

D I A L O G U E

Technology and the Seas: Enforcement in Marine Protected Areas

Summary

Established in over 65 countries and territories, marine protected areas (MPAs) embody a range of habitats, enable the provision of fundamental ecosystem services, protect marine biodiversity and cultural resources, and provide spaces to conduct cutting-edge research and implement innovative policies. Yet management of MPAs can face challenges, including the lack of adequate tools, the need for rules to secure comprehensive monitoring, the vastness of the ocean, and more. There remain questions of how agencies work together to establish these areas both domestically and internationally, what are the innovative technologies that can aid in monitoring, and how MPAs can be enforced. On September 24, 2019, the Environmental Law Institute hosted an expert panel that delved into groundbreaking technologies, innovative legal frameworks, and examples of successful domestic and international MPAs. Below, we present a transcript of the discussion, which has been edited for style, clarity, and space considerations.

Xiao Recio-Blanco (moderator) is Director of the Ocean Program at the Environmental Law Institute.

John Amos is the President of SkyTruth.

Wynn Carney is a Special Agent in the Office of Law Enforcement at the National Oceanic and Atmospheric Administration.

Monica Goldberg is Chief Counsel, Oceans, with the Environmental Defense Fund.

Xiao Recio-Blanco: Thank you to all of you joining and participating in this seminar. I also want to send a special thanks to the Naomi and Nehemiah Cohen Foundation. The Cohen Foundation has supported the ELI Ocean Pro-

gram seminar and webinar series since its inception and it has been instrumental in making this happen.

It is a basic premise of our Ocean Program that the marine environment is vulnerable and must be protected. The need for adequate protection of marine biodiversity is what brings us precisely to today's topic. I would like to start with a quote that some of you might identify, especially if you like old movies. In the 1954 film *20,000 Leagues Under the Sea*, Captain Nemo says, "The sea does not belong to despots. Upon its surface men can still exercise unjust laws, fight, tear one another to pieces, and be carried away with terrestrial horrors. But at 30 feet below its level, their reign ceases, their influence is quenched, and their power disappears."¹

We have Captain Nemo, who is a pioneer ocean preservationist with some blunt methods. Unfortunately, we now know that the ocean is in fact deeply altered by the actions of our "inland kingdoms" in ways we still struggle to understand. At 30 feet below the mark of human actions, that's not banished. Plastic bags have been found at the bottom of the Mariana Trench, the deepest point on earth. Marine biodiversity is in constant threat, with worrisome massive collapses and the threat of disappearance of some of the most iconic marine species. All around the world, fisheries are failing, changing whole ecosystems and sending thousands into unemployment, poverty, and hunger.

To respond to this challenge, in recent years, countries have enacted many new MPAs that in theory protect thousands of square miles of ocean space. However, budgets for environmental compliance and enforcement on a global scale are not increasing at the rate that would allow MPA management and enforcement agencies to keep pace on this expansion of areas of protection at sea. This adds to the current challenges of monitoring vast marine spaces with limited means, budget, and staff. In this context, ocean protection commitments are at risk of becoming no more than window dressing.

1. 20,000 LEAGUES UNDER THE SEA (Walt Disney Productions 1954).

This is one reason why technological innovation for MPA management and enforcement is so important. The availability of remote sensing technologies is already changing the patterns of conduct of illegal actors, raising transparency on the use and abuse of ocean resources and facilitating ocean enforcement operations. Technologies can also do all these things while at the same time capturing useful data to estimate the health of the ocean and providing information that keeps seafarers safer when out at sea. To completely fulfill its promise, these technologies need to be coupled with training and adequate budgetary and regulatory support.

I will conclude this introduction with a short note on ELI's work in this field. Most declarations of new MPAs in recent years have been made as a response to international commitments and pledges. However, these multilateral duties do not specifically require regulatory measures to ensure effective implementation of these new areas of protection. Seeking to shed some light on this situation, in late 2016, ELI—thanks to the support of the National Geographic Society—developed a handbook of legal tools and approaches for effective MPA enforcement.² And we have the pleasure of having John Amos as one of the members of our consultative committee in that project.

With that, I will introduce our first panelist, Wynn Carney. Wynn is a special agent at the Office of Law Enforcement of the National Oceanic and Atmospheric Administration (NOAA). He has worked in law enforcement for 19 years in locations as distant as Georgia, the Everglades, Alaska, and the Mid-Atlantic.

Wynn Carney: Thank you. I've been in the field for many years and now I'm working as a domestic operations program manager. At the Office of Law Enforcement, we have an international side and we have a domestic side. I'm on the domestic side. There is a lot of liaison work, a lot of policy work, looking at procedures, looking at regulations, looking at new laws, and reviewing electronic technologies and seeing what can work and what may not work.

We do have strategic goals in NOAA Fisheries enforcement. This covers sustainable fisheries, maximizing sustainable fisheries or fishing opportunities for fishing communities while ensuring the sustainability of the fisheries. We recover and conserve protected resources while supporting responsible fishing resource development, and improve organizational excellence and regulatory efficiency. That goal is the one that we focus on with our priorities in regards to MPAs, national marine sanctuaries, and so forth.

The Office of Law Enforcement takes these goals. We work with our stakeholders and partners. That can include our state partners and federal partners, non-governmental organization (NGO) partners, and many other partners. We reach out to those partners and we

ask what their priorities are, what they see as a priority that they want us to work on. From there, they give us what they want us to work on and we look at that over our strategic goals and see where they overlap. That's how we make our priorities.³

We don't have a lot of resources presently, so we have to prioritize what we do and focus on specific things. One of those priorities in mostly all divisions of the Office of Law Enforcement is MPAs and national marine sanctuaries. There are no sanctuaries in Alaska, but protected areas, conservation areas, is one of the priorities up there. That is one thing that we have across the board.

We have five divisions within the Office of Law Enforcement and we cover a great area. Within the Office of Law Enforcement we have 130 sworn positions. That includes uniformed officers and special agents who are basically plainclothes enforcement personnel. The special agents are doing more of our complex investigations, such as seafood fraud, work in illegal, unreported, and unregulated (IUU) fishing, and illegal imports coming in. If somebody shoots a dolphin, if somebody shoots a turtle, we're looking at those more complex investigations.

Our uniformed officers are working more in the field, boarding boats, conducting patrols, monitoring, and investigating. They have a lot more interaction with our state partners, our joint enforcement agreement partners, which I'll talk about in a little while, the U.S. Coast Guard and other partners that we have like Customs and Border Protection at the ports of entry.

We do have Office of Law Enforcement divisions everywhere—from Alaska, the Pacific Islands, the West Coast, the Southeast, and the Northeast. Our U.S. primary jurisdiction is 3.36 million square miles of open ocean. That's hard to do with 130 people, so we do have to have our partnerships in place, our collaborations, and our priorities. There are a lot of things we can work on. So, if we don't focus on specific priorities and specific areas, then we'll just be going everywhere like a shotgun round that's going off and just spreading all over the wall. We want to focus within these specific areas.

We have 14 national marine sanctuaries with Mallo Bay being added, and four marine national monuments. We also enforce the high seas and international trade relating to U.S. treaties and international law.

Now, in addition to all of that geographical jurisdiction, we have laws that are enforced by NOAA Fisheries. There are approximately 40 laws we enforce, which is different than a lot of other organizations. Some organizations may have one law that they enforce and, within that law, they can do a lot of things. We have 40. The main ones are the National Marine Sanctuaries Act,⁴ the Magnuson-Stevens Fishery Conservation and Management Act,⁵ the Endan-

2. LEGAL TOOLS FOR STRENGTHENING MARINE PROTECTED AREA ENFORCEMENT: A HANDBOOK (ELI 2016), available at <https://www.eli.org/research-report/legal-tools-strengthening-marine-protected-area-enforcement-handbook>.

3. For more on NOAA Office of Law Enforcement priorities, see <https://www.fisheries.noaa.gov/feature-story/sharing-our-2019-priorities-and-annual-guidance>

4. 16 U.S.C. §§1431 et seq.

5. 16 U.S.C. §§1801-1891d.

gered Species Act,⁶ the Marine Mammal Protection Act,⁷ the Lacey Act,⁸ and the Illegal, Unreported, Unregulated Fishing Enforcement Act.⁹

These aren't all the acts that we enforce. There are many more. But these are the main ones that are enforced pretty much in all of the divisions. Specifically, for example, we could have the Northern Pacific Halibut Act¹⁰ that's enforced in the West Coast in Alaska. But that's specific just to that area. Within each one of these acts we have different statutes, different authorities, different boarding authorities, different authorities to search, to seize, and so forth.

How do we accomplish our priorities? Outreach and compliance assistance is a lot of what we do every day. This, what I'm doing today, is outreach and compliance assistance. Just every day talking informally—it doesn't necessarily have to be formally—is compliance assistance and outreach. A lot of times, we go to fishing shows. We go to boat shows. Just walking on the dock and talking to fishermen is how we give out a lot of our compliance assistance.

Our officers and our agents conduct their investigations. Like I said, the agents conduct more complex investigations. The officers conduct investigations, but they're not as complex. An example of an investigation that's not complex is if you board a boat and you find a bunch of filleted fish on the boat that's not supposed to be filleted. You then have to figure out why the fish were filleted, who filleted the fish, what kind of fish it is, and so forth. That's not a long-term investigation.

A long-term investigation would be someone who's importing illegal crab meat from another country and bringing it into the United States and marketing the crab meat as U.S. crab meat and not crab meat from another country. That would be more of a complex investigation.

Another means of investigation is by patrol. Overt patrol is what our officers are doing. Our vehicles are pretty much all the same, with four uniformed divisions across the country.

We monitor things. I've talked about our enforcement, our sworn staff. But we do have analysts as well. We have analysts that look at data. We have analysts that look at information that's coming in and monitoring what's going on, including vessel monitoring system (VMS) data. We do look at automatic identification system (AIS) data as well. There are many other things we look at too.

We have partnerships with our state partners. Through that, we have our Cooperative Enforcement Program, where we partner with mostly all of the states in the United States that touch the water, from Maine all the way around to Alaska, and including the territories of Puerto Rico, American Samoa, and other places.

We have a federal partnership with the U.S. Fish and Wildlife Service (FWS). There is a lot of crossing with NOAA and FWS, for example with the Marine Mammal Protection Act, the Lacey Act, and the Endangered Species Act. With sea turtles, we have a memorandum of understanding (MOU) with FWS.¹¹ FWS is the primary investigator when it comes to imports or exports of turtles illegally. Domestically, through the MOU, we have primary jurisdiction on any violation that occurs at sea and FWS has primary jurisdiction on turtles that occur on land.

One example of that is someone stealing turtle eggs from the beach. FWS or the state agency where the violation occurs will have primary jurisdiction. If somebody has a turtle excluder device that's not compliant or shoots a turtle in a national marine sanctuary or at sea with a spear gun, then we would have primary jurisdiction on that situation.

Other federal partners include the Coast Guard, Customs and Border Protection, the Food and Drug Administration, and Homeland Security Investigations. We work closely with a lot of these agencies, including the Internal Revenue Service too.

NOAA's Office of the General Counsel works in our Enforcement Section. We have two ways of going with a case. We can either go civilly with a case or we can go criminally with a case. If the case goes civilly and stays in-house with our civil statutes, it will go to the NOAA Office of the General Counsel's Enforcement Section. If the case goes criminally, then it will go to the U.S. Attorney's Office or U.S. Department of Justice. That's all across the country as well.

I want to talk about the best way of enforceability of MPA enforcement. The first thing is enforceable regulations of laws in partnership with the national sanctuaries, with our fishery councils, with our highly migratory species advisory panels. We represent the Office of Law Enforcement when it comes to fishery management areas such as the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the Convention for the Conservation of Antarctic Marine Living Resources. We make sure that any regulation, any law that they're making is going to be enforceable for us and for the Coast Guard. If it's not, then a lot of this is a waste of time because it's tough with our limited resources to actually get out and enforce law if we can't enforce it with our own laws and regulations.

We like straight boundary lines. When it comes to MPAs, it's just easier altogether with enforceability and with going to court. I would say if you have an MPA that's like an amoeba or shaped something like that, there's probably not much enforceability when it comes to that. One,

6. 16 U.S.C. §§1531-1544, ELR STAT. ESA §§2-18.

7. 16 U.S.C. §§1361-1383b, 1401-1406, 1411-1421h, ELR STAT. MMPA §§2-410.

8. 16 U.S.C. §§3371-3378.

9. Pub. L. No. 114-81, 129 Stat. 649 (2015).

10. Pub. L. No. 97-176, 96 Stat. 78 (1982).

11. Memorandum of Understanding Defining the Roles of the U.S. Fish And Wildlife Service and the National Marine Fisheries Service in Joint Administration of the Endangered Species Act of 1973 as to Sea Turtles (Sept. 18, 2015), available at <https://www.fisheries.noaa.gov/resource/document/noaa-fisheries-and-us-fws-memorandum-understanding-sea-turtles>.

we can't expect the stakeholder to know where the boundary lines are and two, we can't expect ourselves to know where the boundary lines are located. Half of the time we have to get a book out and try to figure out where we are in the first place. So, we like straight boundary lines. It helps things out a lot.

A prime example of our collaboration is in the Florida Keys National Marine Sanctuary. We have the Coast Guard that enforces laws down there. The Monroe County Sheriff's Department enforces laws down there. The Florida Fish and Wildlife Commission enforces laws down there. Everybody there is working together because we can't do it all by ourselves. FWS as well because the Florida Keys National Marine Sanctuary is bordered by lands owned by FWS, National Park Service, the Everglades, and so forth. So, we have to collaborate to make sure that we're getting things together and we're focused on certain things.

We are looking at emerging technologies right now. There are a lot of different emerging technologies out there. We're trying to figure out which ones are most effective, which ones are most cost effective, and which way we're going to go. Those can be from radars. There are different areas that we have with radars, different state agencies. Federal agencies have radars that can tell us where a boat is. We are looking at the satellites, looking to see what we can do with satellites to tell us where boats are located and where they're going or where they've been.

We're looking at drones also. Not the drones that you can sit here and operate from this room and that go out a little ways. We're looking at drones that can go a long way because a lot of these MPAs that we have are a long ways out. How do we get out there? How do we enforce in those MPAs within resources? All of a sudden, they see a big white Coast Guard ship coming, then they stop doing what they're doing. That's what we're looking at too.

Not all vessels have AIS, and not all vessels have VMS. We just started looking at hydrophones too to see what we can listen to under the water. But all of these are emerging technologies that we're looking at. Each one of these is a tool. Having said that, using just one of these isn't going to give us the prosecution we want. With VMS and AIS, we can see that a boat is right there, but what is that boat doing? Because with a lot of the regulations that are out there, the boats are allowed to be there. They just can't be fishing there or they can't be doing a specific type of fishing there. With the court system that we have and that we work with, we have to put eyes on those vessels to actually see what they're doing. All these technologies work great, but getting our eyes on those vessels is a totally different story.

Then, there is the effectiveness of MPA enforcement, bringing all those together and making sure that it is effective, including our priorities. Recently, we had a saturation with the Florida Keys National Marine Sanctuary during mini lobster season. We went out there and we focused on the sanctuary protected areas. We focused on other MPAs in the area. We worked collaboratively with the

Florida Fish and Wildlife Commission, the Coast Guard, the Monroe County Sheriff's Department, and FWS. We worked together to focus on those areas. So, that would be an example of how we're effective in what we're doing.

How do we know we're effective in what we're doing? I can go out there and run doughnuts in the water all day long with the boat and use gas. Am I effective in what I'm doing? We're trying to get a baseline. All right, we're going to go here to this geographic area at a certain time and a certain date. They're in a certain fishery. We'll check everybody or check a certain amount of vessels. Then, we will try to get back later and see if we did compliance assistance while we're there, if we did compliance assistance in between those two time periods, and then check the effectiveness of the compliance rate at the first time and the compliance rate at the second time. Is it more effective? That's how we think we found a way to figure out that what we're doing is effective.

If I go out there on a Sunday in October and check a certain amount of boats in a geographic area and we have a 50% compliance rate, then I'll do compliance assistance and outreach at the local fishing store or something. That could be within the next couple of months. Then, I'll go back to that same area that same time and maybe that same day for the next year or maybe six months later, and I'll have a 75% compliance rate. I like to think what I did before is what helped that. So, that's where the effectiveness comes into play.

Then, the impact. You know, it is what it is. It protects. It conserves our MPAs and coral reefs and protected resources; sustains fish stocks; prevents IUU harvesting; prevents illegal trafficking of fish and wildlife; and it levels the playing field. If people are doing things right, then the other people should be doing it right as well. Nobody should be getting monetary gain for doing it illegally.

Xiao Recio-Blanco: Thank you, Wynn. The next panelist is Monica Goldberg. Monica is the chief counsel for the Oceans Program at the Environmental Defense Fund (EDF). She leads the U.S. Oceans Program on legislative and administrative initiatives and oversees litigation undertaken by the program.

Monica Goldberg: Thank you. I oversee our advocacy in all three branches of the U.S. government. Like many NGOs, EDF focuses our oceans work on fisheries. As the United States has started to get a handle on overfishing and recovering overfished species, we've expanded the geographies we work in fairly substantially. So, I also have started to do some policy-advising assistance to folks working out there. A couple of the examples I'll discuss today relate to some of our international activities. That's been an exciting area of expansion for us.

At all times, we really try to find solutions that align the incentives for fishermen and other resource users to comply with environmental regulations so that we get truly durable and transformative responses. That's the underpinning

of a lot of the work that all of EDF's programs do; it's trying to get those incentives aligned. It's definitely relevant in the MPA context. Of course, we don't enforce just for the sake of enforcement. We set up MPAs to give ourselves the benefits we're looking for.

The World Wildlife Fund talks about the benefits specific to fisheries.¹² They're pretty substantial if the restrictions that are inherent in MPAs are complied with. Unfortunately, the world is really home to a lot of scientifically well-designed MPA systems that haven't delivered the benefits folks have hoped for because they were created without a lot of stakeholder input that creates the buy-in for folks to comply with those restrictions. As Wynn pointed out, there's a shortage of resources always. With all of the best tools and technologies, we still have limitations on how much there is to do.

For us, we feel that the secret sauce especially with respect to coastal marine ecosystems is to work with fishermen and other stakeholders and combine well-designed MPA reserves with well-designed fisheries management so you have the incentive for effective compliance systems. Our work in a couple of countries recently epitomizes this approach.

The first one is Belize. We at EDF, with many other groups, have been working in Belize for several years. The progress there has been slow but steady. We've been there for I think a solid decade and we're not alone. But you're really starting to see how progress can be made.

EDF and colleague NGOs, both based in Belize and in the United States, worked extensively and directly with local fishing communities in the formulation of ideas that led to the first trial sites. We worked directly also with the Belize government to demonstrate that these ideas would improve the implementation of the fisheries management and their MPA programs together. Actually, we went so far as to fund certain staff members within the Belizean government, which is kind of unusual. I was surprised to hear that.

We had two pilot programs originally that were established in Port Honduras and Glover's Reef MPAs. Each of those included fishing and non-fishing zones. They really started to show the fishermen that using that combination would lead to better outcomes for them. One of the systems that we worked on with folks in Belize and have worked on in other jurisdictions is called territorial use rights for fishing (TURF). Basically, it gives a particular group of fishermen the opportunity to the right to fish in an area and to exclude other fishermen from that area. Usually, it's centered around a particular community, but in Belize, they can actually self-select to pick one or two TURF areas to fish in.

One of the ways that that helps align the incentives is, for example for the reef, we start to see increases in the population of particular species like lobster or snails or

reef-associated fish. The benefits from that will accrue to the fishermen in that area. So, they can directly see the connection between their efforts and the uptake. The results were really strong. In combination with outreach efforts to a lot of other fishing communities and the government, they have expanded the program to all of Belize's territorial waters.

Today, Belize has a nationwide system of fishing zones to which fishermen self-associate, and MPAs. Together it covers the entire terrestrial sea. The two reinforce each other and create the incentives for fishermen to respect the MPAs because, as I said, they increase the value of the TURFs.

They've actually perceived that to be enough of a benefit that they pushed for the expansion of MPAs, which they originally were targeting 10% of Belizean waters. They ended up putting 12% of their territorial sea into MPAs. They're very proud of the fact that those MPAs were actually in coastal zones as opposed to far offshore.¹³ So, they are places where people might ordinarily just fish, but they have set them aside to recover the fisheries and the reef itself.

There is a combination of government and NGO management of the protected areas themselves. But enforcement stays with the government. So, that's fisheries management regulation itself. It's still a governmental function including enforcement.

As for the results, we have local fishermen largely complying with the MPA restrictions. Most illegal fishing is coming from poaching by fishermen from other countries, which is an issue. That's actually one of the reasons speaking to the enforceable demarcation. They actually went all the way out to the edge of the territorial sea so that there would be a clear demarcation between where things were managed and not managed. In other words, the need for enforcement definitely doesn't go away. But it's materially reduced from previously when they had no-take reserves without having their complementary fishing regulations that gave the incentives for fishermen to comply.

Another example is in the Cebu Province of the Philippines. This is a different situation because it involves ecotourism. As we know, recovering from overfishing a lot of times requires reducing the intensity of the fishing effort for a period of time. That creates a lot of contentiousness in the United States. In other geographies, it can be even harder for folks because they rely on fisheries for really their basic income needs. So, providing an alternative source of livelihood can be a really important way to incentivize folks, or basically make it possible for them to reduce fishing intensity and allow things to recover.

If we think about ecotourism as a potential alternative income source, that does require often an intact and healthy ecosystem. That intact and healthy ecosystem also

12. The World Wildlife Fund has an infographic, Well Managed Marine Protected Areas Support Fisheries, at <https://images.app.goo.gl/TTgZT8D6K9Wni9pFA>.

13. For more information on Belize MPAs, visit <http://www.mpatlas.org/region/country/BLZ/>. See also Jo Griffin, *Why Tiny Belize Is a World Leader in Protecting the Ocean*, THE GUARDIAN, Aug. 14, 2019, at <https://www.theguardian.com/environment/2019/aug/14/why-tiny-belize-is-a-world-leader-in-ocean-protection>.

could involve reduction in the fishing intensity within those areas. So, those restrictions can be tough to implement if you have potentially weak governance in the area, which is true in a lot of the geographies where we work, and especially if the local fishermen or the fishery stakeholders—be they fishermen or community members—don't see a benefit of those restrictions. An example could be more extractive forms of ecotourism that don't give a lot of benefits to the local community.

By contrast, a project in the Philippines that we worked on and evaluated involved ecotourism that is very local. As opposed to the usual charismatic megafauna that ecotourism tends to focus on, it is actually based on a charismatic herring shoal and a fringing reef system that provides the basis for a network of marine reserves.

Fortunately, various occupations associated with the ecotourism resource, such as driving tourist boats and watching over the marine reserves, are accessible to fishermen and can help them deal with potential reductions in fishing that are necessary. It turns out that those occupations are actually much more valuable than fishing itself would have been. Using a combination of regional and local economic statistics and stakeholder surveys, EDF implemented an economic valuation of the mobile marine ecotourism in 2018 and found that the sector provides an estimated US\$20.7 million in revenues annually to the community and supports employment for approximately 1,000 community members, including some fishermen. But in contrast, we estimated the extractive value of the herring shoal would be just about 1% of that compared with the flow of benefits from ecotourism.

As a result, you can see that these herring shoals are not exactly challenging to catch. There's a lot of fish in one place, but in general, the fishermen do respect the no-fishing admonition within the MPAs that are designed to protect them.

Shifting gears and also shifting back to the United States, one of the things that I want to talk about is how technology can help us deal with the challenges that climate change is going to produce in terms of effective MPA design and enforcement. Some of the best-known U.S. MPAs are designed to protect swordfish nursing areas. These were set up mostly in the 1990s when U.S. swordfish were overfished. As you may know, the North Atlantic swordfish has recovered, which is great. The closures remain in place. For example, the Charleston Bump is closed from February 1 until the end of April. It covers the entire South Carolina coast and most of the Georgia coast.

These are set up because the idea is that it was a nursery area where juvenile swordfish would grow up, and obviously it's timed as well. But as climate change starts to change the temperature, composition, and other characteristics of these areas, whether they are correctly sited and timed to protect spawning areas as intended is a question for all of these areas. Technology can help answer those questions.

An example from the West Coast is called the EcoCast. It's a program that uses observer data and conditions in the marine environment, like sea surface temperature and chlorophyll, to predict where fishing vessels will likely encounter sea turtles, sea lions, and sharks. Data collection of this kind can help managers assess the location of MPAs, like the swordfish in nursery areas, as well as the timing of them, and whether to move their location or timing as ocean conditions change or areas with higher juveniles or other things shift. Overall, the more timely, accurate, and comprehensive data that electronic monitoring and recording systems could provide could give regulators a chance to design this in a different way.

In some cases, and we've been involved in some of these efforts, fishermen are arguing that you can have a hard cap on the amount of fish that you catch and enough monitoring, that they can use these tools to avoid the fish and avoid the need for the closure in the first place. But that gets a little bit ahead of ourselves.

Going back to an international example, you were talking earlier about the combinations of different technologies to help enforce regulations including MPAs. I, for one, have been a huge fan of Global Fishing Watch since it launched and I am looking forward to John's presentation on the eyes-in-the-sky aspect. We are also currently scoping a project that would use hydrophones and radar to generate sufficient information to deter illegal fishing in Chile's nearshore ecosystem, especially of something called *loco*, which is a species of marine snail.

The idea is that you can have a low-cost combination of various technologies that combine with artificial intelligence (AI) software that can provide real-time updates to enforcement folks so they can target their outreach in those areas where illegal fishing is taking place. The longer-term vision is whether we can combine these technologies with other data, like satellite data, to actually generate enough information to become the basis for enforcement actions on their own. Right now, I think it's like Wynn said, directing human resources to the right places and shaming can also be a good tool. But ultimately, the sort of Holy Grail is to find a way to have this be a basis for enforcement action itself.

Here again, we are counting on collaboration with the fishermen because all of the estimated illegal catch is taken off the top of the legal quota. Again, the fishermen will be incentivized to help enforce these restrictions, so their higher catch can be implemented. These are also areas where EDF already has relationships with fishermen and we're working on TURF reserves and things like that with them. So, we're hopeful that it will be an interesting combination of, again, the enforcement and the fishing regulations performance.

Xiao Recio-Blanco: Thank you, Monica. With that, we turn to our third panelist, John Amos. John is the president and founder of SkyTruth, an organization that is dedicated to strengthening environmental conservation by illuminat-

ing environmental problems and issues through the use of remote sensing and imaging. He helps develop organizational strategy and partnerships for SkyTruth mentors and technical staff and provides remote sensing expertise.

John Amos: Thank you, Xiao, and thank you for this follow-up to the MPA enforcement handbook work. I hope you all have a chance to dig into that if you're interested in this topic. I'm glad to be back and to do a little follow-up on how the technology has changed since we did that just a couple of short years ago.

I'm here to talk about the work that we do at SkyTruth using the view from space to inspire environmental protection and to make advocates more effective in the work that they do. As you've heard already, there are lots of technologies to apply to understanding what's happening on or in or under the surface of the water. We have passive sonar. We have drones. There are all kinds of equipment and sensors that are being developed and deployed. I'm going to talk about none of that and confine my remarks to what we could do with the hardware tool kit that we're putting into orbit.

I also want to point out that this is really still about monitoring. We can't actually do enforcement from space yet. I think we're heading in that direction pretty quickly. It's my hope that by deploying credible continuous global monitoring systems—and that almost certainly requires space-based platforms to accomplish that at scale—that we will make the enforcement problem a lot smaller because people change their behavior when they know they're being watched. That's our hope. It's maybe a bit naïve, but we'll see what happens, as the president likes to say.

Two of the main satellite technologies we work with are satellite-collected tracking data and satellite imagery. I'm going to start with the tracking data. It turns out that if you put a radio frequency receiver on a satellite, you can actually collect the radio frequency broadcasts that ships are making down on the ocean surface to each other, particularly the broadcast using AIS. This was developed as a collision avoidance safety system—a way for ships to communicate to each other: who they are, how big they are, where they are, how fast they're going, those kinds of things.

It also turns out to be very useful for understanding what's happening on the ocean and for increasingly designing and conducting management regimes that take advantage of this tracking data system. Lots of ships use it because they're required to. Lots of ships that aren't required to still use it because they don't want to get run down in the middle of the night by a car carrier full of Hyundais charging across the ocean. But still, there's a sizeable dark fleet of commercial users to the ocean space who, even though they may be required to use this system, they're not. They're running dark.

Well, if you plot the locations of all of the AIS broadcasts that are made by the 200,000 or so ships at sea who are broadcasting on any given day, you can come up with a

really stunning or, depending on how you look at it, appalling map of human activity in the ocean and the pervasiveness and intensity of the human footprint in the ocean. But it can be a lot more informative once you get past the shock and awe of it to actually home in on a select set of vessels, a specific geography, and a particular time frame. Then, you can start to do some interesting things. For example, you can start to see vessel activity associated with extraction in the ocean.

The era of seabed mining is coming quickly. We worked on a site with University of California, Santa Barbara, to actually take a known fleet of vessels that are supporting ocean surveying and exploration activity that will lead to seabed mining and track their movements from port out to the mining concessions to do whatever activities they're going to do.

Of course, oil and gas exploration and development in the ocean is still a huge form of human activity out there. For example, take the track of a single offshore seismic surveying vessel that was working in the mouth of Cook Inlet last week. I think they're still out there. What it allows you to see with a single track is that not only is the AIS tracking data useful for telling us that there's a ship there and telling us who they are and what they say their activity is that they're engaged in, but by reconstructing the way they're moving on the water we can see patterns of behavior that tell us what they're doing out there in the ocean. And if we apply AI, particularly machine learning, to identifying those patterns across a global data set at scale, we can do some magical things.

So, that's what we did when we built Global Fishing Watch. We actually taught computers how to recognize how a vessel's movement pattern changed when it put gear in the water to actually start to fish. Every point of light on the Global Fishing Watch map is animating I think about two years of cumulative fishing activity. Every point of light is not a fishing vessel. It's fishing effort by a fishing vessel, with some 60,000 fishing vessels making up the collective fishing effort that is on a particular map.

We're learning to do a lot more with tracking data also. One of the patterns of behavior we see that's also of interest within the global fishing industry is apparent vessel rendezvous at sea. Rendezvous at sea can be perfectly innocent. Crews can be swapping crew in and out. They can be trading recipes. They can be shifting supplies from one of the vessels in a fleet to another. But it's also a way to ship fish that was caught by one vessel onto a cargo ship or a processing ship for return to port or even onto another fishing vessel that can take it somewhere else. So, it's a way to actually hide illegally caught fish within the still all-too-opaque global seafood supply chains.

Shifting to the other kind of data that we use, we have done a lot of work at SkyTruth since we started using satellite imagery as a tool to monitor oil pollution events out in the ocean. Radar is very sensitive to the roughness of the sea surface. So, when you put oil in the ocean, it smooths it out. It makes it slick. And that shows up as a dark patch

on a radar image. For example, an incident from a Shell deepwater production facility several years ago was caught off the Niger Delta in Nigeria as a large oil slick.

But it's not just offshore oil platforms that cause oil spills in the ocean. All too frequently, when we look at satellite imagery, particularly radar imagery of the ocean, we see effects from vessels. For example, a 100-kilometer-long oily slick that was left by a passing vessel that was illegally dumping untreated bilge water out of the cargo holds or the bilge tanks to get rid of it. It's the cheapest and easiest way to get rid of it. Doing this out in the ocean used to be the equivalent of sweeping something under the rug that you didn't want anybody to see. But with this technology, now we're able to see it and bring it to light.

Those are some of the things that we've been doing with satellite technologies at SkyTruth. Another great thing about radar satellite imagery is it's really sensitive to big hunks of metal sitting out in the ocean. They show up as very bright points of light on a radar satellite image. We now have access to a public, free, globally available data set of radar satellite imagery through the European Space Agency.

At SkyTruth, we've automated a process to identify all those bright points of light out in the ocean that don't move, that are in the same place week after week after week, and create a global map of human-built offshore infrastructure above the waterline in the ocean—oil platforms, wind turbines, and big floating fish farms—which show up as red dots on the map.

Not only is this useful for taking a different look at the expanding human footprint out in the ocean—you can imagine all the vessel activity to and from each little red dot to support this construction and then whatever operation is happening there—but it's also useful for us at SkyTruth to help us identify the sources of the oil pollution events that we're seeing on satellite imagery. Did that come from the oil platform? Or did it come from a passing vessel? Or did it come from something else?

One of the things we're able to do now with automation is to actually merge different data sets together. A very simple and obvious example of that is about a 140-mile-long bilge slick left by a vessel. It turns out you can actually see the vessel at the end of the slick on the radar satellite image. You can't tell much about the vessel by that bright spot. You can tell roughly how big it is and what direction it was moving, maybe the speed it was moving, that it's a big ocean-going cargo ship or tanker.

When we integrate that with the AIS tracking data for the 200,000 vessels around the world that are broadcasting, we can identify a culprit. Increasingly, we're able to point fingers and name names when we see pollution events like this and identify a likely perpetrator, those scofflaws who are continuing to bilge dump throughout the oceans.

But what about all the vessels out there that, as Wynn had mentioned, are not broadcasting an AIS tracking signal? There's still a lot of traffic in the ocean that is part of the dark fleet of non-broadcasting vessels. Well, we're starting to light those up with satellite imagery.

There's a project we're doing this year funded by the Walmart Foundation to actually assess the risk of human rights violations in the longline tuna fleet in the Pacific. SkyTruth's part of that work is to measure how much dark fleet activity is embedded within the tuna fishers who are broadcasting a tracking signal and acting legitimately.

For example, we have a very ugly radar satellite image but very effective. It shows a series of blue dots. The blue dots plotted on the image are areas where there was an AIS signal that was broadcast, but no vessel appeared on the image. That's kind of strange. They got an AIS ping, but no ship visible on the image. Well, if you look at how these pings are arranged, they are signaling buoys or beacons that are attached to the gear, to the drifting longlines that these tuna fishermen are deploying so that they can go back and retrieve their gear without searching around the ocean floor for it.

Green dots show where we detected a vessel. We had a bright spot on the image that was obviously a vessel. We were able to correlate it with an AIS tracking broadcast. Those guys are in the light fleet. They're broadcasting their activity, but they're not the ones we care about.

Two red dots are the ones we care about. That's where we see ships on the image but could not confidently correlate that with any AIS broadcast. So, those are potentially dark fleet vessels that are embedded within a legitimate longline tuna fishing fleet.

The imagery is getting more and more spectacular. This would've been unbelievable to me when I started my remote sensing career.

A high-resolution color infrared satellite image was taken of a vessel that we thought was potentially engaged in a transshipment. That vessel is a big refrigerated cargo ship in the middle of the image. Based on the AIS signal it was broadcasting, it looked like it came to an almost complete halt out in the middle of the ocean off Papua New Guinea. We went, okay, there's only one reason for a big cargo ship to come to a stop out in the middle of the ocean assuming they're not having engine problems. So, we collected this high-resolution satellite image with 30-centimeter-level detail and, aha, there are two non-broadcasting dark fleet fishing vessels tied up alongside the cargo ship.

There's enough detail on these images if you know a vessel's structure and configuration that you might actually be able to make some identifications based on satellite imagery alone. Again, we're not quite at the level of doing enforcement from space, but clearly we're getting closer and closer to that.

This floors me. It partly scares me and partly amazes me. But now, military and intelligence-style electronic signals intelligence has come to the civilian remote sensing world. The company HawkEye 360 is one of the first out of the gate. They've got a cluster of satellites in orbit now that can detect any strong radio frequency signal coming from anywhere on the surface of the earth and they can triangulate the location.

Let's say you're a pirate fisherman and you don't want to broadcast an AIS signal telling the world here I am. You've turned that off. You're not following any VMS tracking regulations and you're out there fishing illegally. Somebody on the crew's got to call home every now and then. When they pick up a satellite phone and make that call, bam, HawkEye 360 can detect that a call was made. We're not eavesdropping on the content, but now we're able to say, "Hey, there was electronic activity down there in that spot just five seconds ago. Do you know who that is?" So, that's what's coming now. We're starting to work with this data. It's fascinating and scary.

What we've been doing most recently is we're finding ways to actually directly measure behavior from space. Not just presence, but try to figure out behavior. What are they doing, not just who they are. If we can make the behavior and the identification, then we've got the basis to send somebody a notification. We're working now to automate every step of that process, including the notification to any authority or NGO or other stakeholder who wants to be notified of the information that we can collect.

There's more, and more, and more hardware going into space. It is getting really difficult, as a remote sensing professional, for me to keep a handle on all the companies that are flinging hardware into orbit. And I mean flinging; for example, two 18-inch-long satellites that were thrown by a mechanical arm out of the International Space Station. They're being launched 60, 100 satellites at a time in a single launch.

We're rapidly approaching junkyard earth, I guess. The North American Aerospace Defense Command right now tracks pieces of floating hardware, mostly defunct satellites, but a few thousand active ones growing by leaps and bounds every day. All of this is going to get better and more intense and, yes, a little scarier. The secret to being able to manage this already flood of data—becoming an impossible torrent of data and imagery to handle—is automation. It's applying AI, specifically machine learning, and, for imagery, the technique we call computer vision to train computers to sort through all the stuff lightning-fast, and then send human eyes a notification to maybe look at this thing down here right now.

Behind the scenes at Global Fishing Watch labs, they're working on now, basically, going beyond just vessel tracking data to develop a platform that allows for predictions. Where is the fishing effort going to be, not where is it today. Not where are those vessels pinging AIS right now, where are they going to be pinging AIS tomorrow and next week.

Here's an example: the cumulative longline fishing activity over about a month near the Galápagos Islands, superimposed on a color-coded map of ocean temperature at 20-meter depths. We now have data where we can essentially daily create such maps of ocean temperature at multiple different levels in the ocean, some of which are significant to certain fish species, some of which aren't.

And all kinds of other data—oceanographic data, geophysical data—with the intent of training the computers how to recognize in the past the combination of conditions that have facilitated fishing activity of a specific type. So, when we see those conditions now or assembling now, in the future, we can plan enforcement patrols based on where we think the fish are going to be and therefore the fishing effort is going to be.

This is pie in the sky right now. But possibly even designing dynamically managed MPAs in the ocean that are based—Wynn, you're going to hate this—not on straight lines but based on lots of "amoebas" out in the ocean that are constantly shape-shifting and moving as the ocean itself changes.

That raises the possibility of an MPA defined by a set of continuously observable and measurable conditions. Like maybe an orange blob on the kind of temperature gradient you would follow as it tracks across the ocean with El Niño or back and forth. Then, you would say that's my protected area, an enforcement nightmare. But I think that's where this technology is all heading. It creates a possibility at least to think about.

Xiao Recio-Blanco: Thank you, John. Time for questions. We have one here.

Audience Question #1: Has there been any case law related to enforcement actions where an enforcement vessel is engaged in hot pursuit from a sanctuary using either VMS, AIS, or maybe another emerging technology?

Wynn Carney: We've made cases before like that where we get VMS data that a vessel is in an MPA. We get out there, whatever unit it will be—Coast Guard or state partner or one of our vessels. It takes off. There have been cases made from that. I don't know if there's been any case law made from that, but there had been cases made from those types of situations.

John Amos: Can I follow up on that? Internationally we were involved in a hot pursuit in Palau. From Shepherdstown, West Virginia, we had been tracking I think it was a Taiwanese trawler. It was a trawler that had been operating without a license. Clearly, based on their movement behavior, they were fishing within Palau's waters. Palau called us at 6:00 in the evening one night as we were all getting ready to go home, saying, "Okay, we launched our patrol boat. Now, where do we go?"

At the time, they had a 50-foot inflatable patrol boat to patrol out to the 200-nautical mile. It is a vast area. We really wanted to help these guys. Our analyst worked well past midnight basically getting live updates of the AIS position because this vessel was broadcasting an AIS signal. Again, I think like some people who are engaged in illegal activity, they had it on for safety purposes. They had never faced any consequences in the past.

So, our analyst was radioing or e-mailing positions to Palau and they were relaying it to the captain out on the boat. They actually triangulated and made an interception 12 miles from Indonesian waters. They pulled that boat back in and it had a load of shark fin on board. They ended up paying I think about a \$300,000 fine, which for Palau is pretty huge and kind of put down the marker that, okay, we can do this now.

The case itself wasn't determined by the data, but that was one of the rare examples when we were able to do some real-time direction of steel-on-the-water, or in this case inflatable-rubber-on-the-water, to get the job done. But that's anecdotal. It's not systematic. We're not quite there yet.

Audience Question #2: I wanted to know whether any of the panelists are working on the biodiversity of areas beyond national jurisdiction negotiations that are going on at the United Nations in terms of creating MPAs in areas beyond national jurisdictions. I was thinking some of the stuff that you've been working on would be very relevant there.

Monica Goldberg: EDF is not.

John Amos: SkyTruth is not either. We're very small and very busy.

Audience Question #3: This question is directed for Monica. Are TURFs traded or are they solely among fishers or government agencies?

Monica Goldberg: It depends on how you want to design them. My understanding is that in general they tend to be limited to a geographic area or a defined universe of fishermen who either can access that or not. I suppose in theory you could trade them if there was a reason folks wanted to—for example, among family members or people moving in and out of the community. The more limitations you have on trading, the less valuable the license is to the license holder.

At the same time, if you're trying to design the system so that you can keep the fishing effort limited and geographically based, then you could have limits on transferability that would achieve those objectives. It's usually about how the community or how the regulatory body wants to design the program and what kind of objectives they are trying to accomplish.

Audience Question #4: A follow-up question to that on the same topic of TURFs: What are some other incentives like TURFs for stakeholders to comply with more MPA enforcement?

Monica Goldberg: Well, apart from the ecotourism version, I think a lot of these systems, even if they don't have

TURFs, will have spillover effects from the MPAs. Then those benefits that are kind of consistent across MPAs, if you don't limit the number of people that have access to the benefit, the people who are sacrificing aren't necessarily the ones who are getting it if they draw in fishermen from other areas.

That's why we feel like, if you have more ownership, if you will, of the outcome that you're getting from the MPA, then you have more incentive. But at all times, a well-enforced MPA is likely to result in some of the benefits from the World Wildlife Fund slide¹⁴ on spillover effects into outside areas. There's always that incentive. It's just a question of whether it's limited to a certain number of people so that it's more intense for those folks to get that incentive.

Audience Question #5: A kind of obvious theme of all the presentations was the potential for the transition of using remote sensing technology from interdiction to prosecution. I was wondering what the panelists see as the key challenges to making that transition, assuming we all agree that that would be a useful thing.

I think there are some obvious ones that emerge from the presentations. John, you mentioned the technology is evolving. We can observe more and more specific behaviors on the water. But we're still waiting for that technology to continue to develop. Then you alluded to, I think, the need to design a regulatory framework where the predicate violation is observable through remote sensing technology. It has to be designed in a way that's enforceable.

Two others that come to mind would be resolving chain-of-custody issues when you have private entities, the NGO partners that actually hold the evidence. How does that find its way into a prosecution? And then developing an enforcement framework; I mean, these vessels don't always wind up offloading their catch and are not always subject to the enforcement authority of the jurisdiction that's carrying out the remote sensing. So, how do we confront those challenges? Are there any others that didn't make that list?

Wynn Carney: We deal with that already with our regular domestic work with the evidence. Say there's a stranded whale or a dolphin that comes up on the beach and the Stranding Network comes and gets the gear. How do we work on making sure that that evidence is likely needed and that we can use it in the court through seizure or through chain of custody and that kind of thing?

I guess the best answer is that it depends. You probably don't want to hear that. What we do is we try to work with our partners—whether it be a state partner or whether it's an international partner, the NGOs, whoever—who get that evidence and make sure that it's useful in a court of law. We do that all the time. Then, we have our people go to our academies to try to learn that as well.

14. See *supra* note 12.

As far as a regulatory framework for remote sensing technology, as far as putting eyes on it, what makes it tough is again, like I said, they have these areas that you can fish or that you can't fish. Or a specific permitted vessel can be in that area to fish, but another vessel can't fish in that area. It makes it tough. The reason why those laws and regulations are the way they are, to me, a lot of it is trying to make the fishing opportunities as long as possible while keeping it sustainable and making everybody happy—the council, the fishermen, the NGOs, and all that kind of stuff.

Then, we're caught in the middle from the enforcement perspective and we've got to figure out—for example, is today Tuesday? If the boat has two engines running, then it's good to go. But if it only has one engine running, then it can't fish there. So, that's what we have to determine. And that's why we keep on with our collaboration. We're talking. We'll see it all come out and we'll put the brakes on. Like whoa, let's think about this. But sometimes, it doesn't matter what we think depending on the powers that be.

Monica Goldberg: I would add that a lot of the examples that we gave about having stakeholder buy-in enhance compliance, and things like that, were centered on some of the other geographies where we worked. It's definitely relevant to the United States as well. Like you said, there are these very byzantine regulations that come out of the council process. I had been there when they basically said, "Oh, it's not enforceable? Oh, well, I guess you can't do it." And to the extent that you have buy-in from a fishing community or the broader stakeholder community to do more self-policing, that's the goal.

Also with monitoring, like electronic monitoring and electronic reporting, it's less about tracking and more about catch accounting usually. But one of the tensions that we've seen is that, from an enforcement point of view, you might want to keep that data or keep that video forever because you can then go back and reconstruct things later. But, number one, the fishermen don't like that. Number two, the cost goes up when that happens. So, there's also the balancing of how much data can you keep and sort through, and whatever cost there is to that and how does that make you able to make cases or not make cases.

Wynn Carney: And who pays for it.

Monica Goldberg: And who pays for it, fishermen or government. Because some of this storage is not supposed to be an issue anymore these days; it's pretty cheap. But with video, that's a very sizeable file. You would know more about that, John.

John Amos: Yeah, we still have those problems. Just a couple of thoughts. One is that, coming back to the high-resolution satellite image of that vessel, I think that was a 30-centimeter resolution image. So, that was the best commercially available. That's going to continue to shrink. A

former Coast Guard commander told me that when they were doing patrols, one of the things that was considered actionable evidence—and maybe you can confirm this, Wynn—was fishing gear on the deck of the vessel. If it was not stowed, that was a sign of fishing activity. Does that sound right?

Wynn Carney: A lot of it depends on our regulations and what they say. Sometimes, there's a regulation or law that will say it is assumed that if there is gear on deck that you are fishing. Then that helps us out. But sometimes the specific law may not say that.

John Amos: That's exactly where the laws need to match what's observable, and the laws are always going to lag behind that somewhat. But I think what's observable is becoming more and more detailed. So, the technology may create some legal space for new approaches.

The other thing is there needs to be much better intentional coordinated data-sharing. You've heard people say VMS a number of times. That's the closed government vessel tracking system that's satellite-encrypted. I think the fishermen have to pay for it and don't like it. You plug it into the ship's power and then you don't touch it. That's all managed and controlled by whatever government authority is managing that system.

Wynn Carney: It's actually us. We are the ones that regulate it. We've got regulations within it too. The AIS is going to be on the Coast Guard side, and VMS is going to be on our side.

John Amos: I know it's really hard to even share that data within government agencies because of the privacy protection in the authorizing legislation for it. Right?

Wynn Carney: Actually, we have in our regulations how we share it, who we share it with, and so forth. That makes it tough even when we are dealing with international regulations within ICCAT in those places.

John Amos: So, that could be changed. Theoretically, I think it would require an act of the U.S. Congress in our case to make the VMS sharable. Other countries don't necessarily have that problem. Global Fishing Watch has a transparency play where they're going around to all the coastal nations and saying, "Okay, make your VMS data public for the whole world to see it. And the benefits you're going to get from that are it'll appear on our map and all your analysts will actually be able to see it and work with it rather than having it stuck in a box." Interesting things pop out when people start to actually see the data.

From Indonesia, one example was a vessel that we tracked on AIS travelling across the ocean to a notorious pocket of the high seas off Papua New Guinea, where a lot of bad stuff is believed to happen. But the VMS data

that we had access to showed it in port the entire time. So, somehow they took the VMS system off the boat, put it down on a dock, left it on, then trekked thousands of miles across the ocean. When somebody combines those data sets, you start to see these interesting things happening.

Now, maybe they weren't doing anything necessarily illegal, but certainly you'd want to go pay them a visit when they come back in the port. If that's publicly visible to the world, it doesn't matter if they are coming into a port in Indonesia or a port in China or a port in France. If there's that level of communication among port authorities internationally, somebody's going to know that maybe they should say hello and start looking at paperwork.

Xiao Recio-Blanco: If I may add a comment/question building on your excellent question: Do you think that part of this transition toward the use of technology for prosecution will be working with the judges to make sure that the judges are convinced that they can trace the dots from the actor to the action and be convinced themselves that, okay, this is fine?

John Amos: I think that's something that ELI should definitely do.

Xiao Recio-Blanco: The evil agenda behind my question.