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Article

Surveillance Systems for Sustainable Fisheries: Perceptions on the Adoption of Electronic Monitoring in the Northeast US Multispecies Fishery

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Abstract

Amendment 23 (A23) to the Northeast Multispecies Fisheries Management Plan will remake monitoring systems for the Northeast US commercial groundfish fishery. In addition to substantially increasing monitoring coverage, A23 will provide fishers with the option to utilize electronic monitoring (EM) technologies in place of human at-sea observers. Based on twenty-six interviews with representatives of the fishing industry, nongovernmental organizations, regulatory agencies, EM service providers, and other stakeholder groups, this paper examines how the fishery is planning for the adoption of EM. We focus on the differing perspectives on the value of EM as an appropriate tool for protecting the fishery, and as a tool of surveillance that may transform the lives of fishers. We find that while most stakeholders support the use of EM in the future, mistrust within the industry—based on historical regulatory failures, perceived lack of information on technical feasibility, privacy and data ownership issues, and the unknown long-term costs to vessel owners—poses significant barriers to successful adoption of these technologies. We conclude that these barriers can be overcome by investing in co-management driven EM implementations that draw on the expertise of fishers and increase their autonomy over their vessels and their use of data. This study offers critical insights into the conflicting sociotechnical imaginaries that co-produce spaces of surveillance for natural resource management, as well as provides important findings for the fishery as A23 moves into implementation phases.

Introduction

Sustainable fisheries management is a complex process with persistent challenges requiring fishers, scientists, and regulators to evolve in their approaches to fishing practices, data collection, and oversight. While some federally managed fisheries in the United States have responded well to innovations and changes to management practices (Melnychuk et al. 2021), this has not been the case in the Northeast groundfish fishery (NEGF), the focus of this study. The NEGF consists of thirteen bottom-dwelling species, including the iconic Atlantic cod and haddock, and is managed by the New England Fisheries Management Council (NEFMC), one of eight regional councils initiated by the 1976 *Magnuson-Stevens Fisheries Conservation and Management Act* (MSA). The NEFMC manages groundfish through its Northeast

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Multispecies Fishery Management Plan (FMP), and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) handles the implementation and enforcement of FMP rules and regulations decided upon by the NEFMC.

Since its inception in 1985, the FMP has seen dozens of adjustments aimed at achieving sustainability through regulatory measures, including fishing trip limits, area closures, gear restrictions, individual fishing quotas, and annual catch limits (ACLs).[1] Despite these efforts to control overfishing, several species in the NEGF have not rebounded from historic lows to sustainable levels, due in part to illegal harvesting and lack of enforcement as well as from persistent uncertainty in scientific advice and ocean condition changes caused by climate change (Acheson and Gardner 2011; NEFMC and NMFS 2009). To address one of these concerns, namely alleged illegal harvesting and discarding of regulated fish stocks, the NEFMC developed, and NOAA Fisheries approved, Amendment 23 (A23) to the groundfish FMP, which will require increased levels of monitoring of all groundfish sector vessel fishing trips beginning in May 2022 (NOAA Fisheries 2022a).[2] Fishers have the option under A23 to meet new requirements with traditional human at-sea observers. Alternatively, vessels may opt into one of two new electronic monitoring (EM) programs depending on the size of their vessels. Under A23, federal funds will subsidize EM installations and maintenance through the 2023 fishing year, after which costs would be incurred by vessel owners.

While the production and utilization of EM data may provide opportunities for greater participation by fishers in the co-management of natural resources, it also raises concerns about data manipulation and misinterpretation (Blair 2022; Couldry and Powell 2014; Goldstein and Faxon 2020; Ruppert, Isin, and Bigo 2017). The use of EM data could be empowering, but it may also reinforce existing power dynamics and motivations if fishers perceive EM data as improperly interpreted or utilized in order to implement new restrictions on fishers. Archer (2021) refers to "surveillable spaces" as consisting of the surveilled, the surveillors, surveillance technologies, and the "standardizers" who ultimately establish the rules and norms of these surveillance-brokered relationships. In the case of the NEGF, several organizations serve as standardizers, including environmental non-governmental organizations (ENGOs), federal science and regulatory agencies, and academic research institutions. These groups have a shared vision for the future sustainability of the NEGF that rests on modernizing the fishery through robust data collection. However, their visions on the possibilities of EM are not necessarily shared by industry stakeholders. The prevalence of tensions between proponents of surveillance and skeptics who are concerned about unanticipated consequences support arguments that surveillable spaces emerge from competing sociotechnical imaginaries on the power of data-driven measurements for sustainability.

Our study poses three interrelated research questions about the social construction of EM as a means of surveillance in the aim of achieving sustainability within the NEGF: (1) How is EM perceived among various stakeholders in the NEGF; (2) How is the adoption of EM being negotiated by NEGF stakeholders; and (3) What new conflicting sociotechnical imaginaries are present in these spaces between those being surveilled (i.e., NEGF sector vessels) and those implementing this new form of surveillance of the NEGF and/or utilizing the data it produces (i.e., EM service providers, fisheries scientists, and managers)? Our study is based on semi-structured interviews conducted in the months leading up to A23 adoption with twenty-six stakeholders in the NEGF, including representatives from the fishery industry, ENGOs, EM service providers, federal agencies, and other interests.

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[1] Annual catch limits (ACLs) are defined as levels of catch intended to prevent overfishing, which are estimated from the development of overfishing limits and acceptable biological catch determined through scientific stock assessments of fish stocks and species. Individual fishing quotas are determined as a percentage of the ACLs and are distributed to those with federal limited access fishing permits (NOAA 2019).

[2] Illegal discarding refers to the practice of discarding, or returning to the ocean, legal-sized fish that are caught and otherwise have a requirement to be landed or recorded as caught and brought to shore for sale and distribution. Fishers sometimes have an incentive to discard illegally when landing the legal-sized, regulated fish would cause them to reach their quotas and prevent them from being able to take future fishing trips during the rest of fishing year.

We find substantial disagreement over the magnitude and relative importance of illegal discarding across the fishery, where A23 is viewed by some as unjustified given the many concerns superseding illegal discarding. "Resilience" of the fishery was also portrayed differently among the stakeholder groups given differently prioritized vulnerabilities. Additional findings reveal substantial barriers acknowledged by all stakeholders regarding how to adapt EM to fit a diverse range of fishing operations across the groundfish fleet. Fishing industry representatives believe that the true cost of EM is unknown at the vessel level, and that they do not have adequate information to assess the cost-benefits of adopting EM. Finally, we observe that historical erosions of trust between industry and regulators are fueling concerns about information privacy, mission creep, data stewardship, surveillance, and the overall intentions of using EM as a tool for scientific monitoring under A23. EM is frequently characterized as an overly oppressive "witness" program for identifying "bad actors" with no real added value to the fishing industry.

Our study offers important insights into the perceptions of EM that may ultimately impact how A23 is adopted by the NEGF. It further suggests that the success or failure of new surveillable spaces are likely dependent on the alignment of shared goals and cooperative models for natural resource management that draw on the diverse expertise of the surveillors and the surveilled. This research has broader implications for the field of surveillance studies by illustrating a case study of the potential for co-produced surveillable spaces to realize mutually beneficial results for the surveillors and the surveilled in a manner that better aligns the sociotechnical imaginaries of parties on all sides of the discussion.

Background

The extent of noncompliance with fishing restrictions in the NEGF has been a source of intense debate among scientists, fisheries managers, environmental non-government organizations (NGOs), and fishing industry participants and organizations for decades. A study surveying fishers, scientists, managers, and enforcement officials in 2007 estimated the percentage of illegal catch taken in the NEGF to be somewhere in between 12% and 24% (King and Sutinen 2010). Illegal and misreported kept catch and discarded bycatch (i.e., unwanted fish or other species that are returned to the sea) can be a serious problem for the sustainable management of the groundfish resource. Fisheries scientists and managers rely partly on catch information from the industry to conduct stock assessments, reduce bycatch, and set catch limits and quotas (NOAA Fisheries 2018, 2021). Industry supplied data come from several sources, including landings information from federally permitted commercial fish dealers, fishing vessel logbooks and reports, portside sampling conducted by state and federal employees, and vessel monitoring through the use of onboard observers or at-sea monitors (Cooper 2006).[3]

The NEGF has two programs for onboard observing and monitoring that contribute to these datasets: the Northeast Fisheries Observer Program (NEFOP) and the At-Sea Monitoring (ASM) program. The NEFOP program is designed to conduct biological sampling of fish and document bycatch, while the ASM program provides an additional layer of observation of vessels enrolled in sectors to verify catch and areas fished (NEFMC and NMFS 2009; Sun and Fine 2016). The ASM program is a critical component of the NEGF's current quota management (catch-share) system, which is one among many attempts over decades and across industries to reconfigure natural resource management towards neoliberal rationalization and rights-based, individual ownership and trading of resources (Olson 2011; Carothers and Chambers 2012; Hébert 2014). Although the NEGF has multiple monitoring programs, only a portion of fishing trips have been observed, at an annual rate varying between about 14–30% of trips from 2010 to the present (NEFMC 2022).

The lack of monitoring on the majority of fishing trips has led to concerns about the possibility of bias in the data collected by observers and at-sea monitors. In the Groundfish Plan Development Team's (PDT) peer-reviewed report of groundfish monitoring analyses, the NEFMC's Scientific and Statistical Committee

[3] Vessel monitoring refers to the surveillance and recording of fishing activity aboard commercial vessels by government-trained human observers or at-sea monitors. At-sea monitors or observers may be government employees or, in some circumstances, government-hired contractors.

(SSC) concluded that the PDT's analyses demonstrated a clear "observer effect," or a change in fishing behavior among vessels that have observers onboard (NEFMC 2019). Specifically, the analyses determined that vessels with an observer on board fish for less time, keep fewer fish, and earn less money than vessels that are not observed. The presence of an observer effect means that data from observed trips may not be representative of unobserved trips, thus the estimates of discards used to inform stock assessments may be inaccurate. As part of A23's efforts to increase monitoring levels and mitigate any effects from bias in reporting area and discards, EM is seen as a potentially preferable monitoring technology to human observers. EM systems developed in NOAA Fisheries' approved pilot projects entail passive observation surveillance systems that utilize a combination of digital cameras, data recording and storage devices, GPS tracking, and human video auditors to review video recordings of catch and discard activity during sector fishing trips.

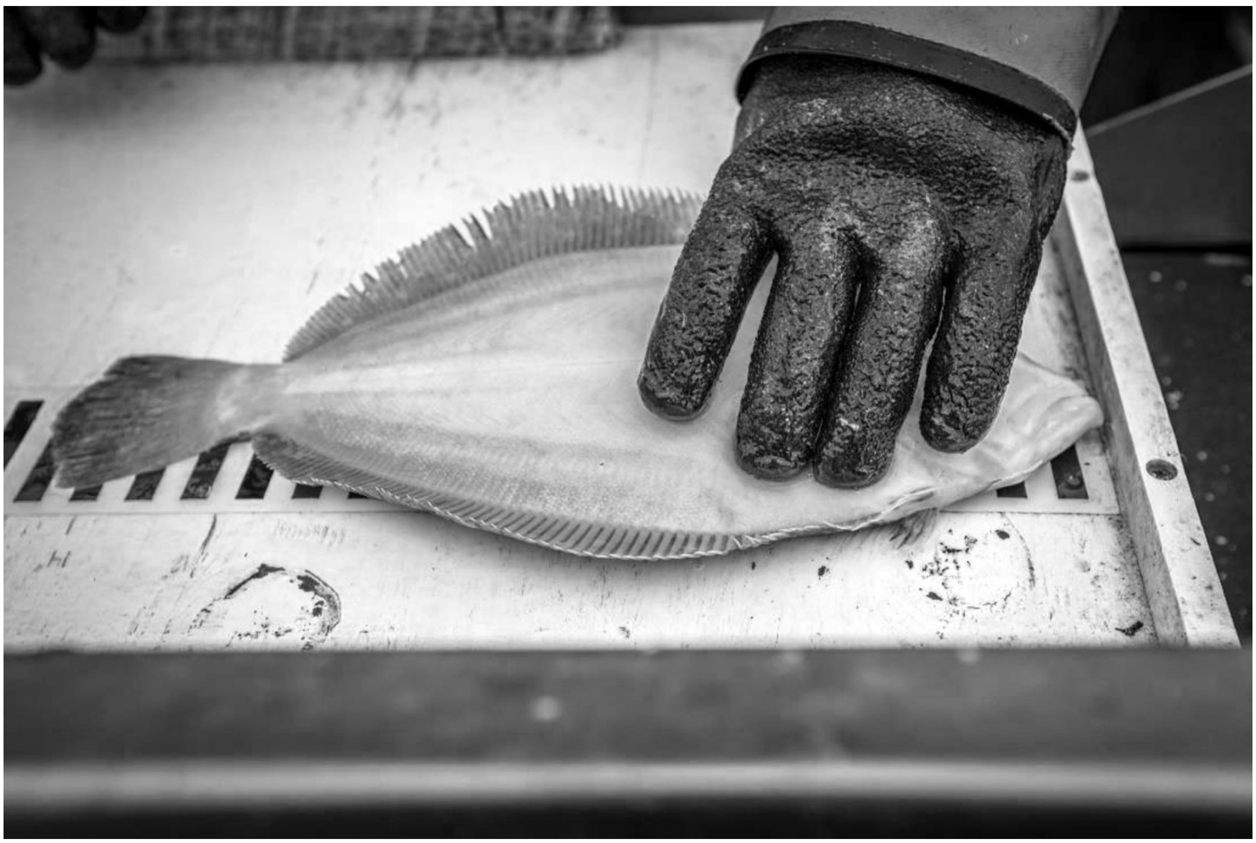

Figure 1: *Video footage of a vessel crew member measuring discarded fish (image courtesy of Teem Fish Monitoring)*

There will eventually be two EM options available to fishers who choose EM in place of taking human at-sea monitors or observers on every trip – the audit and maximized retention models. Under the audit model, crew members record the estimated size of all discarded fish under the surveillance of video cameras while at sea (Figure 1). The audit model samples a portion of the trips for review, but fishers do not know which trips are being monitored as the cameras must remain on for all trips. Under the maximized retention, suitable for high-volume vessels, captains retain and land all of their catch, and EM-based data are recorded alongside a human monitor who meets the vessel at the dock (NOAA Fisheries 2022b). The maximized retention model exempts vessels from minimum fish sizes (under minimum fish size limits they must discard fish under a certain size), but the vessels must retain and land everything they catch.

Both EM programs were first pilot tested before being made available by fisheries regulators as an alternative to human observers (NMFS 2021). The purpose of these pilot programs was to demonstrate that EM can be a cost-effective alternative to hosting on-board human observers and can provide the opportunity to identify potential issues, challenges, and unanticipated consequences of surveillance technologies on commercial fishing vessels. A post-report on the projected costs of EM commissioned by the Nature Conservancy estimated that the average per vessel cost for 100% human observer coverage would be $18,495, whereas the average per vessel cost of 100% EM would be $10,631 (The Nature Conservancy 2019). Despite the effectiveness that pilot programs have shown, many fishers have not participated in these programs due to concerns about long-term costs, data privacy issues, and trust issues with organizations backing EM development. These perceived barriers have had the effect of limiting the ability of pilot programs to test EM applications across a more diverse fleet.

Surveillance in Co-Management of Natural Resources

The co-management of natural resources is generally understood as the sharing of power and decision-making responsibility between diverse stakeholders (Berkes, George, and Preston 1991; Carlsson and Berkes 2005; Ostrom 1990). Despite this relatively succinct definition, co-management arrangements take many different forms depending upon the resource under management and the sociocultural context where the resource is managed. In a review of the evolution of co-management, Berkes (2009) identifies several different aspects, or "faces," of co-management that have emerged in theory and practice, such as institution building, problem-solving, innovation, conflict resolution, knowledge generation, and social learning. Power-sharing arrangements typically involve state or government entities sharing some aspects of authority for managing the resource with resource users. These arrangements are common in smaller-scale fisheries in developing countries where resource users utilize traditional ecological knowledge (TEK) of the resource they are harvesting (Berkes 2009; Evans, Cherrett, and Pemsl 2011). Co-management can also serve as a form of conflict resolution between two or more communities competing for the resource (Evans, Cherrett, and Pemsl 2011; Murunga, Partelow, and Breckwoldt 2021; Ostrom 1990).

Governance, institution building, and participatory processes are also central aspects of many co-management arrangements, but other faces of co-management have special relevance to the development of EM for fisheries monitoring. In particular, the various EM pilot projects developed in the build-up to A23 are instances of co-management that manifest from problem solving, innovation, and collective knowledge production. Co-management arrangements in EM have been characterized as institutional innovation that empowers resource users with the ability to influence management by applying situated knowledge (Nielsen et al. 2004). Successfully fostering innovative co-management strategies also enables resource managers and users to respond to complex problems and rapidly deploy experimental solutions (Parlee and Wiber 2014).

In the case of the NEGF, the complexities of sustainable co-management are often framed as a problem of ensuring the "resilience" of the fishery. In the literature, resilience in environmental systems refers to adaptability, the ability of socio-ecological system to respond to stressors and rapid changes in the environment itself and in the decision-making spaces that shape the environment (Berkes, Folke, and Colding 2000; Jepson and Colburn 2013; Pollnac et al. 2006). Critical to a resilient system is that it recognizes and confronts change rather than resisting it. In the context of our study, we frame resilience as the environmental, economic, and social sustainability of the NEGF, its social-ecological system, and its adaptability to changing stocks, markets, and the pressures of climate change. However, rather than providing an a priori framing of resilience to apply to this case study, our definition is based on emergent themes and terms used by our interview subjects. The adoption of EM as a new monitoring tool in the NEGF serves as an example of an experimental management action, initiated by cooperative agreements between resource users and managers, that may either reinforce or replace the old measures that have fallen short of their resiliency objectives.

Across fisheries globally, spaces of surveillance are expanding to the decks of fishing vessels to fulfill full catch documentation. Within these emerging spaces, EM has garnered significant attention as a potentially powerful tool for automating regulatory oversight. Among projects in different countries reviewed by van Helmond et al. (2020), the main objectives for adopting EM center around the need for detailed data about fishing effort and catch accounting. Secondary objectives focus on bycatch reduction of marine mammals and other protected species, such as dolphins, sharks, and turtles (van Helmond et al. 2020). In a review of EM proposals in support of the European Union's Common Fisheries Policy, interviews with fishery managers and regulators revealed widespread agreement that current methods of at-sea and at-port monitoring are ineffective, and that EM is a solution for enforcing landing obligations and improving statutory compliance (Plet-Hansen et al. 2017).

Acts of surveillance require social and technical actors in order for the system to work, and it is through the negotiations of these networked components that surveillance systems are established (Gad and Lauritsen 2009). Many surveillance systems adopt digital tools to fill the roles of collecting data, alongside data infrastructures to organize and manage data. Developing digital surveillance-based monitoring regimes can be an opportunity for diverse stakeholders to engage with new technologies and encourage participation in governance (Albrechtslund and Lauritsen 2013; Blair 2022; Couldry and Powell 2014; Gray 2018). However, they can also proliferate unproductive approaches to natural resource management, as experienced in Myanmar's forest monitoring program (Goldstein and Faxon 2020) and in agricultural supply chains in the Global South (Archer 2021). In these examples, stakeholders become divided on what tools and platforms to adopt based on what they perceive to be the challenge at hand, their historical relationship to data in addressing challenges, and their place within the digital surveillance system (e.g., the surveilled versus the surveillors).

There are additional downsides to techno-centric approaches to monitoring that blur the lines between oversight, security, and privacy. Infrastructures built to collect and manage the data can reinforce existing power structures, particularly when these technologies are promoted and controlled by government agencies and large corporate interests (Toonen and Bush 2020; Drakopulos et al. 2022; Ruppert 2015; Isin and Ruppert 2020). Archer (2021: 293) refers to the "standardizers" of these spaces as those who embrace monitoring technologies with "almost mystical confidence in their efficacy." These views are lodged in deeper sociotechnical imaginaries (Jasanoff and Kim 2013, 2015) where complex problems are seen as solvable with the assistance of sophisticated technological systems—imaginaries that can come into conflict with the realities of making a living off, and living alongside, managed spaces. In Kenya's small-scale tea farming industry, where farmers are seeking sustainable certifications, certification bodies were sold on the idea that GPS and satellite data could be used to track deforestation. This has had serious implications for tea farmers, given that the Mau Forest is both an essential water source and a source of wood for stoves that provide power for tea manufacturing factories (Archer 2021). In this example, tools deployed by standardizers miss the realities of tea farming, despite the surveillors and surveilled having shared objectives.

For fisheries management, surveillance has long been a source of contention linked to the rights-based system of individual fishing quotas. As Drakopulos (2022) notes, the effectiveness of quota systems relies heavily on monitoring and surveillance, which in the US context has historically depended upon the services of human observers. The introduction of EM in recent years has been met with cautious optimism. EM has generally been proven in pilot programs to be a cost-effective alternative to human observers, a suitable tool for a broad range of vessels, and an approach to monitoring that allows for independent data verification and industry self-reporting practices. Nevertheless, large-scale implementations remain limited due, in part, to conversations that emerge around the persistent unknowns of digital surveillance.

Unsurprisingly, fishers are suspicious of regulatory overreach and have concerns about privacy and confidentiality issues in how data get used (Bradley et al. 2019; Mangi et al. 2015). EM can be deployed not only as a tool for monitoring but also as a technology of control. For fishers, EM has the potential to alter not just workplace environments but also the decks of vessels that are historically considered part of the private domain of fishing life (Clemens 2020). Yet, a proven solution to addressing these concerns, and ensuring higher rates of acceptance from the fishing industry, is to adopt participatory, co-produced digital surveillance models, where EM is situated as an opportunity rather than a threat to fishers' livelihoods (Stanley et al. 2015; van Helmond et al. 2020).

Research Methods

We conducted semi-structured interviews from April to July, 2020, with twenty-six Northeast commercial groundfish fishery stakeholders, including representatives from three environmental NGOs (ENGO), ten from the fishing industry (FI), four from EM service provider companies (EMSP), six from federal governmental agencies (GOV), one from a community non-profit organization (CNPO), and two academic researchers (ACAD). In some instances, interviewees cut across these categories. Interviewees were selected based on prior social network analysis conducted by the researchers in mapping the structure of social media communication networks discussing A23 and EM in the NEGF (Cutler et al. 2022). Due to COVID-19 restrictions on in-person fieldwork, interviews were conducted online via Zoom video conferencing.

The first portion of the interview addressed study participants' positions on the development and implementation of A23. Questions asked included: "Do you feel there was ample preliminary research data and analysis to support A23?" and "What measures is your organization planning to take to address the monitoring requirements of Amendment 23?" The second portion of the interview sought to identify how stakeholders were working together to make sense of A23. Questions in this section included: "Does your organization participate in any cooperative research that has involved testing EM as a tool for fisheries monitoring and data collection?" The final section of the interview examined study participants' perspectives on the tradeoffs of EM, as well as on issues specific to surveillance. Example questions in this section included: "What do you think explains why some vessel owners are likely to choose EM on their boats, as opposed to human observers?" and "How do you, or the constituents you represent, perceive the presence of EM technologies on vessels?"

Interviews were recorded, transcribed, and analyzed using an inductive approach to coding, which identified sixteen broad topical themes. Table 1 displays the percentage of interview segments coded for each major theme, aggregated by interview participants' stakeholder group affiliations. Governance and implementation challenges emerged as the most prevalent topics identified across all stakeholder groups and were the most often coded topical buckets within ENGO and FI interviews. Appropriate technology (i.e., the introduction or implementation of EM in a way that addressed the issue at the appropriate scope and scale) was the most common theme from EMSP interviews; governance was the most common theme from GOV interviews; fishery value or impacts was most common within the CNPO interview; and implementation was most common within ACAD interviews. The major themes identified by topical buckets often overlapped with each other throughout the interviews. For example, themes related to governance were often raised in conjunction with issues related to monitoring implementation challenges and relationships, and were thus analyzed together. What follows is a description of findings based on analysis of these themes and their intersections.

Study Results

Debating the Magnitude of the Problem

Within and across all stakeholder groups there are differences in opinions on the magnitude of misreporting and illegal discarding in the NEGF, which are perceived by some stakeholders as the primary motivators for A23.[4] Many fishing industry participants commented on how analyses underpinning A23 found the presence of observer bias, and they made the case that historical monitoring data likely did not provide an accurate representation of the health of the fishery. Meanwhile, many non-industry study participants believed that current low levels of monitoring incentivize cheating yet admitted that the magnitude of illegal discarding remains unknown.

	ENGO	FI	EMSP	GOV	CNPO	ACAD
N = Interviews	**3**	**10**	**4**	**6**	**1**	**2**
Futures	8	5	8	5	2	2
Resilience	3	5	2	1	7	5
Appropriate Technology	6	6	9	7	3	8
Surveillance	2	2	3	3	0	1
Governance	13	12	7	13	15	9
Fishery Value or Impact	2	5	3	3	26	4
Monitoring Costs	4	4	3	6	2	4
Trust/Credibility	7	5	5	3	5	6
Communication	6	4	5	5	2	2
Resistance/Skepticism	2	2	4	3	2	2
Machine Learning	1	1	3	1	0	2
Electronic Monitoring	7	8	11	11	2	10
At-Sea Monitoring	1	2	2	2	2	1
Fisheries Monitoring	6	5	4	5	2	5
Implementation	8	10	9	9	2	14
Implementation Challenges	9	11	8	9	5	10
Magnitude of the Problem	3	3	<1	2	4	4
Relationships	6	6	7	5	10	9
Knowledge Gaps/Uncertainty	4	5	7	5	7	3
Values	3	3	3	3	3	2

Table 1: *Percentage of interview segments coded for each major theme, aggregated by interview participants' stakeholder group affiliations*

At the center of many of these reflections, A23 is perceived by many as an immediate reaction to the infamous illegal activities of a New Bedford fishing magnate, Carlos Rafael, that prompted a federal criminal investigation (Farzan 2019). As one fishing industry representative commented, "I think some of the analyses were set to prove a hypothesis that there was some high level of cheating going on in the fishery and, other than one very specific high-profile case, what is the evidence that there is high level of mis-reporting, high level of discards of legal-size fish, high level of mis-reporting stock area?" Those in the fishing industry felt that instead of addressing systemic issues that allowed Rafael to alter catch records in a vertically integrated business operation, the entire industry was condensed into being "bad actors." Alternatively, ENGO and GOV study participants asserted that fishers have told them that they do see pervasive cheating, and they want to level the playing field and improve stock assessments through more accurate data.

These differences of opinion on the magnitude of discarding and misreporting are closely tied to how the resilience of the fishery was portrayed by study participants. It was clear that each stakeholder group prioritized vulnerabilities differently when considering the resilience of the fishery. These concerns were frequently framed in the fishery's complicated history of overfishing and resulting actions to rebuild stocks. Stakeholders in academia noted that incentives for illegal discarding and unreported catch are undermining

[4] The stated purpose and need for Amendment 23 is to "improve the reliability and accountability of catch reporting in the commercial groundfish fishery to ensure there is precise and accurate representation of catch (landings and discards)" (NOAA Fisheries 2022a).

efforts to improve the resilience of the fishery. They believed current monitoring levels to be insufficient to ensure accountability—in catch share systems with a market for tradable quota and inadequate enforcement or monitoring, fishers may cheat as a means to increase their profit. GOV study participants pointed out that 100% monitoring coverage for even a brief period under A23 would enable them to determine whether misreporting has been as pervasive as alleged by some stakeholders and indicated by analyses of bias conducted by the Groundfish PDT leading up to the development of A23. In line with this, ENGO participants emphasized that the analyses underpinning A23 demonstrated a clear problem of biased catch reporting, which would mean the monitoring data used for stock assessment are not representative of the fishery.

However, arguments persist that unreported catch draws attention away from other potential factors, such as how climate change may be impacting stock assessments. Academics interviewed for the study are interested in how EM can increase coverage levels and support the fishery in adapting to change. Resilience from the government standpoint emphasized economic and ecological sustainability in similar ways, where they view EM as a cost-effective and sustainable long-term solution to increased monitoring coverage. Fishing industry representatives also have concerns about the fragility of the NEGF, but they insist that economic stability must be included in conversations about resilience. Most stated that the market price of groundfish species has stayed fairly constant over the last decade, whereas the costs of operating a vessel have increased. Many smaller operators felt that once federal funding runs out for the added cost of subsidizing 100% monitoring coverage, the fishery would no longer be profitable for their vessels.

The CNPO representative similarly highlighted that A23 does not express adequate concerns for how increased monitoring will impact the fishing community. This CNPO representative was especially informative on topics related to social resilience within the fishery. Fishers are at higher risk of health conditions and substance abuse than other industries. These health concerns go beyond the fishers; fishers' families experience stress and other conditions while their loved ones are at sea, sometimes in dangerous conditions. Economic and social resilience are closely linked. The CNPO representative expressed concern that the costs of increased monitoring may add disparate mental health and stress impacts. Exacerbating this stress is the uncertainty of when the financial onus for EM will shift from government funded to industry funded.

Appropriate Technologies of Monitoring

In this study, "appropriate technology" refers to the introduction or implementation of a technology for the purpose of addressing a particular issue or challenge, but in a way that aligns contextually with the scale of the problem, the expertise present amongst stakeholders, and available resources (cf. Bishop 2021). Despite the challenges EM presents, many stakeholders acknowledged the appropriate role that EM could play in achieving accountability, traceability, and transparency within the fishery. ENGO study participants claimed they are largely agnostic to the means of achieving accountability but that, unlike past amendments, A23 challenges the status quo by developing a flexible framework and alternative means of monitoring. Without EM as a tool in the toolbox, ENGOs felt that A23 would not have been received with such optimism by some in the industry, indicating that ENGO stakeholders believe that EM may be a practical solution to providing representative catch data and sufficient accountability in the groundfish fishery.

Similarly, study participants from the fishing industry and academia also suggested that EM will improve the integrity of the monitoring system. Fishing industry representatives noted that they want to both "prove" that they are already accountable and build equity on the water by preventing their peers from successfully cheating. Within the fishing industry, it is believed that only "bad actors" will see EM as a threat due to its implications for improving transparency. EM pushes even those fishing industry respondents who say they are already accountable to be more diligent and thoughtful in their fishing practices and vessel operations. While some fishing industry respondents were optimistic about EM's use for improved stock assessments, there are discrepancies across and within stakeholder groups on whether or not EM data will actually be useful for producing new or improved data informing stock assessments. Instead, fishing industry respondents felt that the intent of EM was largely to confirm logbook data.

Major themes emerged related to EM and its ability to produce "objective" data. Many study participants believed that, unlike human observers, cameras can't be "bribed" and "don't sleep," and present less of a risk of human observers misidentifying or misreporting catch. From this perspective, the fishing industry and scientists will be able to converse around independently collected data. As noted by one study subject, "An improvement over human observers is the ability to go back and review the film again. You get a data sheet, but if there's a question you can go back to the actual event. It's re-creatable, if you will. With a human observer it's a data sheet and an affidavit or a memory." This was echoed by government stakeholders who felt that building trust in the data is a necessary next step to management decisions based on EM. EM service providers also highlighted the importance of advancing the credibility of EM, and suggested that success will come from forming closer working relationships between government agencies, scientists, and fishers.

Despite optimism about the promise of EM among some stakeholders, others across the fishing industry expressed skepticism about EM as the appropriate tool for monitoring. One of the key challenges acknowledged by all stakeholders is how to adapt EM to fit a diverse range of vessels and fishing operations across the groundfish fleet. While data reporting can be standardized, hardware installations need to be customized to vessels based on multiple factors, including the gear used and the on-deck layout of operations for catch handling (Figure 2). Fishing industry representatives pointed out that vessels all have different deck layouts and electrical systems and that EM will need to be finetuned and tweaked through experimentation in real-time when EM programs become operational for the fishery. Moreover—in the case of the audit program in particular—the catch compositions of vessels may vary widely, and species or stock identification may be challenging depending upon the quality and positioning of cameras.

Some argue that fishers are more able to build relationships and establish trust with human observers, whereas they may have less agency over their business when subject to anonymous reviewers examining their data under EM. These arguments reflect more ingrained feelings about how EM may be disruptive to co-management approaches, rather than an appropriate technology compatibility with how working relationships are historically formed on the water. Furthermore, after years of feeling that regulators have not held true to their claims to rebuild the fishery, fishers are wary of whether governance of the fishery will be improved simply from increased data collection. This was reflected in a comment by a fishing industry representative who told us of their colleagues, "they feel like each one of these steps, the practical effect is it's taking more agency away from them to be able to control the future of their business, whether that's for their family or multigenerational businesses." Finally, fishers feel that the true cost of EM, in terms of both hard and soft costs, is unknown at the vessel level. Fishers feel ill-equipped with information to assess cost-benefits in order to make a decision on whether to adopt EM or continue with human observers for their vessel.

Interestingly, we found that across all stakeholder groups, there is tentative interest in advancing EM to an automated process via machine learning (AI) once the current EM program becomes operationalized. In these arguments, AI is seen as more efficient and cost-effective. AI could be used to identify and measure fish, as well as reduce video review time by locating timestamps within a video in which crew or fish are on deck. However, EM service providers acknowledge that AI comes with its own challenges. Because AI performs based on algorithms, many felt that it will take considerable work to build algorithms capable of accounting for the diversity of deck operations. This challenge increases when AI is utilized to identify and measure fish, requiring robust algorithms based on extensive training data sets. For some species that have different management plans, like red and white hake, AI may never be able to accurately identify these two species as it requires viewing the gill rakers for identification and classification (gill rakers are bony structures inside fish that support the gills and aid in filter feeding for tiny prey). Fishing industry stakeholders also expressed concern, noting that any AI algorithms developed for EM should draw upon their professional knowledge. We found it noteworthy that the de-personalization of monitoring that might occur with AI, and the potential for further reductions in interacting with a human monitor, was not seen as an issue in our interviews.

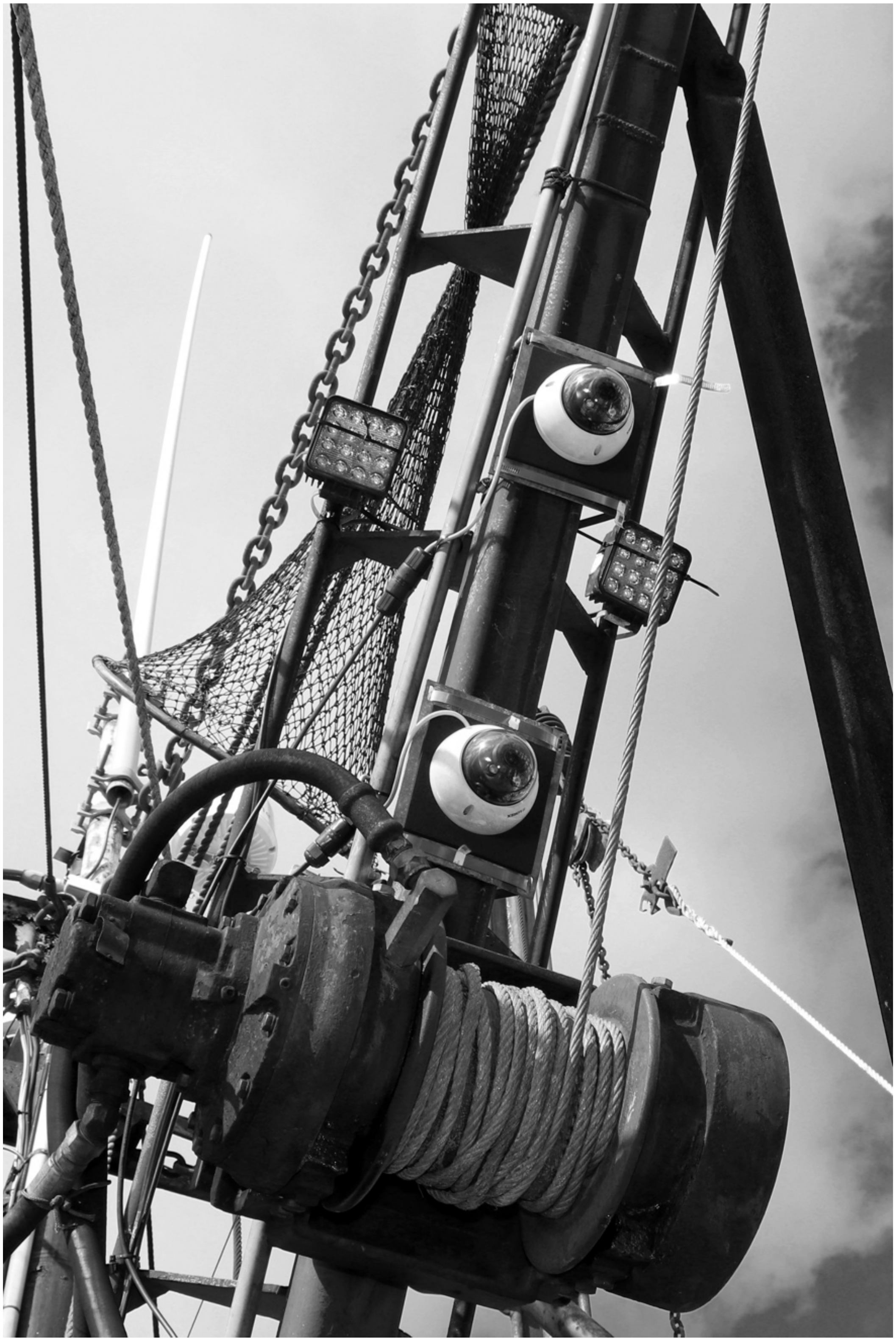

Figure 2: *EM surveillance cameras mounted to a vessel's rigging (image courtesy of Gulf of Maine Research Institute)*

Trust and Resistance to Digital Surveillance

Study participants from the fishing industry raised deep concerns over digital surveillance issues under a 100% monitoring program that utilizes EM technologies. They interpret EM as an intrusion by the fishing industry because they feel that it was imposed on them, rather than developed through co-management approaches. Meanwhile, government and ENGO study participants express uncertainty about what fishers claim to see on the water. They shared stories of fishers describing an abundance of fish, but their assessment reports did not indicate abundance. Government study participants report trying to engage with the fishing industry but being stonewalled with inadequate information or no information at all, limiting their ability to use data for scientific analyses and future cost analyses associated with EM.

Many study participants communicated how these historically eroded relationships of trust have added fuel to the fire of the fishing industry's mounting concerns about information privacy, mission creep, data stewardship, and the overall intentions of A23. Privacy concerns related to EM appear to be amplified by the demographics of those who work in the industry, many of whom prefer the secluded lifestyle of fishing or did not grow up in a digital-heavy age. "There is still that very independent streak… they don't want a camera looking over their shoulder. Granted, cameras are becoming more important, no matter where you go in this day, but still, it's that a lot of these guys are old-school," one sector manager told us.

A23 is also viewed by those in the fishing industry as a program that will be exploited for purposes outside the scope of monitoring. While the vessel is the workplace, it is also the home to the crew while at-sea. Fishers are hesitant and skeptical about a camera capturing footage while off-duty and about who ultimately gains access to this footage. An academic researcher assisting the fishery with EM implementations noted, "having a camera in your living and working space 24/7 that's being watched by multiple people, and some of those people from a managing body, a regulating body, makes folks nervous." Aversion to digital surveillance is further tied to concerns about the ability to fish competitively. Video footage accessed by other vessel owners could compromise strategic business operations and preferred fishing locations. Beyond other vessels, concerns were raised about video footage being obtained and used by activists opposed to commercial fishing.

Study participants from ENGOs, government, and academia are aware of the fishing industry's concerns related to privacy. ENGOs believe that privacy concerns will dissipate once they adopt EM and that the technology will essentially "fade into the background." Government representatives have received comments from some fishers that they feel more privacy with cameras on board because the area under digital surveillance "stops at the deck," unlike a human observer who occupies all areas of a vessel. ENGOs and government representatives are also aware that fishers are nervous about footage of accidental catches of marine mammals being made public and harming their business. For those fishers who are averse to EM, EM service providers suggest that fishers will appreciate the near real-time feedback that EM provides and will, ultimately, be interested in expanding the systems to do more. Meanwhile, government stakeholders believe that monetary incentives may be the most influential means to overcoming privacy concerns and increasing EM adoption.

Discussion

This study fills critical knowledge gaps about the social, economic, and technological challenges faced by a diverse fishing community considering new approaches to the governance of a public resource. In particular, our examination of NEGF stakeholders' perceptions capture the unforeseen challenges of using EM-based surveillance systems for cooperative fisheries management, initiated by a major fishery policy change in A23. Overall, we found in our interviews a consistent desire to move towards better enforcement and monitoring. We also found cautious optimism across stakeholder groups on the potential for EM to be a tool for greater accountability. Government and ENGO representatives describe EM-based monitoring as critical for achieving full accountability in the fishery, which they believe will ultimately build resilience for sustaining fish stocks. Many in the fishing industry concur with these points and, in some instances, NEGF sector managers have proactively worked with vessel owners to implement EM systems and dockside monitoring. These findings have broader implications for surveillance or monitoring in other contexts where a diverse set of stakeholders are engaged, particularly for other natural resource or environmental management issues. The co-production of surveillable space as presented in the cautiously optimistic case of EM for the NEGF could provide a roadmap for conservation-minded surveillance in contexts such as wildlife management (Shrestha and Lapeyre 2018; Adams 2019), "smart farming" in agricultural production (Klauser 2018), or certification processes for labeling products "sustainable" (Archer 2021).

Nevertheless, while most study participants expressed a commitment to collecting high-quality data, A23 itself is perceived by the fishing industry as being developed in the absence of adequate data to support the prescription of significantly expanded monitoring coverage. Those in the industry felt that expediency was chosen over evidence of widespread misreporting. Therefore, the ultimate tension between stakeholder groups is mainly over the amount of surveillance needed given the debate of the magnitude of the underlying misreporting problem. In other words, the surveillable space negotiation rests on "how much" surveillance as opposed to "whether or not" to surveil. It is also clear that stakeholders have differing ideas about how EM may change the daily work environment of the fishing community. While proponents of EM suggest that these systems "can't be bribed" and will support rebuilding the integrity of the NEGF monitoring system, others contend that EM blurs the lines between monitoring a public resource (the ocean) and surveilling the physical spaces of vessels historically considered private by fishers.

These divisions highlight the conflicting sociotechnical imaginaries held by stakeholders on all sides of the EM debate, which serve as persistent sources of resistance to the co-production of surveillable spaces in the NEGF fishery. The debate over whether and how the NEGF fishery should be surveilled is rooted partially in how the fishery is ideologically managed. Following decades of management based on effort controls (i.e., restrictions on time fished and methods used), the NEFMC embraced a broader trend of neoliberal rationalizations of ocean resources in the form of rights-based, tradable, individual fishing quotas and catch shares. NEGF fishers organized loosely into collectives known as sectors and obtained catch entitlements based on the historical landings of their vessels. This approach to management conferred property rights over the NEGF fishery to certain fishing businesses, effectively privatizing a public resource.

It is within this context that the conflicting sociotechnical imaginaries of stakeholders can be better understood. Conservation-minded industry and ENGO respondents held close to the view that despite the catch share system, the NEGF fishery and the ocean writ-large remains a public space and resource that should be monitored for the sustainability of the ecosystem and benefit of all within it—including human communities that utilize it. From this perspective, fishing vessels operating in the NEGF fishery should be considered surveillable spaces warranting higher levels of monitoring mandated by A23. These stakeholders argue EM will provide a technological solution to the problem of increased need for human observers (i.e., staffing shortages, errors in reporting, sleep, etc.). Conversely, other industry respondents viewed increased monitoring, particularly through the looming eyes of ever-present EM cameras, as an infringement on private space and into the conduct of private daily lives within the dynamic living-work spaces aboard commercial fishing vessels. Surveillable space from this perspective must have reasonable boundaries and limitations negotiated through constant dialogue between regulators and industry stakeholders.

Strong residual mistrust within the fishing community, based on the perceived failure of past management actions, has only served to entrench opposition to changes that may come with A23. While most industry stakeholders we interviewed say they could imagine using EM in the future, they also stated that privacy, data ownership, and mission creep concerns must be addressed before they could fully support EM-based monitoring in the fishery. These concerns were often mentioned in concert with the above noted public-private dilemma of rights-based management, privately owned fishing vessels and quotas, and the ocean as a public resource. In the sociotechnical imaginaries of many industry respondents, EM appears as an encroaching nuisance that can only be tolerated if negotiated boundaries are put in place to limit its scope and preserve the confidentiality of private business practices.

Nevertheless, as A23 moves to implementation, many study participants anticipate that the NEGF monitoring program will increasingly rely on EM systems and EM service providers to find success. Conflicting sociotechnical imaginaries of stakeholders could be aligned if regulators and fisheries managers can empower fishing industry stakeholders to apply their situated knowledge and expertise to improve EM systems and their implementation, thus enacting what Nielsen et al. (2004) refer to as "empowering" fisheries co-management. Rather than reinforcing existing power dynamics between fishers, managers, and regulators, wherein fishers routinely disagree with the results of scientific assessments but have little ability to affect outcomes, EM could instead serve to empower fishers by enabling them to validate their lived experiences on the water with granular data.

Conclusion

Participatory management and co-production of knowledge will be particularly important in the context of EM given the contentious nature of surveillance. Archer (2021: 293) notes that "Surveillable spaces are not just spaces that are surveilled but spaces where there is an expectation of surveillance, where non-surveillance (a failure or a refusal to surveil or submit to being surveilled) is seen as irresponsible and unsustainable." In this view, the goals of A23 will be achieved if the fishing industry conforms to their expected roles in accepting the presence of EM on their vessels. However, our findings suggest that fishers are challenging these expectations for reasons not accounted for in A23's development. Fishing industry stakeholders will likely remain hesitant until they feel they have enough details about what EM adoption will mean for their business and way of life. Meanwhile, to those who prescribe to sociotechnical imaginaries where EM is seen as the future of fisheries management (views particularly prominent amongst government agencies and ENGOs), fishers may continue to be seen as "irresponsible" stewards of the fishery if they are unwilling to comply with the surveillance expectations of A23.

To overcome these challenges, our study offers strong evidence that EM-based monitoring will need to be implemented with an expanded menu of options attuned to the needs of a diverse fleet beyond ones currently being considered in the fishery. Cooperative efforts to field test the audit and max retention models leading up to A23 have produced promising results, but there is widespread agreement within the industry that these programs missed opportunities to co-create a technically viable, cost-effective monitoring program—one that draws on the expertise of fishers and increases their autonomy over their vessels and their use of data, as opposed to reducing their agency in management decisions. EM service providers also see themselves as having a role in resolving some of these technical and social concerns, but they feel that regulatory agencies could do more to include them in co-management conversations with vessel owners. By engaging with EM service providers and industry in this way, NEGF regulators may be able to solve persistent trust problems by achieving what Berkes (2009) describes as co-management through innovation, problem-solving, and collective knowledge production. As EM moves into full implementation after the approval of A23, following these developments will be critical to understanding how the limits of what is surveillable will be negotiated between fishers, fisheries scientists, and managers, as well as whether these negotiations will be capable of producing mutually beneficial fisheries management outcomes for a resilient NEGF.

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References

Acheson, James M., and Roy Gardner. 2011. Modeling Disaster: The Failure of the Management of the New England Groundfish Industry. *North American Journal of Fisheries Management* 31 (6): 1005–1018.

Adams, William M. 2019. Geographies of Conservation II: Technology, Surveillance and Conservation by Algorithm. *Progress in Human Geography* 43 (2): 337–350.

Albrechtslund, Anders, and Peter Lauritsen. 2013. Spaces of Everyday Surveillance: Unfolding an Analytical Concept of Participation. *Geoforum* 49 (October): 310–316.

Archer, Matthew. 2021. Imagining Impact in Global Supply Chains: Data-Driven Sustainability and the Production of Surveillable Space. *Surveillance & Society* 19 (3): 282–298.

Berkes, Fikret. 2009. Evolution of Co-Management: Role of Knowledge Generation, Bridging Organizations and Social Learning. *Journal of Environmental Management* 90 (5): 1692–1702.

Berkes, Fikret, Carl Folke, and Johan Colding. 2000. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge, UK: Cambridge University Press.

Berkes, Fikret, Peter George, and Richard J. Preston. 1991. Co-Management: The Evolution in Theory and Practice of the Joint Administration of Living Resources. *Alternatives* 18 (2): 12–18.

Bishop, Catherine P. 2021. Sustainability Lessons from Appropriate Technology. *Current Opinion in Environmental Sustainability* 49: 50–56.

Blair, James J. A. 2022. Tracking Penguins, Sensing Petroleum: "Data Gaps" and the Politics of Marine Ecology in the South Atlantic. *Environment and Planning E: Nature and Space* 5 (1): 60–80.

Bradley, Darcy, Matt Merrifield, Karly M. Miller, Serena Lomonico, Jono R. Wilson, and Mary G. Gleason. 2019. Opportunities to Improve Fisheries Management through Innovative Technology and Advanced Data Systems. *Fish and Fisheries* 20 (3): 564–583.

Carlsson, Lars, and Fikret Berkes. 2005. Co-Management: Concepts and Methodological Implications. *Journal of Environmental Management* 75 (1): 65–76.

Carothers, Courtney, and Catherine Chambers. 2012. Fisheries Privatization and the Remaking of Fishery Systems. *Environment and Society* 3 (1): 39–59.

Clemens, Ryan. 2020. Fisheye Lens: Data Stewardship and Privacy Rights under the Northeast Multispecies Fishery Management Plan's Amendment 23's Proposed Electronic Monitoring. *Vermont Law Review* 45: 323–364.

Cooper, Andrew B. 2006. A Guide to Fisheries Stock Assessment: From Data to Recommendations. Department of Natural Resources University of New Hampshire. https://repository.library.noaa.gov/view/noaa/38414/noaa_38414_DS1.pdf. [accessed August 1, 2022].

Couldry, Nick, and Alison Powell. 2014. Big Data from the Bottom Up. *Big Data & Society* 1 (2): https://doi.org/10.1177/2053951714539277.

Cutler, Matthew, Kirk Jalbert, Katherine Ball, Noa Bruhis, and Teal Guetschow. 2022. Fisheries Co-Management in a Digital Age? An Investigation of Social Media Communications on the Development of Electronic Monitoring for the Northeast U.S. Groundfish Fishery. *Ecology and Society* 27 (3): https://doi.org/10.5751/ES-13474-270313.

Drakopulos, Lauren. 2022. Privatizing the Fisheries Observer Industry: Neoliberal Science and Policy in the U.S. West Coast Fisheries. *Geoforum* 131 (May): 116–125.

Drakopulos, Lauren, Jennifer J. Silver, Eric Nost, Noella Gray, and Roberta Hawkins. 2022. Making Global Oceans Governance in/Visible with Smart Earth: The Case of Global Fishing Watch. *Environment and Planning E: Nature and Space* 6 (2): 1098–1113.

Evans, Louisa, Nia Cherrett, and Diemuth Pemsl. 2011. Assessing the Impact of Fisheries Co-Management Interventions in Developing Countries: A Meta-Analysis. *Journal of Environmental Management* 92 (8): 1938–1949.

Farzan, Antonia N. 2019. The "Codfather" Was a Seafood Kingpin, until Fake Russian Mobsters Took Him Down. Now He'll Never Fish Again. *Washington Post*, August 20. https://www.washingtonpost.com/nation/2019/08/20/codfather-fishing-russian-mobsters-carlos-rafael/ [accessed August 1, 2022].

Gad, Christopher, and Peter Lauritsen. 2009. Situated Surveillance: An Ethnographic Study of Fisheries Inspection in Denmark. *Surveillance & Society* 7 (1): 49–57.

Goldstein, Jenny E, and Hilary Oliva Faxon. 2020. New Data Infrastructures for Environmental Monitoring in Myanmar: Is Digital Transparency Good for Governance? *Environment and Planning E: Nature and Space* 5 (1): 39–59.

Gray, Noella J. 2018. Charted Waters? Tracking the Production of Conservation Territories on the High Seas. *International Social Science Journal* 68 (229–230): 257–272.

Hébert, Karen. 2014. The Matter of Market Devices: Economic Transformation in a Southwest Alaskan Salmon Fishery. *Geoforum* 53 (May): 21–30.

Isin, Engin F., and Evelyn Sharon Ruppert. 2020. *Being Digital Citizens*. 2nd edition. London: Rowman & Littlefield.

Jasanoff, Sheila, and Sang Hyun Kim. 2013. Sociotechnical Imaginaries and National Energy Policies. *Science as Culture* 22 (2): 189–196.

———. 2015. *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*. Chicago, IL: University of Chicago Press.

Jepson, Michael, and Lisa L. Colburn. 2013. Development of Social Indicators of Fishing Community Vulnerability and Resilience in the U.S. Southeast and Northeast Regions. *NOAA Technical Memorandum NMFS-F/SPO-129*, April, 1–72. Washington, DC: U.S. Department of Commerce.

King, Dennis M., and Jon G. Sutinen. 2010. Rational Noncompliance and the Liquidation of Northeast Groundfish Resources. *Marine Policy* 34 (1): 7–21.

Klauser, Francisco. 2018. Research Surveillance Farm: Towards a Research Agenda Notes on Big Data Agriculture. *Surveillance & Society* 16 (3): 370–378.

Mangi, Stephen C., Paul J. Dolder, Thomas L. Catchpole, Dale Rodmell, and Nathan de Rozarieux. 2015. Approaches to Fully Documented Fisheries: Practical Issues and Stakeholder Perceptions. *Fish and Fisheries* 16 (3): 426–452.

Melnychuk, Michael C., Hiroyuki Kurota, Pamela M. Mace, Maite Pons, Cóilín Minto, Giacomo Chato Osio, Olaf P. Jensen, et al. 2021. Identifying Management Actions That Promote Sustainable Fisheries. *Nature Sustainability* 4 (5): 440–449.

Murunga, Michael, Stefan Partelow, and Annette Breckwoldt. 2021. Drivers of Collective Action and Role of Conflict in Kenyan Fisheries Co-Management. *World Development* 141 (May): https://doi.org/10.1016/j.worlddev.2021.105413.

Nature Conservancy, The. 2019. Projected Cost of Providing Electronic Monitoring to 100 Vessels in New England's Groundfish Fishery. https://em4.fish/wp-content/uploads/2019/04/TNC-EM-Cost-Assessment-Report-Submission-to-NEFMC-4_10_19.clean_-1.pdf [accessed August 1, 2022].

NEFMC. 2019. Scientific and Statistical Committee Sub-Panel Peer Review Report for the Groundfish Plan Development Team Analyses of Groundfish Monitoring. New England Fisheries Management Council. https://s3.us-east-1.amazonaws.com/nefmc.org/4.-190513_SSC_Sub_Panel_Peer-Review-Report_OEMethods_FINAL.pdf [accessed August 1, 2022].

———. 2022. Amendment 23 Final Environmental Impact Statement (FEIS) Volume I – Final Submission. https://www.nefmc.org/library/amendment-23 [accessed August 1, 2022].

NEFMC, and NMFS. 2009. *Amendment 16 To the Northeast Multispecies Fishery Management Plan Including a Draft Environmental Impact Statement and an Initial Regulatory Flexibility Analysis*. C.F.R. § 648.87. Vol. 50. http://archive.nefmc.org/nemulti/planamen/Amend_16/final_amendment_16/091016_Final_Amendment_16.pdf. [accessed August 1, 2022].

Nielsen, Jesper Raakjær, Poul Degnbol, K.Kuperan Viswanathan, Mahfuzuddin Ahmed, Mafaniso Hara, and Nik Mustapha Raja Abdullah. 2004. Fisheries Co-Management—An Institutional Innovation? Lessons from South East Asia and Southern Africa. *Marine Policy* 28 (2): 151–160.

NMFS. 2021. Greater Atlantic Regional Fisheries Office and Northeast Fisheries Science Center Electronic Technologies Implementation Plan. National Oceanic and Atmospheric Administration. https://media.fisheries.noaa.gov/2021-08/GARFO%20and%20NEFSC%20ETIP_080621_0.pdf [accessed August 1, 2022].

NOAA. 2019. Glossary: Catch Shares. NOAA Fisheries, July 18. https://www.fisheries.noaa.gov/national/sustainable-fisheries/glossary-catch-shares [accessed February 7, 2023].

NOAA Fisheries. 2018. Using Observer Data. December 13. https://www.fisheries.noaa.gov/national/fisheries-observers/using-observer-data [accessed August 1, 2022].

———. 2021. Northeast Fisheries Observer Program. August 26. https://www.fisheries.noaa.gov/new-england-mid-atlantic/fisheries-observers/northeast-fisheries-observer-program [accessed August 1, 2022].

———. 2022a. Northeast Multispecies Amendment 23 Implementation Outreach Events. April 22. https://www.fisheries.noaa.gov/event/northeast-multispecies-amendment-23-implementation-outreach-events [accessed August 1, 2022].

———. 2022b. Electronic Monitoring in the Northeast. May 12. https://www.fisheries.noaa.gov/new-england-mid-atlantic/commercial-fishing/electronic-monitoring-northeast [accessed August 1, 2022].

Olson, Julia. 2011. Understanding and Contextualizing Social Impacts from the Privatization of Fisheries: An Overview. *Ocean & Coastal Management* 54 (5): 353–363.

Ostrom, Elinor. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge, UK: Cambridge University Press.

Parlee, Courtenay E, and Melanie G Wiber. 2014. Institutional Innovation in Fisheries Governance: Adaptive Co-Management in Situations of Legal Pluralism. *Current Opinion in Environmental Sustainability* 11 (December): 48–54.

Plet-Hansen, Kristian S., Søren Q. Eliasen, Lars O. Mortensen, Heiðrikur Bergsson, Hans J. Olesen, and Clara Ulrich. 2017. Remote Electronic Monitoring and the Landing Obligation – Some Insights into Fishers' and Fishery Inspectors' Opinions. *Marine Policy* 76 (February): 98–106.

Pollnac, Richard B., Susan Abbott-Jamieson, Courtland Smith, Marc L. Miller, Patricia M. Clay, and Bryan Oles. 2006. Toward a Model for Fisheries Social Impact Assessment. *Marine Fisheries Review* 19: 1–18.

Ruppert, Evelyn. 2015. Doing the Transparent State: Open Government Data as Performance Indicators. In *The World of Indicators: The Making of Governmental Knowledge Through Quantification*, edited by Richard Rottenburg, Sally E. Merry, Sung-Joon Park, and Johanna Mugler, 127–150. Cambridge, UK: Cambridge University Press.

Ruppert, Evelyn, Engin Isin, and Didier Bigo. 2017. Data Politics. *Big Data & Society* 4 (2): https://doi.org/10.1177/2053951717717749.

Shrestha, Yashaswi, and Renaud Lapeyre. 2018. Modern Wildlife Monitoring Technologies: Conservationists versus Communities? A Case Study: The Terai-Arc Landscape, Nepal. *Conservation and Society* 16 (1): 91–101.

Stanley, Richard D., Tameezan Karim, John Koolman, and Howard McElderry. 2015. Design and Implementation of Electronic Monitoring in the British Columbia Groundfish Hook and Line Fishery: A Retrospective View of the Ingredients of Success. *ICES Journal of Marine Science* 72 (4): 1230–1236.

Sun, Chin-Hwa Jenny, and Leah Fine. 2016. A Cost-Effective Discards-Proportional at-Sea Monitoring Allocation Scheme for the Groundfish Fishery in New England. *Marine Policy* 66 (April): 75–82.

Toonen, Hilde M., and Simon R. Bush. 2020. The Digital Frontiers of Fisheries Governance: Fish Attraction Devices, Drones and Satellites. *Journal of Environmental Policy & Planning* 22 (1): 125–137.

van Helmond, Aloysius T.M., Lars O. Mortensen, Kristian S. Plet-Hansen, Clara Ulrich, Coby L. Needle, Daniel Oesterwind, Lotte Kindt-Larsen, et al. 2020. Electronic Monitoring in Fisheries: Lessons from Global Experiences and Future Opportunities. *Fish and Fisheries* 21 (1): 162–189.