Advancing Fisheries Management in The Bahamas through Data Tools and Technology: Workshop Report

Environmental Law Institute

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About ELI's Ocean Program

ELI's Ocean Program supports healthy oceans through collaborations with communities, scientists, policymakers, government representatives, and other stakeholders. The Ocean Program is a research center that works in countries around the world on legal and policy frameworks, and their implementation. We particularly focus on sustainable fishing, marine protected areas, marine spatial planning, and coastal resilience and restoration. Our team regularly convenes and facilitates seminars, working groups, panels, and meetings. We support effective and sustainable solutions based on transparent and inclusive processes, local priorities, and best available information.

Advancing Fisheries Management in The Bahamas: Workshop Report. A PDF file of this report may be obtained for no cost from the Environmental Law Institute website at www.eli.org. Please contact oconnor@eli.org for more information.

Cover image: Junkanoo Beach, Nassau, The Bahamas (Taalin RaoShah).

Contents

Workshop Overview

On March 26, 2025, ELI held a workshop in Nassau on *Advancing Fisheries Management in The Bahamas through Data Tools and Technology*. The workshop built upon the work of ELI's Ocean Program in Latin America and the Caribbean, including a 2024 virtual convening on *Strengthening Fisheries Management Through the Use of Data and Data Tools: Experiences in the Caribbean Region*.

The workshop participants represented a diverse set of Bahamian governmental agencies, fisher organizations, and local and international NGOs. See below a full list of participant and speaker organizations (note that some groups were both a participant and a speaker). Some speakers presented in person, while others joined virtually.

Participants:

- Bahamas Department of Marine Resources
- Bahamas Wildlife Enforcement Network
- Royal Bahamas Defence Force
- Bahamas Customs Department
- Bahamas National Trust
- Perry Institute for Marine Science
- The Nature Conservancy
- WildAid's Marine Program
- Bahamas Commercial Fishers Alliance
- National Fisheries Association of The Bahamas
- Blue Shell Productions (Barbados)
- Global Fishing Watch

Speakers:

- Abalobi
- Allen Institute for AI
- Bahamas Wildlife Enforcement Network
- Blue Shell Productions (Barbados)
- Environmental Law Institute
- Global Fishing Watch
- Lambert's Bay Fisher Community (South Africa)
- Oyster Recovery Partnership
- Perry Institute for Marine Science
- Remora XYZ
- The Nature Conservancy
- WildAid's Marine Program
- Woods Hole Group (representing CLS Fisheries)

The goals of the workshop were to:

(1) Share information about various types of technologies available to advance fisheries management;

(2) Facilitate peer-to-peer knowledge exchange about how these types of technologies are used and how they can be helpful to achieve various goals of fisheries management; and

(3) Facilitate discussions among workshop participants about whether and how these types of technologies could be utilized in The Bahamas.

Following welcoming remarks from ELI, the workshop consisted of three sessions:

(1) Combatting Illegal, Unreported, and Unregulated Fishing;

(2) Use of Electronic Reporting, Electronic Monitoring, and Seafood Traceability Tools; and

(3) Assessing Ecosystem Health.

Each session included presentations from speakers representing various groups, including Bahamian governmental agencies, local, regional, and international NGOs, and technology providers and users. After each set of presentations and questions from the audience, participants gathered in small groups to discuss whether and how the technology types discussed could play a role in fisheries management in The Bahamas. Following the breakout sessions, participants discussed their thoughts with the entire group.

Session 1: Combatting Illegal, Unreported, and Unregulated Fishing

Illegal, Unreported, and Unregulated Fishing: Overview

Illegal, unreported, and unregulated (IUU) fishing activities pose a significant risk to the health of fisheries globally, as well as to the legitimate fishing sector, including commercial fishing operations, small-scale, recreational, and subsistence fishers. IUU fishing is a broad category that encompasses fishing operations and fishers that: illegally fish without permission or in violation of existing laws; underreport, misreport, or fail to report their catch; or conduct fishing activities in areas or for fish stocks for which there are no conservation or management measures, in a manner inconsistent with the state's responsibility under international law.[1]

IUU fishing can lead to a number of negative environmental, economic, and social effects. In fact, experts estimate that IUU fishing operations haul between 11 and 26 million tons of fish out of the ocean each year—representing roughly 20 percent of the total fishing supply.[2] These activities can contribute to the overfishing of already depleted fisheries, accelerating biodiversity loss and the degradation of marine ecosystems. IUU fishing can also reduce the profitability of legitimate fishers and exacerbate food insecurity among nearby communities by

[1] Food and Agriculture Organization (FAO) of the United Nations, "What is IUU Fishing?" accessed May 9, 2025, https://www.fao.org/iuu-fishing/background/what-is-iuu-fishing/en/; National Oceanic and Atmospheric Administration (NOAA), "Understanding Illegal, Unreported, and Unregulated Fishing," accessed May 9, 2025, https://www.fisheries.noaa.gov/insight/understanding-illegal-unreported-and-unregulated-fishing.

[2] United Nations, "The Toll of Illegal, Unreported and Unregulated fishing," accessed May 12, 2025, https://www.un.org/en/observances/end-illegal-fishing-day.

taking valuable resources out of the local market.[3] Furthermore, it is estimated that illegal and unreported fishing activities alone generate between $15.5 and $36.4 billion in illicit profits, which, among other consequences, deprives governments of significant tax revenue.[4]

In The Bahamas, it is estimated that nearly 33 percent of all catch falls under IUU fishing,[5] especially affecting the spiny lobster and queen conch fisheries.[6] IUU fishing activities are conducted both by Bahamian vessels and foreign vessels,[7] with a large number coming from the United States and the Dominican Republic. There are several challenges to combatting IUU fishing in The Bahamas, including the difficulty of monitoring the country's vast and dispersed marine territory with limited capacity. Accordingly, several organizations—including TNC and WildAid—government agencies, and fishing associations have formed the Marine Action Partnership (MAP) for Sustainable Fisheries to improve the country's capacity to address domestic and foreign IUU fishing in its Exclusive Economic Zone (EEZ).[8]

Workshop Presentations

a. Joint Analytical Cell's Maritime Awareness Tools by Justin Rizzari (Global Fishing Watch)

Justin Rizzari spoke about the work of the Joint Analytical Cell (JAC), a group of five organizations—IMCS Network, Global Fishing Watch (GFW), TMT, Skylight, and C4ADS—working collaboratively to provide analysis and capacity building to combat IUU fishing. The presentation also highlighted GFW's free, accessible platform.

The GFW Map uses a combination of data sources—Automatic Identification System (AIS), Vessel Monitoring System (VMS), Infrared, Optical, and Radar—and machine learning to analyze vessel behavior and trends, including classifying vessel activity, measuring apparent fishing effort, identifying areas of high apparent fishing activity, and tracking port visits, vessel loitering, and potential transshipment. Using the platform, users can also produce dynamic reports to see, for example, apparent fishing effort over time in The Bahamas EEZ.

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[3] Kimbra Cutlip, "Illegal, Unreported, Unregulated Fishing," Global Fishing Watch, October 18, 2016, https://globalfishingwatch.org/fisheries/iuu-illegal-unreported-unregulated-fishing/.

[4] Global Financial Integrity, *Transnational Crime and the Developing World*, March 2017, https://gfintegrity.org/wp-content/uploads/2017/03/Transnational_Crime-final.pdf.

[5] Paul Medley & Lester Gittens, *2012 Bahamas Spiny Lobster Stock Assessment*, The Bahamas Department of Marine Resources, July 2012.

[6] The Nature Conservancy, "Sustainable Fisheries in The Bahamas," accessed May 12, 2025, https://www.nature.org/en-us/about-us/where-we-work/caribbean/bahamas/stories-in-the-bahamas/sustainable-fisheries/.

[7] Ibid.

[8] The Nature Conservancy, "Sustainable Fisheries in The Bahamas," accessed May 12, 2025, https://www.nature.org/en-us/about-us/where-we-work/caribbean/bahamas/stories-in-the-bahamas/sustainable-fisheries/; WildAid, "The Bahamas," accessed May 12, 2025, https://marine.wildaid.org/projects/bahamas/.

Furthermore, users can see data on specific vessels of interest, such as their activity in a given area, flag state, vessel type, gear type, authorization status, and more. This feature can be especially helpful when investigating potential dark (when the vessel's AIS is turned off) or illegal activity.

The other JAC tools play complementary roles in this context. For example, users can utilize Triton by C4ADS to see vessel ownership or Skylight to see the vessel's most recent activity. Finally, it should be noted that while GFW's core focus is on industrial fishing, they have emerging areas of work in small-scale fishing, including mapping areas designated for small-scale fishers and using optical imagery to analyze fishing activity in coastal communities.

b. EarthRanger by Daniel Zendejas (Allen Institute for AI)

Daniel Zendejas provided an overview of EarthRanger, a tool developed by the Allen Institute for AI as one of several zero-revenue programs under their AI for The Environment initiative, which also includes Skylight. EarthRanger is an all-in-one ecological management system that provides domain awareness by integrating data from many sources: e.g., sensors, drones, and satellite data. This technology integration allows for real-time and historical visualization of events within a certain territory. EarthRanger can also streamline operations by tracking personnel and assets and providing a centralized hub for data entry and field reports (with compatibility on mobile devices). Furthermore, through integrations with platforms like SMART and Tableau, users can analyze and visualize data, generate and schedule reports, and produce insights to inform decision-making. In terms of data security, data is owned by the end user, encrypted during transmission, and stored securely. Notably, EarthRanger has been adopted by around 650 sites in roughly 80 countries.

c. Use of EarthRanger by Ricardo Cummings (Bahamas Wildlife Enforcement Network)

Ricardo Cummings presented on how the Bahamas Wildlife Enforcement Network (BahWEN) benefits from the use of EarthRanger in its operations. BahWEN is a new law enforcement agency in The Bahamas, tasked with the mission to protect natural resources and mitigate wildlife crime in the country, including illegal fishing, poaching of protected species, and illegal mining and deforestation. EarthRanger allows BahWEN to leave track patrols, set up geofencing alerts, and integrate camera traps that send automated alerts when they detect unusual movements. These capabilities have led to immediate threat detection and faster response times. Furthermore, through EarthRanger, BahWEN can analyze past incidents to develop more optimized patrol routes, more efficiently deploy personnel, and identify illegal activity hotspots.

d. BAH WildTip by Edison Deleveaux (WildAid's Marine Program)

Edison Deleveaux introduced a new mobile app for anonymous reporting of natural resources crime, which came out of discussions between WildAid and the MAP Steering Committee. The goal of BAH WildTip is to encourage greater stakeholder involvement to assist in combatting wildlife crime. Essentially, users can submit an anonymous tip with images and/or videos demonstrating that a crime was committed. The tip will be received by the Royal Bahamas Defense Force (RBDF) and then routed to the relevant enforcement agency, so that appropriate action can be taken. The app, which has the support of the Government of The Bahamas, has undergone preliminary testing and will be officially launched in mid-2025.

Workshop Discussion

Overall, there was significant interest in the presented tools to improve monitoring and enforcement, with multiple comments about the need to combat illegal fishing by foreign vessels. Participants recognized that implementing these types of tools would be especially useful in The Bahamas, given the limited capacity of agencies to monitor and combat illegal activity across such a vast marine territory. In terms of other benefits, participants noted that these technologies could increase stakeholder inclusion, cross-agency training opportunities, regional collaboration, and overall domain awareness. However, various potential challenges were raised, including: concerns about data security and confidentiality; limited capacity and resources of agencies; integration with existing technologies; the need for training and retention of skilled personnel; lack of protocols for implementation and necessary infrastructure; the need for overall community support; as well as challenges prosecuting cases (especially with regard to foreigners) and pursuing penalties that deter further violations.

Session 2: Use of Electronic Reporting, Electronic Monitoring, and Seafood Traceability Tools

Electronic Reporting, Electronic Monitoring, and Seafood Traceability Tools: Overview

Several other types of technology tools can help advance fisheries management goals. For example, electronic reporting tools, which are often compatible with mobile devices, allow fishers to log catch digitally rather than on paper.[9] For fishers, these tools can make data entry more convenient. Many electronic reporting tools also provide additional features, such as analyzing trends in catch data based on location, time, and species caught. For fisheries managers, these tools help ensure that the data they receive are more accurate,

[9] See NOAA, "Electronic Reporting," accessed May 15, 2025, https://www.fisheries.noaa.gov/national/fisheries-observers/electronic-reporting; CLS Fisheries, "Electronic Catch Reporting," accessed May 15, 2025, https://fisheries.groupcls.com/fishermen/ers/.

comprehensive, and reliable. Furthermore, storing data digitally rather than on paper can streamline data management and analysis.

Next, electronic monitoring tools represent a set of technologies that can be used to monitor certain activities by and on fishing vessels.[10] VMS can help to effectively address many of the country's fundamental monitoring and compliance needs. VMS tracks the location and speed of fishing vessels through physical devices attached to vessels (which generally use cellular- or satellite-based GPS).[11] In addition to promoting improved and efficient monitoring, compliance, and enforcement, VMS also helps increase safety at sea, provide key data for stock assessments, and identify productive fishing areas. Other types of electronic monitoring tools include, for example, on-board cameras, which help monitor fishing gear used, catch handling, and bycatch.

Finally, seafood traceability tools aim to ensure transparency throughout the seafood supply chain. While electronic reporting and electronic monitoring tools can themselves play a significant role in seafood traceability, there are also several complementary tools, such as smart scales (scales that record various measurements of the fish that has been caught) and mobile apps (that trace fish from where it was caught to the consumer). Given rising consumer demand in this area, traceability tools can help verify and reward legal sustainably caught seafood.[12]

Together, these tools can help fisheries managers better understand their fisheries and respond to changing conditions, combat IUU fishing, reward legitimate fishers, and protect long-term sustainable yield and fishery health.

The Bahamas has not yet implemented electronic reporting or vessel monitoring systems at scale, though the country has had several pilots. Electronic seafood traceability tools are also not yet implemented, though there were pilots. However, the Bahamas spiny lobster fishery was certified as sustainable in 2018 by the Marine Stewardship Council (MSC), after a collaborative effort to improve the fishery.[13]

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[10] Rod Fujita et al., *Designing and Implementing Electronic Monitoring Systems for Fisheries*, Environmental Defense Fund, 2018, https://fisherysolutionscenter.edf.org/tools/designing-and-implementing-electronic-monitoring-systems-fisheries.

[11] NOAA, "Enforcement: Vessel Monitoring," accessed May 15, 2025, https://www.fisheries.noaa.gov/topic/enforcement/vessel-monitoring; Pew Charitable Trusts, "Tracking Fishing Vessels Around the Globe," May 20, 2016, https://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2016/05/tracking-fishing-vessels-around-the-globe.

[12] Monterey Bay Aquarium Seafood Watch, "Improve Traceability," accessed May 15, 2025, https://www.seafoodwatch.org/seafood-basics/sustainable-solutions/improve-traceability.

[13] Matthew Miller, "Spiny Lobster: Sustainable Seafood in the Bahamas," The Nature Conservancy, September 2018, https://blog.nature.org/2018/09/10/spiny-lobster-sustainable-seafood-in-the-bahamas/.

Workshop Presentations

a. *Electronic Reporting, Monitoring, and Traceability Tools* by Taalin RaoShah (Environmental Law Institute)

Taalin RaoShah provided an overview of electronic reporting, electronic monitoring, and seafood traceability tools. As mentioned above, when used together, these tools can help fisheries managers streamline data management and analysis. They also provide fisheries managers with a significantly larger capacity for monitoring and analyzing fishing activity even with a limited physical presence. These tools can also help fishers understand their catch and trends in the fishery, improve their safety, help them manage and keep records of financial transactions, and provide them access to premium markets. Finally, these tools can help combat IUU fishing and protect the long-term health of the marine ecosystems within the fishery.

b. *Electronic Monitoring Pilots in The Bahamas* by Natalie Miaoulis (The Nature Conservancy)

Natalie Miaoulis reviewed the work of The Nature Conservancy (TNC) in The Bahamas, with a primary focus on the organization's electronic monitoring pilot projects. TNC has been working in The Bahamas for over 20 years and is currently working with The Bahamas Department of Marine Resources (DMR) to support improved decision-making, fisheries management, and enforcement. Beginning in 2018, at the request of The Bahamas Ministry of Agriculture and Marine Resources, TNC worked with DMR to develop and implement pilots in three areas.

First, TNC piloted a mobile app that allowed fishers in Grand Bahama to electronically log their catch data and send it directly to DMR. Normally, this same data would be reported by fishers on paper upon arriving at a landing site, which is then given to the local fisheries officer. The fisheries officer must then transfer completed catch forms to DMR, where the records are kept, organized, and analyzed. Second, TNC piloted electronic traceability tools with a seafood processing center in New Providence, helping them to more efficiently document information—electronically, rather than on paper—necessary to uphold MSC's certification of sustainability for the spiny lobster fishery. Third, TNC conducted a pilot to assess the viability of implementing VMS in The Bahamas. Through this project, TNC worked with a select group of Bahamian fishers to pre-test three types of VMS—Global Star Spot Tracer, CLS Nemo, and Advanced AssetPack—of which one (Advanced AssetPack) was chosen for a phase two pilot. Overall, while the pilot found that the system was helpful for safety at sea and identifying unlicensed vessels, it also identified data privacy concerns among fishers, as well as a lack of capacity within the government agencies to implement, monitor, and manage VMS.

c. *Use of VMS, Smart Scales, and Electronic Reporting in Barbados* by Richéda Speede (Blue Shell Productions) & Juan Carlos Martí Revelo (Remora XYZ)

Richéda Speede discussed Barbados' DigiFish initiative, the country's push to transform their landing sites into intelligent spaces through the use of digital technologies. The Barbados Fisheries Division is carrying out this mission by implementing vessel monitoring devices, electronic data intelligence platforms, and seafood traceability tools. Throughout the process, stakeholder engagement has been a key aspect of the DigiFish Initiative. Through workshops, dockside visits, and more, the Barbados Fisheries Division has built trust, awareness, and regulatory support among stakeholders. In addition, this stakeholder engagement has increased digital literacy and helped fishers understand how they will benefit from these tools.

Prior to the DigiFish initiative, fisheries managers had to rely on anecdotal evidence regarding where fishing activity was occurring. Now, the VMS devices have allowed Barbados to efficiently monitor their small-scale and commercial fisheries and ensure that vessels are complying with protected area regulations. In addition, the data intelligence platform, using data from the VMS devices, can generate visualizations of individual vessel activity and perform analyses, such as distance travelled and catch per unit effort. Furthermore, Barbados has piloted the use of two "smart scales" in order to promote more robust seafood traceability. Previous seafood traceability efforts in Barbados occurred via manual data collection, which was time consuming, unreliable, and difficult to integrate with other management systems.

Juan Carlos Martí Revelo provided additional information on how the Remora Smart Scales work. The Smart Scales, which take pictures of fish as they slide through its scanners, use AI to determine the species, weight, and size of the fish. In Barbados, these data are linked with the VMS data, including who caught the fish and where. The Smart Scale then prints a traceability tag that contains all this information and can travel alongside the catch all the way to the consumer.

d. *Use of VMS and Electronic Reporting* by Sarah Greenberg (Oyster Recovery Partnership) & Nick Salvi (Woods Hole Group)

Sarah Greenberg spoke about the use of VMS in the efforts of Oyster Recovery Partnership (ORP) to restore the native oyster population in the Chesapeake Bay in the eastern United States. In a single year, ORP completes over 150 trips in the Bay and deploys over one billion oysters. ORP utilizes the CLS Nemo VMS devices to monitor and track the vessels conducting the "plantings" of oyster shell bushels. Importantly, the VMS devices allow ORP to verify deployments and ensure they stay within site boundaries, track progress towards goals, and monitor restoration success over time. In addition, because each planting occurs within a limited area and time window, there is a need for high accuracy and high-resolution data on

where and when they occurred—which is provided by the VMS devices. The VMS devices also promote operational efficiency and safety by reducing time spent in the field and removing the need for onboard observers. Furthermore, the position data is sent to the Maryland state government and helps to inform adaptive management, stock assessments, and disease assessments.

Nick Salvi provided additional background and information on the CLS Nemo. Since its launch in 2017, CLS Nemo has been deployed in dozens of countries, from the Ivory Coast to United Kingdom to Belize. Nemo, which is a hybrid cellular/satellite VMS device, has a number of innovative features, including the dual solar panel and battery power, Bluetooth connectivity, and an emergency distress button to increase safety at sea. Additionally, fishers can submit their catch reports through a CLS mobile application that links their VMS data to the electronic logbook (e-logbook) data. That data can then be viewed by fisheries managers through the THEMIS fisheries monitoring platform, allowing them to view vessel data in real time, create geo-zones and set up alerts, and manage data on a secure platform.

e. Use of Electronic Reporting and Traceability Tools by Serge Raemaekers (Abalobi) & David Shoshola (Lambert's Bay Fisher Community)

Serge Raemaekers introduced the Abalobi platform, which aims to enable fishing communities across the world to drive their own change using an ecosystem of technologies that meet their needs. Notably, Abalobi's tools are designed for fishers. The Fisher app allows fishers to analyze and visualize data recorded in their e-logbook, share their data with their fishing community, and access weather forecasts. It can also be integrated with VMS devices, including CLS Nemo, allowing fishers to view their location data from past trips. Furthermore, the technology platform helps fishers manage and keep records of their financial transactions, which is especially beneficial for small-scale fishers. Abalobi's Monitor app also allows fisheries managers to view and analyze data that comes in from fishers. These two platforms come together to support Abalobi's Marketplace app, which directly connects small-scale fishers and retailers in a digital marketplace, facilitates "first mile" traceability of catch, and can allow consumers to see the who, what, and how behind the catch ("Fish with a Story").

David Shoshola explained how he, as part of the Lambert's Bay fisher community in South Africa, has benefited from Abalobi's tools. Before Abalobi was adopted by his community, they had no way to prove their income, would have little leverage over the price for which they sold their catch, and would lose a decent portion of their sales to the middleman. However, Abalobi has since empowered them through data storage and analysis and direct access to markets. In fact, many fishers now spend less time at sea and catch less, but have a larger income.

Workshop Discussion

Participants agreed that The Bahamas would benefit from electronic reporting and the use of e-logbooks, with some saying they need to implement electronic reporting. Some also noted that electronic reporting is already required by law, but has not yet been widely implemented or enforced.[14]

Opinions on electronic monitoring were more varied. Some participants viewed VMS positively, believing the benefits outweighed the risks and drawbacks. Others acknowledged its potential, but noted barriers. Key barriers mentioned included limited capacity of government agencies, the high upfront and recurring costs of the devices, the geographic characteristics of the fisheries (which are dispersed across many islands), and the nature of fishing in the country, which largely involves small, artisanal vessels operating in relatively remote communities. Participants did, however, acknowledge the significant benefit of the safety-at-sea features of VMS, particularly for small-scale fishers.

Workshop participants were generally interested in seafood traceability tools. Some noted that seafood traceability applies to export products, and that while The Bahamas has a good system in place, they are writing relevant information down on paper, not collecting it electronically. Traceability tools would thus assist with data accuracy, consistent data collection, and better-informed management. There was particular interest in seafood traceability platforms, including among fishers who expressed interest in learning more about other fishers' experiences.

Participants also recognized the value of smart scales for fisheries management. Some noted that currently, they only collect weight information, but research and conservation require biological data, including size of the fish. Some participants believed that the smart scales may not be practical in The Bahamas due to the dispersed and relatively small-scale nature of the country's fisheries. Some, however, thought that smart scales would be appropriate in specific locations. Some participants also suggested that such tools may be best suited for large, commercial fishing vessels.

Across all tools discussed, commonly cited benefits included: improved recordkeeping; more efficient and improved monitoring, surveillance, and enforcement; and more efficient and improved data collection and analysis. Barriers mentioned by workshop participants echoed those identified in the earlier session and included: cost, limited capacity, training needs, concerns about data privacy and management, community buy-in, unclear implementation

[14] As a note, The Bahamas Fisheries Act of 2020 requires electronic reporting of catch and vessel position by any domestic or foreign fishing vessel in The Bahamas EEZ. The Fisheries Act also provides the legal basis for implementing VMS. Fisheries Act, 2020, §§55, 75 (Bah.), https://faolex.fao.org/docs/pdf/bha211803.pdf.

protocols, and limited digital literacy. While concerns about data privacy appeared to particularly relate to the use of VMS, some participants shared that based on the VMS pilots conducted in The Bahamas, the only persons who had access to VMS data were representatives from DMR, TNC, and fishers who participated in the pilots. At least for some participants, the bigger barrier to implementing VMS appeared to be the upfront and recurring costs of the devices.

Session 3: Assessing Ecosystem Health

Assessing Ecosystem Health: Overview

As climate change accelerates, warming waters, ocean acidification, and extreme weather events increasingly threaten the ocean's health and biodiversity. For example, it is estimated that even global warming of 1.5 degrees Celsius would destroy 70 to 90 percent of coral reefs, which provide critical ecosystem services.[15]

The Bahamas' marine territory scores above average in ocean health, according to the Ocean Health Index.[16] However, the country's waters still face several challenges, including hurricane-induced damages and coral reef bleaching, disease, and habitat loss.[17]

Accordingly, evaluating various aspects of marine ecosystem health—including sea surface temperature, acidity, and coral reef extent—can be a vital first step. Emerging technologies, from online data platforms to drones, can assist fisheries managers, NGOs, and scientists in this effort.

Workshop Presentations

a. *Assessing Ecosystem Health in The Bahamas* by Krista Sherman (Perry Institute for Marine Science)

Krista Sherman presented research of the Perry Institute for Marine Science (PIMS) using technology to assess marine ecosystem and coral reef health in The Bahamas. The Bahamas marine territory is vast and dispersed, with roughly 470,000 square kilometers surrounding 700 islands. Of this marine territory, roughly 11 percent is designated as marine protected areas (MPAs). Seagrass beds, mangroves, and coral reefs encompass approximately 25,000, 2,500, and 3,500 square kilometers, respectively. Threats to these essential marine features include

[15] United Nations, "How is Climate Change Impacting the World's Ocean," accessed May 15, 2025, https://www.un.org/en/climatechange/science/climate-issues/ocean-impacts.

[16] Ocean Health Index, "Global Scores: Bahamas," accessed May 15, 2015, https://oceanhealthindex.org/regions/bahamas/.

[17] Craig Dahlgren et al., *Bahamas Coral Reef Report Card*, Perry Institute for Marine Science, 2020, https://www.agrra.org/wp-content/uploads/2020/08/Bahamas-Coral-Reef-Report-Card-2020.pdf.

climate change, overfishing, coastal development, pollution, invasive species, and marine diseases. PIMS' research has found that the health of seagrass beds, mangroves, and coral reefs are good, fair, and poor, respectively.

PIMS uses a combination of aerial drones and GIS photogrammetry techniques to construct 3-dimensional maps (or "photomosaics") of coral reefs and high-resolution maps of mangroves. Incorporating these technologies with traditional underwater visual census techniques has enabled the team to evaluate impacts of severe natural disasters (e.g., Hurricane Dorian) and emerging marine diseases such as stony coral tissue loss disease (SCLTD), which was first detected in the country in 2019 and is now considered the largest threat to Bahamian coral reefs.[18] These technologies have also allowed the team to apply this information to support the restoration of critical habitats. For example, photomosaics are being employed to monitor the progression of SCTLD and condition of treated colonies. Aerial habitat maps produced before and after Hurricane Dorian have also been used to help prioritize sites for mangrove restoration.

b. Marine Manager by Annie Mejaes (Global Fishing Watch)

Annie Mejaes spoke about a component of the GFW platform, Marine Manager, a free online tool designed to support government officials—including park rangers and fisheries managers—non-profit institutions, and researchers in the design, management, and monitoring of MPAs. Specifically, Marine Manager allows users to customize their own workspace by adding human activity, oceanographic, and ecosystem data layers, creating custom areas of interest, and uploading and analyzing their own polygon, track, or point datasets. Marine Manager also allows users to integrate and compare their own private data with the wide range of publicly available data and machine learning in Marine Manager. For example, a user could look at The Bahamas EEZ and compare their own coral reef survey data within that area with existing data on Marine Manager on sea surface temperature and oxygen concentration. That user could also generate a report on human activity in the EEZ over the last year and compare it to various environmental datasets. Throughout this process, all of the data upload and analysis occur in the user's private workspace. The user data is not accessible to anyone else, unless the user specifically invites others to collaborate in a shared workspace.

Workshop Discussion

Participants were fascinated by Dr. Sherman's research and were concerned about the state of coral reefs in The Bahamas. Participants were also interested in the GFW Marine Manager tool

[18] Craig Dahlgreen et al., *Spatial and Temporal Patterns of Stony Coral Tissue Loss Disease Outbreaks in The Bahamas*, Frontiers in Marine Science, July 2021, https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2021.682114/full.

as a way to visualize and analyze environmental data. There was also a discussion about the potential benefits of expanding technology already used in the country, such as drones, not only to assess ecosystem health, but also for monitoring purposes. Similarly to other sessions, though, some participants expressed that no matter what technology is used, there must be an effort to make it accessible to fishers and the broader public.

Conclusion and Potential Future Directions

In The Bahamas, there are many challenges for fisheries management. IUU fishing, both by foreign and domestic vessels, threatens the long-term sustainability of The Bahamas EEZ. Global environmental threats, including warming waters, declining fish populations, and deteriorating coral reef health are already affecting The Bahamas and will likely only increase in severity over time. In The Bahamas, these challenges are further compounded by the expansive and geographically dispersed marine territory—encompassing approximately 470,000 square kilometers and surrounding 700 islands—as well as limited governmental capacity and insufficient data about catch, vessel activity, and ecosystem health.

Domain awareness tools can help Bahamian agencies monitor this vast marine territory even with limited resources. Many of these tools, such as the GFW Map and Vessel Viewer, Skylight, and EarthRanger, are free and are especially effective when used together. For example, a user could use Skylight for near real-time monitoring and AI detection of dark activity, the GFW tools for investigation into a specific vessel and analysis of activity over time, and EarthRanger for land-based domain awareness and integration with other technology (such as vehicle trackers and data management tools). These tools could be integrated in the government's ongoing monitoring and enforcement efforts. Other locally developed tools, such as BAH WildTip, can complement these tools and improve monitoring capacity. However, there is a need for increased agency capacity and streamlined protocols for effective use of these tools and coordination with other agencies. Furthermore, to deter IUU fishing, especially by foreign vessels, it is important that monitoring and identification of illegal activity translates into enforcement and prosecution.

Next, electronic reporting, which is required under The Bahamas Fisheries Act of 2020, can help improve the efficiency of catch data reporting by fishers. In addition, for fisheries managers, electronic reporting tools can streamline the process of data collection, make collection of data easier and faster, provide accurate and comprehensive data for stock assessments, and facilitate efficient data analysis, management, and storage. Given that electronic reporting is already mandated in the law, brings many benefits, and was favorably discussed during the workshop, this technology has the potential for wide implementation.

VMS also offers benefits, including improved monitoring and compliance, increased safety at sea, and the ability to identify productive and vulnerable fishing areas. However, challenges with implementing VMS in The Bahamas include upfront and recurring costs for the devices, as well as the capacity of Bahamian agencies to manage a VMS program, and the ability to address data privacy concerns.

Seafood traceability tools, such as Remora's Smart Scales and the Abalobi Fisher app, can help prevent IUU fishing, reward legitimate fishers and provide them access to premium markets, and protect the long-term yield of the fishery. In The Bahamas, implementing traceability tools—which would build on the success of the spiny lobster sustainability certification—would need to be adapted to the local context and account for the large number of remote, small-scale fishers in the country.

In addition to these tools, technology for assessing ecosystem health, from the GFW Marine Manager to drones, can help fisheries managers in The Bahamas monitor fishing grounds and MPAs, understand and respond to the effects of climate change, and prioritize action in the most vulnerable areas.

Additional events aimed to build capacity of fishers, governmental agencies, and other relevant stakeholders could be useful to address the areas of interest and concerns about barriers identified by the workshop participants. For example, these events could provide information about how different tools of the same type (e.g., for electronic reporting) compare to one another, including their features, benefits, and challenges, as well as experiences from other countries implementing these technologies and addressing challenges they face. This information would help Bahamian fishers and agencies identify the tools that fit their specific requirements and align with their needs. This additional engagement can also help stakeholders in The Bahamas understand how others have overcome various challenges identified during this workshop, which will increase the likelihood of successful adoption of the selected technologies in The Bahamas.

As there was also interest in certain tools that are already used by some agencies and other stakeholders in The Bahamas, additional events could focus on further training about those tools. Specifically, these events could be designed to train personnel how to customize the tools for their needs and to use specific features, as well as how to integrate those tools with other existing or anticipated technology.