for EM. At the same time, developing robust data adequacy standards of the MSC standard will push tuna fisheries to EM as a means to validate that they are meeting the requirements of the standard.
- **Test third-party service provision.** EM pilots in the region largely rely on government-run video review centers. While this structure will be the best and preferred option for some countries, there may be efficiencies to be gained through third-party contracting of EM program delivery functions. Investment is needed to develop and test performance-based standards and third-party contracting to understand the costs and benefits of taking governments out of primary program delivery roles (e.g., system maintenance, video retrieval, video review) and into the role of auditing analyzed data to ensure its accuracy and utilizing that data to enhance the economic and environmental performance of the region's fisheries. FSM is considering performance-based standards and this effort should be supported to take them to completion and get the standards incorporated into regulations.
- **Support capacity development of national fisheries authorities to improve EM service delivery.** Many governments may want to conduct their own video review or other EM program delivery functions. These governments should be supported to help improve the efficiency and consistency of their programs and drive continuous improvements that will secure the long-term durability and quality of EM programs.
- **Implement bulk procurement.** There are numerous EM pilots in the region, many with just a handful of vessels which can be risky and costly for EM providers to service. With growing demand for EM, there is an opportunity to bring buyers together into a coordinated bidding process. This can improve supply and demand visibility and give providers sufficient scale and certainty to reduce the costs of program delivery and make the requisite investments to improve functionality.

Other Tuna RFMOs

TYPE: LOW/MIXED GOVERNANCE, ON THE EM LEARNING CURVE

While the WCPFC has been out in front of the other RFMOs on EM, there is growing interest and pressure to improve monitoring in the other RFMOs. Investment should:

- **Provide technical support to early adopting countries.** Early adoption countries, such as the Seychelles, have made strong commitments to EM. Providing these countries with technical support will help prove the EM model in tuna RFMOs beyond the WCPFC and build bottom-up pressure for a commitment to 100 percent monitoring for industrial vessels.

EM install, Seychelles.
Photo: Kydd Pollock / The Nature Conservancy

KYDD POLLOCK / THE NATURE CONSERVANCY

Progress Against 2018 Recommendations

PROGRESS AGAINST 2018 RECOMMENDATIONS

The 2018 report presented a series of recommendations to accelerate the growth of EM in fisheries. The paper also presented several three-year targets (i.e., for the end of 2021) associated with the recommendations. This section steps through most of these original recommendations and targets, assesses the current progress status, highlights some of the key developments in the last 18 months, and provides updates to the recommendations. The recommendations have been grouped into four broad categories (Table 3):

1. **Increase Demand for EM**
2. **Reduce the Cost of EM**
3. **Provide Technical Support to Regulators**
4. **Promote Industry Leadership in EM Program Design**

Progress has been made on almost all of the original recommendations, yet nearly all are still relevant opportunities. In short, investment has not been large enough, nor progress fast enough to put EM on track to break out of the business as usual growth scenario. However, momentum does seem to be growing. As one EM provider said, "It seems like [EM] is beginning to take off and move forward.... In the last couple of months the prospects have really increased." Capturing this emerging momentum and translating it into rapid EM growth will require concerted effort and investment from a range of public, private, philanthropic, and NGO stakeholders.

> *"It seems like [EM] is beginning to take off and move forward....In the last couple of months the prospects have really increased."*
>
> —INTERVIEWEE

TABLE 3. **2018 Recommendations for Advancing EM Organized in a Simple Framework**

1. Increase Demand for EM

- **1.1** Demonstrate EM's Capability to Improve Monitoring and Increase Demand for Accountability in Fisheries
- **1.2** Make EM a National or Regional Priority
- **1.3** Demonstrate EM Capability for New Use Cases
- **1.4** Use EM to Demonstate Sustainability in the Marketplace
- **1.5** Identify and Cultivate Industry Benefits from EM

2. Reduce the Cost of EM

- **2.1** Build the Market to Create Economies of Scale
- **2.2** Drive Hardware Cost Reductions
- **2.3** Reduce Video Analysis Costs and Streamline Data Transmission
- **2.4** Reduce Program Costs with Efficient Contracts, Standards, and Structures

3. Provide Technical Support to Regulators

- **3.1** Provide Program Design Assistance
- **3.2** Support Data Modernization Efforts

4. Promote Industry Leadership

- **4.1** Provide Industry Leadership in EM Program Design

1. Recommendations
to Increase Demand for EM

EM has demonstrated its ability to generate high-quality and cost-effective data on fisheries activity. There is growing appreciation among regulators and industry for the benefits of EM, but demand for the tool is still limited. Most fisheries have limited on-the-water monitoring, and therefore regulators may be uncertain about whether there are significant management and compliance challenges that need to be addressed. They may also be uncertain about whether EM is the right tool for their monitoring needs and they can be biased towards maintaining status quo monitoring programs.

Industry may also be reluctant to embrace EM. They often view EM primarily as a compliance tool and are uncertain about whether they will see any benefits such as improved fishery health, more flexible management, or market access benefits.

The 2018 report presented the following recommendations to increase demand for EM, and this section provides an assessment of progress that has been made against them.

1.1 Demonstrate EM's Capability to Improve Monitoring and Increase Demand for Accountability in Fisheries

1.2 Make EM a National or Regional Priority

1.3 Demonstrate New Use Cases for EM

1.4 Use EM to Demonstrate Sustainability in the Marketplace

1.5 Identify and Cultivate Industry Benefits from EM

TABLE 4: **Recommendations from 2018 Report and Recent Progress to Increase Demand for EM**

2018 RECOMMENDATION	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
Make EM a national/regional priority	More effort needed ●●○	Yes	Several countries (e.g., Micronesia T3 challenge, Chile, US) and industry players (e.g., Thai Union, Luen Thai Fishing Venture) have demonstrated strong support or commitments to EM; industry leadership has proven to be an essential element that was not covered in the original recommendation.
Use EM in support of eco-certifications and FIPs	More effort needed ●●○	Yes	Fisheries are using EM to help meet MSC requirements and to support FIPs, but MSC data adequacy requirements and supply chain pressure need to be strengthened to drive additional demand for EM.
Use EM to help prove compliance with import control requirements and incorporate into catch-to-plate traceability solutions.	More effort needed ●●○	Yes	Import control requirements have encouraged several fisheries to trial/implement EM. The need for EM has been integrated into some traceability dialogues, but more work is needed to deliver catch-to-plate solutions.
Target vertically integrated companies as early voluntary adopters of EM	On track ●●●	Yes	Vertically integrated companies, especially branded tuna companies, are driving EM uptake.
Demonstrate the benefits to industry from improved management enabled by EM	More effort needed ●●○	Yes	Some additional proof points from fisheries that have improved management with EM, but there is still not a critical mass of evidence of benefits to fishers.
Advocate for regulatory changes that can increase fisher flexibility as a result of improved accountability from EM	More effort needed ●●○	Yes	Atlantic HMS is exploring adding more flexibility to bluefin management by relaxing time and area closures. Scotland scallop fishery was able to allow more flexibility with dredge limits for vessels with EM, but the link between EM and improved economic outcomes needs to be strengthened.

Develop alternative uses for EM data	Not on track 🔴⚪⚪	No	There is still a lot of excitement about the potential of advanced analytics using EM data to deliver benefits to industry, but this has yet to be demonstrated.
Investigate potential with marine insurance providers to reduce premiums for vessels with EM	Not on track 🔴⚪⚪	No	Potential still exists for EM systems to help reduce insurance premiums, but there has been no known coordinated effort to pursue this opportunity.
Catalyze R&D and trials of new technologies that could be integrated into EM systems	Not on track 🔴⚪⚪	No	Expanding capability will be helpful, but effort should focus on moving EM beyond the minimum viable product stage. Providers are integrating VMS with EM systems, which may be attractive to some smaller vessels.

TABLE 5: **Three-year Targets from 2018 Report to Increase Demand for EM**

2018 THREE-YEAR TARGETS	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
Demonstrate EM capability for transshipment monitoring	On track 🟢🟢🟢	Yes	Initial proof of concept tested and validated on the water.
Demonstrate EM capability for monitoring labor practices	More effort needed 🟡🟡⚪	Yes	Growing interest and discussions, but effort has yet to deliver on-the-water proof points.

Demonstrate EM's Capability to Improve Monitoring and Increase Demand for Accountability in Fisheries

Recommendation overview

The primary argument for EM is that standard fisheries monitoring tools are typically insufficient for delivering accurate information about what goes on at sea. Shoreside approaches, such as dockside monitoring and dealer reports, are incapable of assessing anything that does not reach the dock such as discards or interactions with ETP. At-sea tools, such as inspections, last-haul monitoring, and flyovers typically cover just a tiny fraction of activity. Fishers also often have advanced knowledge of inspections and can adjust activity accordingly. Even human observers, the best available tool for at-sea catch monitoring outside of EM, struggle with issues such as limited coverage rates, changes in behavior of the fishing fleet in the presence of an observer, the need for observers to take breaks, novel challenges like Covid-19, and their inability to view everything that is happening on a boat at once. Co-option, bribery, interference, threats, or violence in the name of falsifying data, even in high governance geographies, further degrade the quality of human observer data if there are structural incentives for fishers not to report accurate information.

In fisheries that have piloted or adopted EM, there has been consistent evidence that compliance under the prior monitoring regime was low, data reporting inaccurate, and that EM improves data quality. As one of the coordinators of a Pacific Islands study on illegal, unreported, and unregulated (IUU) fishing said, "When you look at the e-monitoring and e-reporting tools in terms of the unreported [catch],...in the trials we've done, we have done enough to know that the camera doesn't lie."[9]

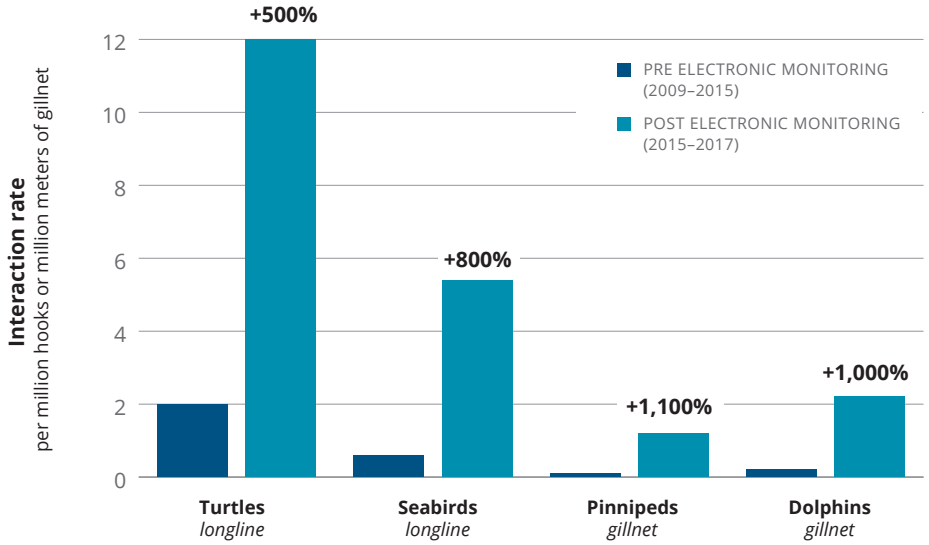
While numerous studies and pilots have demonstrated the effectiveness of EM, it often faces resistance from stakeholders that argue that there is no need for additional monitoring, that EM is not a proven technology, or that EM is too expensive. Continuing to demonstrate that there are critical data gaps in current monitoring programs and that EM can help fill those deficiencies at a reasonable cost will build confidence among regulators and industry that EM is a viable tool to meet many of their monitoring needs.

> *"When you look at the e-monitoring and e-reporting tools in terms of the unreported [catch],...in the trials we've done, we have done enough to know that the camera doesn't lie."*
>
> — INTERVIEWEE

FIGURE 2

Least mean squares interaction rate with protected species

Vessels that fished in all years in EM (2015/2016 to 2016/2017) and non-EM (2009/2010 to 2014/2015)



9. Francisco Blaha, "Towards the Quantification of IUU Fishing in the Pacific Islands Region," Francisco Blaha (blog), March 16, 2016, http://www.franciscoblaha.info/blog/2016/3/16/ynrnkna3fvxbfn5kvs23snro18eff8

Progress demonstrating EM's capability to improve monitoring and build demand for EM

Since the 2018 report, new publications continue to add to the evidence base that absent on-the-water monitoring, data about what happens at sea is likely to be insufficient, and that EM can be a powerful tool for delivering more accurate fisheries data. These studies are critical for demonstrating that there are problems on the water that need to be solved and for building demand for more accountability.

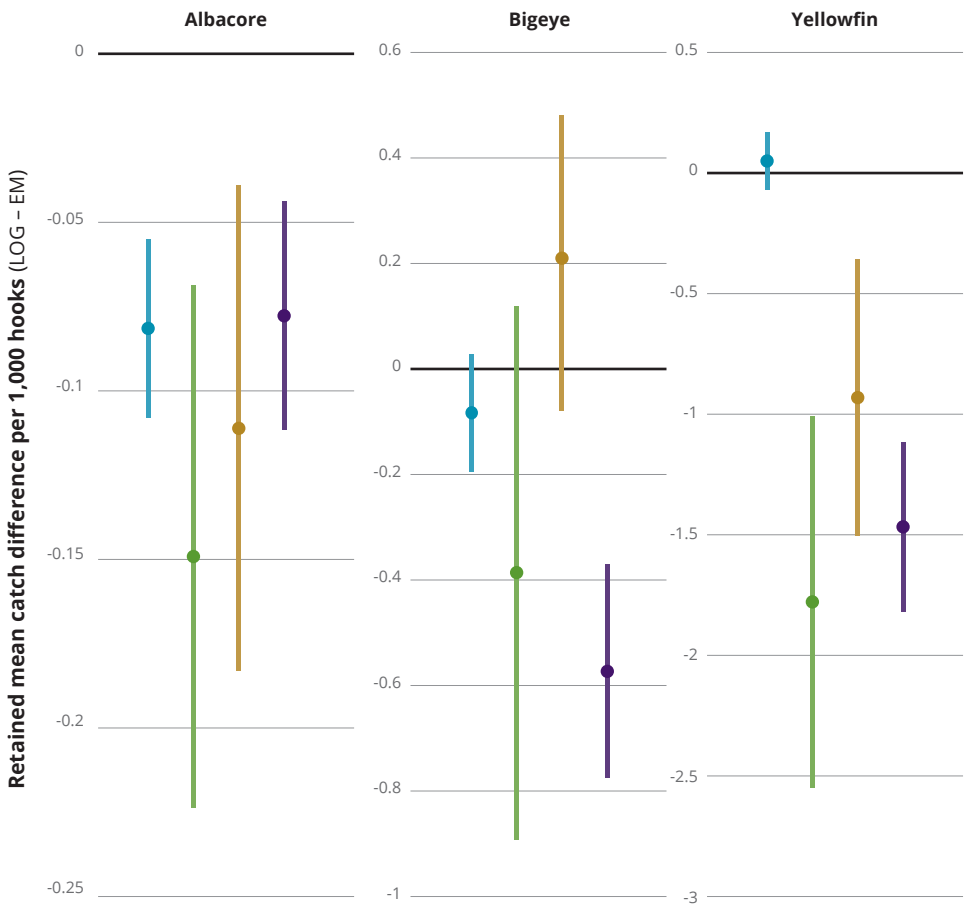
A 2019 analysis of logbook-reported catch in Australia's Eastern Tuna and Billfish Fishery and the Gillnet Hook and Trap sector of the Southern and Eastern Scalefish and Shark Fishery found significant differences in reported interaction rates before and after the implementation of EM. After the implementation of EM, there was a significant increase in reported discards and interaction rates with seabirds, turtles, pinnipeds, and dolphins. Reported interactions with protected species increased by 500 to 1,100 percent (Figure 2). The study concluded that the use of EM has led to significant changes in logbook reporting of discarded catch and protected species interactions.[10]

New data is also emerging from a sub-regional Pacific Islands longline tuna EM project. An analysis comparing logbooks to EM data for vessels in FSM, Palau, and the Republic of the Marshall Islands found that logbook-reported catch rates of the primary retained market species were significantly lower than what was seen on EM footage (Figure 3). If scaled to the entire fleet, the consistent underreporting of target catch amounts to an estimated $10 million USD of unreported catch (Figure 4). This loss could have important implications for fishing license revenues for island states and for tuna management efforts.[11]

FIGURE 3

Differences in catches per 1,000 hooks reported in logbook versus EM for retained market species

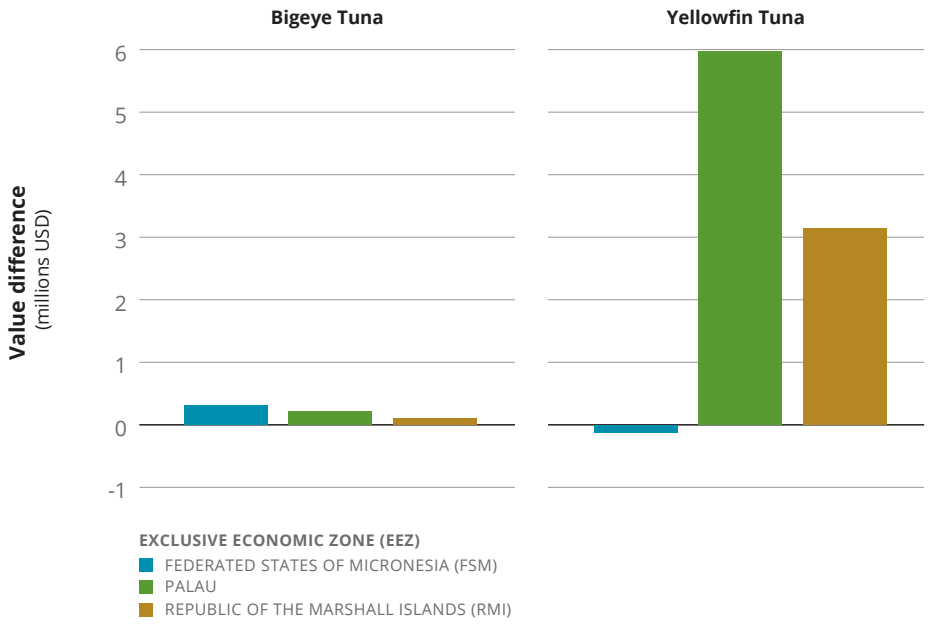
Points show mean estimate. Bars show standard errors.



10. Timothy J. Emery et al., "Changes in Logbook Reporting by Commercial Fishers Following the Implementation of Electronic Monitoring in Australian Commonwealth Fisheries," Marine Policy 104 (June 2019): 135–45, https://doi.org/10.1016/j.marpol.2019.01.018
11. The Nature Conservancy. "Insights from Electronic Monitoring of tuna longline boats." (In Press).

FIGURE 4

Estimated economic value of underreported catch when scaling estimates to the entire fleet



BOX 3

Recent Examples of the Cost of Not Having EM

Indian Ocean yellowfin tuna: Indian Ocean yellowfin is one of the most poorly managed yellowfin stocks. Faced with an overfished stock, catch reductions of 20 percent were recommended beginning in 2017. But not only were reported catch levels in that year three percent higher, it came to light that Spanish vessels had exceeded their catch allocation by 9,000 tons, or approximately 20 percent. Although catch reductions were implemented to support stock recovery, without an on-the-water monitoring solution, it could not be enforced. In response, the Seychelle's and the EU inked a new partnership agreement in 2019 which includes requirements for the use of electronic monitoring. According to the Seychelle's Fishing Authority, they are beginning to implement camera systems on all vessels in their EEZ as of the start of 2020.

Covid-19 induced monitoring gaps: Covid-19 has exposed a new vulnerability of human observer programs. Fisheries agencies around the world have suspended requirements for human observers, creating a huge monitoring gap on the water. These measures are essential to protect the health of observers and fishing crews but will lead to increased illegal activity on the water. In response to the suspension of observer requirements, a consortium of more than 50 retailers, brands, and seafood companies called on governments to make electronic monitoring an accepted alternative to human observers for tuna fisheries. While human observers are being sidelined, vessels with EM systems are still being monitored and have been the only source of at-sea data for many fisheries during COVID restrictions.

Structural issues of having observers on board vessels: The dynamics of having human observers at sea collecting data on fishing operations can be problematic. Far from shore, observers are vulnerable to pressure, bribery, and abuse from the crew of the operation they are supposed to be monitoring. It is this very reason that observers are typically not used for compliance functions. Even so, cases of mistreatment, abuse, and even murder are not uncommon. In April 2020, a Kiribati fishery observer was found dead on a Taiwanese fishing vessel with a massive head wound and bruising. Observers carry out dangerous work on fishing vessels and it is our obligation to ensure that they are protected. EM offers one way of ensuring their protection given the power dynamics and lack of oversight at sea. EM can remove observers from these dangerous situations or be a deterrent to abuse at sea.

In this same project, turtle bycatch as well as overall species richness per set were found to be significantly higher with EM than in logbooks.[12] The study also found that in 2017, tuna longliners in Palau discarded more than 15,000 sharks, but only about 2,500 were reported. The logbooks also miss many species, for example, they commonly report all billfish catch as blue marlin, but EM systems also commonly observe striped marlin and black marlin in catches. This means blue marlin catches are over-reported, whereas striped and black marlin are under-reported.

While data from EM programs and projects are demonstrating the tool's value, we have also seen more examples of the costs of not having EM aboard vessels (Box 3), including:

- Underreporting of yellowfin tuna in the Indian Ocean[13,14,15]
- Covid-19-induced monitoring gaps[16]
- Structural problems with having human observers on vessels[17]

These examples are just the latest to show that without comprehensive monitoring and accountability at sea, some fisheries face systematic IUU activities in their licensed fleets, and that EM can address this challenge. As one regulator commented, "I've always said that there are certain fisheries that you cannot operate without 100 percent coverage; the incentives are just too strong to misreport."

> *"I've always said that there are certain fisheries that you cannot operate without 100 percent coverage. The incentives are just too strong to misreport."* —INTERVIEWEE

Updates to the recommendation to demonstrate EM's capability to improve monitoring and build demand for EM

Continuing to demonstrate EM's ability to provide the granular data necessary for effective fisheries management remains a priority moving forward. Additional studies in key fisheries and geographies are needed to show that without on-the-water monitoring, data about what is happening at sea is likely to be wrong, and that EM can solve this challenge. EM has moved beyond the proof of concept stage for many monitoring functions and there is a need to build a critical mass of well-documented trials and programs so that this is widely understood by regulators, fishing industry, and the seafood marketplace alike.

Demonstrating EM in key regions that span a range of governance capacity will be a springboard for faster growth. Successful implementation in the Western Pacific will demonstrate EM in a mixed governance region and will likely set off a cascade to the other tuna RFMOs. Chile's emerging programs can be a model that spurs adoption in the Humboldt Current and other moderate fisheries governance countries. Finally, projects in high-governance countries (e.g., US, EU, New Zealand, Australia) can push the frontiers of EM (e.g., unlocking flexible management, proving new program delivery models, integrating EM into stock assessments). (See the EM Development Around the World section for more detail on priority geographies.)

12. Ibid.
13. Jessica Rattle, "A Case Study on the Management of Yellowfin Tuna by the Indian Ocean Tuna Commission" (Blue Marine Foundation, June 2019), https://www.iotc.org/documents/blue-marine-foundation-case-study-management-yellowfin-tuna-iotc.
14. Jason Holland, "EU, Seychelles Come to Terms on New Tuna Fishing Agreement," Seafood Source, October 29, 2019, https://www.seafoodsource.com/news/supply-trade/eu-seychelles-agree-new-tuna-fishing-agreement
15. Salifa Karapetyan, "Seychellois Expert Says EU Overfished Tuna; EU Ambassador Says Union Is Investigating," Seychelles News Agency, December 13, 2019, http://www.seychellesnewsagency.com/articles/12095/Seychellois+expert+says+EU+overfished+tuna%3B+EU+ambassador+says+union+is+investigating
16. Sustainable Fisheries Partnership, "WalMart, Major Retailers Call for Governments to Ensure Sustainably Produced Tuna During Covid-19." May 7, 2020. https://www.sustainablefish.org/News/Walmart-Major-Retailers-Call-for-Governments-to-Ensure-Sustainably-Produced-Tuna-during-COVID-19
17. Aaron Orlowski. "Kiribati fishery observer dies at sea in the South Pacific." Seafood Source, April 14, 2020, https://www.seafoodsource.com/news/supply-trade/kiribati-fishery-observer-dies-at-sea-in-the-south-pacific

RECOMMENDATION 1.2

Make EM a National or Regional Priority

Recommendation overview

In declaring that EM is a priority, government stakeholders can help speed EM growth. Policy mandates are a powerful signal, but high-level commitments and clear indications of support for the tool can help build momentum and shift conversations from EM is "impossible" to "inevitable."

Progress making EM a national or regional priority

In the last couple of years several governments have made EM a priority. In early 2020, Chile moved from a regulation requiring EM on industrial vessels to implementation on over 100 vessels and will soon be expanding EM to the semi-industrial fleet. Just prior to the release of our original paper, FSM announced a commitment to achieve full tuna transparency by 2023 and put forth a challenge to other Pacific island countries to do the same. With limited observer coverage on longline vessels, this challenge will only realistically be met with EM, and FSM is in the process of finalizing regulations and an implementation strategy.

Elsewhere, the Seychelles has made a bold commitment to 100 percent monitoring of its tuna fleet, New Zealand is moving again on implementation of its 2017 regulatory mandate for EM on industrial fishing vessels, and the US continues to be a world leader in EM implementation, having recently set forth an electronic technology directive encouraging the exploration of EM. These national and regional EM developments are discussed in more detail in a later section of this paper (See EM Developments Around the World).

Updates to the recommendation to make EM a national or regional priority

Industry leadership was not highlighted in the 2018 report, but clearly the private sector has a critical role to play in catalyzing public sector leadership and in driving progress where public sector leadership is slow to develop. There have been several key developments on this front: companies such as Thai Union and Luen Thai Fishing Venture have been leading the push for EM in industrial tuna fisheries, including on vessels operating primarily in Areas Beyond National Jurisdiction (ABNJ). Likewise, the International Seafood Sustainability Foundation's (ISSF)[18] best practices for well-managed fish aggregating device (FAD) fisheries include 100 percent observer coverage (either human or electronic). This recommendation was one of the drivers for the development of voluntary EM programs on purse seine vessels managed by the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the Indian Ocean Tuna Commission (IOTC).

Building commitments and support for EM within governments and industry is a powerful signal that can accelerate EM market development. Providing technical support to influential countries or industry members can allow them to pull the entire EM market forward (e.g., Denmark in the EU, FSM and Fiji in the Pacific, Chile in Latin America, Thai Union for tuna fisheries).

RECOMMENDATION 1.3

Demonstrate New Use Cases for EM

Recommendation overview

EM has traditionally been used for monitoring functions such as improving the accuracy of commercial logbook reporting, catch estimation, discard monitoring, and assessing ETP interactions. These remain as key applications for EM, but there has been growing interest in monitoring labor conditions and transshipments, which are an important component of IUU activities in tuna fisheries. Large retailers and seafood companies have faced negative publicity from exposés of slavery, labor abuses, and illegal activity in their supply chains.

The 2018 report recommended demonstrating the effectiveness of EM for monitoring labor practices and transshipments. Attention to and demand for solutions to these issues have only increased in the last 18 months. This section briefly discusses the rationale for supporting these new applications for EM and recent progress made on this front.

18. ISSF includes most of the world's largest tuna companies (e.g., Thai Union, Bumble Bee) and undertakes and facilitates initiatives to support tuna sustainability.

Progress demonstrating EM's capability to monitor transshipments

Within the WCPO, an estimated $142 million USD in IUU catch is transshipped every year.[19] These transactions, many of which happen on the high seas, can channel illegal and unreported catch into the market. At-sea rendezvous have also been associated with human trafficking and human rights abuses. A 2019 analysis by the Pew Charitable Trusts found that at least five times as many carriers operated within the WCPFC convention area in 2016 than vessels that submitted high seas transshipment reports, indicating that many transshipments are likely going unreported.[20] In addition, since reefers can be at sea for very long periods of time, the standard practice of using human observers for monitoring transshipments puts those observers at elevated safety risk and degrades confidence in the quality of the data they collect. The recent suspension of observer requirements on fishing vessels and reefers due to Covid-19 has illuminated another weakness of the current transshipment monitoring structure in tuna fisheries which EM could mitigate.

EM was recently tested on a reefer vessel undertaking at-sea transshipment activities as a part of the Tunago FIP.[21] The trial successfully demonstrated using EM to monitor at-sea transshipments. While it was not possible to validate the species being moved between vessels because of bulk transfer and flash freezing, it was viable for confirming transshipment events, estimating the total volume of fish moved, and ensuring that other illegal activities (e.g., human trafficking) were not happening. EM aboard the fishing vessels participating in transshipment activities filled the species information gap and this proof of concept provides the foundation for a scalable monitoring regime that dramatically reduces the IUU risk of at-sea transshipments.

Progress demonstrating EM's capability to monitor labor practices

Labor abuses and modern slavery are serious concerns in the global fishing sector. In the last few years, a series of investigations and exposés have brought to light issues such as inhumane work schedules, gross underpayment or forced labor, confiscation of documents, lack of decent food and clean water, unsanitary and unsafe working conditions, physical and verbal abuse, lack of medical care, and even murder at sea.[22,23,24] Given the general environment of lawlessness, poor regulation, and lack of control and enforcement at sea, some operators have resorted to these abuses to maintain the viability of their fishing operations. This problem is only exacerbated by overharvesting of fish stocks, which forces vessels to go further afield and on longer trips in search of fish, putting even more pressure on the economics of the catch sector.[25]

There are also more routine elements of good labor practices, such as adherence to safety protocols, which are sporadically monitored and enforced in almost all fisheries. This should be of interest to insurers and vessel owners alike who are seeking to increase confidence that rules are being followed and reduce the risk of false claims.

EM could be well-suited for monitoring labor practices at sea. While interest in EM for this purpose has grown, it has yet to be demonstrated on the water. In the past couple of years, the dialogue has expanded between environmental and human rights organizations, which has been a learning process for all involved. The environmental NGOs lack expertise on labor issues, and the labor NGOs have limited knowledge about fisheries. There has also been increasing dialog within national fishing authorities and regional bodies, such as the WCPFC and Pacific Islands Forum Fisheries Agency (FFA). However, there have been clear signs of progress towards using EM for labor monitoring purposes. The dialog is also opening to other important stakeholders, such as the Seafarer's International Union, that understand fisheries and have a deep interest in labor issues. These new voices are helping build a broader and more sophisticated understanding of the issues at play and how to move forward.

In response to the concerns around labor practices in seafood supply chains, many of the world's largest

19. Pew Charitable Trusts, "Transshipment in the Western and Central Pacific," September 2019, https://www.pewtrusts.org/-/media/assets/2019/09/international_fisheries_transshipment_report.pdf
20. Ibid.
21. "Pacific Ocean Tuna - Longline (Thai Union)," FisheryProgress.org, n.d., https://fisheryprogress.org/node/7651/actions-progress. Accessed March, 2020.
22. Associated Press, "Seafood from Slaves," 2016, http://www.ap.org/explore/seafood-from-slaves/
23. Margie Mason, "Myanmar Fisherman Goes Home after 22 Years as a Slave," July 1, 2015, http://www.ap.org/explore/seafood-from-slaves/myanmar-fisherman-goes-home-after-22-years-as-a-slave.html
24. Supang Chantavanich, Samarn Laodumrongchai, and Christina Stringer, "Under the Shadow: Forced Labour among Sea Fishers in Thailand," Marine Policy 68 (June 2016): 1–7, https://doi.org/10.1016/j.marpol.2015.12.015
25. Ibid.

Seychelles. Photo: Kydd Pollock / The Nature Conservancy

BOX 4

Validating Compliance with Seafood Task Force Code of Conduct and Vessel Auditable Standards

The Seafood Task Force Code of Conduct and Vessel Auditable Standards is a welcome effort to try and root out poor labor practices in the supply chains of major retailers and seafood suppliers. The code covers 15 elements and the associated standards are intended to determine compliance with the code through audits or other activities. Audits will be sufficient for some elements, but other parts of the code play out on the water and will require onboard monitoring to have confidence that standards are being met. These include:

- Freedom of movement and personal freedom,
- Humane treatment,
- Working hours, and
- Health and safety.

retailers and seafood companies are working to solve the problem. The Seafood Task Force, whose membership includes many of the largest retailers in the EU and US and their seafood suppliers, is an example of industry action to address labor issues. The Task Force put forth a Code of Conduct and Vessel Auditable Standards at the end of 2018.[26] The code covers a variety of vessel-auditable standards such as forced labor, humane treatment, and workplace safety, for which EM could be well-suited to monitor (Box 4).

Funders are also paying attention to this issue. For example, FishWise received funding from the Walmart Foundation in 2020 to ramp up their work on improving labor conditions at sea.[27] In 2019, FishWise released guidance on vessel transparency for seafood companies, which highlighted EM as one of the initiatives that companies could leverage to increase transparency and accountability in their supply chains.[28]

With increasing focus on eliminating human labor abuses in seafood supply chains, we anticipate that this dialog and work will point toward applying EM to monitor labor practices on high-risk vessels. At the same time, there will need to be more work to ensure that monitoring does not put the people it is meant to protect at additional risk.

Updates to the recommendation to demonstrate new use cases for EM

This recommendation is still a priority moving forward, with demand for monitoring of transshipment and labor practice still strong. Advancing EM for monitoring labor practices has proven somewhat challenging, but there is enormous interest in this use case and the dialogue over the last couple of years has set the stage for meaningful on-the-water progress. As next steps, EM should be piloted on the water for monitoring labor practices.

Building on the success of the transshipment proof of concept test, a larger-scale trial should be developed with a goal of informing a region-wide EM program to verify transshipment monitoring in the Western Pacific.

An additional opportunity is developing in the US where the first trials of EM on a recreational charter and for-hire vessel were just completed. Recreational fisheries in the US are data poor and, in some cases, have more catch than commercial vessels. There is an opportunity to build on these trials and explore a broader application of EM in recreational fisheries.

26. Seafood Task Force, "Vessel Auditable Standards," 2018, https://www.seafoodtaskforce.global/wp-content/uploads/2019/01/STF_Code-of-Conduct-and-Vessel-Auditable-Standards-V.2_20181212.pdf
27. Ned Daly, "With Support of Walmart Foundation, FishWise Increases Focus on Human Rights in Seafood," Seafood Source, February 6, 2020, https://www.seafoodsource.com/news/environment-sustainability/with-support-of-walmart-foundation-fishwise-increases-focus-on-human-rights-in-seafood
28. FishWise, "2019 Open Water Guidance on Vessel Transparency for Seafood Companies," 2019, https://fishwise.org/wp-content/uploads/2019/02/FishWise_VesselTransReport2019-02.pdf

Use EM to Demonstrate Sustainability in the Marketplace

Recommendation overview

More than two decades old, the sustainable seafood movement is now firmly entrenched in the global marketplace. More than 16 percent of the world's seafood catch is now certified or under full assessment against the MSC standard and an additional nine percent is in a FIP. These market-based approaches have been instrumental in raising the profile of sustainable seafood and encouraging improvement on the water. The 2018 report suggested that EM could be advanced as a way to support fisheries seeking MSC certification or that are involved in a FIP.

Efforts to improve traceability are also moving ahead due to pressure from markets, governments, and civil society, but there are still major implementation challenges. Traceability solutions are largely dock-to-plate efforts and may not provide certainty that the fish was harvested legally, sustainably, and without labor abuses. Recognizing this gap, the 2018 report recommended that EM be advanced in traceability initiatives to provide true catch-to-plate solutions.

Governments are also driving improved monitoring and traceability through the implementation of import control requirements such as the US Seafood Import Monitoring Program (SIMP) and Marine Mammal Protection Act (MMPA) Import Provisions, and the EU regulation to prevent, deter and eliminate IUU fishing (EU IUU Regulation). The 2018 report recommended the use of EM to demonstrate compliance with these international trade requirements.

Finally, the 2018 report recommended a focus on vertically integrated companies as a segment of the market where EM would be more likely to gain traction as a tool for demonstrating sustainability in the market. These companies are more likely to feel and act on the pressure to deliver more sustainable and socially responsible product.

Progress is being made across all these areas—eco-certifications, FIPs, traceability, compliance with import requirements, and targeting vertically integrated companies—but market pressure needs to be amplified if it is to become a major driver for EM.

Progress using EM in support of eco-certifications

Many people involved in EM projects have cited the MSC standard as one of the incentives for moving ahead with EM. This was highlighted by interviewees for this report for Chilean hake, Scotland's scallop fishery, and tuna fisheries. But, since 2018, it has become apparent that there are some limitations to the MSC standard's ability to encourage EM and, in some cases, the MSC standard is paradoxically proving to be a deterrent to EM.

MSC provides no guidance to Certified Assessment Bodies (CABs) on what constitutes adequate data in terms of quality or quantity for undertaking an assessment of a fishery against the MSC standard. This creates a perverse structural incentive to collect and provide less and lower-quality data to secure certification. In practice, several fisheries certified to the MSC standard are likely out of compliance with fisheries regulations or would be found to not meet the MSC standard if more comprehensive monitoring were in place. For example, many of the fisheries that are certified in the EU are likely to be out of compliance with the EU landings obligation. With more than 10 percent of MSC certified fish coming from EU fisheries,[29] this could be a major challenge. Insufficient data may also be a concern in other MSC certified fisheries with strict discard or bycatch limits, shark finning, or ETP interactions. Questions have also been raised about the certification of some longline tuna fisheries, which have observer coverage of only about five percent—far short of the level widely accepted by science and compliance experts.

The MSC recognizes this issue, and in a recent comment in response to the Swedish Agency for Marine and Water Management (HaV) about a proposed EM trial they said, "The landing obligation poses challenges for MSC-certified fish in many parts of Europe. If the control system is not improved, existing certifications may be withdrawn. Camera surveillance in collaboration with HaV could be a way for Swedish MSC-certified fish to obtain the documentation needed to demonstrate compliance with the landing obligation."[30]

The MSC is in the front half of a five-year cycle during which it will update its fisheries standard. As a part of this review, the organization is looking at monitoring best practices and how to improve the evidentiary quality and quantity in MSC assessments. There have been two

29. CEA Consulting. 2020. "Progress Toward Sustainable Seafood - by the Numbers, 2020 Edition."
30. Swedish Agency for Marine and Water Management. "Proposal for design of experiments with camera surveillance of fishing vessel." (2019)

technical workshops—one in London and one in San Francisco—in which the concept of a risk-based framework for data requirements was developed. The idea is that fisheries will be classified into different risk buckets (high, medium, low) based on criteria such as whether the fishery spans multiple EEZs, or if it has a high likelihood of ETP species interactions. The risk classification will provide guidance to certification assessment bodies on the quantity and quality of data the fishery needs.

The updated MSC standard will not be complete until 2022, but the idea of increasing the rigor of monitoring requirements based on risk levels in the fishery will likely be considered during this review. If this is included in the updated standard, it should provide additional incentive for EM as it will be the best tool to meet the more rigorous data requirements for some fisheries.

Progress using EM in support of fishery improvement projects

FIPs, which are a tool to help fisheries make progress in a structured way towards MSC certifiability, now cover more than 9 percent of global landings. The FIP movement has matured in the last five years, with more clearly defined processes, requirements, and reporting. But many FIPs still struggle to progress due to a lack of data and an inability to drive sustained improvements over time. In the last few years, more FIPs are using EM as a tool to reduce risk, collect data, inform improvement actions, and demonstrate progress. While neither FIPs, nor the target of MSC certifiability demand the use of EM, the FIP platform is being leveraged to bring together stakeholders and address supply chain risk more broadly. This has led several FIPs to incorporate EM, particularly for longline tuna vessels in the Pacific.

Thai Union is one of the big tuna companies that is driving the uptake of EM in the Pacific. The organization has set a target that by the end of 2020, at least 75 percent of their branded tuna will come from an MSC certified fishery or a FIP. For the longline fisheries that are in FIPs, Thai Union is requiring the use of EM systems. The company believes that minimum required observer coverage in the longline sector will expand beyond the current five percent, and EM implementation may be a viable option for how to do this. Other tuna companies, such as Luen Thai and Tunago, are also integrating EM into their FIPs.

For the tuna companies supporting EM in their supply chains, being in a FIP is not sufficient to ensure the fish was caught sustainably, legally, or without labor abuses. But these companies are somewhat unique. For most of the market, sourcing from a FIP, regardless of whether there is strong on-the-water monitoring, meets the market's bar for sustainability. Therefore, pressure has not been forceful or focused enough to compel suppliers to adopt EM. As one EM stakeholder said, "Unfortunately, I am not seeing the market drive from the retailers. I was hoping that they would push for transparency in their supply chain, but it has not happened so far. They are pushing for MSC and FIPs, but not for EM."

Progress incorporating EM into catch-to plate traceability systems

There is growing engagement from the conservation community around seafood traceability. The Seafood Business for Ocean Stewardship (SeaBOS) Task Force I on improving traceability in global seafood is an example of one of the major traceability efforts underway. Companies committed to SeaBOS control about 11 percent of the world's seafood catch and are using the platform to help advance traceability and pilot novel new approaches. The traceability efforts are a welcome piece of the puzzle of ensuring the legality and origin of seafood, but these systems often begin at the dock. If not connected to on-the-water monitoring programs, traceability systems can track seafood through the supply chain but, in most cases, cannot provide confidence that the product was fished in compliance with regulations, without labor abuses, and in an ecologically sustainable manner.

Linking on-the-water EM to traceability systems is a way to close this loophole. There is recognition among many companies that EM is a necessary part of a complete traceability system, but the individual capacity to implement it is highly variable. Some companies, however, are moving ahead. One of the SeaBOS members recently piloted an on-vessel EM system linked to a blockchain traceability system as well as species recognition and facial recognition software. The results of the trial were positive, and they are looking to test it at a larger scale.

The trialing of true catch-to-plate traceability systems linked to EM is be a good first step, and a stronger push is also needed to highlight the loophole in traceability systems not linked to robust on-the-water monitoring.

Progress using EM to demonstrate compliance with import control regulations

Import control programs, such as the EU IUU Regulation, the US SIMP, and the US MMPA Import Provisions have provided incentive for fisheries to adopt or pilot EM. Under these regulations, fisheries may be barred from exporting product to the EU or US if they cannot demonstrate the legality of the product (US SIMP and EU IUU Regulation) or that it was harvested to the same standards as US fisheries (US MMPA). In the last 18 months,

evidence has emerged indicating that these rules are providing incentive for fisheries to adopt EM.

For some fisheries in Chile, such as swordfish and toothfish, concern about market access to the US under the MMPA Import Provisions is pushing fleets to EM. Likewise, Sri Lanka and the Maldives are moving ahead with EM pilots for tuna vessels within the IOTC area and concern about access to the EU market is believed to be one of the drivers. Sri Lanka has already received a yellow and red card under the EU IUU Regulation.[31] Tuna companies, which export a large portion of their catch to US and EU markets, have become some of the early adopters of EM as a tool to help them stay on top of import requirements and other sustainability demands from the marketplace.

> *"Unfortunately, I am not seeing the market drive from the retailers. I was hoping that they would push for transparency in their supply chain, but it has not happened so far. They are pushing for MSC and FIPs, but not for EM."* —INTERVIEWEE

Updates to the recommendation to use EM to demonstrate sustainability in the marketplace

EM is well-suited for supporting eco-certifications, FIPs, traceability, or demonstrating compliance with seafood import requirements, and the 2018 recommendation for using EM for these functions still stands. However, since many fisheries can meet the market's bar for sustainability without EM, this recommendation is insufficient. This work needs to be complemented with efforts to:

- Participate in the MSC standard revision process to ensure that data adequacy requirements are updated with a risk-based framework that requires sufficient on-the-water monitoring to be confident that data feeding into the assessments accurately reflects fishery impacts.
- Increase pressure on retailers by highlighting the risks that are still present in their supply chains. This pressure should be leveraged to develop partnerships with a handful of leading retailers who can drive EM in their supply chains.

RECOMMENDATION 1.5

Identify and Cultivate Industry Benefits from EM

Recommendation overview

As long as EM is seen primarily as a compliance tool, it will continue to face resistance from industry. EM programs can tighten economic constraints on fishers in the short-term as they improve the enforcement of catch limits, discards, and other regulatory requirements. But in the long-run, EM can improve stock health and enable more efficient fisheries management that can benefit industry. For example, EM can support individual catch quota management, gear switching, or sanctioning of individual vessels as opposed to the entire fishery. The 2018 report recommended advocating for these types of management solutions and demonstrating their benefits to industry. In fisheries that were early adopters of EM, we are starting to see some of the science and management benefits. But most of the EM trials and programs are at an earlier stage and are building an understanding of the state of the fishery and compliance levels. This is an essential first step but needs to be followed by management changes that provide more flexibility to industry while still protecting stock and ecosystem health.

The 2018 report also identified two additional areas to leverage EM data for the benefit of industry; First was developing alternative uses of EM data (e.g., to improve fishing operations), and the second was using EM to reduce insurance premiums.

There is a lot of excitement about how data and analytics can transform the fishing and seafood sectors. Even McKinsey & Company has entered the dialogue, having recently released a special report on the application of advanced analytics for the fishing sector and its potential benefits for fishing and food companies. But real-world progress on this front has been limited.

An overview of the progress cultivating EM benefits for industry follows and is organized into the following sections:

- Demonstrating the benefits to industry from improved management enabled by EM
- Demonstrating alternative uses of EM data
- Using EM to reduce insurance premiums

31. A yellow card is a warning that the country has been identified as having inadequate measures to prevent IUU, and a red card means that the country is banned from supplying fish to the EU market.

Progress demonstrating the benefits to industry from improved management enabled by EM

A recent example of EM enabling more efficient management comes from the Atlantic HMS fishery in the United States. This fishery developed an individual bluefin quota management program in 2015 to limit bluefin landings and dead discards while optimizing fishing opportunities. EM has been instrumental in enabling this management system, which has dramatically reduced bluefin catch while affording flexibility to the industry. Now that the EM program has been in place for a few years, the HMS fishery is beginning to explore other ways it can leverage the additional data from EM to improve management.

Time and area closures have been one of the management approaches to limit bluefin tuna bycatch. These are relatively coarse tools and may not be very effective. Managers found that high-risk areas of bycatch are not consistent and closing them results in the loss of fishery-dependent data that leaves them in the dark about whether the right areas are being closed. EM is providing more real-time data on bluefin bycatch, allowing managers to consider relaxing some of the time and area closures, and changes could be on the docket for 2020.[32] These changes would increase the flexibility for fishers to fish where they would like, while giving managers confidence that they are meeting the management objectives for the fishery.

Robust on-the-water monitoring can also allow managers to scale-back uncertainty buffers, which are used to protect against overfishing given uncertain catch data. In the New England Groundfish fishery, there has been a long debate about the appropriate level of at-sea monitoring in the fishery. The fishery is managed with annual catch entitlements for many species, and overall landings are constrained by catch limits on choke species (e.g., cod). With only partial observer coverage in the fishery, this creates a strong incentive to discard and actual catch levels of cod are believed to be far higher than reported. Through the Amendment 23 process, the fishery is evaluating different monitoring options for the fishery, including the Fishery Management Council's preferred alternative of 100 percent at-sea monitoring with the option to meet that requirement with EM. This option would also include the elimination of uncertainty buffers, and analysis estimates that the fishery would be more profitable under this scenario than the "No Action" case with just 13 percent at-sea monitoring and uncertainty buffers in place.[33]

Another recent example of flexibility afforded by EM comes from the Scotland scallop fishery. In this fishery, the regulators reduced the number of dredges allowed inside of six nautical miles from ten to eight. Without comprehensive on-the-water monitoring, the only way to enforce this would be to limit the total number of dredges on boats to eight. But with EM, boats can maintain a higher number of dredges for fishing outside the six nautical mile zone and demonstrate compliance with the eight-dredge limit when fishing closer to shore, which is a clear benefit to the industry.

These are great examples of how the improved data and accountability of EM can help managers efficiently meet the ecological objectives of the fishery while simultaneously protecting the economics of the fishing industry. But more of these management measures are needed if more flexible management is going to be a selling point for EM to the fishing industry.

Progress developing alternative uses of EM data

In the era of machine learning and big data, a common hope is that there is significant value to be unlocked from additional data. Several applications for how to use EM data beyond supporting compliance and fisheries management have been suggested. They include identifying bycatch hotspots for fleets and using machine learning to optimize fishing operations. While these are interesting use cases, the idea that EM data has a lot of unknown value waiting to be unlocked has yet to be widely demonstrated.

There has, however, been some work looking into this opportunity. For example, the Cape Cod Commercial Fishermen's Alliance has investigated an industry-controlled, fisheries dependent data repository.[34] The concept is to pool fishermen's data and provide a structure to manage its use and storage. This would be parallel to government data repositories and give industry access to their data, which they could use for independent research or to develop new business opportunities. This type of structure could be a model for managing growing fisheries EM data streams, but we have yet to see strong demand for this data.

Some fishing companies are also using data with more sophistication. Aker Biomarine, a well-resourced company that fishes for krill to supply the nutraceutical and feed markets, appears to be one of the fishing companies on the leading edge of advanced analytics. They have been developing a machine-learning model to help

32. Confidential interviewee, December, 2019.
33. New England Fishery Management Council. "Draft Amendment 23 to the Northeast Multispecies Fishery Management Plan: Public Hearing Document." (2020)
34. Keith Porcaro. "Building a fishermen-first data ecosystem." (Digital Public 2019)

them determine when and where to fish. According to the company, they currently spend 10 percent of their time searching for krill, and the expectation is that this will drop to near zero with the machine learning.[35] This is an exciting window into the future of advanced analytics, some of which could be enabled through EM. But, for now the core value of EM is still supporting sustainable fisheries management, ensuring compliance, and demonstrating good practices to the seafood marketplace.

Progress using EM to reduce insurance premiums

The 2018 paper recommended investigating the idea that EM could mitigate the risk of a vessel, which could translate into lower insurance premiums. For example, the use of EM is likely to reduce the risk of any vessel being engaged in illegal activities. It can document that the crew are following safety protocols. EM can also be used to discredit frivolous claims or to help determine fault if something happens at sea. But we are not aware of if these benefits have translated into reduced insurance premiums for vessels with EM, or if anyone has pursued this opportunity.

Updates to the recommendation to identify and cultivate Industry benefits of EM

The link between EM, improved fisheries management, and better performing fisheries needs to be strengthened to build industry demand for EM. More specifically, granular output data from EM should enable individual quota systems, more targeted sanctions, and the rollback of spatial closures, uncertainty buffers, gear restrictions, or possibly even discard bans. High-governance regions where EM is well established (e.g., US, Australia) would be ideal geographies to pursue these types of management changes. A provocative case could be to use EM to enable flexibility under the EU landing obligation in exchange for full on-the-water monitoring. This could allow vessels to continue to discard uneconomical fish, while still accurately accounting for total fishing mortality.

We are less sanguine about the role of philanthropic or public investment to unlock additional benefits of EM data beyond its core application of supporting better fisheries management. There has been limited progress in the last few years, and the market is likely to explore these opportunities on its own accord where it sees merit. Likewise, pursuing insurance premium reductions seems better left to the private sector.

35. Philip Christiani et al., "Precision Fisheries: Navigating a Sea of Troubles with Advanced Analytics" (McKinsey & Company, 2019), https://www.mckinsey.com/~/media/McKinsey/Industries/Agriculture/Our%20Insights/Precision%20fisheries%20Navigating%20a%20sea%20of%20troubles%20with%20advanced%20analytics/Precision-fisheries-Navigating-a-sea-of-troubles-with-advanced-analytics-vF.ashx

2. Recommendations
to Reduce the Cost of EM

The most cited concerns about EM programs are costs and who will pay for them. In fisheries with high levels of observer coverage (e.g., US West Coast Groundfish Trawl), EM may be substituting for a portion of the human observer coverage and can reduce overall monitoring costs. In most cases, however, EM is being considered in fisheries with limited on-the-water observer coverage and therefore the cost of an EM program will be almost entirely additional to current monitoring costs.

EM costs are an investment in high-quality data necessary for effective fisheries management, and managers have generally been underinvesting in good fisheries data and putting fisheries at risk. But the costs of EM are still a barrier to program development. Governments worry about how they will fund these programs, and industry generally does not want additional monitoring, let alone to pay for it. At the same time, EM providers are reluctant to unilaterally cut prices to build the EM market given thin margins and lack of clarity from industry and governments on EM demand at different price points.

There is no doubt that bringing the cost of EM programs down will be essential for the tool to scale. This section reviews some of the key recommendations from the 2018 report, including:

2.1 Build the Market to Create Economies of Scale

2.2 Drive Hardware Cost Reductions

2.3 Reduce Video Analysis Costs

2.4 Deploy New Standards and Program Structures to Improve the Efficiency of EM Service Delivery

TABLE 6: **Recommendations from 2018 Report and Recent Progress to Reduce the Cost of EM**

2018 RECOMMENDATION	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
Explore the development of an industry association that can pursue activities that lift the entire EM market	More effort needed ●●○	Yes	Early scoping conversations were initiated in January 2020. This effort appears likely to move forward in the latter half of the year.
Convene buyer consortiums to make procurement requests for quotation (RFQs) more consistent and help to drive forward shared interests.	More effort needed ●●○	Yes	TNC is scoping the concept of bulk procurement, but implementation is not underway yet.
Create a secure, open-source collection of labeled and anonymized EM video that can be accessed to develop AI and image recognition software	On track ●●●	Yes	TNC developed FishNet.AI which now has 100,000 images and growing; NOAA is also scoping development of an opensource library; need to grow the number of tagged images and prevent balkanization of different efforts.
Foster better communication between current research and development efforts	More effort needed ●●○	Yes	More throughtful collaboration is needed to identify development priorities, and improve coordination between public, private, and NGO stakeholders.
Advance image recognition from R&D phase to first commercial-scale rollouts	On track ●●●	Yes	More effort is needed to achieve market-ready products, but target is still in reach by the end of 2021. Particular focus should be placed on models for integration of AI into EM provider software packages and business processes.
Advance onboard processing and demonstrate initial proof points of cost-effective, real-time data transfer	On track ●●●	Yes	Early demonstrations completed with compression, but cost-effectiveness may still be a challenge.

Pursue the use of program-related investments (PRIs) to the EM vendor community, and competitions and prizes to ensure that vendors remain growth-oriented and open to potential risks (e.g., software evolution).	More effort needed 	Needs to be updated	Experience has shown that prizes for proof of concept technology development are insufficient; this needs to expand to efforts that help integrate AI into providers' product flows and derisk development.
As the market matures in the future, look to disaggregate services (e.g., hardware, software, and video review) to increase competition over time	N/A	Needs to be updated	Effort should be focused on testing performance-based standards and industry-driven models, rather than disaggregating services.
Explore cost sharing opportunities, incentives, and business models to mitigate or amortize program costs	More effort needed 	Yes	Multiple cost-sharing and recovery approaches are being used; "EM as a Service" is an interesting concept that is being tested.

TABLE 7: **Three-year Targets from 2018 Report to Reduce the Cost of EM**

2018 THREE-YEAR TARGETS	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
Hardware costs drop 50 percent relative to today's prices	Not on track 	Yes	Some development of lower-cost models for smaller vessels, but no evidence of reductions in hardware costs for large vessels.
Software and AI advancements reduce review time by at least 50 percent	Not on track 	Yes	Significant progress has been made in building image libraries and demonstrating proof of concepts, but 50 percent appears out of reach in the next 18 months.

Build the Market to Create Economies of Scale

Recommendation overview

In the long run, growing the size of the EM market will almost certainly be the primary driver for EM cost reductions. In its current form, EM is a low volume, moderately customized product, that requires support from many different stakeholders (e.g., vessel owners and crew, regulators, EM providers, NGOs). One EM provider highlighted this challenge reflecting on a recent conversation he had with a fishing industry member: "They thought that EM had reached a stage that it was a plug-and-play, fully automated system. When they heard that this would be a process, they wanted to delay instead of helping it progress, and wanted to wait for someone to come up with the solution."

The 2018 report put forward two recommendations to try and address this issue through simplifying program design and enhancing the transparency of EM demand and supply curves. The first focused on building the "EM supply curve" through a pre-competitive EM provider association to drive interoperability across EM offerings, to simplify and standardize EM product offerings to balance performance against cost, and to advance global market development. The second recommendation focused on building the "EM demand curve" by strategically organizing EM buyers to conduct coordinated procurement.

Progress developing an industry association

Industry associations are common to support pre-competitive collaboration to overcome shared challenges. As one EM provider said, "We technology vendors have some homework to do. There isn't enough drive and we are fighting in our own worlds." Such an association could be used to help develop open standards, program standardization, improve the interoperability between systems, raise the profile of EM, promote EM to governments, or help overcome other shared challenges (e.g., AI development). This concept has not taken off yet, but there is interest, and discussions took place at the beginning of 2020 at NOAA's national EM workshop about forming an industry group to work on interoperability and other industry-wide challenges. The details of what interoperability would look like still need to be worked out, but a first step could include standardizing the output files of EM systems (e.g., how sensor data is reported, encryption, video formats, etc.).

> *"They thought that EM had reached a stage that it was a plug-and-play, fully automated system. When they heard that this would be a process, they wanted to delay instead of helping it progress, and wanted to wait for someone to come up with the solution."* —INTERVIEWEE

Progress developing buyer consortiums

While there are some EM programs that are being executed at significant scale (i.e., more than 100 vessels), much of the market consists of small pilots. With just a handful of vessels, providers cannot spread development costs over many systems, they are often saddled

BOX 5

Bulk Procurement

Bulk procurement is a way to organize EM demand and provide more scale and certainty for EM providers. The process leverages **performance-based standards** and organizes EM customers into a single large procurement (e.g., >100 EM systems). The performance-based standards provide clear guidance to providers on the outcomes that fisheries managers and supply chain stakeholders care about—receiving accurate, analyzed science, compliance, and social conditions data from fishing vessels. In the bulk procurement process, these standards also drive scale by providing uniformity across the project. The hope is that making EM demand transparent and easily accessible to EM providers will give them the market visibility, project uniformity, and overall volume to bring down pricing and invest in critical functionality improvements to their systems.

Bulk procurement also allows for bidding processes that can further drive price competition and transparency. One option to explore is using second price reverse auctions in which the sellers bid in at lower and lower prices to deliver EM services for the buyer group. The provider with the lowest bid will win the contract and receive the second lowest bid for pricing. For buyers, reverse auctions typically result in lower prices and provide more transparency on the supply curve (e.g., the cost of services across the different EM vendors).

with uncertainty about program durability, and have to supply to small programs with different requirements. As one EM provider said about cost assessments from pilot projects, "The costs will not be representative of what they will look like at scale." To try and build more scale in projects, TNC is working with several major partners to organize competitive bulk procurement processes.

The idea is to aggregate EM demand to conduct coordinated bulk procurement that positions EM providers to achieve economies of scale that both reduce pricing and position them to invest in necessary functionality improvements and service delivery infrastructure (Box 5).

Recommendation updates

The failure of EM providers to self-organize an industry association is a disappointment. This remains a priority and we are hopeful that the initial dialogs initiated at NOAA's national EM workshop lead to a concerted exploration of an EM provider association. Public, NGO, philanthropic, and private sector stakeholders should apply pressure for and support to providers to advance this process.

Coordinated bulk EM procurement remains a promising strategy to break through the scale barrier, improve price transparency, and give providers the demand visibility to help EM markets to grow. Longline tuna fisheries appear readiest for bulk procurement, but it can be applied anywhere.

RECOMMENDATION 2.2

Drive Hardware Cost Reductions

Recommendation overview

Hardware costs are typically smaller than the operational costs of an EM program, but they remain a major sticking point in deliberations about whether to move ahead with the technology. The actual up-front costs of an EM system vary by fishery and vessel type but tend to be approximately $10,000 USD for larger vessels. According to one EM program manager, "A significant contributor to the reluctance to roll out EM is the up-front cost. It is no longer a novel and new technology, so the costs are now being borne by industry." The 2018 report put forward a three-year target to drive hardware cost reductions of 50 percent.

Progress driving hardware cost reductions

Over the last couple of years, several providers have developed lower-cost EM systems targeting small- and mid-scale vessels (Box 6). These systems have many of the same features as larger systems but are "right-sized" for smaller vessel configurations. For example, they may support fewer cameras, draw less power, have less storage capacity, and have a smaller footprint. However, little progress has been made on bringing down the cost of systems for larger vessels. As one EM program manager said, "A fifty percent cost reduction in three years? I don't think that we are going to see that without some serious disruptions in the market."

Recommendation updates

Much of the cost of EM systems comes from original equipment manufacturer (OEM) parts (e.g., cameras and sensors). EM is a small part of this market and providers have no leverage to drive price reductions for these products. Instead, hardware price reductions will come from better system integration, right-sizing systems to vessel requirements, and perhaps creating more standardized offerings.

The new lower-cost systems are a welcome addition to open the EM market to smaller-scale vessels. These systems might also be applicable for use in some industrial fisheries if stakeholders strike the right balance between system performance and cost. Another way to encourage hardware price reductions would be for an EM industry association to support the development of "standardized offerings." The application of financing and business models (e.g., hardware as a service) could also reduce up-front costs, but it is unclear whether simply amortizing them will overcome stakeholder opposition. We see more opportunity and need to drive down the ongoing costs of EM programs (e.g., video review) and are withdrawing our overall recommendation for stakeholders to focus on reducing hardware costs.

> *"We technology vendors have some homework to do. There isn't enough drive and we are fighting in our own worlds."* —INTERVIEWEE

Reduce Video Analysis and Costs and Streamline Data Transmission

Recommendation overview

While the up-front costs of EM systems garner a lot of attention, the ongoing costs of EM programs are typically commensurate or higher.[36] The 2018 paper focused on the role that AI can play in reducing video review costs and set forth a target for reducing video review cost by 50 percent.[37] This target was backed by several recommendations and targets for advancing AI.

This section walks through some of the progress that has been made in bringing down video review costs and is structured into three main segments:

- Advancing AI
- Strategically reducing video review rates
- Enabling "near real-time" data transfer

Strategically reducing video review rates was discussed in the 2018 paper, but no specific recommendation or targets were presented.

> *"We have seen growth that has been exponential on the AI and automation side, which has exceeded my expectations."* —INTERVIEWEE

Progress advancing artificial intelligence

The vision for AI is that it will eventually be capable of performing species identification and volume estimates onboard vessels, cost-effectively delivering "near real-time" data on fishing activity to fishery managers on a timeframe that can match the pace of global seafood supply chains. The excitement about the possibilities of AI has helped make it a development bright spot. According to one EM program coordinator, "We have seen a growth that has been exponential on the AI and automation side, which has exceeded my expectations."

A range of investments are necessary to achieve that vision, including:

- Building pre-competitive training data sets
- Stepwise development of AI to deliver short-term benefits before the full vision is realized
- Integration of AI into EM provider business processes and software platforms.

Each of these is discussed below.

BOX 6

Development of Lower Cost EM Systems

Anchor Lab is developing an EM system geared more towards small-scale boats, which will be tested in crab net and trawl fisheries in Australia. The goal is to have a system that has similar functionality to a standard EM system, but at a price that is a fraction of a full-system price (e.g., 50 percent).

Flywire has been on the market for several years now and has deployed systems in several smaller-scale fisheries. A modular hardware design allows for systems to scale with vessel size.

Integrated Monitoring, a relatively new entrant to the EM vendor landscape, stated that it will be delivering two-camera systems for the Maldives pole and line fleet at a cost of a few thousand dollars per vessel.

Not to be left out, **Marine Instruments** is developing a modular system, which allows better matching of equipment to the monitoring demands on the vessel. This new product was slated to hit the market in the first quarter of 2020.

Saltwater released a two-camera system for smaller vessels.

Satlink is releasing the SeaTube Nano, a lower-cost version of their EM system which is better suited to smaller vessels. The product has similar functionality to their SeaTube and SeaTube Lite products.

Onboard EM camera, Maine. Photo: Heather Perry / The Nature Conservancy

36. For example, a recent analysis of the costs of operating an EM program for 100 vessels in the New England groundfish fishery with a 50 percent video review rate, EM video review was estimated to be responsible for half of the ongoing program costs.
37. The 2018 recommendation was framed in terms of review time, but cost is a more appropriate metric.

- **Progress building pre-competitive training data sets.**[38] In response to the need for more training data, TNC launched an open-source platform of EM imagery, Fishnet.AI. TNC has brokered agreements with governments and industry to supply labeled EM imagery to the database and is including stipulations in new contracts with EM providers that they must supply tagged EM footage to the library. The database currently has approximately 100,000 tagged images. The goal is for FishNet.AI to serve as a resource for EM providers and other groups who are interested in advancing AI. NOAA has also been approached by a technology company to help them develop an open-source image library.
- **Stepwise AI development.** In the near-term, the most immediate application is for AI-assisted review. For example, AI can help to identify when events of interest occur, such as the presence of a fish on deck. This can enable EM reviewers to accelerate their work—instead of having to fast forward through video that does not have anything happening in it, AI can tag specific events that need their attention. It can also support wireless transfer by reducing file size.

  There are multiple pathways for AI-assisted EM review. In one, EM video will continue to be pulled from boats on hard drives and AI will be deployed on shore to streamline video review in the office. In another structure, AI can be pushed on to the vessel and automatically edit video footage based on event detection. Then, only relevant video clips could be wirelessly transmitted from the vessel to the cloud for analyst review. The latter scenario is particularly attractive as it would eliminate the cumbersome process of hard drive exchange, allow for more real-time analysis, and streamline video review. Development of both onshore and on-vessel AI applications are likely to happen in parallel, but according to one EM program manager, onshore AI that identifies footage for humans to review is likely to have the highest return on investment in the near term.

  We have seen early progress on both pathways. At least one provider is developing a quick screening tool that automatically identifies catch events for longline fisheries and braille movements in purse seine fisheries. In New England, several groups are collaborating to use AI to assist with length measurements, species identification, and event tagging (e.g., gear deployment, bringing fish on board, etc.). These proof-of-concept demonstrations are encouraging incremental steps towards the development of product-ready AI.
- **Integration of AI into EM provider operations.** Over the last several years, there has been a growing recognition that it is a big step from demonstrating the proof of concept of AI to delivering product-ready solutions that EM providers can integrate into their business processes and software platforms. As one EM expert said, "Several EM vendors have made claims about AI development and integration for years, but we have not seen the delivery of products that tangibly improve functionality or reduce review costs."

  Providers are making some progress, but AI development needs to be accelerated and integrated into EM program operations. To do so, several barriers need to be addressed. The cost and risk of AI development can be high, and providers remain cautious about how much they are willing to invest in integrating AI into their product flow. There is also a question as to whether EM providers have the knowledge and skills to do this in-house and build a business model around it.

  TNC is working to address these barriers. After partnering with Amazon Web Services to refine AI algorithms for EM, TNC is now working alongside several EM providers, Amazon, and a software development and product management firm to both integrate this tool into the providers' video analysis software and to catalyze pre-competitive EM provider support for a third party "AI for EM" product management approach. This should help reduce individual EM provider investment needs and risks, provide world-class AI engineers to solve the challenge of automating the review of EM video, and deliver a scalable approach to continuous improvement.

Progress reducing video review rates

In the 2018 report, recommendations for achieving EM data review cost reductions focused primarily on AI. Beyond AI, though, we have seen creative approaches to revisiting how much EM data needs to be reviewed and for what purposes. According to one EM provider, "Stakeholders are beginning to ask questions and explore required review rates in more sophisticated ways, which bodes well for the cost-effective use of video review to meet monitoring objectives." In the long-run, AI will enable comprehensive video review at little additional cost, but in the near-term finding efficient ways to reduce review rates will be imperative for reducing video analysis costs.

In many pilots and emerging programs, the default is to review 100 percent of EM footage. This may be

38. Training data is an initial data set used to help a program understand how to apply technologies like neural networks to learn and produce sophisticated results. For EM, this is a set of fishing images with informational tags (e.g., fish present, species of fish).

BOX 7

Approaches for Reducing Video Review Rates and Recent Progress

Approaches for reducing video review rates

Driving down video review rates is, perhaps, the number one near-term cost-reduction opportunity for EM programs, and there are different principles depending on whether EM is being used for compliance or science.

EM for science. The frequency of events of interest and necessary confidence intervals will dictate the required review rate. Low frequency events, such as ETP interactions, will require higher review rates, while lower review rates will be sufficient for higher frequency events.

EM for compliance. Review rates need to be set to drive fleet compliance. This will be based on a combination of frequency of events of interest, penalties for non-compliance, and likelihood of prosecution.

Risk-based approaches. Identifying and reviewing fishing activity that has higher risk of non-compliance or probability of events of interest (e.g., ETP interactions) can enable further reductions in video review rates.

Recent progress reducing video review rates

NOAA recently looked at how the quality of discard estimation improved with increasing levels of random video review in the New England groundfish fishery. The analysis found that for almost all species, increasing review rates above 15 to 20 percent yielded limited improvements in the alignment of discard estimates from EM and vessel trip reports. While the appropriate review rate for each fishery and monitoring objective will vary, this type of work highlights that review rates much lower than 100 percent can be effective.

In a 2019 letter to the New England Fishery Management Council, NOAA indicated that its vision for an EM program for the groundfish fishery would have decreasing review rates over time. In an example being considered, the review rates would start at 50 percent in year one, be scaled back to 30 percent in year two, and drop to 15 percent in year three. This would be paired with requirements for vessels found to not meet minimum required reporting thresholds to continue to have their video reviewed at higher rates. This kind of transition from higher to lower review rates allows program managers to obtain baseline data, work through initial kinks, and collaborate with fishers to improve onboard catch handling and practices to streamline video review at the outset of the program, but with a clear direction towards reducing the review rate and program costs as it matures.

Recent progress developing risk-based approaches

Risk-based approaches have also been used in existing EM programs that apply higher review rates to vessels with prior compliance issues. TNC is including this approach in its forthcoming EM performance standards for longline pelagic fisheries. The standards suggest the classification of trips into different risk classifications. Those in the highest risk class would have 100 percent of their video reviewed, while those in the lowest class would have a much lower percentage (e.g., 20 percent) reviewed, which is a more efficient way to apply video review resources and incentivize compliance.

EM video review, Republic of the Marshall Islands. Photo: Kydd Pollock / The Nature Conservancy

Risk-based review can also be based on more than just prior compliance levels. For example, if data from trips are indicating that an area of the fishery is experiencing high levels of turtle interactions, this could trigger a higher level of review for activity in that area to improve confidence in the overall level of turtle interactions in the fishery. TNC is exploring this approach in the Solomon Islands and trying to use EM data on ETP interactions to prioritize risk-based video review.

There are also lessons to be learned from other industries on how to efficiently audit data and analyze video to identify non-compliance. In particular, the casino gaming industry may have risk-based approaches that can be applied in the fishing sector to help streamline the amount of EM video that needs to be reviewed.

appropriate in the pilot stage to build an understanding of the fishery and data collection so that informed decisions can be made about review rates for full program implementation. But, until AI development advances, far lower review rates are likely sufficient to achieve programmatic objectives. With cameras running 100 percent of the time, and fishers not knowing what portion of a trip will be reviewed, sampled data should be unbiased allowing expansion of subsamples to broader estimates or the use of logbooks as a verified data source. People are digging into the question of what an appropriate review rate is and demonstrating that relatively low rates can meet science and compliance goals (Box 7).[39,40,41]

39. Daniel W. Linden, "Determining a Minimum Video Review Rate to Estimate Discards in New England Groundfish," https://em4.fish/wp-content/uploads/2019/11/Video_and_Data_Processing.pdf
40. Michael Pentony, November 26, 2019, https://s3.amazonaws.com/nefmc.org/191126_Letter_GARFO-to-NEFMC-re-approval-of-audit-model-EM-and-video-review-rates.pdf
41. The Nature Conservancy. "Electronic Monitoring Performance Standards for Licensees Long Line Pelagic." In press, (2020)

Progress streamlining data transmission

Standard practice in most EM programs is for video footage to be stored on a hard drive, which is physically transported (e.g., by mail, courier, etc.) to a review center for analysis. Due to the large file sizes of EM video footage and limited internet connectivity in some locations, this anachronistic approach remains the most cost-effective way to transfer video files for most EM programs. This process can be a source of frustration for fishers and has created challenges (e.g., delayed or unmailed drives) in the early stages of EM programs. Furthermore, it can create large lags between when a fishing event happens and when stakeholders have analyzed information on that event, which degrades EM's value.

To streamline data transmission, EM programs are exploring Wi-Fi, cellular, and satellite data transmission. While data upload speeds and costs are coming down for these technologies, these are largely exogenous variables. However, many EM service providers are working on improving onboard activity recognition and compression, which will make these data transmission modes more viable.

- **Wireless In-Port Transfer.** In a few instances (e.g., Denmark, Hawaii), wireless networks have been used to transfer EM videos from vessels at the end of trips as an alternative to physical hard drive removal. These trials have had mixed success—in Denmark, for example, turnaround time in port for some vessels was too short to allow for a full download of a trip's video review, although an improvement in transfer rates at the latter end of the trials significantly reduced this problem.[42] Furthermore, for vessels that are at sea for months on end, in-port transfer will be of limited value.
- **Cellular transfer.** Sending complete video files over cellular networks is still typically uneconomical but is becoming more viable through compression or selection of video. In New England, the Gulf of Maine Research Institute (GMRI) and one of their providers have used cellular networks to transmit data from 120 groundfish trips at a "substantial, but not astronomical cost."[43] SnapIT have also demonstrated the ability to compress and offload video over cellular networks. In many parts of the world, data speeds can be higher and costs lower than in the US or EU, which could make them more conducive to cellular data transfer. Looking ahead, the rollout of 5G and satellite-based 4G networks may open new opportunities for "near real-time" data transmission, particularly as AI and video compression are pushed onto vessels.
- **Satellite transfer.** The high cost of satellite means that in the near-term this tool will be best suited for moving basic data (e.g., GPS locations, sensor readings) or very selective transmission of images.

Updates to the recommendations to reduce the cost of video review and data transmission

Bringing down the cost of video review and streamlining data transmission is imperative if EM is going to scale, and the 2018 recommendations are still appropriate. One important change since 2018 is that it has become clearer that open-source demonstration projects are insufficient to drive integration of AI into EM service providers' products. More investment is needed to de-risk AI development, provide technical support for EM service providers, and identify ways for EM service providers to coordinate on development. More specifically, we see the following as investment priorities to drive down video review costs:

- Drive near-term cost reductions by reducing video review rates and applying risk-based approaches.
- Continue to support the expansion of training data libraries and ensure they are not balkanized (i.e., encourage sharing of tagged images).
- Build provider pre-competitive alignment for AI development, connect providers with world class AI engineering support, and provide resources to de-risk product development and integration of AI assisted review into provider workflows.
- Invest in the development of longer-term AI applications, including on-vessel AI, and more fully automated review solutions.

42. Kristian S. Plet-Hansen, Heiðrikur Bergsson, and Clara Ulrich, "More Data for the Money: Improvements in Design and Cost Efficiency of Electronic Monitoring in the Danish Cod Catch Quota Management Trial," Fisheries Research 215 (July 2019): 114–22, https://doi.org/10.1016/j.fishres.2019.03.009

43. Mark Hager, "Building Efficiencies: Successes, Difficulties, and Recommendations from AI Development in the New England Groundfish EM Programs," https://www.youtube.com/watch?v=iPFBKeQKOkQ&feature=youtu.be

Reduce Program Costs with Efficient Contracts, Standards, and Structures

Recommendation overview

How a program is designed can have implications on the overall cost of delivery. For example, overly prescriptive hardware specifications can lock providers into delivering systems that are over-engineered and unnecessarily expensive for the monitoring needs. In hindsight, the recommendations from the original report on how to drive efficiency in EM service delivery through different program structures and business models were rather general or off the mark. So rather than discuss those recommendations, this section provides an overview of three key areas that have moved forward in the last 18 months that can influence EM program delivery and costs:

- Advance innovative contract design that aligns stakeholder incentives
- Move EM service provision from governments to EM providers
- Develop performance-based standards

Progress advancing innovative contract design

EM providers are typically paid on an hourly basis for video review. This does not create structural incentives for providers to streamline process to accelerate review and bring costs down. In response, and following models from other industries, there has been some exploration of EM contracts using a pay-for-service model, which was recommended in the 2018 report. Rather than paying by the hour of video review, contracts have been structured to pay for processed data, which is what fisheries managers actually need. Contracts can also be structured with incentives for providers to improve the reliability of EM equipment and reduce service response time.

Like service models in other industries (e.g., cooling as a service, energy efficiency as a service), the structure is meant to incentivize efficiencies in the delivery of the end product—in this case processed fisheries data—with the provider taking the cost reductions to their bottom line and the client benefiting through a lower or more certain price and confidence that they will only be paying when the product or service they care about is successfully delivered. Newly initiated EM programs are using this type of contract model and will be the first tests of whether it can reduce costs and incentivize improved service delivery.

As the EM market grows, it seems that "EM as a Service" will become the dominant model and will be a key strategy for aligning incentives between governments, industry, and EM providers.

Progress moving EM service provision to EM providers

The original EM programs in British Columbia are structured so that a third-party provider handles most aspects of the program. They are responsible for the systems, reviewing video, and delivering analyzed data to the regulatory agency. In this type of structure, the government's role is to define the data requirements of an EM program and minimum levels of service, select EM provider(s), and to ensure that they continue to meet specified levels of service. These third-party models can be the most efficiently run EM programs.

In many of the new pilots, governments are executing many of the operations of the EM program, including video review and storage (e.g., Chile and Pacific Islands). In some cases, governments have ended up filling service gaps, such as hardware maintenance. There are good reasons that the government may want to control these aspects of the program (e.g., capacity development, control, employment), and some government-run programs are efficient and successful. But it is also risky and potentially costly for governments to build out their own video review centers. Experience from various EM pilots has shown that there can be a high degree of variability in the performance of government-run review centers. Once governments are in control of EM video and data, it can also complicate matters as it may then be subject to public disclosure laws or long retention policies.

While there are cases where it makes sense for the government to operate its own review center and provide other components of EM service delivery, it seems that for EM to scale, third-party contracting will need to be applied more broadly. Essentially every government fishery agency is capacity constrained and trying to provide EM services themselves only exacerbates these constraints. Under a third-party contracting model, government agencies can then focus on what they need from the program, which is robust analyzed data to manage their fisheries.

Progress developing performance-based standards

EM programs usually draft minimum standards for their EM programs including hardware and operational requirements. But, according to one EM provider, these standards are often developed without any EM providers

at the table and end up having stipulations that unnecessarily increase the cost and complexity of the program. Similarly, one regulator said, "The idea of trying to develop technical standards for EM vendors…what we found is that they don't need that kind of guidance. You can't have a standard on the power supply or the frame rate, or the type of camera."

To help streamline the development of EM standards and ensure that they are crafted in ways that are not overly prescriptive, TNC has developed scalable minimum EM performance standards for pelagic longline vessels, which will be applied first in the FSM. Performance-based standards have a couple of key benefits including:

- **Encouraging innovative and cost-effective ways of delivering services.** Performance-based standards define data and service requirements for an EM program. For example, the standards may state that the EM system must be able to record and transmit location and time data at the start of gear deployment and retrieval or must have image quality sufficient to accurately identify species. But the standards will steer clear of prescriptive requirements, such as what specific sensors the system will use to perform this function or the frame rate and number of pixels required. They shift the focus from process to results. This gives providers, who have the expertise about how to design an EM system, flexibility to meet the minimum performance requirements in the most efficient way and drive continuous improvement and innovation.
- **Enabling fleet-driven, multi-provider programs.** Some fisheries are now exploring or structured with a model in which multiple providers are approved to provide EM services to the fishery, and vessels are free to contract with any of the approved providers. This arrangement relies on a clear set of performance-based standards. While there are logical arguments that this multi-provider approach should drive competition and efficiency, there is no empirical evidence yet as to whether this approach will have cost or level of service benefits relative to the single-provider model. Even within the EM provider community there are differing perspectives. According to one provider, "The truth is competition breeds innovation…I personally have not seen the economies of scale [from a single provider model]." Another provider disagreed, noting, "I don't see a standards and certification [multi-provider] approach working."

Update to the recommendation to reduce program costs with efficient contracts, standards, and structures

The first "EM as a Service" contracts have been inked, and this model needs to be vetted to validate that it drives cost reductions and service improvements.

The 2018 report flagged that there was an opportunity to move regulators out of some of the EM service delivery roles (e.g., video review) and outsource this to third-party providers. This must be a near-term priority to validate whether and in what contexts third-party contracting is a more cost-effective and efficient approach that can overcome the challenge of government capacity constraints.

Scalable performance-based standards need to be tested to confirm whether they offer cost savings, service benefits, or streamline EM program implementation. Completing performance-based standards in FSM and rolling them into regulations is a critical next step. They should also be used to support fleet-driven models that allow multiple providers to compete to provide services in a single fishery. This multi-provider model should be tested to validate whether it stimulates competition, cost reductions, and service improvements. Chile, which already has multiple providers supplying EM systems for the industrial fleet, and the US appear to be ideal testing grounds for the multi-provider model.

> *"The idea of trying to develop technical standards for EM vendors…what we found is that they don't need that kind of guidance. You can't have a standard on the power supply or the frame rate, or the type of camera."* —INTERVIEWEE

3. Recommendations
to Provide Technical Support to Regulators

Regulators are essential stakeholders for developing EM systems, and our original report presented a handful of recommendations to speed the learning process for decision-makers in newly implementing regions. When asked about whether there was still a challenge getting regulators up-to-speed on EM, one government representative said, "I am still talking to a room full of Luddites. There is a bit of a delta between where EM is and where the decision makers are."

While there is a wealth of information about EM programs, it needs to be disseminated to decision makers in such a way that they can be confident that their concerns about EM will be addressed.

The 2018 report put forth several recommendations to provide support for regulators including:

3.1 Provide Program Design Assistance

3.2 Support Agency Data Modernization Efforts

TABLE 8: **Recommendations from 2018 Report and Recent Progress to Provide Technical Support to Regulators**

2018 RECOMMENDATION	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
Develop best-practice toolkits	On track ●●●	No	Multiple toolkits have been published since 2018.
Facilitate regulator convenings	On track ●●●	Yes	There are multiple convenings every year providing an opportunity for regulators to interact (e.g., NOAA EM Workshops).
Build a global expert working group	More effort needed ●●○	Yes	A global expert working group has not been created, but the recently created ICES WGTIFD for the N. Atlantic may be a model for how regions can deliver curated advice and support to regions developing or refining EM programs.
Design pilots to lead to widespread implementation	More effort needed ●●○	Yes	There is a need to be somewhat opportunistic in getting EM trials moving, but this guiding principle is important. Among ongoing trials, some are more clearly designed as a step towards full implementation than others.
Continue to document and communicate the current state of EM and chart a pathway forward	More effort needed ●●○	Yes	Many new studies and EM reviews have been published in the last 18 months, but communicating the current state of progress for EM is an ongoing priority.
Support agency data modernization efforts	N/A	Yes (But an issue larger than EM)	In the US, the findings of the Fisheries Innovation Task Force are being pushed forward through the Net Gains Alliance, but we do not have a clear sense of the progress on agency data modernization more broadly.

Provide Program Design Assistance

Recommendation overview

The 2018 report presented several recommendations for providing program design assistance to regulators. These included:

- Build a global expert working group
- Facilitate regulator convenings
- Develop best-practice toolkits

Progress building a global expert working group

One idea proposed in our 2018 paper was to develop a global expert working group that could be deployed to help newly implementing regions as they design, develop, and implement EM programs. The Regulatory Assistance Project, an organization of former power sector regulators and workers that provides guidance to decision makers designing power sector policies, regulations, and markets, was presented as a potential model for this group. While a global working group has not moved forward, ICES convened the first meeting of the WGTIFD in 2019. The working group includes representatives from roughly 15 countries and includes regulators, EM service providers, NGOs, and academics. The group is tasked with reviewing fishery-dependent data gathering technologies and assessing their risks and benefits across different fishery types for science and management purposes. This North Atlantic regional working group may prove to be a model for how to synthesize EM developments, curate information, and help stakeholders evaluate EM program design options.

There have also been several organically formed bilateral exchanges in the last couple of years. For example:

- Chile collaborated with the Pacific States Marine Fisheries Commission (PSMFC) to learn about EM programs on the West Coast of the US
- The European Fisheries Control Agency has sought guidance from NOAA as they put together their pilot projects
- The Pew Charitable Trusts sponsored a staff member from the Inter-American Tropical Tuna Commission (IATTC) to attend EM meetings at the WCPFC.

NGOs and EM service providers also play a pivotal role in bringing the lessons from other parts of the world to newly implementing regions. These types of exchanges help ensure that new programs build from the existing body of experience on EM and do not reinvent the wheel.

Progress facilitating regulator convenings

Convenings have also served an important role in disseminating information about EM developments and facilitating conversation. In the US, NOAA held two sessions of its third national EM workshop at the end of 2019 and beginning of 2020, which brought together leading EM experts. EM also continues to garner more attention at the International Fisheries Observer and Monitoring Conference, and there have been several EM convenings in Europe in the last year and a half. These events are important for disseminating the latest knowledge about EM among experts and for demystifying the tool for decision makers who are beginning to explore it.

Progress developing EM toolkits

The 2018 report proposed EM toolkits as a resource to guide managers through the development of an EM program. Just prior to the release of our original paper, TNC released an EM toolkit, and soon after EDF released their own version. NOAA is also in the process of putting together a best practice document, slated for completion in late spring or early summer 2020. These documents may prove most useful for people that are quite new to EM. If EM is going to scale more broadly it needs to reach this type of broader audience that is not currently steeped in the details of EM.

Updates to the recommendation to provide program design assistance to regulators

Helping newly implementing regions successfully design and implement efficiency EM programs is still a top priority for advancing EM. This assistance can help speed the process, avoid common pitfalls, and give regulators the information and help they need to push ahead. Toolkits, case studies and regulator convenings are helpful resources, but there is no substitute for connecting regulators with others who have been through the process before to provide targeted technical advice and support as they advance EM programs. We still believe that formal expert working groups are a worthwhile investment to support EM program development, and the efforts of the newly created WGTIFD could be ramped up and may be a model for the field.

Support Data Modernization Efforts

Recommendation overview

To ensure that EM data could be efficiently and seamlessly integrated with other data streams and agency functions, the 2018 report recommended supporting agency data modernization efforts.

Progress supporting data modernization efforts

In 2018, the Fishing Data Innovation Task Force had just released a set of recommendations for transforming fisheries management data systems to handle the increasing volume and types of fisheries data. To help advance these recommendations, the Net Gains Alliance was launched in 2019 with funding from the Walton Family Foundation. The Alliance is working to demonstrate the benefits of modern, interoperable data management systems to better integrate and utilize various fisheries data. Future of Fish also released a paper on accelerating government fisheries data modernization and has followed that up with international efforts to try and put the findings of the work into practice.

Updates to the recommendation to support data modernization efforts

Data modernization is a huge challenge that is much larger than EM. Efforts like the Net Gains Alliance that encourage agencies to tackle this challenge are complementary to EM programs. But interviewees for this progress update did not provide any assessment of the developments on this front, or specific guidance on how to further advance data modernization efforts. While data modernization is a worthy pursuit, it is too big of an issue to be prioritized as part of a targeted EM strategy.

4. Recommendations
to Support Industry Leadership in Program Design

TABLE 9: **Recommendations from 2018 Report and Recent Progress to Promote Industry Leadership in Program Design**

2018 RECOMMENDATION	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
Support industry leadership in EM program design	More effort needed ●●○	Yes	Industry is being integrated to varying degrees, and this remains a priority to build buy-in and to integrate industry feedback into program development.
Support strategic testimonials from fishers	More effort needed ●●○	Yes	Fishers are the best messengers for other fishers, and their testimonials are common in EM dialogues in the US. There may be opportunity to expand the use of this tactic in other regions.

RECOMMENDATION 4.1

Provide Industry Leadership in EM Program Design

Recommendation overview

An EM program is more complicated than simply putting cameras onboard vessels. A successful program includes a set of obligations and operational practices among the different stakeholders. For the fishing industry, this can include things such as basic maintenance of EM systems to ensure they are operational (e.g., wiping lenses), reporting requirements, and catch handling procedures to enable video reviewers to efficiently review the data. These obligations can impact the operational flow on the vessel. Industry also has concerns about cost and the privacy implications of having their workplace filmed. If non-compliance with regulations is common in a fishery's practices, industry is likely to have serious concerns about both liability and the economics of their business with more comprehensive monitoring.

As the stakeholder group most immediately impacted by EM, it is important to bring industry to the table to ensure that their views are integrated into the design and iteration process to build their commitment to the program. Without industry support, an EM program can face major challenges. As the Fiji Fishing Association said in their comments on the longline EM pilot, "Co-operation of crews and owners is essential, and it is doubtful if a blunt 'compulsion' regime will ever work in WCPO where voyages of two or three months are often the norm."[44]

How to effectively cultivate industry leadership in EM program design will be contextual, but could include integrating industry leadership into EM working groups, using trusted third parties to assist with EM pilots and industry outreach, and showcasing fishers with experience with EM as messengers to break down resistance. As one regulator said, "The work that our NGO partner is doing getting cameras on vessels, and [fishers] seeing that the sky does not fall in. I think this is really instructive."

To help build industry leadership in EM program design, the 2018 report recommended the inclusion of industry leadership in EM working groups and the use of strategic testimonials from fishers. We have not tracked the extent to which these approaches are being used, but believe they are effective means to ensure industry perspectives are incorporated into EM program design processes and to build industry support for EM programs.

Recommendation update

We still believe that cultivating industry leadership in EM program development is essential, and this recommendation is still valid. The following approaches can help ensure that industry views are integrated into EM program development:

- Inclusion of industry representatives in EM working groups
- Collaborative on-the-water piloting

Strategic testimonials from other fishers about their experience with EM can also be a powerful and politically salient tool. This is not the case in all regions, but in places such as the US it is a useful tactic to reduce industry resistance to EM.

44. Fiji Fishing Industry Association, "Four Years of Electronic Monitoring (EM) in Fiji's Surface Long Line Fleet - What Now?," October 2019

THE NATURE CONSERVANCY

EM Developments Around the World

EM DEVELOPMENTS AROUND THE WORLD

The 2018 report presented several country or regional targets for EM, and there has been significant of progress against these targets in the last 18 months (Table 10). Many of the regions are on track to meet these targets—although some will get there after 2021—and there have been EM developments in all the priority regions identified except North Asia.

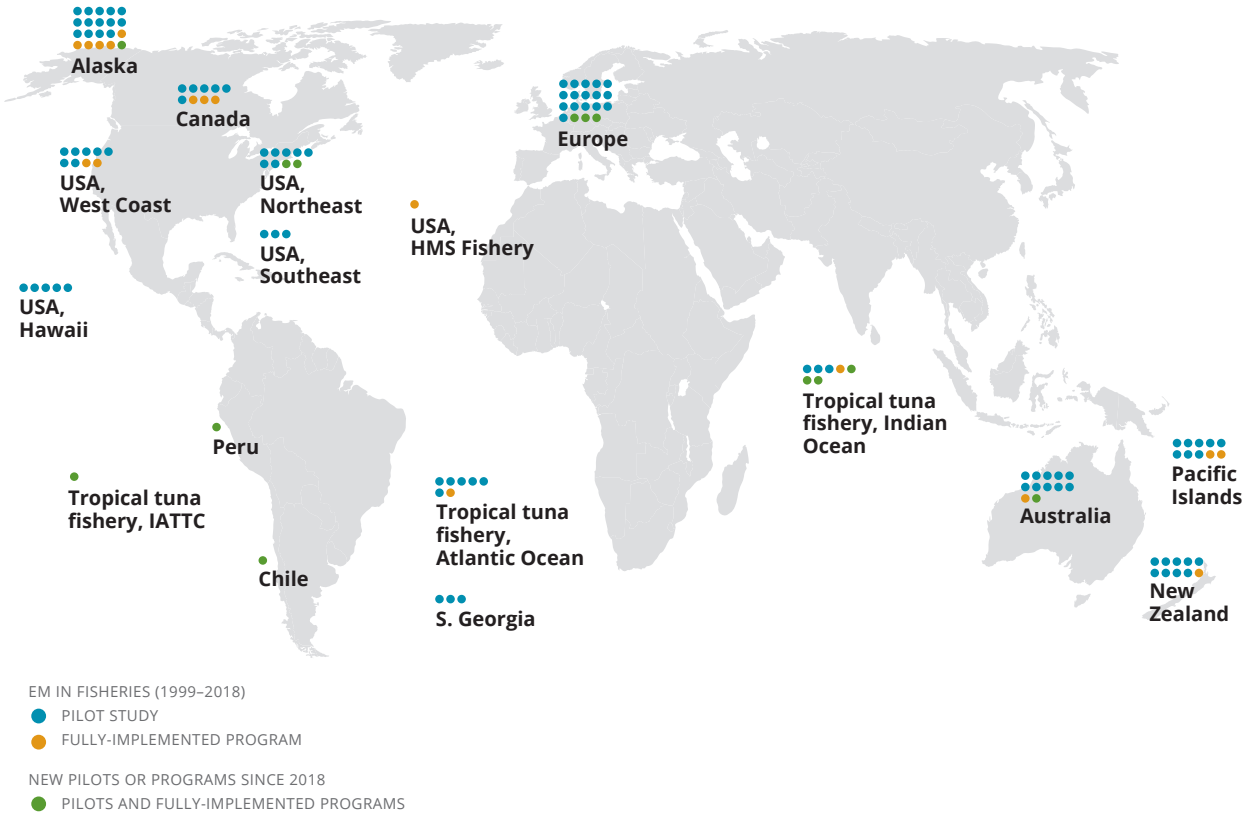
The following section discusses EM progress across different geographies. There is no global database of EM pilots or programs, and this section is not intended to be comprehensive. Instead, it provides a picture of how adoption of EM is progressing in different regions (Figure 5) and synthesizes key trends.

To help structure the progress of EM, we have grouped countries into the following archetypes:

- **EM is established**
- **On the learning curve**
- **Caught in an accountability trap**

The types of interventions required in these different archetypes will vary.

FIGURE 5. **Number of EM pilots and programs from 1999–2018 and a selection of new pilots and programs since the end of 2018**[45]



45. Adapted from Aloysius T. M. van Helmond et al., "Electronic Monitoring in Fisheries: Lessons from Global Experiences and Future Opportunities," *Fish and Fisheries 21*, no. 1 (2020): 162–89, https://doi.org/10.1111/faf.12425.

TABLE 8. **Three-year EM Development Targets by Geography from the 2018 Report**

2018 THREE-YEAR TARGET	PROGRESS STATUS	UPDATES
United States: *Continued rollout of EM in priority federally managed commercial fisheries (e.g., HMS, trawl, pelagics), and development of stronger national guidelines to streamline implementation*	On track	Some bumps in the road, but there are several fully implemented programs and EM trials operating under exempted fishing permits moving toward full implementation (e.g., West Coast groundfish, New England groundfish). There are now almost 600 vessels participating in federally managed fisheries with EM systems. EM is also being tested in new fisheries (e.g., recreational sector) and new EM policy directives are providing clearer guidance for the regions.
Australia: *Adoption of EM in the majority of Commonwealth fisheries*	More effort needed	Progress is slower than anticipated but expansion of EM to additional Commonwealth fisheries was still planned as of the beginning of 2020. Development is underway for EM at the state level, including Queensland's inshore vessels.
New Zealand: *Full implementation of EM mandate*	More effort needed	EM development appears to be back on track with the first mandated EM program in place to monitor dolphin interaction and bycatch. A more collaborative approach between government and industry has developed with a shift from EM as the objective to achieving objectives with EM. Scoping is underway for the next fisheries, but program cost, funding, and privacy are still a concern.
Western and Central Pacific Fisheries Commission (WCPFC): *Regulatory mandate for longline permits and implementation in the majority of Forum Fisheries Agency nations.* *Initial piloting of EM for purse seine vessels*	More effort needed	Several island nations appear to be on the path to requiring EM as a licensing requirement. FFA has drafted longline EM policy, the Data Coordinating Committee has developed draft EM Data Standards, and industry leaders are pushing EM forward. With 100 percent observer coverage on purse seiners, EM can play a complementary role, especially for compliance and observer safety functions. As highlighted by Covid-19, EM can also provide a backstop if observers cannot be deployed.
Europe: *Adoption of EM for high-risk vessels in select EU nations (e.g., Denmark, UK, Netherlands).*	More effort needed	Continued discussion about the failure to enforce the landings obligation and that EM is the only tool capable of monitoring the regulation. Several N. European countries (Denmark, Sweden, Netherlands) are taking initial, unliateral steps forward on EM, but more effort is needed to break the gridlock. For Brexit countries no longer in the EU, there may be significant fisheries management changes and opportunities for EM. Scotland is moving forward on a plan to implement EM in multiple fisheries. Early discussions are also underway in Norway and Iceland.
North Asia: *Pilot EM trials for domestic fisheries at scale in China, Japan, and Korea, tied to fisheries reform goals that demand comprehensive monitoring*	Not on track	There was some early dialogue about EM in Japan, but focus now is on digital data collection. Limited insight into China and Korea, but there is some anecdotal evidence of interest in China's distant water squid fishery.
Newly Industrialized Countries: *Pilot EM trials at scale for industrial-scale fisheries in major middle-income countries: Peru, Chile, Argentina, Mexico, and Brazil. Further develop proof points of low-cost EM systems in small-scale fisheries (e.g., Indonesia and Mexico).*	On track	EM is being rolled out for Chile's industrial fleet, and semi-industrial fleet deployment is slated for 2022. A few vessels in Peru are now testing EM. Testing of low-cost EM cameras is continuing in Indonesia.

Progress in Regions
Where EM is Established

In places where EM is established, investment should be focused on pushing the boundaries of EM, developing supportive policies and directives, and resolving some of the more persistent challenges (e.g., data management, program financing).

More specifically, work should be focused on:

- **Identifying new fisheries or use cases for EM**
- **Refining regulations, directives, and implementation to make program delivery more efficient**
- **Integrating data from EM into science**
- **Using EM data to improve management**

Canada

Canada was the home of the world's first EM trial in the British Columbia (BC) Area "A" crab fishery, which started in 1999. Canada now has several fully implemented EM programs, including the BC Area "A" crab fishery, the BC Groundfish Hook and Line/Trap Catch Monitoring Program, and the BC Hake Fishery. In total there are just under 300 vessels participating in fully-implemented EM programs.[46] Although Canada was an early adopter of EM, there have been no new fully adopted programs since 2006. A 2019 analysis of Canada's Pacific Region Fisheries found that for the most part, catch reporting tools have been applied in fisheries where they are feasible.[47] In other words, the absence of additional EM programs in Canada's Pacific region over the last decade is likely due to the lack of suitable fisheries for the tool. In the Atlantic region, several groups are testing an electronic whale interaction mitigation system, but the effort has so far been focused on non-video solutions.

United States

The United States has more vessels with EM systems than any other country. There are eight fully implemented programs and 11 pilots/pre-implementation programs in process. In total, nearly 600 vessels are part of an EM program. The US continues to explore additional opportunities for EM and is also making changes to policies to try and improve the efficiency of its EM programs. While there have been some bumps in the road, the US has largely embraced EM and the benefits it can provide fisheries management.

On the policy side, the National Marine Fisheries Service (NMFS) updated its Policy on Electronic Technologies and Fishery-Dependent Data Collection in May 2019.[48] While the policy does not mandate anything, it encourages the consideration of electronic technologies including EM. The Policy also states that no electronic technology program will be approved by NOAA if it creates an unfunded or unsustainable cost of implementation.[49] The language recognizes the long-term funding challenges for the government and indicates that they are looking to move program costs to industry as the technology has matured and their experience with EM programs has grown.

NMFS also put forward a proposal to reduce the required retention time for EM video and data that have been collected in programs funded by industry to 12 months.[50] While the cost of data storage has declined over time,

46. Aloysius T. M. van Helmond et al., "Electronic Monitoring in Fisheries: Lessons from Global Experiences and Future Opportunities," *Fish and Fisheries 21*, no. 1 (2020): 162–89, https://doi.org/10.1111/faf.12425
47. Howard McElderry and Phillip Meintzer, "Design Considerations to Optimize Monitoring for Canada's Pacific Region Fisheries" (Archipelago Marine Research Ltd., March 2019), https://em4.fish/wp-content/uploads/2019/03/McElderry-Meintzer-2019-FisheryMonitoringDesignConsiderations-1.pdf
48. Brett Alger, "Policy on Electronic Technologies and Fishery-Dependent Data Collection" (National Marine Fisheries Service Office of Science and Technology, May 2019), https://www.fisheries.noaa.gov/national/laws-and-policies/science-and-technology-policy-directives
49. Ibid.
50. Brett Alger, "Third-Party Minimum Data Retention Period in Electronic Monitoring Programs for Federally Managed U.S. Fisheries" (National Marine Fisheries Service Office of Science and Technology, April 3, 2020), https://www.fisheries.noaa.gov/national/laws-and-policies/science-and-technology-policy-directives

requirements to store video for extended periods (sometimes indefinitely) create an unnecessary cost burden for EM programs. This directive applies a common-sense approach to reducing the video and data retention requirements and their associated cost.

There have been some notable EM program developments in the United States in the last 18 months.

On the West Coast, the groundfish fishery is in the process of trying to move to a fully industry-funded third-party provider model, and this transition has been challenging. The fishery has 100 percent accountability requirements in place that can be met with human observers or EM. The fishery has been using PSMFC as its EM video reviewer during the pilot phase, and they have provided this service at a price that makes EM a cost-effective alternative to human observers for a portion of the groundfish fleet. This has also been subsidized for the fleet. But, at last check, PSMFC will not be bidding as a third party provider for EM video review for the fully implemented program because they are concerned about receiving payments directly from industry. The bids from other providers have been coming in at significantly higher cost than what PSMFC charges, likely because PSMFC already performs video review for the groundfish and other fisheries on the West Coast (e.g., Alaska) and already has all of the required infrastructure in place. PSMFC is also a quasi-governmental organization that does not require the same return on investment as private-sector EM providers.

On top of the higher priced bids coming in from EM providers, the West Coast Groundfish Observer Program is also proposing to audit 10 percent of the EM video footage as part of a debrief/audit of the third-party reviewer. This additional review-of-the-reviewer step is anticipated to cost approximately $450,000 USD each year and would be a cost recovered from industry. The higher cost of EM video review with a new third-party provider paired with the additional $450,000 USD annual cost to audit the provider has the potential to tip the economics back in favor of human observers and stall EM development. The debate is ongoing, and stakeholders are in a tricky spot of trying to steer the program to a fully cost-recovered third-party model that NMFS is encouraging, while not undermining what has been a successful EM program.[51] This debate also highlights the path dependence of EM piloting and program development.

In Alaska, EM continues to move ahead with five fully implemented EM programs and two pilots. The small boat fixed gear program, which was just getting underway when we released our 2018 paper, is running well. The midwater trawl fishery is now exploring EM and will be operating a pilot under an exempted fishing permit in 2020, with a target of being under regulation in 2022.

Hawaii recently completed a review of its longline EM pilot and found that EM could substitute for human observers. EM could be used to accurately identify almost all species of importance for management with just a couple exceptions. For the deep-set longline fishery, EM is expected to be a cost-effective alternative to human observers as vessels take trips that average 22 days in length, but fish for only 13 days. Work will continue to improve the ability to use EM to identify the species that it could not match observers on in the year-long trial (e.g., bigeye and turtle identification to the species level). But with observers only covering 20 percent of the deep-set trips, a viable model appears to be expanding EM to cover all trips and scaling observer coverage back to 10 percent. According to one person interviewed for this report, this could be done at a similar cost to the existing observer program.

On the East Coast, after a successful pilot, the herring and mackerel fishery is moving ahead with an exempted fishing permit (EFP) that will allow the use of EM as a replacement for human observers. Enrollment in the EFP ended at the end of April 2020 with EM trips expected to begin in June. The expectation is that this will move to full implementation in the future.

The Northeast scallop fishery recently began piloting EM to improve the timeliness of the collection of vessel data, which is used to open and close the fishery. The first stage of the pilot was successful and is now moving to deploy EM on more boats.

EM has also been tested as a way of validating captains' required catch reports on two for-hire recreational fishing boats in the region: one party boat and one charter boat. The recreational sector is a major source of fishing mortality and catch uncertainty, with very limited monitoring, and these trials are an exciting first step in assessing the applicability of EM in that context.

51. Melissa Mahoney, "West Coast Groundfish EM Program at a Crossroads," December 6, 2019, https://em4.fish/west-coast-groundfish-em-program-at-a-crossroads/

Australia

Australia has 75 vessels operating with EM in their Eastern and Western Tuna and Billfish Fisheries and their Gillnet Hook and Trap Fisheries. The next likely candidate for adoption of EM is the trawl fishery, which has piloted EM on a couple of vessels. The process for rolling out EM in this fishery has slowed, but at last check the intention is to have full program implementation in 2022. Following the trawl fishery, the Northern Prawn fishery would be one of the likely next candidates. Together these fisheries would bring an additional estimated 80 to 90 vessels into EM programs and would mean that over half of Australia's federally managed vessels would be in an EM program.

At the state level, EM is being explored for roughly 200 inshore trawl, gillnet, and line vessels in Queensland. If this moves ahead in full, the program would have almost three times the number of vessels as Australia's federal EM programs.

Australia Fisheries Management Authority (AFMA) is also working to expand its use of EM data. EM is already used for logbook compliance, and they are using the data to apply targeted sanctions (e.g., sanctioning vessels with high levels of seabird bycatch). The agency is now exploring how they can better integrate the EM data stream into stock assessments. Under the EM program, validated logbook data is accepted as the data from fishing trips, but this data would be an entirely new data stream for stock assessments and there is still some skepticism that fisher reported data can be used. Work is underway to understand how to integrate this new data stream into the models and build confidence that with EM, logbooks can be a trusted source of data for science.

Progress in Regions
On the Learning Curve

In places that are on the EM learning curve, efforts will need to focus on building confidence that EM can efficiently meet monitoring objectives without breaking budgets or politics.

This will include:

- **Providing technical support for regulators**
- **Facilitating dialog and providing information to stakeholders**
- **Executing EM pilots on the water, iterating on designs, and proving that EM can cost-effectively meet monitoring objectives**
- **Building bottom-up support for EM (e.g., through industry partners, or leading countries)**

New Zealand

Legislation was approved in 2017 to require EM for all commercial fishing vessels, which could cover up to approximately 1,000 vessels. A change in administration and concerns from the fishing industry put the rollout of EM on hold, but it is now back in motion. New Zealand now has a regulated mandatory EM program for 20 vessels with the primary objective to assess and minimize Māui dolphin interactions, but also to verify catch reporting. The government paid for the cost of the equipment and is also reviewing the video for this program. Initial reports are that the trial is working well.

Looking forward, four key issues are likely to influence the continued rollout of EM in New Zealand's fisheries.

- First, there is a low level of observer coverage in the inshore fleet and strong incentives for misreporting catch data.
- Second, a revised Hector's and Māui Dolphins Threat Management Plan is under development. A draft plan was put out for public consultation and garnered over 13,000 submissions, indicating the importance of both fisher livelihoods and dolphin conservation. While fishers say dolphin interactions are very rare, there is limited evidence to prove this. EM provides a potential path forward to validate the absence of dolphin bycatch and to verify self-reported catch data.
- Third, costs of managing New Zealand commercial fisheries are recovered from the fishing industry and the industry is concerned the current high costs of EM could make sectors of the industry uneconomic.
- Fourth, data privacy concerns are an ongoing point of contention for industry.

Significant challenges remain but EM appears likely to be cautiously rolled out in more fisheries in the coming years. Initial opposition from parts of the fishing industry, which is common in almost all regions at the beginning of an EM rollout process, has lessened as the government adopts a more collaborative approach, including supporting additional EM trials managed jointly by industry groups and conservation NGOs. These trials are designed to explore how privacy and cost concerns might be addressed by different approaches to EM.

Scotland

Scotland is an emerging leader for EM. The country has completed trials of EM on demersal vessels, as well as a large pelagic vessel. While these trials did not make it to full implementation, Marine Scotland is now moving ahead with the Inshore Fleet Modernisation Program. As a part of this program, there are three fisheries in queue for EM: scallops, inshore trawl, and inshore pot and creel.

There are now 13 scallop vessels with EM systems, with an aim to eventually cover 114 vessels. Illegal fishing within MPAs created the momentum for EM in this fishery, but there are other factors that have led to camera-based systems as opposed to just location tracking. Fishery regulations only allow vessels to fish with eight dredges in inshore waters, but they can fish with 10 dredges offshore. With cameras, vessels can fish inshore and demonstrate that they are abiding by the eight-dredge limit and still fish with 10 dredges in offshore waters. The fleet is also interested in pursuing MSC certification and an EM program could provide data to support the assessment process.

The next fishery slated for EM is the inshore trawl fleet that fishes primarily for langoustines and nephrops. This fishery is believed to have a lot of bycatch and discard issues, but the agency cannot put observers on these boats due to safety concerns. This inshore trawl project is still in the scoping phase but would cover 118 vessels if fully implemented.

Finally, the third phase of the program is looking to implement EM on the inshore pot and creel fishery, which has 1,440 vessels, but this is on the distant horizon right now.

In addition to these EM projects and plans, Scotland is also partnering with the University of East Anglia on AI development.

Chile

Chile adopted legislation that required the installation of EM systems on all industrial vessels by the end of 2018 and on artisanal boats longer than 15 meters by 2020. Implementation is behind schedule, but installations on the industrial fleet were well under way by the beginning of 2020. By the end of January there were more than 100 industrial vessels newly equipped with EM systems and beginning to record video. Rollout for artisanal fleet is now expected in 2022.

A driver for the EM program in Chile has been the United States' import provisions of its Marine Mammal Protection Act, which requires nations exporting fish products to the US to be held to the same standards as US commercial fishing operations. Chile has numerous fisheries that export to the United States and by January 2022, they must apply and receive a comparability finding for each of these fisheries to continue to export to the United States. Industry says that mammal bycatch is limited, but there is little data to support this claim. EM is being deployed to help fill this data gap, with the intent of demonstrating that Chilean fisheries meet the necessary standards to continue exporting to US markets.

Uncertainty about the level of discards is also driving EM adoption. The scale of the issue is not well understood in many Chilean fisheries, and it can be a source of conflict between industrial and artisanal vessels. A study of the demersal crustacean fishery found that observer reported discards in the fishery were 65 to 125 percent higher than those reported in captain logbooks. The study concluded that absent conditions that drive accurate self-reported data, logbooks cannot be used to make administrative and quota decisions.[52]

Looking ahead to 2022, the rollout of EM for the artisanal fleet (vessels longer than 15 meters) could bring a large number of vessels into the EM program. If this moves ahead, it could become one of the largest EM programs in the world.

52. Marcelo San Martín et al., "Are Self-Report Fishing Log-Books a Solution for Measuring Catch, Bycatch and Discards?: The Case of Crustacean Demersal Fishery in Chile." (9th International Fisheries Observer and Monitoring Conference, Vigo, Spain, June 2018), https://ifomcvigo.com/wp-content/uploads/2018/08/proceedings-9th-ifomc.pdf

WCPFC

The WCPFC continues its steady progression to broader adoption of EM with a goal of adopting an EM conservation and management measure at its 2020 Annual Session. The region is home to numerous pilots, including the recently completed 50-vessel pilot for longline vessels in Fiji run by the Food and Agriculture Organization of the United Nations (FAO). There have also been pilots in several longline fleets of the island states, including the Federated States of Micronesia (FSM), Marshall Islands, Palau, Cook Islands, and the Solomon Islands. Not to be left out, the distant water fishing nations of Japan and Taiwan have also trialed EM for their tuna fleets. As of the end of 2018, there were approximately 80 longline vessels in the WCPFC equipped with EM (excluding Australia and New Zealand).

The WCPFC has a target for human observers to cover five percent of longline trips, but many countries struggle to meet even this modest level of coverage. There is growing consensus that current observer coverage is insufficient and that EM can fill this monitoring gap. Market demands for sustainability are also driving EM forward in the region. Thai Union has a target that at least 75 percent, with a goal of 100 percent, of its branded tuna will come from fisheries that are MSC certified or in a fisheries improvement project. Other tuna companies, such as Luen Thai and Tunago, are also integrating EM into their supply chains.

Island nations have been driving EM from the bottom up and FSM leadership has been particularly influential. The country has moved all the way from EM pilots to a commitment to having 100 percent of longline vessels fishing in its exclusive economic zone (EEZ) with EM by 2023. Through the Technology for Tuna Transparency (T3) Challenge, FSM is encouraging others in the region to match their commitment to on-the-water monitoring. With the encouragement of FSM, the Marshall Islands, and other members, the Parties to the Narau Agreement (PNA) has also been out in front of EM.

At the end of 2019, the Forum Fisheries Agency put forward their Draft Regional Longline Electronic Monitoring Policy. In this document, they propose developing a set of minimum EM standards at the RFMO level but leaving EM program design and implementation to the member states. The end goal would be a set of harmonized EM programs across the region. The Pacific Community (SPC) has also continued to explore EM, including research on the capability of EM to provide the data required in the longline WCPFC regional observer program minimum standard data fields.

There is still much work to be done, but the WCPFC appears to be well on its way to widely adopting EM.

IOTC

Within the territory of the IOTC, Spanish purse seine vessels that are part of the National Association of Tuna Freezer Vessel Shipowners (ANABAC) and Organización de Productores de Atún Congelado (OPAGAC) are voluntarily using EM for their trips. French purse seine vessels that are part of Orthongel have also adopted EM voluntarily. Between these two groups there are about 27 vessels operating with EM in the IOTC region.[53] The voluntary EM programs of these producer groups are the only large-scale programs that are not managed by national or subnational governments.[54] All of the data analysis is handled independently, and these vessels only submit the processed data required by governments or the RFMO.

Countries in the IOTC are also beginning to explore EM in the region. As a part of a World Bank project, the Maldives is beginning to install EM systems on its pole and line fleet. According to one person involved in the project, the plan is to roll out EM on all of the approximately 700 pole and line vessels by the end of 2020. The program is also exploring placing systems on collector vessels. One of the drivers of EM adoption for the pole and line fleet is to stay ahead of the European Union's IUU carding system. There is also an important human element as well, as the systems will have 2G capabilities which will allow for crew members to use communication apps and make emergency voice calls.

Although the IOTC has a limited role in the voluntary French and Spanish programs and the Maldives work, they are also beginning to explore EM. A key driver for the RFMO is the limited observer coverage and the significant safety concerns for observers in the region, both from piracy and from unsafe vessels. The RFMO is moving ahead with a pilot in Sri Lanka, which is just getting underway. According to one person involved in the

53. Van Helmond, Aloysisu T.M., et al., 2019 "Electronic monitoring in fisheries: Lessons from global experiences and future opportunities." *Fish and Fisheries, Volume 21*, Issue 1, 162-189.
54. Ibid

trial, the EU's yellow and red-carding of Sri Lanka is driving efforts in the country to improve accountability and was a key factor in Sri Lanka volunteering for the trial.

The recent scandal of the Spanish fleet under-reporting yellowfin catches in the IOTC is opening more opportunities for EM. The Seychelles is taking the lead and has made a commitment to 100 percent EM coverage for all vessels fishing in its territorial waters. Pilot projects are getting underway for both longline and purse seine vessels in that country and TNC is providing on-the-water support for these trials.

ICCAT

There are several vessels with EM systems in ICCAT. Orthongel, OPAGAC, and ANABAC are operating purse seine vessels with EM systems. As in the IOTC, this is a voluntary EM program run completely by industry. At the end of 2018, the FAO completed its trial of EM on 14 purse seine vessels that operate in the Ghanaian EEZ. The pilot was successful on many counts, but at the end of 2018 the vessels had discontinued the use of the EM systems. The EM systems, however, may soon be put back into service as a part of FIPs.

Although EM is currently voluntary in ICCAT, some recent changes may start a stronger movement to EM. ICCAT recently agreed to require 100 percent observer coverage on purse seine vessels year-round, and to expand longline observer coverage to 10 percent in 2022 for vessels greater than 20 meters.[55] They have also agreed to develop EM minimum standards by 2021.

IATTC

IATTC is in the early stages of exploring EM, particularly to collect data from purse seine vessels. There is an EM pilot underway with two small vessels and two larger Ecuadorian-flagged vessels. One of the objectives of the IATTC EM program on purse seine vessels is to determine the effectiveness of EM compared to human observers. While small in scale, this pilot is an important first step in IATTC's exploration of EM.

Early progress is also being made in the longline fleet. IATTC scientific staff and the IATTC Working Group on Bycatch have recommended at least 20 percent observer coverage on longline vessels fishing for tunas in the Convention Area, and the Working Group on Bycatch has suggested that human observer coverage could be supplemented by EM in order to achieve that goal. It is likely that IATTC staff will present preliminary EM standards at the Scientific Advisory Committee in May 2020. One early opportunity for EM may be on smaller purse seine vessels that do not currently have human observers.

55. Victor Restrepo and Holly Koehler, "ICCAT Moves to Protect Atlantic Bigeye and Close Gaps in Monitoring and Data Collection," December 4, 2019, https://iss-foundation.org/iccat-moves-to-protect-atlantic-bigeye-and-close-gaps-in-monitoring-and-data-collection/

Progress in Regions
Caught in an Accountability Trap

In these fisheries, the management system paired with insufficient monitoring has fully embedded non-compliance in fishery operations. Although industry resistance to better accountability is a barrier to EM in almost all fisheries, in these fisheries the resistance has become especially acute and has ground progress to a halt. These fisheries have experience with EM pilots, the capacity to implement EM programs, and recognize that EM can drive compliance with regulations. But portions of industry see full implementation and compliance with existing regulations as an existential threat to their viability and are vehemently opposed.

For fisheries/regions caught in an accountability trap, interventions need to find a way to break the gridlock and create agreements that balance economic, social, and ecological objectives. In these cases, progress may be slow as some actors dig in their heels. But there are signs of progress in some of these challenging contexts, such as the New England groundfish fishery and the EU. Interventions should include:

- **Building public pressure for better accountability, highlighting the current lack of compliance, or even litigating**
- **Creating a coalition of the willing to take the first step forward**
- **Providing incentives to and working with early adopters to demonstrate the benefits of EM**
- **Supporting pilots to work through any unresolved questions about EM**

European Union

In some regions, fisheries regulations paired with limited on-the-water monitoring have created fisheries in which non-compliance is firmly embedded in their operations. This is the current situation in the EU. The landing obligation requires that all fish caught be landed, but with limited quota for some species and little or no market value for small size classes, there are strong incentives in many EU fisheries to discard. Although quotas were increased to compensate for the impact of the landing obligation, all indications are that discarding continues unabated, undermining the objective of the Common Fisheries Policy to achieve maximum sustainable yield.

This has created an environment in which it is difficult to take any steps forward to implementing EM. For some parts of the fishing industry, the prospects of full accountability are an existential threat, as discarding is fully embedded in their current business model. Member states are likewise reluctant to lead on this issue, since implementing EM for their vessels will disadvantage their fishing industry if other member states do not follow suit. Despite these challenges, it is widely recognized that EM is the only way to ensure compliance with the landing obligation and some countries are taking a leadership role.

Denmark has been one of the strongest supporters of EM in the EU and ran the longest running EM trial in the EU. The country has long supported EM, and at the end of March 2020 shared plans to move forward. The country announced that it will move ahead with an EM requirement for vessels that have over 20 sea days a year in the Kattegat Sea. It is estimated that 15 vessels will be equipped this year with EM and that 100 vessels currently meet these criteria and will be required to install EM systems under this decision.[56]

Sweden has instructed its Agency for Marine and Water Management (HaV) to investigate the use of EM to ensure compliance with the landing obligation. In January 2019, HaV proposed piloting EM in three different fisheries: bottom trawl for fish and nephrops, bottom trawl for shrimp, and a pelagic trawl fishery. The proposal is for EM to be tested on five vessels in each fishery over a period of three years.

The Netherlands is taking a different approach to EM and the landings obligation. Industry is fiercely opposed to the landings obligation and is working on an EM pilot with 12 vessels to fully document what they are catching with the intent of still being able to discard.

56. Mogens Jensen and Nanna Møller, March 30, 2020, https://www.ft.dk/samling/20191/almdel/mof/spm/698/svar/1647184/2171422.pdf

In addition to this progress at the national level, the European Fisheries Control Agency released its guiding document, "Technical guidelines and specifications for the implementation of Remote Electronic Monitoring (REM) in EU fisheries." The document puts forth a set of minimum technical requirements and standards for EM, which could be used to help control of the landing obligation.

There appears to be three general scenarios for how things will play out in the EU:

- **Industry fends off implementation.** Industry continues to fend off implementation of the landings obligation which will likely have negative impacts on the health of fish stocks and the long-term economic prospects for the fishing industry.
- **Top-down implementation.** Government mandates the implementation of EM to enforce the landing obligation with no concessions made to industry. This causes significant near-term economic pain for the industry and serious implementation and political challenges.
- **A grand bargain.** Industry and government reach a grand bargain in which both sides make concessions. There will be sacrifices on both sides, but the result is a compromise that addresses the challenge of controlling unreported discards while addressing the economic concerns of the industry.

The third option appears to be the only stable and durable solution to the conflict over the landing obligation.

United States: New England Groundfish

The New England groundfish fishery has been, perhaps, the most problematic test case for EM in the United States. The multispecies fishery is managed with strict quotas, and choke species prevent the fishery from landing larger amounts of other species that are not overfished. This structure provides a strong incentive to discard landings of choke species. The fishery has human observer coverage for 40 percent of the trips in 2020, but because of the strong incentive to discard there is consensus that data from observed trips cannot be extrapolated to provide fleetwide estimates. Gulf of Maine cod is one of the key constraining stocks in the fishery and despite continued ratcheting down of catch entitlements for this stock, its status has continued to decline. An analysis by the Groundfish Plan Development Team found that unreported cod discards could mean that cod catch is 2.3 times higher than reported. Observer requirements in the fishery have increased in the last couple of years, growing from 15 percent in 2018 to 40 percent in 2020.[57,58] But even at this higher level of observation, discarding may just be further concentrated in unobserved trips.

Several EM pilots are ongoing in the fishery, and these pilots are answering some of the remaining questions about how EM will work in the fishery. In our estimation, ultimately the argument now is less on the technical feasibility of EM, and more on the need for a regulatory requirement. As one person working on EM in the region said, "We have all of the volunteers that we are going to get, we are working with these boats, and they are doing okay."

There are, however, signs that things are moving. According to another person who has been involved, "It is actually going okay. It is such a large decision and inflection point for the fishery, and there are actors trying to slow things down. But there is more and more interest by the month to move forward."

A key breakthrough may have been made in January 2020, as the Fishery Council released its draft decision document on Amendment 23 and made 100 percent at-sea monitoring its preferred alternative for the fishery. While this does not mean that the final ruling will require this level of coverage, it indicates that pressure is mounting to bring full accountability to the fishery. If this preferred alternative is adopted, many in the fleet will likely move to EM to meet this monitoring coverage requirement.

57. NOAA Greater Atlantic Regional Fisheries Office, "Northeast Multispecies (Groundfish) Fishing Year 2019 Regulations (Sector Measures)," April 25, 2019, New England/Mid-Atlantic, https://www.fisheries.noaa.gov/bulletin/northeast-multispecies-groundfish-fishing-year-2019-regulations-sector-measures

58. Chris Chase, "New England Fishery Management Council Examining 100 Percent At-Sea Monitoring for Groundfish," SeafoodSource, February 6, 2020, https://www.seafoodsource.com/news/supply-trade/new-england-fishery-management-council-examining-100-percent-at-sea-monitoring-for-groundfish

BOX 8

Covid-19 Implications for EM

In response to Covid-19, fishery management bodies around the world have been suspending human observer requirements. This is an essential step to protect the health of observers, captains, crew, and other workers but it is opening the door to widespread illegal activity on the water and limiting the collection of scientific data. Concerns are mounting that these suspensions could backslide into permanent cuts in on-the-water monitoring, and major retailers and seafood companies are worried about the additional risk this creates in their supply chains.

But the situation is also highlighting the value and resilience of EM. For example, while NOAA has suspended human observer requirements in response to Covid-19, vessels with electronic monitoring are unaffected. This is strengthening demand for the tool. For example, a group of some of the world's largest retailer's brands, and seafood companies banded together to call for RFMOs to make EM an accepted alternative to human observer coverage in tuna fisheries.

While Covid-19 is building demand for EM, it is also having enormous impacts that will influence the ability to turn that interest into progress. For example:

- **Retailers** are emerging as winners from the pandemic as they are experiencing unprecedented demand with shelter-in-place orders. This increased demand is likely to persist, even after economies start to open back up. With strong balance sheets and more market power, retailers will become an even more important sector for driving sustainable fishing, fair labor practices, and 100 percent monitoring on the water.
- **The fishing industry** is being hit hard by Covid-19. While there are some bright spots (e.g., high demand for shelf-stable tuna), reports of price declines, challenging logistics, and economic pain are widespread. When we emerge on the other side of the pandemic, the economic condition of fisheries will inhibit the political feasibility of top-down EM mandates, and likely require more collaborative approaches, incentives, and cost sharing.
- **Governments** are spending at unprecedented levels to keep their economies afloat. There will be additional rounds of recovery spending and finding ways to direct some of these funds to support the fishing industry and linking it with increased monitoring requirements may be an opportunity. On the other hand, fisheries agencies will likely be even more resource constrained for the foreseeable future, limiting their ability to take on new programs.
- **International cooperation** is moving ahead, but an endless stream of web meetings and calls is unlikely to build the same level of trust, and facilitate the complex negotiations required to move issues forward in RFMOs. If in-person meetings resume in the near-term, this is unlikely to have a major impact on advancing EM, but a prolonged shutdown or waves of shutdowns will likely slow progress on many RFMO priorities, including EM.
- **Philanthropy** is still in a strong financial position with US equity markets recovered to the same levels they were before the pandemic. The global economy is in a precarious spot though, and a more severe or prolonged market decline will inhibit their spending capacity.

Onboard fisheries observer. Photo: NOAA

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APPENDIX A: FUTURE EM SCENARIOS

TABLE 9. Future Scenarios for EM

SCENARIO	DESCRIPTION	NUMBER OF VESSELS WITH EM IN 2028
Baseline	Support for EM continues at its current levels. Costs of EM systems and video review come down, but absent significant growth in the size of the market or support for technological improvements, cost reductions are largely incremental. In this scenario, growth of EM is mostly constrained to fisheries that are already exploring EM such as the US, Canada, Australia, New Zealand, Northern Europe, Chile, Peru, and RFMOs.	about 6,000
Expanded Growth	Investment in EM rises significantly from current levels. This increased effort allows for major reductions in the ongoing costs of video review and the commercial application of AI in several key fisheries (e.g., tuna longline). With increased scale and experience, design and implementation of EM programs become more efficient and the EM market becomes more competitive, driving innovation and cost reductions. In this scenario, EM remains largely a regulatory-driven tool, but expanded investment in EM results in increased penetration of EM systems in RFMOs and greater coverage in the Northern EU, US, New Zealand, Chile, and the Peruvian anchoveta fishery.	about 12,000
New Paradigm	EM becomes the tool of choice for monitoring high-value commercial fisheries with acute monitoring demands (e.g., catch quota, discards, ETP interactions, and traceability requirements). In addition, private sector benefits of EM (e.g., business analytics, market access) become a major driver of industry demand for EM. Hardware and software advancements have brought the price of EM systems, video review, and data transmission and storage down dramatically. These changes paired with a well-established understanding of how to design and implement EM programs in different contexts unlock additional market opportunities for the tool. Performance and interoperability standards are well established, and a highly competitive EM supplier industry has developed. In high governance regions, EM is seamlessly integrated with other electronic systems (e.g., vessel monitoring systems (VMS), electronic reporting, and agency back-end systems) to allow for one-touch data reporting. Under this scenario, EM achieves widespread penetration in many commercial fisheries that are suitable for EM in high fisheries governance regions (e.g., US, Northern EU, and New Zealand) and begins to gain a foothold in more challenging but globally important fisheries regions (e.g., Southern EU, Indonesia, and North Asia). Deployment within RFMOs reaches broad coverage rates of 75 percent.	about 25,000
Vision Attained	This scenario builds from the New Paradigm scenario by extending the reach of EM into additional regions. Countries that have largely relied on input controls to manage their fisheries (e.g., China, Indonesia, Japan, Korea) begin adopting EM as a tool that enables management to transition to output controls such as total allowable catch (TAC) and catch quota systems. Coverage levels of vessels in these countries remain relatively low (five percent), but due to the large numbers of vessels, this amounts to thousands of additional EM systems. Extensive advancements in AI and hardware have reduced costs and made EM applicable for an even larger share of the world's fisheries. This allows for even further penetration into fisheries in the EU, North America, and Latin America, and enables EM to achieve 100 percent coverage for longline and purse seine vessels in RFMO fisheries.	about 51,000

APPENDIX B: SUMMARY OF 2018 RECOMMENDATIONS

TABLE 10. Summary of Recommendations from 2018 Report and Recent Progress

2018 RECOMMENDATION	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
Recommendations to build demand for EM			
Make EM a national/regional priority	More effort needed	Yes	Several countries (e.g., Micronesia T3 challenge, Chile, US) and industry players (e.g., Thai Union, Luen Thai Fishing Venture) have demonstrated strong support or commitments to EM; industry leadership has proven to be an essential element that was not covered in the original recommendation.
Use EM in support of eco-certifications and FIPs	More effort needed	Yes	Fisheries are using EM to help meet MSC requirements and to support FIPs, but MSC data adequacy requirements and supply chain pressure need to be strengthened to drive additional demand for EM.
Use EM to help prove compliance with import control requirements and incorporate into catch-to-plate traceability solutions.	More effort needed	Yes	Import control requirements have encouraged several fisheries to trial/implement EM. The need for EM has been integrated into some traceability dialogues, but more work is needed to deliver catch-to-plate solutions.
Target vertically integrated companies as early voluntary adopters of EM	On track	Yes	Vertically integrated companies, especially branded tuna companies, are driving EM uptake .
Demonstrate the benefits to industry from improved management enabled by EM	More effort needed	Yes	Some additional proof points from fisheries that have improved management with EM, but there is still not a critical mass of evidence of benefits to fishers.
Advocate for regulatory changes that can increase fisher flexibility as a result of improved accountability from EM	More effort needed	Yes	Atlantic HMS is exploring adding more flexibility to bluefin management by relaxing time and area closures. Scotland scallop fishery was able to allow more flexibility with dredge limits for vessels with EM, but the link between EM and improved economic outcomes needs to be strengthened
Develop alternative uses for EM data	Not on track	No	There is still a lot of excitement about the potential of advanced analytics using EM data to deliver benefits to industry, but this has yet to be demonstrated.
Investigate potential with marine insurance providers to reduce premiums for vessels with EM	Not on track	No	Potential still exists for EM systems to help reduce insurance premiums, but there has been no known coordinated effort to pursue this opportunity.

2018 RECOMMENDATION	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
Catalyze R&D and trials of new technologies that could be integrated into EM systems	Not on track 🔴⚪⚪	No	Expanding capability will be helpful, but effort should focus on moving EM beyond the minimum viable product stage. Providers are integrating VMS with EM systems, which may be attractive to some smaller vessels.
Recommendations to reduce the cost of EM			
Explore the development of an industry association that can pursue activities that lift the entire EM market	More effort needed 🟡🟡⚪	Yes	Early scoping conversations were initiated in January 2020. This effort appears likely to move forward in the latter half of the year.
Convene buyer consortiums to make procurement requests for quotation (RFQs) more consistent and help to drive forward shared interests.	More effort needed 🟡🟡⚪	Yes	TNC is scoping the concept of bulk procurement, but implementation is not underway yet.
Create a secure, open-source collection of labeled and anonymized EM video that can be accessed to develop AI and image recognition software	On track 🟢🟢🟢	Yes	TNC developed FishNet.AI which now has 100,000 images and growing; NOAA is also scoping development of an opensource library; need to grow the number of tagged images and prevent balkanization of different efforts.
Foster better communication between current research and development efforts	More effort needed 🟡🟡⚪	Yes	More throughtful collaboration is needed to identify development priorities, and improve coordination between public, private, and NGO stakeholders.
Advance image recognition from R&D phase to first commercial-scale rollouts	On track 🟢🟢🟢	Yes	More effort is needed to achieve market-ready products, but target is still in reach by the end of 2021. Particular focus should be placed on models for integration of AI into EM provider software packages and business processes.
Advance onboard processing and demonstrate initial proof points of cost-effective, real-time data transfer	On track 🟢🟢🟢	Yes	Early demonstrations completed with compression, but cost-effectiveness may still be a challenge.
Pursue the use of program-related investments (PRIs) to the EM vendor community, and competitions and prizes to ensure that vendors remain growth-oriented and open to potential risks (e.g., software evolution).	More effort needed 🟡🟡⚪	Needs to be updated	Experience has shown that prizes for proof of concept technology development are insufficient; this needs to expand to efforts that help integrate AI into providers' product flows and derisk development.

2018 RECOMMENDATION	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
As the market matures in the future, look to disaggregate services (e.g., hardware, software, and video review) to increase competition over time	N/A	Needs to be updated	Effort should be focused on testing performance-based standards and industry-driven models, rather than disaggregating services.
Explore cost sharing opportunities, incentives, and business models to mitigate or amortize program costs	More effort needed	Yes	Multiple cost-sharing and recovery approaches are being used; "EM as a Service" is an interesting concept that is being tested.
Recommendations to provide technical support to regulators			
Develop best-practice toolkits	On track	No	Multiple toolkits have been published since 2018.
Facilitate regulator convenings	On track	Yes	There are multiple convenings every year providing an opportunity for regulators to interact (e.g., NOAA EM Workshops).
Build a global expert working group	More effort needed	Yes	A global expert working group has not been created, but the recently created ICES WGTIFD for the N. Atlantic may be a model for how regions can deliver curated advice and support to regions developing or refining EM programs.
Design pilots to lead to widespread implementation	More effort needed	Yes	There is a need to be somewhat opportunistic in getting EM trials moving, but this guiding principle is important. Among ongoing trials, some are more clearly designed as a step towards full implementation than others.
Continue to document and communicate the current state of EM and chart a pathway forward	More effort needed	Yes	Many new studies and EM reviews have been published in the last 18 months, but communicating the current state of progress for EM is an ongoing priority.
Support agency data modernization efforts	N/A	Yes (But an issue larger than EM)	In the US, the findings of the Fisheries Innovation Task Force are being pushed forward through the Net Gains Alliance, but we do not have a clear sense of the progress on agency data modernization more broadly.
Recommendations to promote industry leadership in EM program design			
Support industry leadership in EM program design	More effort needed	Yes	Industry is being integrated to varying degrees, and this remains a priority to build buy-in and to integrate industry feedback into program development.
Support strategic testimonials from fishers	More effort needed	Yes	Fishers are the best messengers for other fishers, and their testimonials are common in EM dialogues in the US. There may be opportunity to expand the use of this tactic in other regions.

TABLE 11. Summary of Selected Three-year Targets from 2018 Report

2018 THREE-YEAR TARGET	PROGRESS STATUS	STILL A PRIORITY?	UPDATE
Three-year targets to build demand for EM			
Demonstrate EM capability for transshipment monitoring	On track	Yes	Initial proof of concept tested and validated on the water.
Demonstrate EM capability for monitoring labor practices	More effort needed	Yes	Growing interest and discussions, but effort has yet to deliver on-the-water proof points.
Three-year targets to reduce the cost of EM			
Hardware costs drop 50 percent relative to today's prices	Not on track	Yes	Some development of lower-cost models for smaller vessels, but no evidence of reductions in hardware costs for large vessels.
Software and AI advancements reduce review time by at least 50 percent	Not on track	Yes	Significant progress has been made in building image libraries and demonstrating proof of concepts, but 50 percent appears out of reach in the next 18 months.

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(cover) Onboard camera, Seychelles;
Tuna catch, Republic of the Marshall Islands.
(back cover) Fishing boats outfitted with EM,
Republic of the Marshall Islands. Photos:
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