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ABSTRACT

The United Nations is currently drafting an international legally binding agreement on the conservation and sustainable use of marine biodiversity in the High Seas ("Agreement").[1] The Agreement is timely because it is painfully apparent that biodiversity across the globe is rapidly declining.[2] One of the key strategies for species protection and rehabilitation that the Agreement outlines is the creation of marine protected areas ("MPAs"). The Agreement defines a MPA as a geographically defined area designated and managed to achieve specific long-term biodiversity conservation and sustainable use objectives and provide higher protection than the surrounding areas.[3] Further, the Agreement outlines a procedure for identifying areas for MPAs, consultation requirements, implementation, monitoring, and review. Yet, nowhere in the Agreement is there an open concession of how climate change could radically alter the efficacy of MPAs over time – one of the major climate impacts is that marine biodiversity is migrating to

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1. Revised Draft Text of an Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction, Nov. 18, 2019, A/CONF.232/2020/3 [hereinafter Revised Draft Text of an Agreement].

2. *See* S. DIAZ ET AL., INTERGOVERNMENTAL SCIENCE-POLICY PLATFORM ON BIODIVERSITY AND ECOSYSTEM SERVICES, SUMMARY FOR POLICYMAKERS OF THE GLOBAL ASSESSMENT REPORT ON BIODIVERSITY AND ECOSYSTEM SERVICES OF THE INTERGOVERNMENTAL SCIENCE-POLICY PLATFORM ON BIODIVERSITY AND ECOSYSTEM SERVICES (2019).

3. Revised Draft Text of an Agreement, *supra* note 1.

unprecedented areas due to significant changes in ocean conditions. In this paper, I argue that dynamic ocean management is the best approach for the Agreement to ensure that marine biodiversity is protected despite its movement to new areas.

INTRODUCTION

Climate change is already leading to unprecedented changes in ocean temperature, chemistry, and circulation.[4] These changes in ocean conditions lead to shifts in the spatial distribution and abundance of some fish and shellfish stocks, as well as certain habitats.[5] These shifts are problematic because they challenge fisheries governance worldwide, both in terms of sharing resources between fishing entities as well as regulating fishing to secure ecosystem integrity.[6] Further, Indigenous peoples and other local communities dependent on fisheries have their livelihoods, incomes, and food security fundamentally altered.[7] Changes in the location of marine biodiversity abundance and habitat also undermine static efforts to protect and rehabilitate vulnerable species and habitats.

On December 24, 2017, the United Nations General Assembly decided to convene an Intergovernmental Conference to draft an international legally binding agreement specifically related to the conservation and sustainable use of marine biodiversity in the High Seas ("Agreement").[8] One of the central components of the Agreement is the utilization of area-based management tools, such as marine protected areas ("MPAs"). An MPA is a geographically defined area designated and managed to achieve specific long-term biodiversity conservation and sustainable use objectives and provide higher protection than the surrounding areas.[9]

MPAs provide numerous benefits to marine biodiversity, including restoration and enhanced resilience of marine communities.[10] Further, they

4. *Issues Brief: The Ocean and Climate Change*, INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE, https://perma.cc/G6QG-5SNM [hereinafter *Issues Brief: The Ocean and Climate Change*].

5. Nerilie Abram et al., INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, SUMMARY FOR POLICYMAKERS OF THE IPCC SPECIAL REPORT ON THE OCEAN AND CRYOSPHERE IN A CHANGING CLIMATE (2019) [hereinafter Abram].

6. *Id.*

7. *Id.*

8. INTERGOVERNMENTAL CONFERENCE ON MARINE BIODIVERSITY OF AREAS BEYOND NATIONAL JURISDICTION: BACKGROUND, https://perma.cc/J6CJ-CGHA. Due to COVID-19, further discussion of the High-Seas Conservation Agreement is postponed "to the earliest possible available date to be decided by the General Assembly." U.N. GAOR, 74th Sess., U.N. Doc. A/74/L.41 (Mar. 9, 2020).

9. Revised Draft Text of an Agreement, *supra* note 1.

10. Ellen Pikitch, A PRIMER ON MARINE PROTECTED AREAS, BACKGROUND FOR THE 10X20 CONFERENCE (Mar. 7, 2016) [hereinafter Pikitch].

act as an "insurance policy" if other means of fisheries management are unsuccessful – helping to bring back "large old fish that have always been the engines of reproduction and population replenishment."[11] MPAs could significantly aid in the conservation and rehabilitation of marine biodiversity being that 18.99 percent of global oceans and only 1.18 percent of High Seas, the area in which the Agreement applies, are protected.[12]

The Agreement states that areas chosen for MPAs will be identified by utilizing the best available science, the precautionary approach, and an ecosystem approach.[13] Indicative criteria are specified in an annex within the Agreement.[14] Out of the 21 indicative criteria, climate change is mentioned just within the context of assessing an area's vulnerability.[15] This leads to one major question: How will vulnerable marine species be protected as they shift to entirely new areas due to climate change? In this paper, I argue that dynamic ocean management is the best method for the Agreement to take already-occurring biodiversity shifts into account when laying its framework for the identification, implementation, and monitoring of MPAs.

In this paper, I will first take a closer look at the scientific basis for the changing ranges of marine biodiversity. Then, I will examine the Agreement, highlighting how it does not sufficiently acknowledge potential climate change impacts on marine biodiversity and future MPAs. I will present dynamic ocean management as a solution for protection of marine biodiversity that will shift to unprecedented areas due to climate change. Next, I break down the centuries-old practice of adaptive management to evaluate how its successes and failures could inform dynamic ocean management's integration within the Agreement. I then analyze how principles of dynamic ocean management could be incorporated within the Agreement. Further, I assess the feasibility of implementation of dynamic ocean management under the Agreement using the Bluefin tuna (*Thunnus thynnus*) and deep-sea fish species as examples. Lastly, I deconstruct potential challenges to the use of dynamic ocean management within the Agreement. These challenges include the development of proper information systems for habitat and species distribution modeling, as well as monitoring and enforcement of dynamic MPA boundaries.

11. Pikitch, *supra* note 10.
12. *Explore the World's Marine Protected Areas*, PROTECTED PLANET, https://perma.cc/8834-2FST.
13. Revised Draft Text of an Agreement, *supra* note 1.
14. *Id.*
15. *Id.*

I. CLIMATE CHANGE'S IMPACTS ON OCEANS AND MARINE BIODIVERSITY

Global oceans are already impacted in a multitude of ways by climate change. Due to the continued growth of greenhouse gas emissions, effects on oceans will worsen with time. Current ocean impacts consist of increased water temperatures, greater upper ocean stratification, further acidification, oxygen decline, and altered net primary production.[16] Marine heatwaves and extreme El Niño and La Niña events are projected to become more frequent.[17] Additionally, the Atlantic Meridional Overturning Circulation is projected to weaken.[18] These changes affect the ocean surface to the deepest reaches of the ocean floor.[19]

Increased ocean temperature and acidification, and oxygen loss, are some of the most severe climate change-related ocean impacts. The Intergovernmental Panel on Climate Change reports that it is "virtually certain" that the world's oceans have continuously warmed since 1970 and have absorbed more than 90% of excess heat in the climate system.[20] Further, marine heatwaves have "very likely" doubled in frequency since 1982 and are increasing in intensity.[21] Ocean acidification has markedly increased since the 1980s as oceans took up between 20–30% of total anthropogenic CO_2 emissions.[22] With increased acidification comes difficulty with shell formation for keystone aragonite shell-forming species.[23] Oxygen loss between ocean depths of 100 and 600 meters is projected to emerge over 59–80% of the ocean by 2031–2050 under high greenhouse gas emissions scenarios.[24] Even more strikingly, five primary drivers of marine ecosystem change are projected to emerge prior to 2100 for over 60% of the ocean under high greenhouse gas emissions scenarios and for over 30% of the ocean under low emissions scenarios.[25] Altogether, these worsening physical and chemical conditions have an unprecedented impact on the ocean and its abundance and distribution of biodiversity.[26]

16. Abram, *supra* note 5, at 18.
17. *Id.*
18. *Id.*
19. Lisa A. Levin et al., *The Deep Ocean Under Climate Change*, 350 SCIENCE 766, 766 (2015) [hereinafter Levin].
20. Abram, *supra* note 5, at 9.
21. *Id.* (A marine heatwave is defined as "when the daily sea surface temperature exceeds the local 99th percentile over the period 1982 to 2016").
22. *Id.*
23. *Id.*
24. *Id.* at 19.
25. *Id.* (The five primary drivers of marine ecosystem change: surface warming and acidification, oxygen loss, nitrate content and net primary production change).
26. *Id.* at 18.

Since the 1950s, numerous marine species have shifted geographical range and seasonal activities due to changing ocean conditions.[27] Rates of poleward shifts in distributions across different marine species are 52 ± 33 km per decade for organisms in seafloor ecosystems and 29 ± 16 km per decade for organisms in the epipelagic (upper 200 meters from sea surface).[28] Rate and direction of observed shifts in distributions are shaped by ocean temperature, oxygen, and currents across depth, latitudinal, and longitudinal gradients.[29] Biodiversity range changes have led to altered ecosystem structure and functioning in the North Atlantic, Northeast Pacific, and the Arctic.[30]

Range changes of commercially important fish stocks will significantly impact fishery-dependent nations. One study done by a group of marine scientists projected future shifts in the distribution of 892 commercially important marine fish and invertebrates in relation to 261 of the world's exclusive economic zones ("EEZs").[31] Comparing 1950-2014 with 2090-2100, the researchers found that many EEZs are likely to receive one to five new, climate-driven transboundary stocks by the end of the century.[32] In Iceland, climate change-induced fish migration goes beyond scientific modeling. For the past two fishing seasons, Icelanders could not harvest capelin because their numbers plummeted due to warming waters, which caused significant financial disruption to the Icelandic economy.[33]

The deep sea is also experiencing its own unique set of challenges due to climate change, many of which are still not fully understood.[34] Deep sea habitats, consisting of canyons, seamounts, methane seeps, and hydrothermal vents, are hotspots of biodiversity and biomass.[35] Many species that live in such habitats live in highly stable thermal regimes – warming of 1°C or less may cause shifts in depth or latitudinal distribution of species and alter species interactions.[36] For example, near the Antarctic Peninsula, warming above a 1.4°C threshold allowed invasion of lithodid crabs, insatiable predators that appear to have "decimated" bottom-

27. Abram, *supra* note 5, at 12.
28. *Id*.
29. *Id*.
30. *Id.*
31. Malin L. Pinsky et al., *Preparing Ocean Governance for Species on the Move: Policy Must Anticipate Conflict Over Geographic Shifts*, 360 SCIENCE 1189, 1189 (2018). *See also* Alan Ronan Baudron et al., *Changing Fish Distributions Challenge the Effective Management of European Fisheries*, 43 ECOGRAPHY 494 (2020).
32. *Id.*
33. Kendra Pierre-Louis, *Warming Waters, Moving Fish: How Climate Change Is Reshaping Iceland*, N.Y. TIMES (Apr. 6, 2020, 3:36 PM), https://perma.cc/B2EG-S5NW.
34. Levin, *supra* note 19, at 766.
35. *Id.*
36. *Id.*

dwelling invertebrates.[37] Additionally, increased ocean acidification is likely reducing the suitable habitat range for deep-water corals and other calcifying species.[38] Expansion of low oxygen zones has led to "habitat compression" for a variety of fish species.[39] Other areas of the High Seas experience cumulative adverse impacts when expanding midwater deoxygenation from the ocean floor combines with warming and acidification from the ocean surface to reduce habitability of the water column for vertically migrating fish and krill.[40] For many deep-water species, there is still not much data on range shifts, life-history alterations, rapid evolution, or physiological changes necessary to adapt to deep-ocean climate change.[41] However, marine scientists are working vigorously to further understand deep-sea fish behavior.[42] Considering the variety of unprecedented changes in distribution of pelagic and deep-sea species, it is necessary for State Parties under the Agreement to join together to ensure that these species are protected, rather than exploited, in their new habitats.

II. THE AGREEMENT

The 1982 United Nations Convention on the Law of the Sea ("UNCLOS") is the primary source of international obligations related to the conservation and management of species and habitat in the High Seas.[43] The Agreement builds upon select provisions of UNCLOS and stresses the need for a comprehensive global regime to better address High Seas marine biodiversity conservation and sustainable use.[44] The High Seas consist of all areas of the sea that are not included in an exclusive economic zone, territorial sea or internal waters of a State, or archipelagic waters of an archipelagic State.[45] High Seas protection is essential to marine biodiversity conservation, considering that 64% of the ocean is considered the High Seas.[46]

There are four main elements to the Agreement: (1) marine genetic resources, (2) area-based management tools, including MPAs; (3) environmental impact assessments; and (4) capacity building and transfer

37. Levin, *supra* note 19, at 766–67.
38. *Id*. at 767.
39. *Id.*
40. *Id.* at 768.
41. *Id.*
42. Ian Evans, *'Really Amazing': Scientists Show that Fish Migrate Through the Deep Oceans*, THE GUARDIAN (Apr. 1, 2020), https://perma.cc/ACZ8-XR2W (new research demonstrated that certain deep-sea fish migrate along the ocean floor).
43. United Nations Convention on the Law of the Sea, Dec. 10, 1982, UN Doc. A/CONF.62/122 [hereinafter United Nations Convention on the Law of the Sea].
44. Revised Draft Text of an Agreement, *supra* note 1.
45. United Nations Convention on the Law of the Sea, *supra* note 43.
46. Levin, *supra* note 19, at 768.

of marine technology.[47] The Agreement defines an area-based management tool as a tool for a geographically defined area through which one to several sectors or activities are managed with the intent of achieving certain conservation and sustainable use objectives and affording higher protection than that provided in the surrounding areas.[48] MPAs more specifically pertain to long-term biodiversity conservation and sustainable use objectives.[49] Although the focus of this paper is on MPAs, the element related to capacity building and the transfer of marine technology will be implicated when analyzing how dynamic ocean management can best be incorporated within and implemented by the Agreement.

MPAs present numerous benefits to marine biodiversity, such as by increasing biomass, numerical density of species, and organism size.[50] One study found that fisheries outside of highly and fully protected MPAs were likely unsustainable in almost all cases without MPA population spillover.[51] Additionally, highly to fully protected MPAs increase biodiversity, which fosters species population resilience from changing physical and biological conditions.[52] Biodiversity can also provide a buffer to climate change. One study that synthesized global, fishery-independent data showed that more diverse fish communities have greater resilience to temperature variations.[53] All of MPAs' benefits demonstrate why the International Union for Conservation of Nature approved a resolution calling for protection of 30% of the world's oceans by 2030.[54]

Despite the numerous benefits that MPAs provide, some of those benefits will be undermined when certain target species migrate out of MPAs to unprecedented areas. The Agreement does not actively acknowledge such a possibility. Instead, the Agreement only mentions climate change within one of its 21 indicative criteria for MPA area identification – "vulnerability, including to climate change and ocean acidification."[55] While it is important to protect certain areas that are particularly vulnerable to climate change, it is also important to acknowledge that if one of the main goals of an MPA is to protect a

47. *Marine Biodiversity of Areas Beyond National Jurisdiction (BBNJ)*, INTERNATIONAL UNION FOR CONSERVATION OF NATURE, https://perma.cc/6XTN-QAZE.

48. Revised Draft Text of an Agreement, *supra* note 1.

49. Revised Draft Text of an Agreement, *supra* note 1. *See also* Margaret Cooney et al., *How Marine Protected Areas Help Fisheries and Ocean Ecosystems*, CENTER FOR AMERICAN PROGRESS (Jun. 30, 2019), https://perma.cc/6TNN-7LLG (explaining that there are four classifications for MPAs based on their degree of biodiversity protection and extractive activities: minimally protected, lightly protected, highly protected, and fully protected) [hereinafter Cooney].

50. Cooney, *supra* note 49.

51. *Id.*

52. *Id.*

53. *Id.*

54. *Issues Brief: The Ocean and Climate Change*, *supra* note 4.

55. Revised Draft Text of an Agreement, *supra* note 1.

particular target species or habitat, more exacting analysis must be conducted to ensure climate-induced shifts in the location of the species or habitat are not overlooked.

Dynamic ocean management, a method of managing protection of marine biodiversity in real-time, presents a solution to the issue posed by target species and habitat shifting outside of designated MPAs. Dynamic ocean management is an outgrowth of adaptive management – a primarily terrestrial land management strategy that has been used for centuries to ensure sustainable use of species and habitat. The successes and failures of adaptive management could help to inform the integration and implementation of dynamic ocean management within the Agreement to ensure that the Agreement's goals of species and habitat protection are achieved.

III. ADAPTIVE MANAGEMENT AND THE NORTHWEST FOREST PLAN: LESSONS LEARNED FROM THE PLAN'S SUCCESSES AND FAILURES

Adaptive management differs from traditional management in two keyways. First, with adaptive management, management is planned and run as an experiment.[56] Second, there is a direct feedback loop between researchers and managers, so management can be improved as continued research provides data on the system.[57] Adaptive management enables managers to test different strategies throughout the management process to determine which is most effective.[58] The process for adaptive management entails formulating questions, selecting alternate methods to test those questions, and testing those methods in real time.[59]

The concept of adaptive management is not new. In fact, peoples of many ancient civilizations practiced the art and science of what is now called adaptive management long before modern science outlined the concept.[60] For example, the Yap people in Micronesia utilized adaptive management techniques to create and maintain coastal mangrove depressions and seagrass meadows to support fishing.[61] In the mid-1970s, C.S. Holling, an ecologist at the International Institute of Applied Systems

56. Kimberly J. Reever Morghan, Roger L. Sheley & Tony J. Svejcar, *Successful Adaptive Management: The Integration of Research and Management*, 59 RANGELAND ECOLOGY & MGMT., 216, 217 (2006).

57. *Id.*

58. *Id.* at 216.

59. *Id.*

60. GEORGE H. STANKEY & BRUCE SHINDLER, ADAPTIVE MANAGEMENT AREAS: ACHIEVING THE PROMISE, AVOIDING THE PERIL 1 (1997) [hereinafter STANKEY & SHINDLER].

61. *Id.*

Analysis in Austria, expounded the concept of adaptive management, stating that comprehending how nature responds to human disturbance is central to living with the unforeseen.[62] He further elaborated that managers are to treat the management system as an experiment and expect the unexpected.[63] Thus, adaptive management has always emphasized perceiving change as a given, which then helps maintain a management strategy's efficacy over time since the strategy changes in tune with the environment.

One contemporary example of adaptive management was the creation of an Adaptive Management Area Network Strategy ("Strategy") within the United States' 1994 Northwest Forest Plan.[64] The Strategy entailed establishing ten Adaptive Management Areas ("AMAs") in western Oregon, western Washington, and northern California.[65] Within each AMA, a four-phase adaptive management cycle was implemented, which allowed for new knowledge gained to influence the future of the adaptive management strategy.[66] In the first phase, plans were framed using existing knowledge, current technology, organizational goals, and existing inventories.[67] During phase two, on-the-ground actions were implemented.[68] Phase three entailed monitoring outcomes of those actions, and in phase four, results were analyzed.[69] After the cycle was completed, it started again, influenced by lessons learned from the prior cycle.[70] Unfortunately, despite the conceptual soundness of the AMAs, there were numerous challenges with implementation, including costs, as well as a lack of clear leadership for implementation efforts.[71]

Adaptive management programs require significant and consistent funding.[72] However, given that adaptive management is a fluid process, it is difficult to concretely estimate the funding needed. Ultimately, researchers implementing the Strategy determined that it is necessary to seek "innovative, alternative" funding sources, in addition to funding provided through a regular appropriation process.[73] Further, scientists and project managers developed a list of fundamental considerations to allocate

62. STANKEY & SHINDLER, *supra* note 60.
63. *Id.*
64. ADAPTIVE MANAGEMENT AREA NETWORK STRATEGY AND PLAN WORK, https://perma.cc/8L2K-2DGE.
65. *Id.*
66. U.S. DEP'T OF AGRIC., FOREST SERV., PNW-RP-567, LEARNING TO MANAGE A COMPLEX ECOSYSTEM: ADAPTIVE MANAGEMENT AND THE NORTHWEST FOREST PLAN (2006) [hereinafter U.S. DEP'T OF AGRIC., FOREST SERV.].
67. *Id.*
68. *Id.*
69. *Id.*
70. *Id.*
71. *Id.*
72. *Id*.
73. *Id*.

scarce resources.[74] These included the notion that "it is important to not lose sight of the vision of adaptive management" and that "specific research projects to be undertaken need to reflect the judgments of need and priority of those doing the work as well as those for whom it was undertaken" (emphasizing a "bottom-up," rather than "top-down," approach).[75] Thus, one major lesson to take away from the Northwest Forest Plan is that innovative funding sources are needed for adaptive management, and that funding should be allocated largely depending on the needs of those implementing the management strategy.

Additionally, in analyzing the successes and failures of the Strategy, researchers found a lack of leadership within both management and research organizations, which led to "debilitating" effects on implementation efforts.[76] However, there were certain exceptions to this finding, including the Applegate and Hayfork AMAs where leadership from local citizens complemented agency leadership.[77] Strong leadership from individuals appeared to be a significant reason for AMA success, as opposed to developing organizational capacity.[78] Ultimately, researchers analyzing the Strategy's success determined that in order for adaptive management to succeed, "there must be clear definitions, goals, and objectives for adaptive management along with organizational commitment and support, capacity building, and leadership. Public involvement must be meaningful and effective, with visible progress and on-the-ground results."[79]

Further, understanding the "requisite attributes" for the successful implementation of adaptive management practices is helpful when analyzing how to best implement dynamic ocean management under the Agreement.[80]

Top scientists involved with implementation of the Strategy outlined a set of "requisite attributes" essential for any creative and innovative management policy to succeed.[81] These attributes included: (1) leadership at all levels maintaining an environment for innovation and accountability; (2) integration of adaptive management practices within all aspects of day-to-day business; (3) a recognition that adaptive management requires major adjustments in organizational processes, structures, and resources; (4) capacity to act, including internal resources such as time, money, and technical and social expertise and skills; (5) an agreement on expectations

74. U.S. DEP'T OF AGRIC., FOREST SERV., *supra* note 66.
75. *Id.*
76. *Id.*
77. *Id.*
78. *Id.*
79. *Id.*
80. *Id.*
81. *Id.*

between the many different interested parties; (6) clear performance benchmarks; and (7) formal and explicit documentation of the nature of changes, effects, and consequences.[82] These requisite attributes could be helpful in facilitating a successful dynamic ocean management strategy under the Agreement.

Additionally, when an adaptive management strategy is implemented, it takes some time before certain innovations' relative impact can be gauged.[83] Managers assessing the success of the Northwest Forest Plan lamented that it was not fully possible for them to state anything conclusively about the adaptive management strategy's results since it typically takes 12 to 15 years for the relative impact to be assessed.[84] Thus, managers implementing a dynamic ocean management strategy under the Agreement must be aware that it will take some time before they are able to see the true value of such an approach.

Overall, there are several broader lessons to be taken away from the implementation of the Strategy and applied to the implementation of dynamic ocean management under the Agreement: (1) scientists and researchers need to normalize uncertainty within the process, and recognize that uncertainty can ultimately lead to more ideal management outcomes over time; (2) innovative, alternative funding sources must be sought out to help ensure that fluctuating demand for resources will be met; (3) strong leadership by individuals is necessary to ensure the efficacy of the management strategy [within the context of dynamic ocean management—incorporate voices of the global fishing community]; and (4) an adaptive management cycle must be clearly designated and agreed upon by all interested parties before implementation begins. One stark difference between adaptive management under the Strategy and dynamic ocean management under the Agreement is the nature of the physical environment itself – meaning, the Strategy was implemented terrestrially, while I argue that dynamic ocean management be implemented across swaths of the open ocean. Implementing dynamic ocean management across the open ocean is more complex given the resources needed to reach, designate, monitor, and enforce MPA boundaries. These additional complexities underscore the importance of encouraging citizen monitoring and enforcement by the global fishing community. This paper will now examine the theory behind dynamic ocean management and how the strategy is best incorporated within the Agreement while bolstering ocean conservation goals.

82. U.S. DEP'T OF AGRIC., FOREST SERV., *supra* note 66.

83. *Id.*

84. *Id.* (At the time of their evaluation, adaptive management's specific application to the Northwest Forest Plan was less than a decade old).

IV. HOW TO INCORPORATE DYNAMIC OCEAN MANAGEMENT WITHIN THE AGREEMENT

Dynamic ocean management is defined as management that rapidly changes in space and time in response to the shifting nature of the ocean and its users based on the incorporation of new biological, oceanographic, social and/or economic data in near real-time.[85] It integrates existing datasets (i.e., animal tracking, remote sensing, fisheries observer data), advanced analytical processing and modeling techniques, and rapid data sharing technology to enable near real-time management of the ocean.[86] This method of management is more effective than traditional management because it more tightly aligns management response times with changes in the environment, marine species movements, and resource use.[87] It also better balances ecological and economic objectives – when a temperature dependent habitat of a hypothetical mobile marine species was simulated, 82.0 to 34.2 percent less area needed to be managed using a dynamic approach.[88] Further, fisheries management that consistently evaluates and updates practices over time, informed by reports of future ecosystem trends, reduces climate risks to fisheries.[89]

Dynamic ocean management is used around the world for certain target species. One example is TurtleWatch, a program developed by the NOAA Pacific Islands Fisheries Science Center designed to reduce bycatch of loggerhead sea turtles in the shallow-set longline fishery based in Hawaii.[90] Using satellite tracking, National Oceanic and Atmospheric Administration ("NOAA") scientists determined the temperature preferences of loggerhead sea turtles and then highlighted areas longline fishermen should avoid to reduce turtle bycatch.[91] Another example is presented by the New England scallop fishery.[92] There, fishermen voluntarily report bycatch of yellowtail flounder on a daily basis to the School of Marine Science and Technology at the University of Massachusetts Dartmouth.[93] The school then compiles the bycatch data and emails it to scallop fishermen the following day, instructing which areas to avoid.[94] Integrating principles of dynamic ocean management within the

85. Sara M. Maxwell, *Dynamic ocean management: Defining and conceptualizing real-time management of the ocean*, 58 MARINE POL'Y 42, 43 (2015) [hereinafter Maxwell].
86. Maxwell, *supra* note 85, at 43.
87. *Id.*
88. *Id.* at 42.
89. Abram, *supra* note 5, at 30.
90. Maxwell, *supra* note 85, at 43.
91. *Id.*
92. *Id.*
93. *Id.*
94. *Id.*

Agreement is an ideal method to protect biodiversity shifting location due to climate change because it allows a deeper understanding of changing ocean conditions to sync with a deeper understanding of changing species and habitat ranges. Of course, because this management strategy requires real-time data collection and analysis, it could become quite expensive over time. However, as mentioned in Section III, project managers should seek out innovative and alternative funding mechanisms in addition to any government appropriations.

The concept of, and goals underlying, dynamic ocean management sync with the purpose and desired outcomes of the Agreement. Here, I highlight specific portions of the Agreement which either (a) demonstrate that dynamic ocean management is the best management strategy to accomplish the Agreement's goals or (b) could serve as specific areas for the General Assembly to integrate principles of dynamic ocean management. These Parts and Articles are: (1) Part 1 – "General Provisions," Article 5 – "General principles and approaches" and Article 6 – "International Cooperation" (2) Part III – "Measures such as area-based management tools, including Marine Protected Areas," (3) Part V – "Capacity-Building and Transfer of Marine Technology," (4) Part VIII – "Implementation & Compliance." Both Annexes, as well as the creation of the Conference of the Parties and the Scientific Technical Body under Art. 48 and Article 49, respectively, will further enable a successful dynamic ocean management strategy under the Agreement.

A. Part I – "General Provisions": "General principles and approaches" and "International cooperation"

Many of the general principles and approaches articulated within the Agreement implicitly hint that a dynamic ocean management approach is better attuned to its goals. Such principles and approaches include the precautionary principle, an ecosystem approach, an integrated approach, "an approach that builds ecosystem resilience to the adverse effects of climate change and ocean acidification and restores ecosystem integrity," and the use of best available science.[95] The creation of MPAs generally satisfy these principles and approaches, but such concepts are undermined when the species and habitat to be protected shift in location due to climate change.

Since the Agreement pertains to the High Seas, the habitats and species meant to be protected are those in deep-sea and pelagic environments. As mentioned in Section I of this paper, deep-sea habitats and species are particularly vulnerable to climate-caused changes in the ocean environment (i.e., the majority of deep-sea species live in highly

95. Revised Draft Text of an Agreement, *supra* note 1.

stable thermal regimes).[96] Thus, adjusting the locations of MPAs using dynamic ocean management is especially pertinent to the protection of such species and habitats.

Further, in Article 6, the Agreement states that parties to the Agreement must promote international cooperation in marine scientific research and in the development and transfer of marine technology.[97] Under the Agreement, it is possible that a new global, regional, or sectoral body could be established to accomplish such goals.[98] Given that dynamic ocean management is based off a steady stream of new scientific data, it is imperative that State Parties work cooperatively to ensure that such data is generated efficiently and accurately.

Thus, in Part I, it is apparent that dynamic ocean management fits with the goals of the Agreement, and the Agreement lays the international structure necessary for needed data to be generated. Part III provides more explicit detail on how State Parties can establish new MPAs, as well as monitoring and reviewing their successes or failures. It is here that the implementation of a dynamic ocean management approach is fruitful in the insurance that protected areas are functioning to their maximum conservation potential.

B. Part III – "Measures such as area-based management tools, including Marine Protected Areas"

Part III pertains to the creation, monitoring, and review of MPAs. Here, a dynamic ocean management approach must be implemented to ensure that MPAs successfully protect target species and habitat. This approach aligns with the objectives of the Part, and the Part lays a foundation so the management strategy can be properly executed.

Specific objectives outlined in Part III, Article 14 include the creation of a system of ecologically representative MPAs; the restoration and rehabilitation of ecosystems and biodiversity with a view to the enhancement of their productivity and health; and building resilience to stressors, including those related to climate change and ocean acidification.[99] With its use of real-time data streams, dynamic ocean management enables more sustainable use of marine resources because fishers are better informed on the status of various commercial fish stocks.[100] Further, dynamic ocean management approaches are "robust" to climate-induced ocean changes because they account for changing species

96. Levin, *supra* note 19, at 766.
97. Revised Draft Text of an Agreement, *supra* note 1.
98. *Id*.
99. *Id*.
100. Elliott L. Hazen et al., *A dynamic ocean management tool to reduce bycatch and support sustainable fisheries*, 4 Sci. Advances 1, 1 (2018) [hereinafter Hazen].

distributions at scales complementing those of human activity in the ocean.[101]

The institutional structure that the Agreement outlines would enable the collection of necessary data for a dynamic ocean management approach. One central objective is to enhance coordination and cooperation among States and relevant global, regional, subregional and sectoral bodies to enable a holistic and cross-sectoral approach to ocean management.[102] Since dynamic ocean management requires the collection of large amounts of data from day-to-day, consistent dialogue amongst the many stakeholders involved is essential. Another Agreement objective is the establishment of a comprehensive system of area-based management tools.[103] These tools include habitat modeling frameworks, which are key to ensuring effective species and habitat protection using dynamic ocean management.[104]

The Agreement states that areas requiring protection areas shall be identified using the best available science, the precautionary approach, and an ecosystem approach.[105] Further, specific indicative criteria are outlined in Annex I of the Agreement.[106] Nowhere in the Agreement is it mentioned that climate change could actively work to undermine the creative intent of some MPAs. This means, if an area is specifically identified as one requiring protection because it contains a larger population of an endangered species, but that species is highly temperature-dependent and thus migrated to an area with cooler water, the creation of that protected area is moot. In Article 21, the Agreement states that MPAs must be monitored on the basis of an adaptive management approach and by taking into account the best available science.[107] This approach means it would take much longer to determine that X species moved from a protected area to an unprotected area, and further presents the risk that the population could be decimated in that new area. Conversely, dynamic ocean management works to ensure that human's understanding of species

101. Hazen, *supra* note 100, at 2.

102. Revised Draft Text of an Agreement, *supra* note 1.

103. *Id.*

104. Hazen, *supra* note 100, at 2.

105. Revised Draft Text of an Agreement, *supra* note 1.

106. *Id.* (Indicative criteria for identification of areas: "(a) Uniqueness; (b) Rarity; (c) Special importance for the life history stages of species; (d) Special importance of the species found therein; (e) The importance for threatened, endangered or declining species or habitats; (f) Vulnerability, including to climate change and ocean acidification; (g) Fragility; (h) Sensitivity; (i) Biological diversity [and productivity]; (j) Representativeness; (k) Dependency; (l) Exceptional naturalness; (m) Ecological connectivity [and/or coherence]; (n) Important ecological processes occurring therein; (o) Economic and social factors; (p) Cultural factors; (q) Cumulative and transboundary impacts; (r) Slow recovery and resilience; (s) Adequacy and viability; (t) Replication; (u) Feasibility").

107. Revised Draft Text of an Agreement, *supra* note 1.

movement is updated in real time so efforts to protect endangered species are also updated in real time. Additionally, if MPAs are more tailored to the real-time movement of endangered species, it may be less costly ultimately. Specialized reserve design software, Marxan, finds spatial solutions that maximize marine biodiversity conservation while minimizing cost.[108]

The Agreement outlines the creation of certain institutional arrangements entrusted with the duty of ensuring that State Parties work cooperatively and efficiently with their implementation of the Parts of the Agreement. Both the Conference of the Parties as well as the Scientific and Technical Body could work to implement dynamic ocean management. The Conference of the Parties was created to monitor and review implementation of the Agreement.[109] This duty includes the promotion of coherence among efforts to conserve marine biodiversity and establishing subsidiary bodies for implementation of the Agreement as appropriate.[110] The Scientific and Technical Body is entrusted with revising the indicative criteria for the creation of MPAs, if necessary, among other tasks.[111] This body is composed of multidisciplinary experts and is free to draw on "appropriate advice" from other scientists, experts, and existing arrangements.[112] Additional functions include standard-setting and review of MPAs, as well as identifying efficient, innovative and "state-of the-art technology and know-how" related to conservation of marine biodiversity.[113] Dynamic ocean management is a highly innovative method to ensure that marine biodiversity remains protected despite its climate-induced movement to unprecedented areas. Both the Conference of the Parties and the Scientific and Technical Body are the appropriate institutional arrangements to propose, implement, and monitor the use of dynamic ocean management under the Agreement.

C. PART V – "CAPACITY-BUILDING AND TRANSFER OF MARINE TECHNOLOGY"

Part V of the Agreement details capacity-building and the transfer of marine technology for the objectives of the Agreement. Marine technology is defined broadly as data and information, including observation facilities and equipment (i.e., remote sensing equipment), and computers with

108. Heather Welch and Jennifer McHenry, *To Conserve Ocean Life, Marine Reserves Need to Protect Species that Move Around*, THE CONVERSATION (Feb, 3, 2020, 3:25 PM), https://perma.cc/73T9-LESD.
109. Revised Draft Text of an Agreement, *supra* note 1.
110. *Id.*
111. *Id.*
112. *Id.*
113. *Id.*

software containing models and modelling techniques.[114] Ensuring the swift and efficient sharing of this technology is essential to ensuring that dynamic ocean management is successfully implemented.

Further, one specific Agreement objective is to develop the marine scientific and technological capacity of the State Parties to ensure that they have the capacity to develop, implement, monitor and manage MPAs.[115] Under the Agreement, the Conference of the Parties have the power to adopt rules of procedure for itself, as well as for any subsidiary body that it may establish.[116] One subsidiary body noted in the draft Agreement is "a capacity-building and transfer of marine technology committee."[117] Establishing such a committee is critical to ensure more efficient and effective oversight for the State Parties as they work to share data with each other, including by creating initial information systems.

In Annex II of the Agreement, types of capacity-building and transfer of marine technology are further explicated – this includes information dissemination and awareness-raising. One area flagged under this category is stressors on the ocean, including the adverse effects of climate change and ocean acidification that affect marine biodiversity in the High Seas.[118] Compiling information on climate change's effects on the ocean is essential for dynamic ocean management models to accurately predict how marine biodiversity is shifting location over time. Further, Article 51 establishes a clearing-house mechanism, an open-access web-based platform which will serve as a centralized platform to enable State Parties to have access to and disseminate relevant data and scientific information.[119] Taken together, this section will enable the appropriate sharing of information needed to make sure that dynamic ocean management is successfully protecting target species.

D. PART VIII – "IMPLEMENTATION AND COMPLIANCE"

Part VIII of the Agreement highlights the necessity for State Parties to take appropriate action to ensure successful implementation of the Agreement.[120] State Parties must monitor the implementation of their obligations under the Agreement and the Conference of the Parties has free license to adopt cooperative procedures and institutional mechanisms to promote compliance.[121] This means that State Parties could be held accountable for not doing their part in collecting necessary data for

114. Revised Draft Text of an Agreement, *supra* note 1.
115. *Id.*
116. *Id.*
117. *Id.*
118. *Id.*
119. *Id.*
120. *Id.*
121. *Id.*

dynamic ocean management models. The Conference of the Parties could conduct their own independent review and pressure State Parties to develop the appropriate agencies to gather necessary data.

The Agreement, as drafted, provides a solid foundation for the facilitation of a dynamic ocean management strategy. Once implemented, it is necessary to ensure that the appropriate data is continuously collected and disseminated to commercial ocean-users. State Parties must be educated on the proper protocol to complete such duties and must be held accountable if they do not abide by protocols. To demonstrate how this management strategy may be instituted, this paper examines how dynamic ocean management could be utilized to protect a pelagic, migratory fish, as well as deep-sea benthic fish species.

V. IMPLEMENTING DYNAMIC OCEAN MANAGEMENT UNDER THE AGREEMENT: PROTECTING PELAGIC AND DEEP-SEA SPECIES

The Agreement only applies to the High Seas, it therefore protects two main classes of species: pelagic (those dwelling in the water column) and benthic (those living on the deep-sea ocean floor). Here, I assess the feasibility of protecting those classes of species by looking at the highly migratory, pelagic bluefin tuna (*Thunnus thynnus*), and deep-sea, benthic fish species.

A. DYNAMIC OCEAN MANAGEMENT AND BLUEFIN TUNA (*THUNNUS THYNNUS*) PROTECTION

Atlantic bluefin tuna, the largest variety of tuna, are currently listed as endangered largely due to their commercial value.[122] They migrate throughout the Atlantic Ocean, as well as the Mediterranean Sea, and can dive deeper than 3,000 feet.[123] UNCLOS lists them as one of its 17 highly migratory species.[124] Their populations have drastically declined due to overfishing and illegal fishing throughout the past several decades.[125] Their distributions are also shifting due to climate change. One study found that, on average, bluefin habitat distribution limits shifted poleward 6.5 km per decade in the northern hemisphere and 5.5 km per decade in the southern hemisphere.[126] Given the bluefin's highly migratory nature, a static MPA

122. *Bluefin Tuna Facts*, WORLD WILDLIFE FOUNDATION, https://perma.cc/UZ6D-3DF6 [hereinafter *Bluefin Tuna Facts*]. (One single Atlantic bluefin once sold for over $1.75 million).

123. *Id.*

124. United Nations Convention on the Law of the Sea, *supra* note 43.

125. *Bluefin Tuna Facts*, *supra* note 122.

126. Maite Erauskin-Extramiana et al., *Large-Scale Distribution of Tuna Species in a Warming Ocean*, 25 GLOBAL CHANGE BIOLOGY 2043, 2043 (2018).

is not effective in ensuring that it is not overfished. Additionally, the mapping of the bluefin's migration pattern would lead to inadequate protection because a singular map does not account for changing ocean conditions from climate change. Thus, the appeal of dynamic ocean management is clear because it allows for real-time data of the bluefin's migrations to inform protection efforts.

One of the more problematic dimensions of a dynamic ocean management strategy for bluefin protection is the collection of sufficient data to inform said strategy. This must be a highly collaborative effort, not just on the shoulders of State Parties, but also international coalitions (i.e., International Commission for the Conservation of Atlantic Tunas ["ICCAT"]) and large global nonprofits (i.e., World Wildlife Fund) must be involved in the effort. ICCAT is an intergovernmental fishery organization which complies fishery statistics from its members and other fishing entities, coordinates research, and generates science-based management advice.[127] The World Wildlife Fund has been tagging bluefin in the Mediterranean Sea since 2008 to help fisheries managers better understand their migratory behaviors.[128] Under Part V of the Agreement, information from such institutions must be shared via the clearing-house mechanism so appropriate migration models are generated. Then, such information must be distributed to commercial fishers so that they are consistently informed of the protected bluefin's whereabouts. Fishers could be wary of such dynamic closures cutting into their catch, yet one study showed that dynamic closures could be two to ten times smaller than static closures, while also still providing adequate protection of endangered nontarget species.[129]

Illegal fishing is another issue and is one of the largest contributors to the bluefin's rapid decline.[130] This requires actors under the Agreement to be more deliberate in monitoring compliance with the dynamic boundaries of the MPAs. One method of monitoring compliance is randomly tagging bluefin determine who catches the fish. Through the location and punishment of bad actors, State Parties under the Agreement present a significant disincentive to illegal fishers, who thus are forced to abide by dynamic MPA boundaries.

B. DYNAMIC OCEAN MANAGEMENT AND DEEP-SEA FISH SPECIES PROTECTION

Understanding deep-sea fish species migratory behavior is more enigmatic than the Atlantic bluefin. Regardless, it is imperative that deep-

127. INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS, https://perma.cc/8DL5-TXMH (last visited May 10, 2020).
128. *Bluefin Tuna Facts*, *supra* note 122.
129. Hazen, *supra* note 100, at 1.
130. *Bluefin Tuna Facts*, *supra* note 122.

sea fish are protected because some species are listed as endangered before humans understand them. For example, records of catches logged by trawlers from 1978 to 1994 in the North Atlantic show that at least five deep-sea fish species population levels that qualify for the World Conservation Union's critically endangered list.[131] Additionally, many deep-sea fish are commercially important which has given the international scientific community further impetus to try to understand them before it is too late.

The United Nations Environmental Programme ABNJ Deep-seas and Biodiversity project, and the Deep Ocean Stewardship Initiative published a technical paper in 2018 which showcased an effort to better understand climate change's effects on deep-sea fisheries.[132] Together, these institution's expert scientists generated predictions on chemical, physical, and biological oceanography under a range of various climate change scenarios.[133] One salient point was that distribution changes are expected as species populations shift from their current locations to new areas due to climate change.[134] Species distribution models ("SDMs") were presented as a useful tool to more closely understand these changes.[135] Using species occurrence data from the Ocean Biodiversity Information System and a set of projections of changing physical and chemical ocean conditions at the ocean floor in 2100, habitat suitability for six cold-water coral species and six commercially important fish species was modeled under current and future climate conditions.[136] Model predictions demonstrated that many species could face habitat reduction by 2100 and, in some cases, showed that the reductions could encompass more than 50 percent of the area currently considered suitable habitat.[137] This is the type of species-specific habitat suitability modeling that must inform the Agreement's dynamic ocean management approach. However, there are certain challenges that must be overcome for said modeling to more accurately and effectively inform a dynamic management approach. Some of those challenges are presented in the following section of this paper.

131. Ian Sample, *Deep Sea Fish Face Extinction*, THE GUARDIAN (Jan. 4, 2006), https://perma.cc/2BP9-TL56.

132. FOOD & AGRIC. ORG. OF THE U.N., ISSN 2070-7010, DEEP OCEAN CLIMATE CHANGE IMPACTS ON HABITAT, FISH, AND FISHERIES (2018) [hereinafter FOOD & AGRIC. ORG. OF THE U.N.].

133. *Id.*

134. *Id.*

135. *Id.*

136. *Id.*

137. *Id.*

VI. DECONSTRUCTING CHALLENGES TO THE IMPLEMENTATION OF DYNAMIC OCEAN MANAGEMENT UNDER THE AGREEMENT

A dynamic ocean management strategy under the Agreement is feasible, but several outstanding issues must be acknowledged and addressed so that the management strategy is successful. These challenges include ensuring that accurate data is consistently provided to inform modeling and that compliance with dynamic MPA boundaries is effectively monitored and enforced.

A. DEVELOPMENT OF PROPER INFORMATION SYSTEMS FOR IMPLEMENTATION

Dynamic ocean management is a highly data-driven management strategy. The fact that the deep-sea remains considered one of the most chronically unstudied areas of the ocean presents new challenges for a dynamic ocean management approach under the Agreement. However, the United Nations Environmental Programme technical paper, mentioned in Section V(b) of this paper, demonstrates that deep-sea scientific research is growing, albeit further strides must made in data's accuracy to ensure that models informing MPA boundaries are more tailored. For example, considering that the deep ocean floor is biodiverse on a small-scale, it is more ideal for models to be based on *in situ* (local) measurements, rather than global datasets.[138] Extrapolating from a global dataset would not allow for researchers to as accurately pinpoint areas needing MPAs or anticipate biodiversity's climate change-induced range shifts. Despite this uncertainty, the UNEP paper still argues that species distribution or habitat suitability models are useful tools in predicting possible future changes in the distribution of deep-sea species.[139]

B. MONITORING COMPLIANCE WITH, AND ENFORCING, DYNAMIC MPA BOUNDARIES

One additional challenge with creating dynamic MPAs is monitoring compliance and ensuring that MPA boundaries are properly enforced. Sara Maxwell, an ocean sciences scholar, proposes several practical tactics for encouraging compliance: outreach and education, "participatory monitoring," and increasing the use of vessel monitoring technology.[140] Community consultation, conflict management mechanisms, education or

138. FOOD & AGRIC. ORG. OF THE U.N.
139. *Id.*
140. Sara M. Maxwell, et. al, *Pragmatic approaches for effective management of pelagic marine protected areas*, 26 ENDANGERED SPECIES RESEARCH 59, 67–70 (2014) [hereinafter Maxwell].

capacity-building, and accountable and participatory management have shown themselves to be some of the best methods for achieving compliance.[141] "Participatory monitoring" involves MPA users and stakeholders in the surveillance and enforcement process.[142] This method increases capacity, further educates users about regulations, grows public perception of the legitimacy of regulations, and reduces enforcement costs.[143] "Peer reporting" is especially helpful in remote MPAs since the potential for infractions is high because the chance of being caught by an enforcement vessel is low.[144] Thus, participatory monitoring increases monitoring capacity and would allow State Parties to better target the use of enforcement vessels under the Agreement. Lastly, it is beneficial to make use of the increased amount of vessel monitoring technology, which includes cooperative and non-cooperative systems.[145] For example, the use of transceivers is one method of cooperative monitoring.[146] Non-cooperative vessel monitoring technologies include aerial flights, passive acoustic monitoring arrays, satellite systems, and operated drones.[147]

Not every ship found in a dynamic MPA should be presumed a bad actor. Since MPAs informed by a dynamic ocean management strategy change consistently, it is imperative first and foremost that an effective information system is created to ensure that all stakeholders have knowledge of the dynamic MPA boundaries over time. In Annex II of the Agreement, different varieties of information are flagged for dissemination and awareness-raising – one of these specific varieties is the boundaries of MPAs.[148] Since dynamic ocean management's success is heavily reliant on fishers and other commercial ocean-users understanding the boundaries of MPAs, it is a positive step that the Agreement is working to build up channels of communication. Taken together, these methods could increase stakeholder cooperation and compliance with dynamic MPA boundaries and assist with targeting bad actors for enforcement.

141. Maxwell, *supra* note 140, at 67–68.
142. *Id.* at 68.
143. *Id.*
144. *Id.*
145. *Id.* at 69.
146. *Id.* at 70.
147. *Id.*
148. Revised Draft Text of an Agreement, *supra* note 1.

CONCLUSION

Incorporating principles of dynamic ocean management into the Agreement could significantly increase the efficacy of MPAs for certain target species. This argument is timely considering how rapidly ocean conditions are changing due to climate change and how species ranges are shifting to unprecedented locations as a result. Considering that dynamic ocean management is highly technology and information based, it is imperative to ensure that the proper institutional structures are developed to enable this method of management. Additionally, with shifting MPA boundaries comes additional difficulty in monitoring and enforcing those boundaries. Managers must be conscious of these potential issues to actively work to subvert them when implementing dynamic ocean management under the Agreement. Despite these challenges, dynamic ocean management prevails over traditional management strategies in ensuring that essential species are protected as their habitats inevitably change due to climate change.

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