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Monitoring, control and surveillance of future high seas MPAs: what role for emerging technologies?

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After years of scientific debates, legal controversies and political wrangling, States have concluded an agreement on the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction (ABNJ). This treaty establishes a mechanism for creating area-based management tools (ABMTs), including marine protected areas (MPAs) in areas beyond national jurisdiction (ABNJ).[1] This mechanism was missing until now and will facilitate the implementation of the 30x30 target adopted under the Convention on Biological Diversity's (CBD) 2023 Kunming-Montreal Global Biodiversity Framework.

A key condition to ensure the success of future high seas MPAs is to develop effective monitoring, control, and surveillance (MCS) of human activities. To this end, diverse actors provide a wide range of emerging technologies and services, offering cost-effective and accessible methods for conducting MCS activities on the high seas. Under what conditions can these tools be effective? What technical and political measures need to accompany them? This *Study* aims to provide insights and recommendations to stakeholders developing high seas MPA proposals. It draws on lessons learned from existing experiences with MPAs and of high seas governance.

[1] For ease of reading, this document will use the term "High Seas MPAs" to designate those areas, which can be established both on the high seas, i.e. the water column beyond the exclusive economic zones, and on the seabed beyond the continental shelves of coastal States, formally known as "the Area".

KEY MESSAGES

Over the last decade, there has been a rapid increase and spread of innovative MCS technologies, driven by falling prices and open access to satellite data, and greater investment in artificial intelligence, big data solutions, cloud computing, and skilled human resources.

These technological tools, provided by companies and non-profit organizations, can bring a significant added value to the implementation of management plans of future high seas MPAs, by optimizing resource allocation and providing near real-time insights into suspected illegal activities at sea.

However, technology alone will not be enough. Supporting policy and technical measures—such as addressing capacity gaps, fostering cooperation for maritime patrols, strengthening port State controls, reforming national judicial systems, and ensuring effective information sharing—will be essential to operationalize technology and ensure the effective management of future high seas MPAs.

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1. INTRODUCTION

On March 4, 2023, at the United Nations headquarters in New York, following years of negotiations and after a final "marathon" session, Rena Lee, the President of the Intergovernmental Conference, declared with relief: "The ship has reached the shore". The international community then celebrated a treaty that could legitimately be described as historic in terms of its scope–half of the planet–the length of time it took to draw up–more than fifteen years, including the first informal UN discussions–and the troubled geopolitical context from which it emerged. Since then, and as of October 8, 103 States have signed the Agreement, 13 States have ratified it, and the entire ocean community is currently mobilizing to prepare for its future implementation.[2]

Part III of the BBNJ Agreement establishes a mechanism for creating area-based management tools (ABMTs), including marine protected areas (MPAs) in areas beyond national jurisdiction (ABNJ). It specifies that States Parties, individually or collectively, may submit MPA proposals to the BBNJ Secretariat. The Scientific and Technical Body (STB) will then evaluate these proposals. After a broad consultation phase, the Conference of the Parties (CoP) will decide whether to adopt the proposal, ideally by consensus but with the possibility of a ¾ majority vote. The BBNJ Agreement provides a list of what Parties have to include in their MPA proposals. One of these elements is "a draft management plan encompassing the proposed measures and outlining proposed monitoring, research and review activities to achieve the specified objectives".[3]

One of the challenges to implementing high seas MPAs will be to ensure there is effective monitoring, control, and surveillance (MCS) of human activities, a key enabling condition to avoid "paper parks". MCS encompasses "a wide range of tools, technologies and policies that can be used in a variety of contexts to promote compliance, increase transparency and contribute to the conservation and sustainable use of marine resources".[4] Some of the MCS and enforcement challenges for high seas MPAs are likely to be similar to remote and large-scale MPAs where authorities also face difficulties in obtaining data and conducting monitoring and enforcement activities.[5] However, these challenges will be more significant on the high seas, given the specific nature of this area and the coordination issues involved in managing it.

In this respect, when asked how the international community will keep an eye on future high seas MPAs, many stakeholders suggest that satellite technology and artificial intelligence (AI) will play a key role in providing the solution. There is indeed an increasingly wide range of technological tools and technology providers playing a role in MCS activities (2) and these new tools and services will bring a significant added value to the implementation of management plans of future high seas MPAs (3). However, this *Study* argues that MCS on high seas MPAs can only be effective if accompanied by complementary measures (4).

2. AN INCREASINGLY WIDE RANGE OF TECHNOLOGICAL TOOLS AND TECHNOLOGY PROVIDERS INNOVATING MCS

In the last decade, traditional approaches to MCS such as onboard observers, logbooks and surveillance vessels and aircrafts, have been supplemented by a range of new technological tools such as satellite technology and artificial intelligence (2.1) that are provided by a variety of actors (2.2).

1.1. Emerging technologies expanding the MCS toolkit

For decades, the MCS of human activities at sea has been a central pillar of maritime policies, whether for defence purposes or to fight against maritime crime. In the context of the conservation and sustainable use of marine biological resources, traditional MCS tools, such as onboard observers, logbooks and surveillance vessels and aircrafts, have progressively been supplemented by the use of technologies, such as electronic recording and reporting services, satellites, remote sensing, analytical software and algorithms, electronic monitoring systems and drones. **Table 1** below provides a non-exhaustive overview of traditional and technological MCS tools, and their advantages and limitations for the future management of high seas MPAs.

[2] https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXI-10&chapter=21&clang=_en

[3] BBNJ Agreement, Article 19(f).

[4] Cremers, K. *et al*. (2020). Strengthening monitoring, control and surveillance of human activities in marine areas beyond national jurisdiction: Challenges and opportunities for an international legally binding instrument. *Marine Policy*, Volume 122.

[5] Appleby, T. *et al*. (2021). Sea of possibilities: Old and new uses of remote sensing data for the enforcement of the Ascension Island marine protected area. *Marine Policy*, Volume 127.

TABLE 1. **A non-exhaustive overview of MCS tools, their benefits and limitations for high seas MPAs**

TRADITIONAL MCS TOOLS			
Tool	Description	Main benefits	Main limitations
Aerial & vessel manned surveillance	Aircrafts or vessels occupied and operated by humans for MCS operations at sea.	High deterrence; compliance officers onboard can cross-check reported information; accepted as proof in court; interruption of ongoing illegal activity; possibility to take immediate action.	Can be expensive for States without patrol vessels; risky for human life; significant human resources required; limited jurisdiction of patrol vessels in ABNJ; low detection rate of infringements if not combined with risk assessments or previous detection of suspicious activities (rerouting patrols).[6]
Observer programmes	Most observer programmes have been established to document data and information for scientific purposes, but some allow for independent human presence on fishing vessels to document non-compliance with regulatory requirements.	Can be done through joint operations organized by States on the high seas; live cross-checking of reported data.	Observers do not have enforcement power; risk to their integrity and safety; risk of bribes; vessels do not always have the conditions to host onboard observers; expensive as vessels stay for long periods of time on the water; number of observers is too small compared to the number of operating fishing vessels.

TECHNOLOGICAL MCS TOOLS			
Tool	Description	Main benefits	Main limitations
Electronic recording and reporting services (ERS)[7]	A digital platform or a set of digital tools designed to collect, store, manage, and analyze data electronically.	Provides independent reporting verification; less time-consuming to fill in than paper-based logbooks; easier to cross-reference with data coming from other tools.	High costs of training, equipment, and technological infrastructure; self-reporting, misreporting and non-reporting; digital data is often confidential.
Automatic identification systems (AIS)[8]	Satellite systems that transmit a vessel's position to alert other ships to avoid collisions and for search and rescue actions.	Publicly available; can be used to identify ships suspected of criminal activities; signals are sent automatically.	Risk of tampering; can be turned off; confidentiality and safety concerns; not used by all vessels.
Vessel monitoring systems (VMS)[9]	Satellite surveillance tool for fishing vessels providing information on their position and activity.	Admissible as evidence in several courts; more difficult to tamper with compared to AIS.[10]	Expensive for small fleets; no global regulation or standard; data is reported once every 1 to 4 hours;[11] VMS data is subject to legal and confidentiality constraints and the flag State does not have to share the data with other stakeholders.[12]
Satellite imagery	Pictures and data collected by imaging satellites orbiting the Earth.	High-resolution technology can be used to identify smaller vessels; the combination with AI software enhances analysis of satellite imagery data.[13]	Since satellite image data is large, it often requires a combination with other tools or AI, algorithms and software for data analysis;[14] not admissible as evidence in several courts.

6 Logan, R. K. *et al.* (2020). Sleuthing with Sound: Understanding Vessel Activity in Marine Protected Areas Using Passive Acoustic Monitoring. Mar*ine Policy*, Volume 120.

7 Traditionally, logbooks and other reporting equipment have been paper-based. ERS can be combined with paper-based reporting tools. As exemplified in Table 2, most MCS activities that rely on digital tools often include a paper-based minimum requirement in case the electronic system malfunctions.

8 Global Fishing Watch (GFW). What is AIS? Retrieved August 1, 2024, from https://globalfishingwatch.org/faqs/what-is-ais/.

9 Food and Agriculture Organization (FAO). Fishing Vessel Monitoring Systems (VMS). Retrieved August 2, 2024, from https://www.fao.org/figis/pdf/fishery/vms/en?title=FAO%20Fisheries%20%26amp%3B%20Aquaculture%20-%20Fishing%20Vessel%20Monitoring%20Systems%20.

10 Appleby, T. *et al*. (2021). Sea of Possibilities: Old and new uses of remote sensing data for the enforcement of the Ascension Island marine protected area. *Marine Policy*, Volume 127.

11 Depending on gear, data storage and management capacity of the regulatory body.

12 Ewell, C. *et al*. (2017). Potential ecological and social benefits of a moratorium on transshipment on the high seas. Marine *Policy*, Volume 81.

13 Beukema, P. *et al.* (submitted on December 6, 2023) Satellite Imagery and AI: A New Era in Ocean Conservation, from Research to Deployment and Impact. *NeurIPS Computational Sustainability 2023*, http://arxiv.org/abs/2312.03207.

14 Rolf, E. *et al*. (2021). A Generalizable and Accessible Approach to Machine Learning with Global Satellite Imagery. *Nature Communications*, Volume 12; Beukema, P. *et al*., *ibid*; Hay, G.J. *et al*. (2005). An Automated Object-Based Approach for the Multiscale Image Segmentation of Forest Scenes. *International Journal of Applied Earth Observation and Geoinformation*, Volume 7.

TECHNOLOGICAL MCS TOOLS			
Tool	Description	Main benefits	Main limitations
Remote sensing i.e. Satellite Synthetic Aperture Radar (SAR)[15] and Visible Infrared Imaging Radiometer Suite (VIIRS)[16]	Identification of objects from a distance by satellite[17] either by using radar to detect objects (SAR) or detecting light emitted by vessels (VIIRS).	Ensures the detection of vessels up to a size of 10–15 m that are not using or transmitting AIS or VMS data;[18] SAR can operate in any weather condition; VIIRS is particularly efficient at capturing images at night.[19]	Requires significant financial and human resources for data access, storage and analysis; accessing the data can take several days; global coverage is not available on a daily basis[20]; some images may lack the necessary quality to fully identify vessels or determine their actual activity at sea.[21]
Long-Range Identification and Tracking (LRIT) system[22]	System mandated by the International Maritime Organization (IMO) to enhance the security and safety of shipping and marine environments by tracking the movements of ships through the Global Navigation Satellite System (GNSS).	States may request the position of a vessel at the frequency of 6-hour intervals or higher.[23]	While AIS only requires vessels to turn the receiver on, LRIT requires active participation by the vessel owner;[24] data is not publicly available.
Analytical software i.e., "Big Data", cloud computing, machine learning and Geographic Information Systems (GIS)	Computer programs and tools designed to analyze data, extract meaningful insights, and support decision-making processes.	Optimizes MCS services leading to targeted interventions, thereby saving time and effort that would otherwise be used on manual operations.[25]	Human resources required to operate analytical software are highly qualified and can be costly.
Unmanned vehicles (UVs) i.e., drones (unmanned surface vehicles (USV), unmanned underwater vehicles (UUV) and remotely operated vehicles (ROV))	Aircrafts or vessels that are pre-programmed or operated remotely by humans.	More cost-effective than manned patrols; does not expose staff to high-risk areas; discretion; conducts more extensive surveillance; covers long distances for extensive periods.	The initial investment can be expensive if the conception and creation of the vehicle are not internalized; for data collection purposes only: if the vehicle intercepts illegal or suspected activity, then no immediate follow-up action is possible on the water.
Electronic monitoring systems (EMS) i.e., closed-circuit television (CCTV) cameras[26]	Electronic devices that record or give a live view of onboard activities. The captured photos or videos are then reviewed and analyzed during or after vessel activities at sea through artificial and/or human intelligence.	Can be used to identify and record non-compliant behaviour; serves as a deterrent; images can be used in court; less expensive and less dangerous than onboard observers.	Reluctance due to privacy considerations; cameras can easily get dirty, covered or not focus on the right target; big quantities of data to analyze.

15 SAR is an active satellite-based remote sensing technology that creates high-resolution images of the Earth's surface.

16 VIIRS is a type of passive satellite-based remote sensing designed to detect nighttime lights, such as artificial illumination from fishing boats.

17 Remote sensing usually occurs through satellite imagery but can also be done using aircraft. Emphasis should be placed on being "remote" from the object trying to be identified. See Earthdata. What is Remote Sensing? Retrieved August 3, 2024, from https://www.earthdata.nasa.gov/learn/backgrounders/remote-sensing.

18 Reggiannini, M. *et al*. Remote Sensing for Maritime Traffic Understanding. *Remote Sensing*, Volume 16; Paolo, F.S. *et al*. Satellite Mapping Reveals Extensive Industrial Activity at Sea. *Nature*, Volume 626.

19 Li, Y. *et al*. Nighttime Fishing Vessel Observation in Bohai Sea Based on VIIRS Fishing Vessel Detection Product (VBD). *Fisheries Research*, Volume 258.

20 Elvidge, C. June 8, 2018. Identification of 'dark vessels'. GFW. Retrieved August 4, 2024, from https://globalfishingwatch.org/research/viirs/.

21 Appleby, T. *et al*. Sea of Possibilities: Old and New Uses of Remote Sensing Data for the Enforcement of the Ascension Island Marine Protected Area. *Marine Policy*, Volume 127.

22 IMO. Long-Range Identification and Tracking (LRIT). Retrieved July 23, 2024, from https://www.imo.org/en/OurWork/Safety/Pages/LRIT.aspx.

23 While the IMO has set a standard of 6-hour intervals for all shipping vessels bearing a LRIT system, States can request the position of a vessel at a higher frequency: See: https://www.imo.org/en/OurWork/Safety/Pages/LRIT.aspx.

24 "Active participation" means that vessel managers have to manually send signals of their position to the relevant authorities. See: https://www.dgshipping.gov.in/Content/LRITNationalDataCentre.aspx

25 For instance, MCS officers can use AI to conduct data analysis on areas in the high seas to predict where illegal, unreported and unregulated (IUU) fishing is most likely to occur. Authorities can then prioritize these areas for MCS activities, making those more targeted and more cost-effective.

26 Observer programmes can be considered a traditional tool and are often complementary to EMS.

While the MCS toolkit is growing rapidly, there is no 'one size fits all' approach to MCS. Rather, there are a range of factors that need to be considered when evaluating the suitability of a particular MCS action, including: purpose, costs, access, reliability, coverage, ease of manipulation and privacy.[27] **Table 2** provides examples of MCS tools used in existing high seas MPAs established by States Parties to CCAMLR and OSPAR/the North-East Atlantic Fisheries Commission (NEAFC).[28]

TABLE 2. MCS tools used to manage fisheries in high seas MPAs in the NEAFC and CCAMLR Convention Areas

TOOL	NEAFC	CCAMLR
Electronic Reporting System (ERS)	All contracting Parties use ERS including both digitized and paper-based logbooks. All Parties have access to NEAFC's ERS User Interface and can see all fishing activity information reported.[29]	All vessels operating in the CCAMLR area are obliged to use standardized ERS including both digitized and paper-based logbooks. The ERS is tailored to specific fisheries.[30]
Vessel monitoring systems (VMS)	Centralized VMS reporting every hour from the vessel to the Fisheries Monitoring Centre (FMC) then directly and immediately to the NEAFC Secretariat.[31]	Centralized VMS reporting every hour from the vessel to the FMC which must be forwarded to the CCAMLR Secretariat. Vessels may additionally transmit directly to the Secretariat.[32]
Remote sensing (RS)	RS can be used to verify VMS compliance.[33]	Synthetic-aperture radar (SAR)[34] has been trialled[35] and implemented on a needs basis in response to illegal, unreported and unregulated (IUU) fishing activities. Other RS solutions have been investigated as research tools.[36]
Observer programmes	Observers are required to collect scientific data on all exploratory vessels carrying out bottom sea research.[37] While NEAFC has no requirement for observers onboard of every vessel, each State may have its own observer programme.	All vessels are required to have a scientific observer onboard.[38]
Electronic monitoring systems (EMS)	No common standards. Each State party may have its own EMS requirements.	There are no mandatory EMS requirements, however, some discussions are taking place.[39]
Manned surveillance	States Parties conduct joint patrols and inspections at sea, whereby inspectors from a contracting party can board another party's vessels.	States Parties conduct aerial and at-sea joint patrols under the CCAMLR System of Inspection.[40]

[27] Cremers, K. *et al*. (2020). Strengthening monitoring, control and surveillance of human activities in marine areas beyond national jurisdiction: Challenges and opportunities for an international legally binding instrument. *Marine Policy*, Volume 122.

[28] NEAFC designated part of OSPAR's MPAs as "Vulnerable Marine Ecosystems" where fishing is banned. MCS of fishing activities is being run by NEAFC.

[29] Since early 2000, NEAFC has used the NAF (North Atlantic Format) format for exchange of fishing activity information. This includes vessels positions, catch on entry, daily or weekly catch reports, catch on exit, transhipment reports etc. Since 2023 or 2024, all NEAFC's Contracting Parties have access to NEAFC's ERS User Interface and can see all fishing activity information reported. Following some changes, NEAFC is undergoing a transition where only the EU fleets use the UN FLUX standard while other Parties have 2 years from March 2024 to implement the FLUX standard.

[30] CCAMLR Conservation Measures 23-01, 23-02, 23-03, 23-04, 23-06, and 23-07.

[31] NEAFC. NEAFC Scheme of Control and Enforcement. See: https://www.neafc.org/mcs/scheme.

[32] CCAMLR Conservation Measures 23-01, 23-02, 23-03, 23-04, 23-06, and 23-07.

[33] NEAFC does not set any requirement for remote sensing. States Parties and FMCs are encouraged to "use various methods for providing the Geographical Position of a vessel" before reporting to the Secretariat (See NEAFC Scheme of Control and Enforcement, 2024 and https://faolex.fao.org/docs/pdf/mul190964.pdf page 98).

[34] SAR is an active satellite-based remote sensing technology that creates high-resolution images of the Earth's surface.

[35] CCAMLR. CCAMLR Satellite Overwatch Report (Decision of the Thirty-Seventh Meeting of the Commission, Paragraph 3.8). Retrieved August 12, 2024, from https://meetings.ccamlr.org/en/ccamlr-38/bg/06.

[36] Ibid.

[37] NEAFC. Submission by the North-East Atlantic Fisheries Commission: To the report of the Secretary-General of the United Nations on the actions of States and regional fisheries management organizations and arrangements addressing the impacts of bottom fishing on vulnerable marine ecosystems and the long-term sustainability of the deep sea fish stocks. Retrieved August 12, 2024, from https://www.un.org/Depts/los/bfw/NEAFC__2022.pdf.

[38] Each vessel operating in the convention area must have at least one observer designated under the terms of the Scheme of International Scientific Observation. All observers must be nationals of a CCAMLR Member State and can be placed onboard the fishing vessels of another CCAMLR Member once a bilateral arrangement between Members is agreed. See: CCAMLR. Text of the CCAMLR Scheme of International Scientific Observation. Retrieved August 13, 2024, from https://www.ccamlr.org/en/system/files/e-pt10_4.pdf.

[39] CCAMLR. The Application of Electronic Monitoring in CCAMLR Fisheries. Retrieved July 15, 2024, https://meetings.ccamlr.org/en/sc-camlr-41/bg/32.

[40] CCAMLR. Aerial Surveillance Patrols Undertaken by New Zealand during the 2020/2021 Ross Sea CCAMLR Season. Retrieved July 15, 2024, https://meetings.ccamlr.org/en/ccamlr-40/bg/22; CCAMLR. The Bilateral Cooperation between France and Australia in the Southern Ocean. Retrieved July 17, 2024, https://meetings.ccamlr.org/en/ccamlr-xxx/bg/09; CCAMLR. CCAMLR System of Inspection. Retrieved August 12, 2024, from https://www.ccamlr.org/en/document/publications/text-ccamlr-system-inspection.

1.2. A diversity of actors providing technologies

Beyond national administrations, non-State actors play an increasing role in providing MCS tools and data, conducting analyses and developing capacity-building and transfer of marine technology. These actors–which include private companies, non-profit organizations and initiatives and networks–are instrumental in visualizing what is going on in the ocean[41] and can support States and international bodies to properly manage future High Seas MPAs.

Private companies

Over the last decade, there has been a rapid increase and spread of innovative MCS technologies, supported by private companies. This trend, coupled with falling prices and open access to satellite technology, has led to more resources being dedicated to artificial intelligence, big data solutions, cloud computing, and skilled human resources. The extent to which a State or an intergovernmental organization collaborates with a private actor depends on its capacity needs and the cost of the additional tools and services. Despite the presence of national private companies, some States prefer to develop their own technology. Others might work closely with the industry and research sectors to develop solutions that suit their needs.

Public administrations, usually after a call for tender, can subscribe to services or purchase tools from private companies. For instance, after receiving a yellow card from the European Commission,[42] Ecuador has chosen to outsource fisheries inspections and control to the Ecuadorian company Altura, while still keeping general oversight of MCS activities. The company has developed an integrated system to monitor and control navigation and fishing activities (catches, landings, etc) of the vessels arriving at Ecuadorian ports and sends weekly reports to government authorities. The integrated system and AI helped make MCS more thorough and decreased the number of necessary inspectors.

In addition, intergovernmental organizations regularly call on the services of private companies for MCS. This is particularly true in the fisheries sector. The International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Commission (IOC), the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), the South Pacific Regional Fisheries Management Organisation (SPRFMO), the North Pacific Fisheries Commission (NPFC) and the General Fisheries Commission for the Mediterranean (GFCM) use “THEMIS”, a tool developed by Collecte Localisation Satellite (CLS), a company that integrates marine data of multiple sources (satellites, catch reports, oceanography, etc.) into a single platform.[43]

Non-profit organizations

Not all States have the budget to pay companies for additional MCS tools and services. Non-profit actors have been filling this gap. They collaborate closely with States and companies, and play complementary roles. Some of the activities developed by non-profit organizations include: facilitating access to data, capacity-building, and analyzing assessment needs for MCS. For example, Global Fishing Watch (GFW) focuses on transparency issues.[44] Skylight, a product of the Allen Institute for AI (AI2), addresses the enforcement gap “by leveraging AI and big data, providing free, operationally relevant, and high-quality insights”.[45] Along with national authorities and other non-profit actors, the NGO WildAid assesses MCS needs within the exclusive economic zone (EEZ) of States. WildAid elaborates MCS plans of MPAs under the Eastern Tropical Pacific Marine Corridor (CMAR) thereby enhancing MCS cooperation between those countries.[46] OceanMind, a UK-based NGO, has also been essential in providing MCS assistance to remote and large-scale MPAs under the UK’s jurisdiction. They support the UK government by communicating MCS needs, analyzing satellite data and providing data-based recommendations.

Initiatives and networks

Several international MCS platforms and networks have also been established with the objective to strengthen cooperation and coordination on MCS at a global, regional or sectoral level.[47] For example, the International Monitoring, Control and Surveillance (IMCS) Network is a voluntary organization with 89 members and observers including State and non-State actors that facilitates the “establishment of cooperation, information, and technical assistance mechanisms in the areas of monitoring, control, and surveillance.”[48] The Joint Analytical Cell (JAC) is a collaborative effort initiated by the IMCS Network in partnership with founders Trygg Mat Tracking (TMT) and GFW. The JAC has five members with the recent inclusion of the Allen Institute for AI (Skylight) and the Center for Advanced Defence Studies (C4ADS). This initiative aims to enhance access to data, intelligence, and tools on a large scale to improve fisheries management worldwide and support effective action

41 Toonen, H.M. and Bush, S.R. The Digital Frontiers of Fisheries Governance: Fish Attraction Devices, Drones and Satellites. *Journal of Environmental Policy & Planning*, Volume 22.

42 https://ec.europa.eu/commission/presscorner/detail/en/QANDA_19_6037.

43 https://fisheries.groupcls.com/fr/administrations/themis-centre-de-surveillance-des-peches-fmc/.

44 https://globalfishingwatch.org/transparency/.

45 https://www.skylight.global/about#mission

46 CMAR is an intergovernmental initiative between Colombia, Costa Rica, Ecuador and Panama.

47 Cremers, K. *et al*. (2020) Strengthening Monitoring, Control and Surveillance in Areas Beyond National Jurisdiction. STRONG High Seas Project.

48 IMCS Network. Our Story. Retrieved June 7, 2024, from https://imcsnet.org/our-story.

against IUU fishing.[49] Whereas the IMCS Network mostly handles capacity-building questions and requests, the JAC also conducts capacity needs assessments to understand the needs of a country in relation to MCS. This dynamic partnership strengthens global efforts to provide government authorities greater access to tools and technology and a means to enhance their own respective MCS tools and services.

Valuable support for future High Seas MPAs

When developing high seas MPA proposals under the BBNJ agreement, States Parties are required to collaborate and consult with a variety of actors, including "civil society, the scientific community, the private sector, Indigenous Peoples and local communities".[50] As demonstrated above, private companies, non-profit organizations and initiatives and networks can be of major support for the MCS of these MPAs. States will therefore have to identify, according to each MPA and its characteristics, the actors who can best help them implement MPA management plans.

3. TECHNOLOGY AND THE IMPLEMENTATION OF MANAGEMENT PLANS OF FUTURE HIGH SEAS MPAs

Emerging technological tools will help States overcome several challenges of managing future high seas MPAs.

They create affordable MCS options and drive further innovation. High seas MPA managers can then optimize their resources through the use of these technologies. For example, these technologies give whoever is doing MCS a ground to notify the responsible flag State. In case a vessel enters an MPA without having the authorization to do so, some ongoing pilot projects are looking into how AI-powered technology can help identify if a fishing activity is taking place and, if so, which gear is being used.

In addition, emerging technological tools and accompanying services can help target and reroute patrols. Firstly, they can help with risk analysis for preventive action. For example, by combining different sources of data (e.g. satellite, currents) and with the help of AI, companies like CLS can determine patterns and anticipate illegal activities which is useful for MPA managers. Secondly, satellite imagery can help identify suspected illegal activities in near real-time. Skylight offers an AI-powered tool that can detect vessels not transmitting VMS or AIS.

Unmanned vehicles can also help reduce patrolling costs while expanding the area covered under surveillance. For example, drones can be particularly useful for remote or inaccessible areas as the operational costs are lower and they have a longer endurance compared to manned aircraft. This is particularly relevant for high seas MPAs, as many remote MPAs require an operational duration of at least 15 hours of maritime surveillance and manned patrols only conduct 1-2 hours of active surveillance per mission in remote marine areas.[51] This allows keeping a deterrent effect without exposing staff to higher-risk areas. The Portuguese Navy is developing a "Multifunctional Naval Platform" that integrates state-of-the-art technology and can be adapted to new emerging technologies. This vessel will function as an aerial, land and submarine drone carrier that can enhance unmanned MCS activities in vast and remote regions.[52]

4. NECESSARY COMPLEMENTARY MEASURES TO TECHNOLOGICAL TOOLS

Whereas the use of modern technological tools is an increasingly cost-effective and accessible method for supporting MCS activities on the high seas, some challenges persist, and five complementary measures are needed to make these technological tools work.

4.1. Closing capacity gaps

One of the major challenges for the management of high seas MPAs is the disparity in MCS capacity between States. This disparity can be seen in financial, policy and technical terms. For instance, some States struggle to acquire the most modern and efficient technological MCS tools while others have different policy priorities closer to their coast. Beyond access to these technologies, a key condition for making them effective for MPA management is the capacity of analysts to analyze and interpret the data received from different sources, and take follow-up decisions. Without just and equitable access to finance and capacity-building, developing countries could have difficulties to benefit from the increasing diversity of MCS tools and develop the skills to use them. The role of e.g. development aid, non-profit organizations and initiatives and networks will therefore be crucial to close these gaps. Intergovernmental organizations such as the UN Office on Drugs and Crime (UNODC) also help strengthen ongoing capacity-building efforts.[53]

[49] IMCS Network. Joint Analytical Cell (JAC). Retrieved June 7, 2024, from https://imcsnet.org/joint-analytical-cell-jac.

[50] BBNJ Agreement, Article 19(2).

[51] Brooke, S.D. *et al*. (2010). Surveillance and enforcement of remote maritime areas (SERMA). Paper 1: Surveillance Technical Options. Marine Conservation Biology Institute.

[52] « D. João II »: um navio inovador para explorar o oceano: https://www.portugal.gov.pt/pt/gc23/comunicacao/noticia?i=d-joao-ii-um-navio-inovador-para-explorar-o-oceano

[53] For instance, UNODC convened roundtable discussions on MPAs through its Global Maritime Crime Programme in biodiversity-rich nations across Southeast Asia and the Pacific to foster cooperation among agencies. In parallel, UNODC delivered enforcement training across the region, emphasizing the protection of large MPAs and the use of advanced monitoring tools, such as satellite-based surveillance.

The BBNJ Agreement also provides opportunities to close financial and technical capacity gaps. It sets up a financial mechanism that can provide support for States Parties to access MCS tools and services.[54] The Global Environment Facility (GEF) Trust Fund as part of the Agreement's financial mechanism and mobilized funds from States Parties can also contribute to closing the financial gap.

Furthermore, the treaty establishes a Clearing-House Mechanism (CHM), an open-access platform that all States Parties are meant to use as a repository for information relevant to achieving the treaty's objectives.[55] The CHM aims to enhance transparency and coordination among States involved in high seas MPAs by making information accessible. The CHM could therefore facilitate match-making exercises targeted to States' MCS needs by building financial and technical capacities.[56] The CHM can match States with a financial need for MCS to States or non-State actors that can provide financing or donations in-kind.[57] From a technical perspective, State and non-State actors could use the CHM as a platform to search for or offer opportunities to transfer marine technology and facilitate access to related MCS know-how or expertise.[58] By including non-State actors in this platform, non-profit organizations and networks could contribute to the sharing of marine technology and technical capacity-building. This multi-stakeholder approach will be essential for the enforcement of high seas MPAs under the BBNJ agreement.

4.2. Developing cooperation for patrols at sea

Manned aerial and surface patrol vessel surveillance remains one of the traditional methods to monitor MPAs. High seas MPAs will, by definition, be located primarily in remote maritime areas. Sending traditional patrol assets to these areas will therefore be costly (e.g. in terms of fuel, maintenance, and other operational costs) and time-consuming in comparison to remote satellite detection. However, past experience has demonstrated the value that a persistent patrol presence provides in terms of deterrent effect, which still provides justification for a certain level of these efforts to continue.

Moreover, not all flag States have the capacity to conduct surveillance patrols on the high seas and thus cooperation amongst States will be essential. At the regional level, there are various initiatives through which enforcement authorities share intelligence and conduct joint cooperative compliance inspections of vessels at sea. UNODC, for example, has supported maritime operations in cooperation with EU Copernicus, GFW and Skylight since 2019 in West Africa, connecting Maritime Domain Awareness and maritime operations.[59] Certain States that share maritime boundaries have established "shiprider agreements" that facilitate the ability of the flag State of a patrol vessel to carry onboard compliance and enforcement officers of another coastal State who have the authority and jurisdiction to conduct boardings and take enforcement action when non-compliance is documented.

In some cases, these cooperative arrangements have extended to RFMOs which have established high seas boarding and inspection schemes that allow the ability for enforcement officers of one member to board and conduct inspection of vessels flagged to another member without the need for expressed consent of the vessel's flag State authorities or without any officer from the vessel's flag State being onboard. An example of one of these robust cooperative enforcement frameworks can be found in the Pacific where members of the Pacific Islands Forum Fisheries Agency have established the Niue Treaty Subsidiary Agreement, which allows them the ability to join enforcement powers of their fisheries officers and even share enforcement assets.[60] In the North-East Atlantic, NEAFC member States conduct joint patrols and inspections at sea and allow inspectors from one contracting party to board another contracting party fishing vessel.[61] The African Union (AU) indicates in its 2050 Africa's Integrated Maritime Strategy that it strives to increase joint surveillance operations at sea and all AU States "are encouraged to establish cross-border hot-pursuit arrangements" which allows an offended State to pursue and catch a vessel suspected of illegal activities in the EEZ of a neighbouring State.[62] The Fisheries Committee of the West Central Gulf of Guinea (FCWC) established a Regional Monitoring, Control and Surveillance Centre through which States maintain a regional record of authorized fishing vessels and conduct regional and joint at-sea patrols.[63] The International Criminal Police Organization (INTERPOL) also regularly supports States by providing intelligence and assisting with enforcement operations.[64]

States Parties to the BBNJ Agreement should therefore consider similar arrangements for high seas MPAs that would allow for coordination, cooperation, and sharing of the burden of monitoring human activities that may be occurring in remote MPAs. These arrangements might also include cross-border hot-pursuit rules. This is especially beneficial for States with limited capacity for MCS activities on the high seas. Through joint MCS activities, States can minimize costs, improve overall monitoring and surveillance coverage, and increase trust amongst compliance and enforcement authorities.

54 BBNJ Agreement, Article 45(c)

55 BBNJ Agreement, Article 51.

56 BBNJ Agreement, Article 51(3)(b).

57 BBNJ Agreement, Article 51(3)(b).

58 Ibid.

59 https://www.copernicus.eu/en/copernicus-documents-library/fisheries-control-use-case-ghana

60 https://tunapacific.ffa.int/niue treaty subsidiary agreement/

61 https://www.neafc.org/

62 https://cggrps.com/wp-content/uploads/2050-AIM-Strategy_EN.pdf

63 https://fcwc-fish.org/regional-mcs-centre

64 https://www.interpol.int/en/Crimes/Maritime-crime/Our-response

4.3. Strengthening port State controls

The United Nations Convention on the Law of the Sea (UNCLOS) places the responsibility on flag States to control their vessels. The BBNJ Agreement does not change this and thus it remains flag States' responsibility to conduct MCS activities in ABNJ, for example, in future high seas MPAs. Flag States with limited control capacity on the high seas mostly rely on controls in port. UNCLOS gives coastal States the competence to determine the conditions for entering their ports.[65] Many technical conventions of the IMO also contain provisions for ship inspections in port.[66] The Paris Memorandum of Understanding (MoU) on Port State Control (PSC), as well as eight other regional MoUs, set up an inspection regime for foreign-registered vessels and take action against those that are not compliant with international maritime safety, security and pollution conventions. Annually, these regional PSC regimes publish a report in which they identify flag States with the highest level of vessel detentions after inspections in port.

With the entry into force of the Food and Agriculture Organization of the United Nations (FAO) Port State Measures Agreement (PSMA) in 2016, States Parties have taken on the obligation to play a more active role in addressing IUU fishing through port State measures.[67] The PSMA applies to both fishing and fishing-related activities such as the landing, packaging and transporting of fish, as well as the provisioning of personnel, fuel and gear at sea. The PSMA requires States parties to refuse entry into their ports in case there is "sufficient proof" that a vessel has engaged in IUU fishing or related activities.[68] The port State is obliged to communicate its decision to the vessel's flag State and in some cases also the relevant RFMOs and other international organizations.[69] States Parties to NEAFC have gone a step further and port inspectors have access to all fishing activity information onboard. Before vessels enter the port, inspectors can also check vessel tracks and activities, including whether vessels were active in closed areas or MPAs in the high seas. The vessel that wants to enter the port has to send an electronic form to the port State. The vessel can enter the port if all the answers of the vessel and its flag State address NEAFC requirements.[70]

The global minimum standards that the regional MoUs and the PSMA set in terms of inspections of foreign vessels seeking entry to ports of another State can be useful in the context of high seas MPAs. These port State control measures "can support compliance where flag State responsibility is unreliable".[71] They also have a deterrent effect, because the vessel that has allegedly conducted illegal activities as well as its flag State are put in the spotlight.

Therefore, to facilitate the management and enforcement of high seas MPAs, more States have to become party to the PSMA, expanding its coverage. In addition, to ensure its full implementation, national port capacities need to be strengthened. In any case, port State control "cannot substitute for flag state regulation; ideally, port state control would add transparency in the shipping industry while supplementing the regulatory efforts of the flag state".[72]

4.4. Reforming national judicial systems

MCS in high seas MPAs will only be effective if national judicial systems adapt to technology development. A challenge in relation to follow-up actions after identifying suspected illegal human activities in high seas MPAs is ensuring there is a 'legal finish,' meaning that "the suspected persons are duly prosecuted and convicted by a court of law, if found guilty".[73] This is frequently missing, because of a lack of domestic legislation or international cooperation.[74] In addition, the regulatory framework often does not keep up with the rise of innovative technology. For example, courts do not always accept images coming from satellite technology as sole evidence. Prosecution authorities also need permission from the vessel and/or flag State to have access to VMS data or need to rely on the PSMA and other international information-sharing agreements.[75] Several initiatives by States and non-State actors provide training to judicial personnel on maritime crime.

Strengthening the judicial system and ensuring sanctions are deterrent can significantly enhance MCS efforts.[76] In the case of West Africa, a study by Doumbaya *et al.* demonstrates that illegal fishing was responsible for loss of more than US$2.3 billion a year between 2010 and 2016, of which only US$13.8 million a year was recovered through MCS.[77] The study demonstrates that higher fines contribute to "reducing incentives of illegal fishing

65 UNCLOS, Article 25.

66 https://www.imo.org/en/ourwork/msas/pages/portstatecontrol.aspx

67 Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (approved by the FAO Conference 22 November 2009 and entered into force on 5 June 2016; PSMA), Article 2.

68 Ibid, Article 9.

69 Ibid.

70 NEAFC Scheme of Control and Enforcement, Article 22.

71 Hammond, A. and Jones P.J.S. (2021). Protecting the 'blue heart of the planet': Strengthening the governance framework for marine protected areas beyond national jurisdiction. *Marine Policy*, Volume 127.

72 O'Hara, K. (2022). Accidents on the High Seas and Flags of Convenience: Whether the BBNJ Draft Treaty Will Address Insufficient Regulatory Compliance by Open Registry States. *Georgia Journal of International and Comparative Law*, Volume 50.

73 UNODC. (2023). Flag State Jurisdiction and Transnational Organized Crime at Sea: Issue Paper.

74 Ibid.

75 Appleby, T. *et al*. (2021). Sea of possibilities: Old and new uses of remote sensing data for the enforcement of the Ascension Island marine protected area. *Marine Policy*, Volume 127.

76 Cremers, K. *et al*. (2020). Strengthening Monitoring, Control and Surveillance in Areas Beyond National Jurisdiction. STRONG High Seas Project.

77 Doumbouya, A. *et al*. (2017). Assessing the Effectiveness of Monitoring Control and Surveillance of Illegal Fishing: The Case of West Africa. *Frontiers in Marine Science*, Volume 4.

through a higher capability of catching offenders (increased resources for MCS), and providing higher incentives to avoid being caught".[78] Applying deterrent fines for not respecting the MPA management plan could therefore help enforce high seas MPAs. A study by Belhabib and le Billon that provides a "global assessment of the linkages between observed fisheries-related offences across the world's oceans between 2000 and 2020" found that "3 of the top 20 companies with the highest number of offences figure among the top 10 companies with the highest fishing effort in the high seas".[79] Moreover, crimes in the fisheries sector are often interconnected with other types of crime, such as money laundering and human trafficking, so a cross-sectoral and inter-ministerial approach is needed.[80]

4.5. Ensuring information sharing

Organizations with a high seas mandate already collect a significant amount of information on human activities and this data could simultaneously be used for the future management of high seas MPAs. RFMOs and the IMO, for example, have put in place obligations for vessels to report on their activities in the high seas. This means that States do not start from scratch collecting relevant data for high seas MPAs.

MCS experts unanimously consider that, beyond access to technology, a key element of effectiveness is transparency and data communication. Information sharing offers substantial benefits. While concerns about sensitive data persist, improved information sharing can reduce costs for parties with limited capacities and enhance MCS coverage on the high seas through international cooperation. By imposing minimum MCS requirements, RFMOs can for instance enhance international cooperation. In the NEAFC context, States Parties mandate their vessels to share their ERS data with inspectors, regardless of the inspectors' nationality or State of jurisdiction.[81] This demonstrates how information sharing can strengthen high seas conservation efforts and enhance global marine biodiversity protection. This example also makes a case for using the CHM in the context of the MCS of future MPAs and for the creation, within each future MPA, of a dedicated department/staff responsible for collecting all data from the area and sharing it with decision-makers.

5. CONCLUSION

While the required number of ratifications of the BBNJ Agreement for it to enter into force has yet to be reached, States and other stakeholders can already start preparing proposals for the first high seas MPAs. For the MCS of these future areas, and in addition to traditional tools, the international community should harness the power of emerging technologies such as satellite imagery, remote sensing, and AI-powered analytics to improve the efficiency and effectiveness of MCS activities. These technologies will facilitate the implementation of future high seas MPA management plans, by optimizing resource allocation or providing near real-time insights into suspected illegal activities. States willing to prepare high seas MPA proposals should therefore conduct MCS needs assessments for each site, involving experienced international organizations, leveraging the extensive network of technology providers and considering public-private partnerships.

Nevertheless, technology alone will not suffice, and accompanying policy and technical measures will be necessary to ensure the MPA's effectiveness. In this regard, collaboration will be key to success. Collaboration among States, first, to conduct joint patrols, share intelligence, establish cross-border enforcement mechanisms and ensure data transparency. But also collaboration with non-State actors: private companies, non-profit organizations, and international networks can provide expertise, data, and capacity-building support, leveraging their resources and innovative solutions for effective MPA management. This cooperation will be of paramount importance to close capacity gaps. Addressing disparities in MCS capacities among States will require promoting access to financial resources and capacity-building initiatives. In addition to ongoing initiatives carried out within the framework of development aid or by NGOs and networks specializing in MCS, the CHM established under the BBNJ could provide a relevant platform to facilitate matchmaking between States with MCS needs and potential donors or technology providers, enhancing access to necessary tools and expertise.

Finally, and still with the aim to enhancing the potential of MCS technologies, national reforms will have to be implemented, especially to strengthen the effectiveness of port State controls and ensure the legal admissibility of evidence from satellites and other technological tools for detecting infringements.

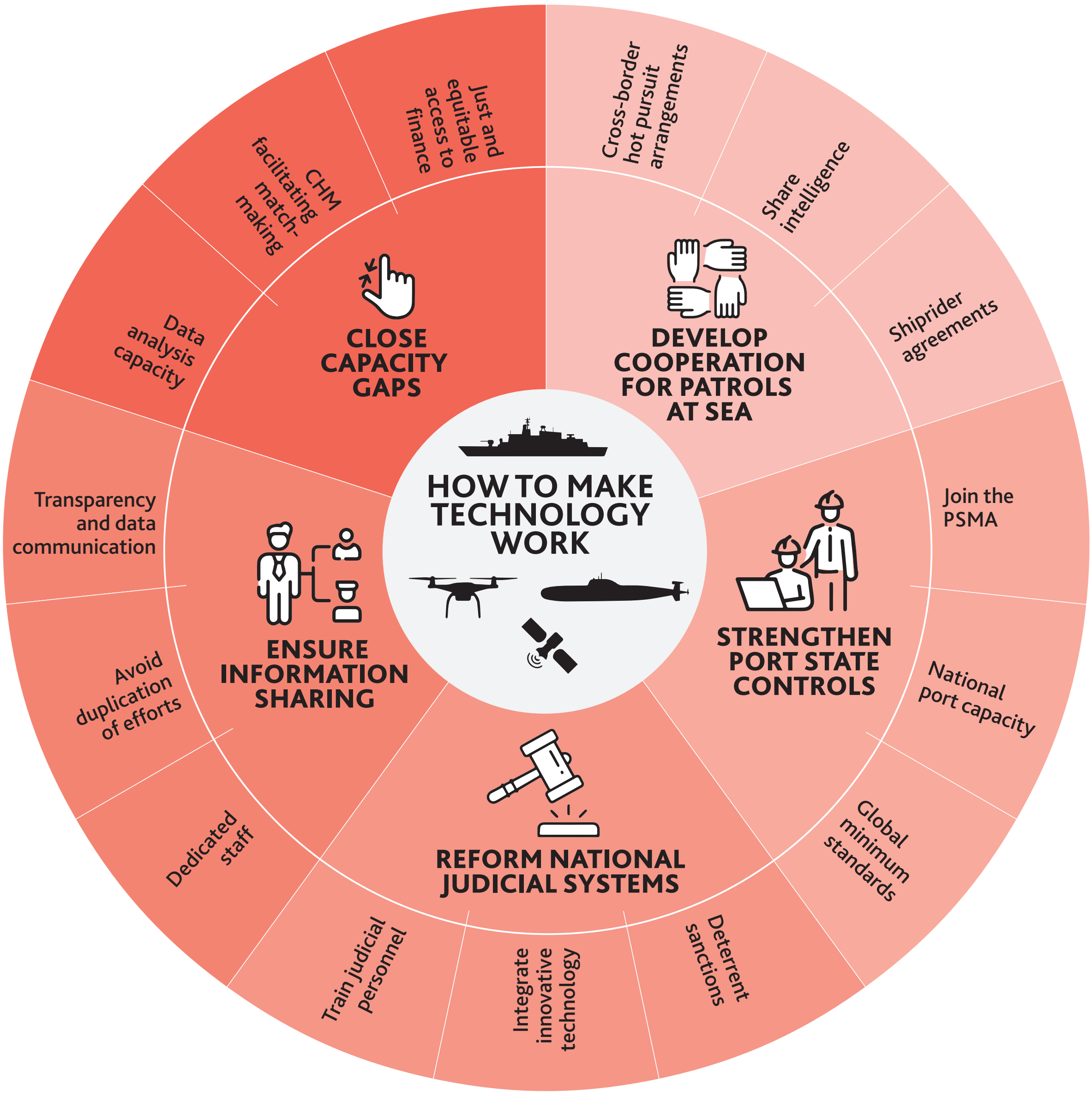
[78] Ibid.

[79] Belhabib, D. and Le Billon, P. (2022). Fish crimes in the global oceans. *Science Advances*, Volume 8.

[80] Cremers, K. *et al*. (2021). Options for Strengthening Monitoring, Control and Surveillance of Human Activities in the Southeast Atlantic Region. STRONG High Seas Project; UNODC. UNODC Approach to Crimes in the Fisheries Sector. Retrieved June 7, 2024, from https://www.unodc.org/documents/Wildlife/UNODC_Approach_to_Crimes_in_the_Fisheries_Sector.pdf.

[81] NEAFC Scheme of Control and Enforcement.

Figure 1. Complementary measures to technological tools for effective high seas marine protected areas



Monitoring, control and surveillance of future high seas MPAs: what role for emerging technologies?

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