ASSESSMENT OF OCEANIC BLUE CARBON IN THE UNITED ARAB EMIRATES

POLICY OPTIONS

UAE Oceanic Blue Carbon Pilot Study
Abu Dhabi Global Environmental Data Initiative (AGEDI)

AGEDI
Abu Dhabi Global Environmental Data Initiative

GRID ARENDAL
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Assessment of Oceanic Blue Carbon in the UAE: Policy Options

UAE Oceanic Blue Carbon Pilot Study

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The principal investigators for the UAE Oceanic Blue Carbon Pilot Study are Steven Lutz of GRID-Arendal, Norway, and Dr. Heidi C. Pearson, of Blue Climate Solutions, a project of The Ocean Foundation, and the University of Alaska Southeast, USA. Jane Glavan and Angela Rubilla of the Abu-Dhabi Global Environmental Data Initiative (AGEDI) provided technical support.

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ABOUT THE REPORT

The UAE Oceanic Blue Carbon Pilot Study aims to provide a first-level assessment of oceanic blue carbon ecosystems and policy opportunities within the United Arab Emirates. The principal investigators have utilized existing datasets and methodologies to quantify and assess the capacity for fish, cetaceans, dugongs, sea turtles, and seabirds inhabiting UAE's marine environment to store and sequester carbon. Through two reports, the analysis represents the world's first oceanic blue carbon audit and policy assessment at the national level and will allow relevant policy and management entities in the UAE to evaluate options for the potential implementation of oceanic blue carbon policies at the local and national levels.

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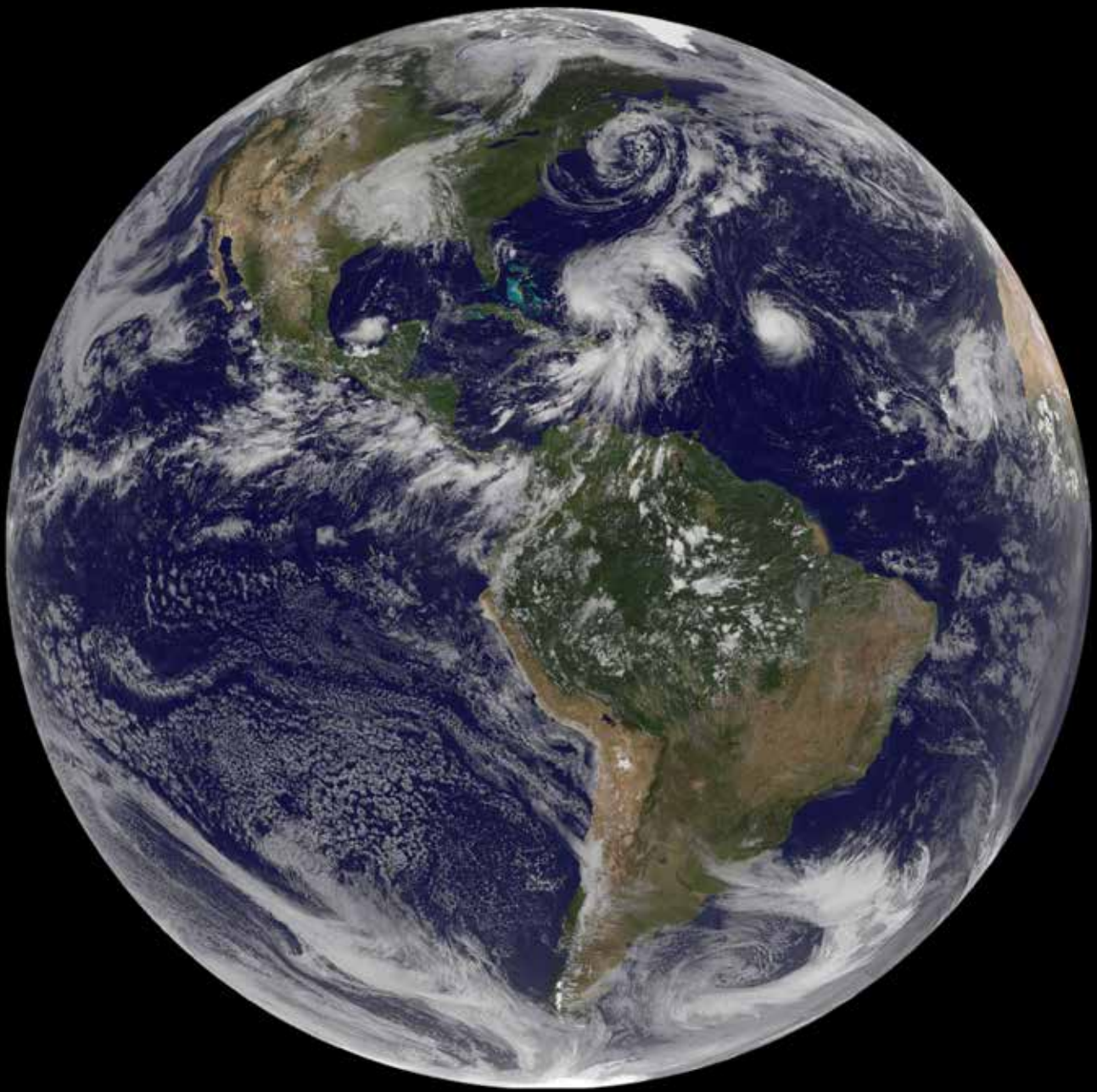
ABSTRACT

Oceanic blue carbon refers to the natural ways that marine vertebrates can trap and sequester carbon, potentially mitigating the effects of climate change. Protecting and enhancing oceanic blue carbon stores may lead to conservation and climate change mitigation benefits. While the science of oceanic blue carbon is nascent and progressing, its relevance to policy and management are unknown. Within this context, a pilot study was conducted in the United Arab Emirates (UAE) to help understand potential oceanic blue carbon policy options in addressing the global climate change challenge and in supporting sustainable fisheries and marine policy. This report presents the results of a survey of 28 coastal and marine environmental stakeholders to assess knowledge, attitudes, and perceptions of the concept of oceanic blue carbon and its relevance to policy. This survey's major finding is that the application of oceanic blue carbon policy has significant relevance to the areas of climate change, biodiversity conservation, and fisheries management in national, regional, and international contexts. These findings are the world's first of their kind and significantly contribute to conversations regarding ocean conservation, sustainable management of marine resources and nature-based solutions in the context of climate change mitigation.



INTRODUCTION

OCEANIC BLUE CARBON

Covering 70% of the Earth's surface, the ocean is considered the most life-sustaining environment on the planet (Visbeck 2018). It provides a wide array of ecosystems that support global biodiversity, sustain the global economy, contribute to food security worldwide, and play a major role in climate regulation (Hendriks et al. 2010, Mega 2016). Decades of research have provided clear evidence that the ocean is central in regulating the global climate system and buffering against the impacts of climate change (IPCC 2013). The ocean is the main source of thermal inertia in the climate system (Barnett 2001, IPCC 2013) and is the sink for roughly 30% of human-caused carbon dioxide emissions (Landschuetzer et al. 2016).

Coastal blue carbon

Carbon fixed and stored in vegetated coastal and marine ecosystems, in both plant biomass and sediments below.

Oceanic blue carbon

Carbon fixed and stored in the ocean and seafloor sediments through the actions and influences of marine animals.*

*This study focuses on marine vertebrates.

Figure 1. *Coastal and oceanic blue carbon (image credits in order of appearance: Steven Lutz; Dimitris Poursanidis; Peter Prokosch; Glenn Edney; Doug Beckers; David Peart).*

Carbon in the ocean is stored through the biomass, feeding activities and other life processes of marine life such as coastal vegetation, phytoplankton, krill, fish, seabirds, sea turtles, and marine mammals. This encompasses coastal ecosystems that fix and store carbon such as mangrove forests, seagrass meadows, and salt marshes (i.e., "coastal blue carbon"), oceanic primary production, and the ocean's biological carbon pump (Duarte et al. 2004, Nellemann et al. 2009, Sigman et al. 2012, Neuer et al. 2016). In this study, we focus on marine fauna, specifically marine vertebrate species, which are termed "oceanic blue carbon" (Fig. 1). Nine oceanic blue carbon mechanisms for marine vertebrates have been identified (Fig. 2) (Lutz and Martin 2014, Lutz et al. 2018).

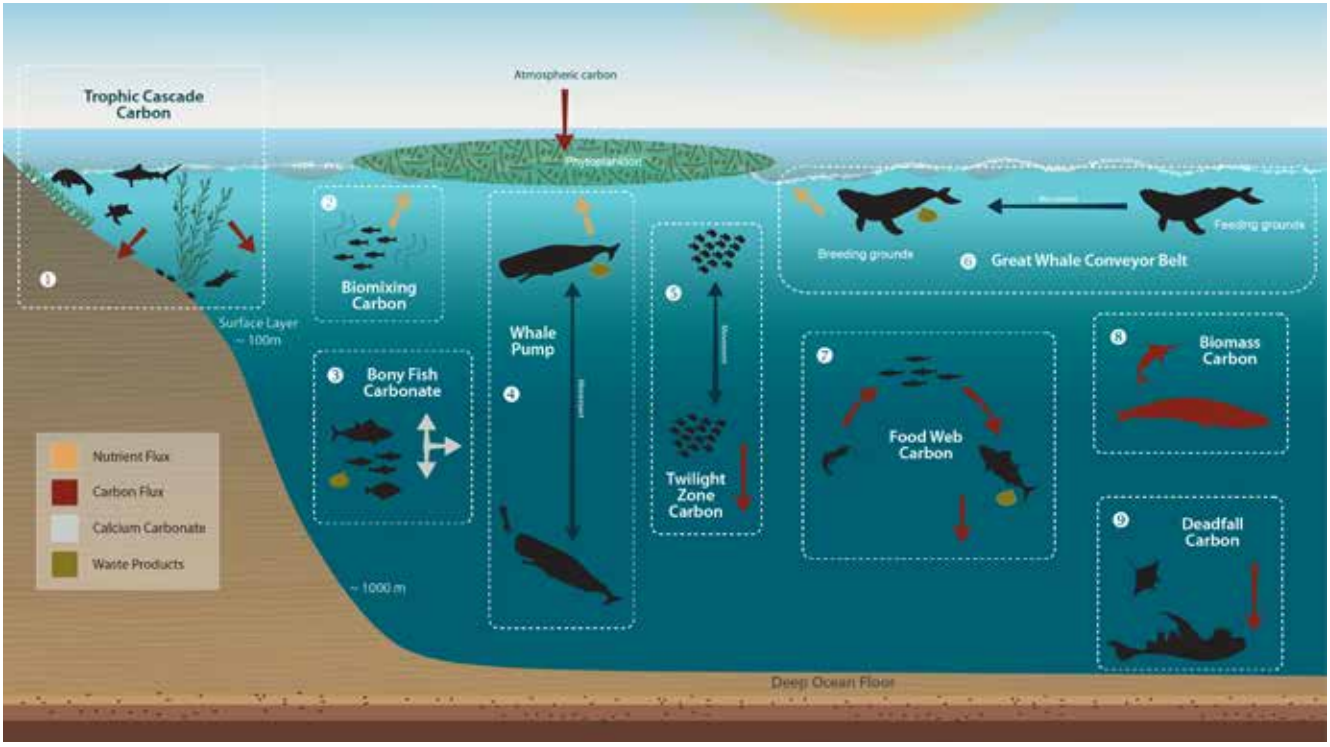


Figure 2. *The nine oceanic blue carbon mechanisms for marine vertebrates (Lutz et al. 2018). 1) Marine predators help plants to grow by keeping herbivore populations in check. This helps maintain the carbon storage function of coastal vegetation. 2) The swimming movement of marine animals can stir up nutrients towards surface waters. These nutrients can be used by phytoplankton as they grow, absorbing carbon. 3) Bony fish excrete carbon in the form of calcium carbonate. This raises the pH of seawater and potentially provides a buffer against ocean acidification, which is one effect of climate change. 4) All whales dive underwater to feed and return to the surface to breathe. At the surface, they release buoyant fecal plumes that are rich in nutrients that phytoplankton need to grow. 5) Mesopelagic fish migrate towards the surface at night to feed, then return to deep waters during the day. This helps transport carbon to deep waters where it can be released as fecal pellets. 6) Many whales migrate from nutrient-rich feeding grounds to nutrient-poor breeding grounds. At the breeding grounds, whales release nitrogen-rich urea that can stimulate phytoplankton growth. 7) Fish eat and repackage food into carbon-rich fecal pellets that sink rapidly. Fecal material that reaches the deep sea can remain locked away for hundreds to thousands of years. 8) All living things are made of carbon and thus serve as carbon reservoirs throughout their lifespans. The larger and more long-lived the animals, the more carbon is stored. 9) When large marine vertebrates die, their carcasses sink to the seafloor. There, the carbon inside their carcasses can support deep-sea ecosystems and be incorporated into marine sediments.*

CONTEXTUALIZING OCEANIC BLUE CARBON POLICY

The concept of oceanic blue carbon was introduced into climate change policy discussions in 2008 (Lutz 2008a, b, c, d, e, f, g, World Bank and FAO 2009). These discussions first focused on the value of "fish carbon" and then on "whale carbon," as described in the following sections.

FISH CARBON

Discussion on the potential benefits from ocean carbon sequestration resulting from healthy fish stocks, i.e. fish carbon (World Bank and FAO 2009), has increasingly grown in the arenas of fisheries and climate change policy since 2008 (e.g., Lutz 2008a, b, c, d, e, f, g, World Bank and FAO 2009, San Feliu De Guíxols Ocean Carbon Declaration 2010, Rogers et al. 2014, Lutz and Martin 2014, Laffoley et al. 2014, UN 2017, Chami et al. 2018, Ocean Conservancy 2020, Wright et al. 2020, Greenpeace International 2020, Buckminster Fuller Institute 2020, EJF 2021). Efforts that illustrate a broad consensus of support for advancing oceanic blue carbon in science and policy include the 2010 San Feliu De Guíxols Ocean Carbon Declaration (San Feliu De Guíxols Ocean Carbon Declaration 2010), the 2017 Oceanic Blue Carbon Voluntary Commitment (UN 2017) and a 2021 open letter to world leaders (EJF 2021). The Oceanic Blue Carbon Voluntary Commitment was endorsed by over 100 organizations and members of the scientific community at the 2017 UN Ocean Conference. It recognized that "in the open ocean, marine vertebrates, such as whales, sharks and finfish, may… contribute to the ocean's carbon function," and advanced the following actions:

- Raise awareness and improve international recognition of the value of the conservation of marine ecosystems and ocean life in addressing the global climate challenge.
- Ask policy makers to include the carbon functions of coastal and oceanic marine ecosystems in strategies for conservation and climate change mitigation.
- Support cross-disciplinary research to improve understanding and quantification of the role of marine ecosystems and ocean life in the global carbon cycle, including the removal of carbon from the atmosphere and storage in the oceans.

WHALE CARBON

Whales are featured in at least four oceanic blue carbon mechanisms (see mechanisms 4, 6, 8, and 9 in Fig. 2) and their potential role in climate change mitigation policy, i.e., whale carbon, has been advanced since 2010 (Blue Climate Solutions 2010). Since 2016, the value of whale carbon

has been increasingly recognized in international policy, notably in support of whale conservation and research, including through three resolutions at the International Whaling Commission (IWC), in 2016 and 2018.

During the 67th meeting of the International Whaling Commission (IWC) in 2018, 41 nations recognized and highlighted the potential role whales play in retaining carbon in the ocean and helping to reduce the effects of climate change, through the passage of two resolutions (Fig. 3). These included the "Resolution on Advancing the Commission's Work on the Role of Cetaceans in the Ecosystem Functioning" and "The Florianópolis Declaration" (IWC 2018a, IWC 2018b). The resolutions called for the following:

- Encouragement of member states "to integrate the value of cetaceans' ecological roles into local, regional, and global organisations on biodiversity and environment, including climate change" (IWC 2018a). The resolution also commends the IWC's "Scientific and Conservation Committee for their

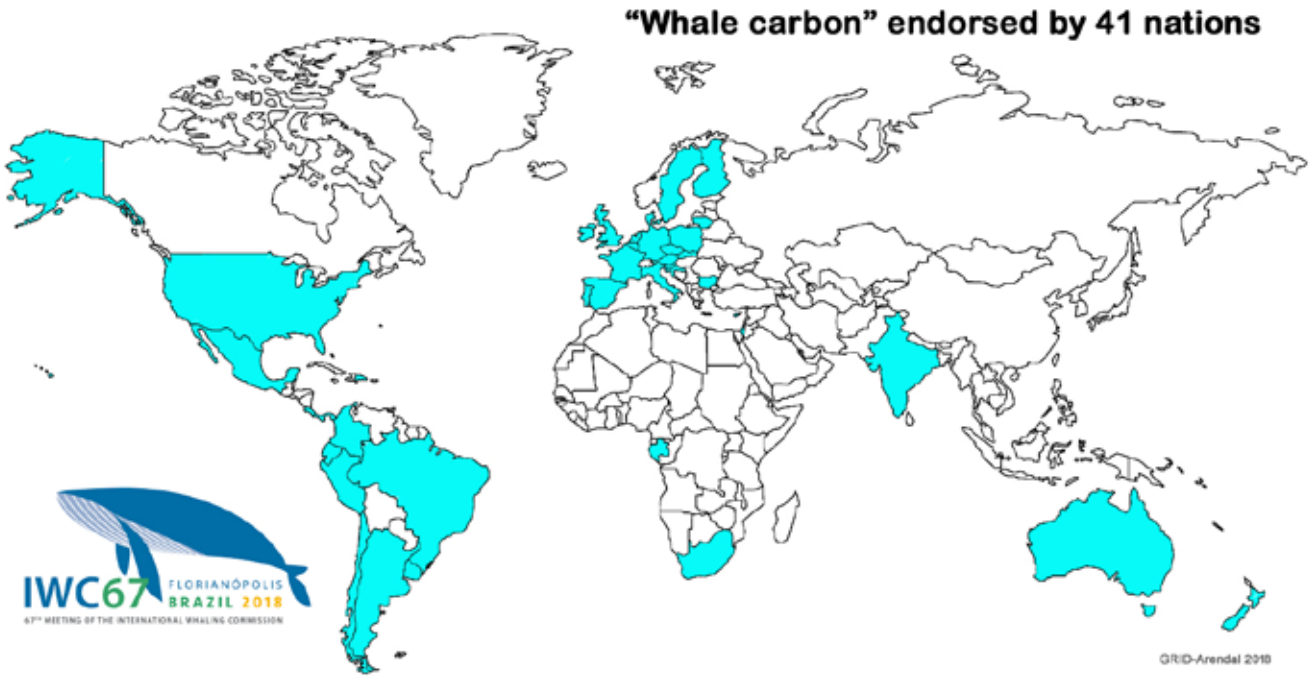


Figure 3. *41 nations endorsed the concept of whale carbon at the IWC in 2018 (Lutz and Pearson 2018). These are Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Chile, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Finland, France, Gabon, Germany, India, Ireland, Israel, Italy, Lithuania, Luxembourg, Mexico, Monaco, Netherlands, New Zealand, Panama, Peru, Poland, Portugal, Slovak Republic, Slovenia, South Africa, Spain, Sweden, United Kingdom, United States of America, and Uruguay.*

efforts to increase understanding of the contribution of cetaceans to ecosystem functioning", which is a reference to a 2016 resolution passed at the 66th meeting of the IWC in 2016, which asked the IWC's Scientific Committee to research how whale conservation may help mitigate climate change (IWC 2016).

- Recognition that the role of the IWC has evolved to include "the maintenance of healthy cetacean populations to fulfil the vital ecological and carbon cycling roles these animals play in the global marine ecosystem functioning" (IWC 2018b).

Since 2016, civil society has supported the endorsement of whale carbon at the IWC, including through the submission of reports and related documents that recognize the concept to the 66th and 67th meetings of the IWC (Altherr and Hodgins 2018, AWI 2018, IUCN 2016, WWF 2016, WDC 2016). Author S. Lutz relates that the 2021 IWC Workshop on Cetacean Ecosystem Functioning, held in conjunction with the Convection on Migratory Species, has continued discussions recognizing the value of whale carbon (Lutz 2021).

In 2018, an article exploring the economic value of whale ecosystem benefits was published in the International Monetary Fund's Finance & Development (F&D) magazine (Chami et al. 2018). The authors estimated a value for the average great whale, based on its various activities including whale carbon, at more than USD $2 million, and over USD $1 trillion for the current global stock of great whales. This story was profiled in international media, such as Time magazine (US) (Randow 2019), National Geographic magazine (US) (Stone 2019), elDiario (Spain) (Rodríguez 2019), GQ magazine (Italy) (Trabucchi 2019), UNEP News and Stories (Kenya) (UNEP 2019), Naturpress (Norway) (Ali 2020), and MPA News (US) (MPA News 2020). The concept was also presented

at the 2019 World Economic Forum Annual Meeting in Davos, Switzerland (Rooney 2019), a side event at the UN Climate Change Conference COP 25 of the United Nations Framework Convention on Climate Change (UNFCCC) (Fundación MERI 2019), and at the 2020 T20 meeting hosted by Saudi Arabia to inform the Group of Twenty (G20) (Mansouri et al. 2020).

In 2021, four oceanic blue carbon mechanisms, including whale carbon, were featured in the Seaspiracy documentary on the Netflix streaming video service (Seaspiracy 2021). Within a week of release the documentary trended on the platform as one of its top 10 most watched films and programmes (Baker 2021), disseminating the concept of oceanic blue carbon to potentially millions of the general public worldwide.

SURVEY RATIONAL

The purpose of this study is to assess the awareness and perceptions of marine polices in order to assist policymakers in the identification of knowledge gaps and build sustainable and effective management of coastal and marine ecosystems. In order to achieve this goal, the results of a survey about stakeholders' attitudes, knowledge, and perceptions of the concept of oceanic blue carbon are presented. The results of the survey provide information about stakeholders that can drive the application of oceanic blue carbon policy within the United Arab Emirates (UAE) and internationally. This research – a national oceanic blue carbon policy assessment – is the first of its kind and considerably contribute to conversations about ocean actions, including sustainable fisheries management, in the mitigation of climate change.

UNDERSTANDING STAKEHOLDER PERCEPTIONS AND ATTITUDES

Understanding stakeholders' attitudes towards and perceptions of marine policies can provide key insights into how to best advance said policies. For example, researchers have suggested that public perceptions of the potential benefits and impacts of Marine Protected Areas (MPAs) are an important indicator of social acceptability of those MPAs (Blyth et al. 2002, McClanahan et al. 2005, Leleu et al. 2012). If stakeholders perceive that MPAs will provide ecological, social, or economic benefits to their region, they may be more likely to support and comply with MPA regulations. On the contrary, if not understood, societal factors that are impacted by the implementation of different types of protected areas may result in or contribute to negative and/or unexpected outcomes because of human reactions to the regulations. Such reactions may include simply ignoring the rules or increasing extraction of resources due to weak enforcement, while its impacts may include exacerbation of socioeconomic hardship due to closing of traditional fishing grounds, resulting in political backlash and other undesirable outcomes (Grober-Dunsmore and Ridgley 2000a, Grober-Dunsmore and Ridgley 2000b).

The research on oceanic blue carbon is currently nascent and expanding, and understanding potential policy options is key to realizing the relevance of the concept. Without this knowledge, the relevance of oceanic blue carbon to policy and management may not be fully comprehended or appreciated. For example, Laffoley (2020) notes that "since 2009 there has been a surprising dedication to just three of the original ecosystems identified for carbon values (mangrove forests, saltmarshes and

seagrass meadows) despite a growing awareness that many other aspects of carbon in the ocean are also important and worthy of protection… There was subsequently little uptake of interest on offshore carbon sinks and pathways which is surprising given the possibilities back then of industry such as fishing having impacts on such sinks."

Additionally, in defining the potential for coastal and marine ecosystems to be included in climate mitigation policy, Howard et al. (2017) indicate that it is not possible to manage marine fauna for climate mitigation purposes. The IUCN notes potential jurisdictional challenges related to the management of marine systems and fauna for climate change mitigation (IUCN 2017). Furthermore, in defining criteria for actionable blue carbon ecosystems, Lovelock and Duarte (2019) identify that management is not practical or possible to maintain or enhance carbon stocks and reduce greenhouse gas emissions for marine fauna.

Understanding perceptions and attitudes on oceanic blue carbon can assist policymakers in assessing the viability of harnessing it in policy and management options that aim to support sustainable and effective management of fisheries, marine mammals, and other marine life.

ADVANCING NATURE-BASED SOLUTIONS TO CLIMATE CHANGE

The recognition of the roles that natural ecosystems can play in climate change mitigation and adaptation are often referred to as nature-based solutions. Parties to the Paris Agreement can develop their Nationally Determined Contribution (NDC) actions and priorities based on a portfolio of measures including the conservation and restoration of nature as a climate change solution. Up to 158 countries contain coastal and oceanic blue carbon ecosystems and resources (i.e., states with an Exclusive Economic Zone (Flanders Marine Institute 2019), marine fisheries (Sumaila et al. 2019), marine mammals (Jefferson et al. 1993), and coastal blue carbon habitats (Herr and Landis 2016)), thereby recognizing and including the value of coastal and oceanic blue carbon in policy and management may help countries achieve their commitments to address climate change.

Since introduction of the term "blue carbon" in 2009 (Nellemann et al. 2009), the role that coastal blue carbon ecosystems play in climate mitigation has experienced a rapid increase in recognition. In 2016, 28 countries included the conservation and restoration of these ecosystems as mitigation actions in national pledges to fulfil the Paris Climate Agreement (UNFCCC 2015a, Martin et al. 2016, Herr and Landis 2016). However, actions related to marine life and ocean ecosystems, beyond coastal vegetation (i.e., coastal blue carbon), are largely absent from such pledges.

Nature-based solutions are a high priority within the United Arab Emirates (UAE). The research conducted for this study follow and builds on prior coastal blue carbon projects such as the Abu Dhabi Blue Carbon Demonstration Project, and the National Blue Carbon Assessment, which quantified carbon stocks and the other services provided by coastal and marine blue carbon ecosystems along the coast of the UAE (AGEDI 2013, Kauffman and Crooks 2015). These initiatives also contributed to the improved understanding of coastal blue carbon on the regional and international scales (Crooks et al. 2013, Crooks et al. 2014, Campbell et al. 2014). These projects enhanced capacity at multiple stakeholder levels, including the measuring and monitoring of carbon in coastal ecosystems and the management of associated data. In addition, they identified options for the incorporation of these values into policy and management and supported recognition of the value of coastal blue carbon in the UAE's NDC to fulfil the Paris Agreement (UNFCCC 2015b).

The 2018 report from the Intergovernmental Panel on Climate Change (IPCC) urges immediate action to prevent major global climate disasters (IPCC 2018). Recognizing the role that marine life plays in the carbon cycle can potentially help the UAE and all coastal and island nations answer that call as an innovative and important nature-based strategy for combating climate change.

SUPPORTING SUSTAINABLE FISHERIES MANAGEMENT

Efforts that support the sustainable management of fishery resources globally and within the UAE are urgently needed. Marine fisheries throughout the globe are in crisis and there is a critical need to avert the further escalation of this issue (Coulthard et al. 2011). According to the World Bank (2017), 90% of the world's fisheries were experiencing economic overfishing in 2011. Fig. 4 illustrates the global increase of fish catches since 1950.

Furthermore, according to the Environment Agency – Abu Dhabi, the UAE's fisheries resources are severely overexploited with an estimated 90% decline in the adult (reproductive) stock size for the three key demersal indicator species – Hamour (Epinephelus coiodes, orange spotted grouper), Shaari (Lethri nus nebulosus, spangled emperor), and Farsh (Diagramma pictum, painted sweetlips) (EAD 2019). "Thirty percent is the international sustainable fisheries management threshold below which these stocks are considered to be overexploited yet in the UAE, best available information infers that the relative adult stock size of these three species are considered to be around 10%

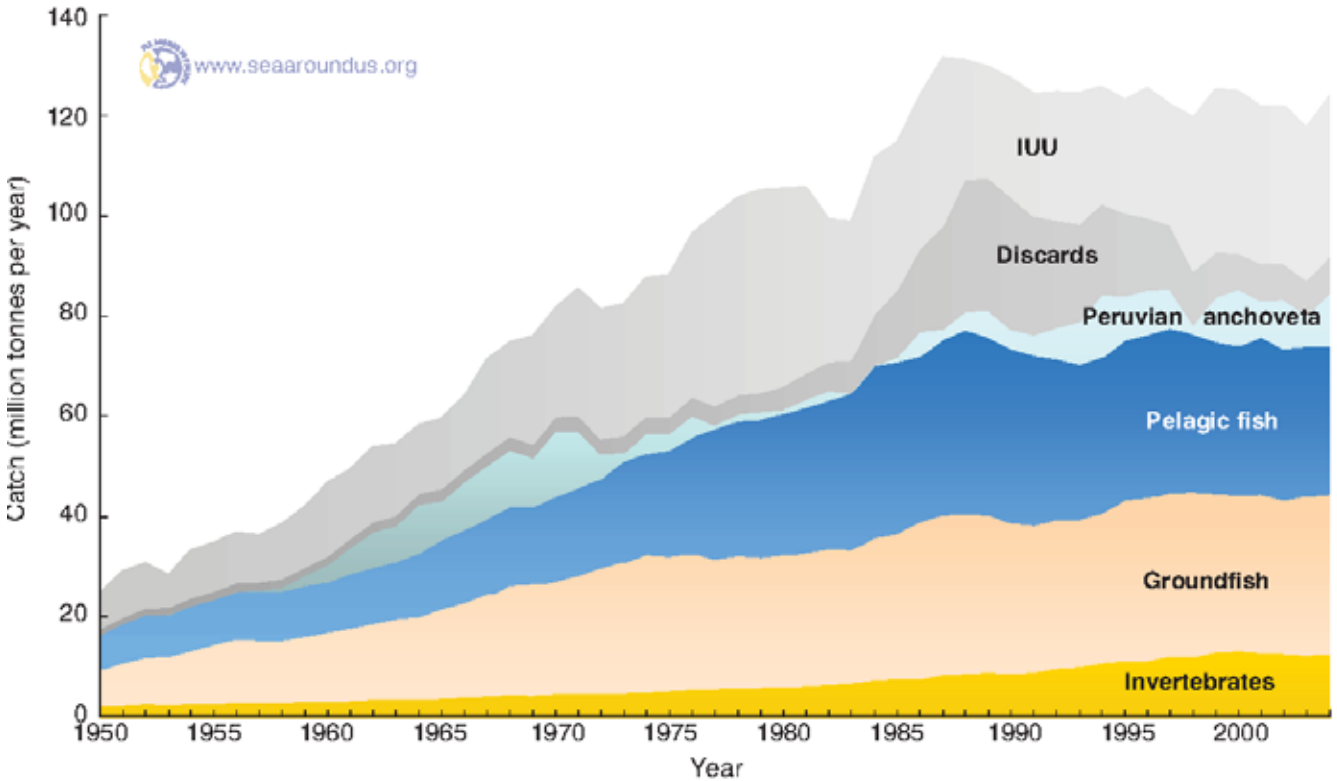


Figure 4. *Global marine fisheries catches, 1950-2004 (Pauly 2008).*

of their unexploited state" (Environment Agency – Abu Dhabi 2019).

The severely overexploited state of the fishery sector is the main driver for the UAE's National Framework Statement for Sustainable Fisheries for the years 2019-2030.

Recognizing the roles that marine life play in the carbon cycle can potentially provide additional incentives to policies that sustainably manage fisheries resources and marine mammals.

RESEARCH QUESTION

Following the recognition of coastal blue carbon in national and international policy and management, recognition of "whale carbon" at the IWC, and the context of a global fisheries crisis and the global climate change challenge, this pilot study aims to help answer the following research question:

> **Is the value of oceanic blue carbon relevant to the policies and the sustainable management of coastal and marine environmental resources and actions to address the global climate change challenge?**

METHODS

Testing the pilot study's research question included assessing the following five themes:

1. Identification of views on the potential importance of oceanic blue carbon to marine and climate policies.
2. Identification of relevant policies to oceanic blue carbon (this section assumes that oceanic blue carbon can be accounted for). Both marine management and climate policies within the UAE and regional and international agreements were assessed.
3. Identification of the types of data needed to incorporate the value of oceanic blue carbon into policy and management.
4. Identification of potential co-benefits and impacts from the application of oceanic blue carbon.
5. Identification of recommendations for the application of oceanic blue carbon.

Existing reports and publications were reviewed for information on relevant climate and fisheries policies within the UAE. This activity guided the development of the survey instrument, which consisted of 48 questions related to the five themes. The survey instrument is included in Appendix 1.

It was determined that the most appropriate method to collect data about knowledge, attitudes, and perceptions was through face-to-face and telephone surveys of a selected sample of key policy stakeholders within the UAE. The survey was administered in May to June 2019 by an established environmental firm with policy experience in the UAE. The survey respondents were also identified by the local environmental firm. The survey was designed for a small number to maximize time and effectiveness of the survey, with a rate of response of 100%. Surveys were administered through individual and focus group interviews, with a total of 28 participants interviewed and 21 survey datasets collected.

Data was collected from the respondents assessing their knowledge, attitudes, and perceptions about oceanic blue carbon policy options. The survey questions used for this analysis included multiple choice or five-point Likert scale–style questions and open-ended questions. Interviews were conducted in English and lasted an average of 40 minutes. Consent was requested for each interview. The interview started with a standardized definition (Fig. 1) of the concept of oceanic blue carbon and a short video (Toomey 2018) shown to each participant.

1. Fish Carbon - Exploring Marine Vertebrate Carbon Services (4:12 minutes), available at: https://vimeo.com/295991431.

RESULTS

For the following results, the term “majority” refers to a percentage of 51% to 79% of respondents, and “vast majority” refers to a percentage of 80% or more of respondents.

PARTICIPANTS – DEMOGRAPHIC OVERVIEW

This section identifies the stakeholder group and backgrounds of the persons interviewed.

28 participants were interviewed. The majority (60%) of participants were from the government sector (Fig. 5). Other participant sectors were reported as follows: intergovernmental (10%), other (10%), non-government organization (10%), private (5%), and academic (5%).

The experience level (years working in their respective fields) of participants ranged from 1 to 32 years with an average of 16.7 years. The vast majority of participants (85%) have been involved in the application of or discussions about coastal blue carbon within the UAE (i.e., they are familiar with the Abu Dhabi Blue Carbon Demonstration Project and/or the UAE National Blue Carbon Assessment).

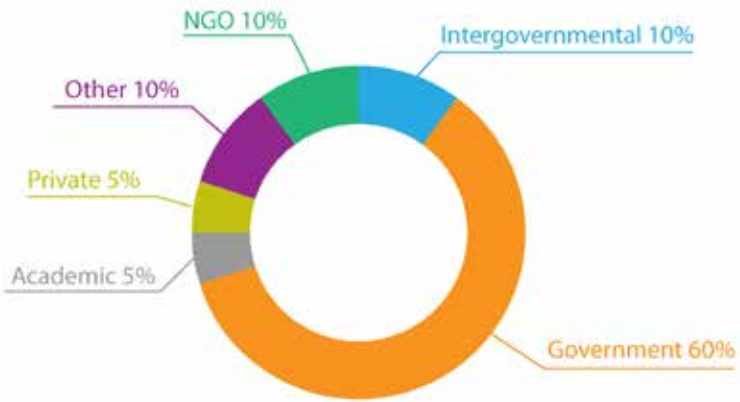


Figure 5. *Sectors of survey participants*

PERCEPTION OF MARINE ENVIRONMENT

This section identified a baseline for views on the state of the marine environment.

The majority (75%) of participants viewed the general condition of the marine environment in the waters of their local area to be fair. 15% of participants viewed it as poor (Fig. 6). The vast majority of participants also viewed the general condition of the marine environment throughout the UAE to be fair or poor. The majority (75%) of participants viewed current levels of fishing activity in the waters of their local areas to be high. The vast majority (85%) of participants viewed current levels of fishing activity in the waters throughout the UAE to be high.

Participants viewed the top three impacts to their local marine environment to be overfishing, climate change, and pollution/dumping (listed in order of relevance) (Fig. 7). Looking forward, the impacts of climate change (both direct and indirect effects) was identified by participants (25%) as the largest marine environmental problem in the UAE five years from now.

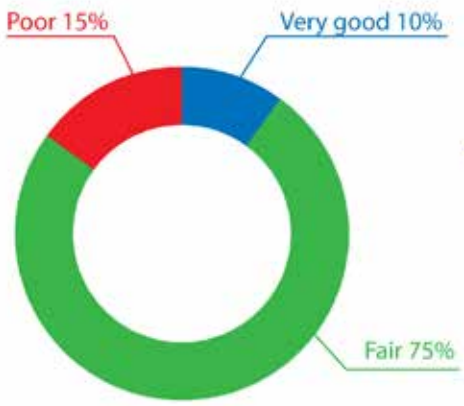


Figure 6. *Perception of the general condition of the local marine environment*

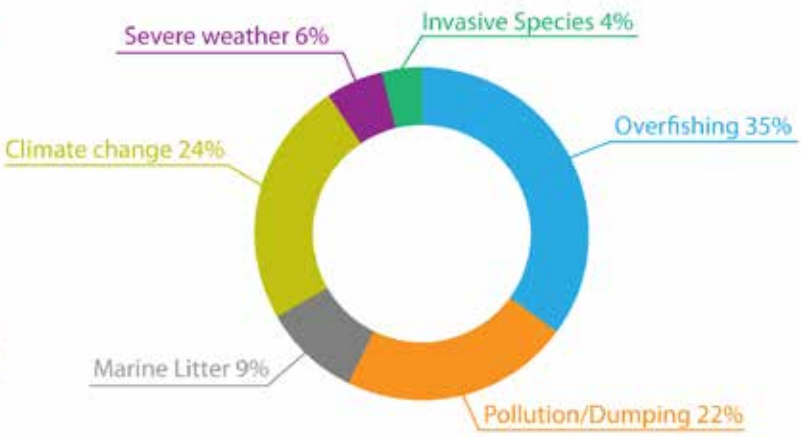


Figure 7. *Perception of which factors most impact the local marine environment (respondents chose three from a list of six)*

POLICY AND MANAGEMENT

This section aimed to identify views on the potential importance of oceanic blue carbon to marine and climate policies.

The majority (65%) of participants agree or strongly agree that the recognition of the value of oceanic blue carbon could help improve fisheries management within the UAE (Fig. 8). The majority (55%) of participants agree (or strongly agree) that the recognition of the value of oceanic blue carbon could help improve the condition of the marine environment within the UAE. The vast majority (85%) of participants agree or strongly agree that the recognition of the value of oceanic blue carbon could help the UAE meet its goals in addressing climate change (Fig. 9).

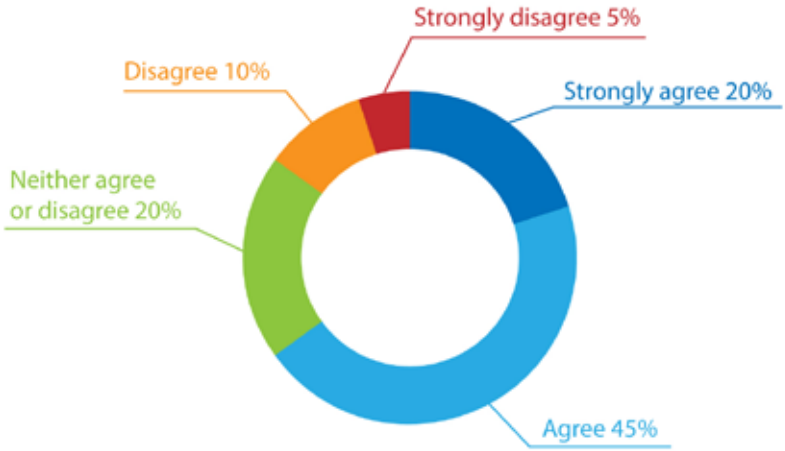


Figure 8. *Perception of whether recognition of the value of oceanic blue carbon could help improve fisheries management within the UAE*

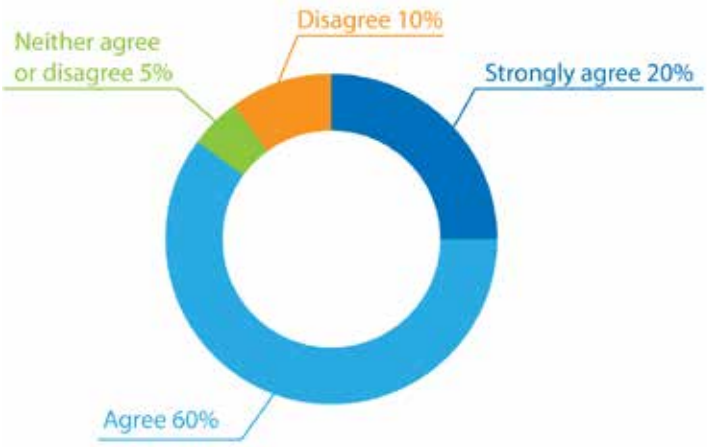


Figure 9. *Perception of whether recognition of the value of oceanic blue carbon could help the UAE meet its goals in addressing climate change*

RELEVANT POLICIES

This section aimed to identify policies relevant to oceanic blue carbon. It was assumed in this section that oceanic blue carbon could be accounted for.

Participants' views on the potential relevance of the value of oceanic blue carbon to marine management strategies and climate policies within the UAE are identified in Table 1. The vast majority of participants viewed oceanic blue carbon as relevant to the range of national policies and management strategies, with the exception of the management of Hamour, where only a majority viewed it as relevant.

Participants also noted that oceanic blue carbon relates to a range of other national policies and management strategies, including: National Plan of Action (NPOA) for species and habitats, marine litter policies, National Fisheries Framework, aquaculture policies, National Adaptation Programme – Environment sector, coastal sustainability strategy, green growth initiative, emirate-level adaptation strategies, and National Framework for Sustainable Fisheries 2019-2030. Additionally, aligning research with education and a higher ministry was suggested.

Table 1. Views on the relevance of oceanic blue carbon to national policies and management strategies

National marine management strategy / climate policy	**Relevance rate** (% of respondents)
Fisheries management	80%
Management of sharks	80%
Management of Hamour	70%
Management of sea turtles	90%
Management of marine mammals	85%
National policy on biodiversity	85%
Management of MPAs within the UAE	80%
National climate change policies	95%
Coastal zone management within the UAE	80%

Participants' views on the potential relevance of the value of oceanic blue carbon to regional and international agreements are identified in Table 2. The vast majority of participants viewed oceanic blue carbon to be relevant to regional and international agreements with the exception of National carbon accounting under the Paris Climate Agreement, where a majority viewed it as relevant, and International efforts to address illegal, unreported, and unregulated (IUU) fishing, where a minority (35%) viewed it as relevant.

Participants related a wide range of other potentially relevant regional and international agreements or treaties and related parties, including:

- Regional Organization for the Protection of the Marine Environment (ROPME)
- Indian Ocean Rim Association (IORA)
- Convention on Migratory Species (CMS)
- Gulf Cooperation Council (GCC) Wildlife Convention
- Regional Commission for Fisheries (RECOFI)
- Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
- Marine turtles
- Important Bird and Biodiversity Areas (IBAs)
- Key Biodiversity Areas (KBAs)
- Important Marine Mammal Areas
- Ecologically or Biologically Significant Marine Area (EBSA) descriptions
- Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA)

Table 2. Views on the relevance of oceanic blue carbon to regional and international agreements

Importance of blue carbon in regional and international agreements	**Relevance rate** (% of respondents)
National carbon accounting under the Paris Climate Agreement	75%
National climate pledges to fulfil the Paris Climate Agreement	80%
Regional fisheries management	80%
Actions to fulfil the CBD	85%
International efforts to manage whales	80%
International efforts to manage endangered species	80%
International efforts to manage marine biological diversity in waters beyond national jurisdiction	90%
International efforts to address illegal, unreported, and unregulated (IUU) fishing	35%*
Actions to achieve UN SDG 13: Climate Action	95%
Actions to achieve UN SDG 14: Life Below Water	85%

*Participants' views were split approximately equally between "relevant" (35%), "not relevant" (30%), and "don't know" (35%).

APPLICATION AND DATA NEEDS

This section aimed to identify the types of data needed to incorporate the value of oceanic blue carbon into policy and management.

Regarding communication of data and information, infographics were the format in which the participants identified (15%) as a preferred means to receive data on oceanic blue carbon. Other formats included the following: publications, technical reports, videos, e-calculator (for marine vertebrate biomass carbon), text-based article, charts, executive briefs, interactive maps, Excel sheet (numbers), executive summary for decision making, ArcGIS, statistical reports, and raw data for decision makers.

Participants reported other factors (beyond the potential mitigation of climate change) that would help oceanic blue carbon to be incorporated into policy and management regimes, including:

- Improving scientific knowledge in the region
- Improving species conservation and management
- Ecosystem services values
- Sustainable use of marine resources
- Habitat conservation
- Economic implications of carbon values after knowing impacts on fish stocks
- Recognition of species as part of natural capital for the country
- Co-benefit of improved fisheries management
- Ecological resilience and resistance of species to massive eutrophic changes
- Improving citizen science
- Advancing baseline data collection
- Improving food security reports on overfishing

Figure 10. *Perception of the difficulty of incorporating the value of oceanic blue carbon into policy and management*

The majority (60%) of participants believed that the incorporation of the value of oceanic blue carbon into policy and management would be somewhat difficult, with an additional 25% of participants viewing its application as very hard (Fig. 10).

Participants related a multitude of other challenges that the concept of oceanic blue carbon would need to overcome, including the following:

- Lack of standardized methods for collecting baseline data including quantification and measurement of biomass carbon
- Difficulty in collecting carbon accounting data for migratory and unexplored species (green turtles are migratory, however hawksbills and dugongs stay in the area)
- Lack of standardized methods for the validation of data (how will the data be published, and how to

interpret the linkages in a clear way?)

- Need for consistent, extensive, and comprehensive survey work in a region (many more data points needed)
- Lack of consistent, historic baseline data including data management and monitoring in the region
- Lack of data and awareness, and uncertainty in the science behind oceanic blue carbon
- Connecting oceanic blue carbon to climate change and relating it to local lifestyles (per carbon footprint) in 5-20 years
- Difficulty in harnessing biomass carbon to sustainable fisheries and marine wildlife management in terms of dugong mortalities and fisheries regulation
- Need for a more informed and systematic assessment and approach to understand policy options for the UAE (what are list of priorities, which is more efficient for the UAE?)
- Need to involve other stakeholders such as those from CO2-producing industries

CO-BENEFITS AND IMPACTS

This section aimed to identify potential co-benefits and impacts from the application of oceanic blue carbon.

The majority (65%) of participants agree or strongly agree that the recognition of the value of oceanic blue carbon could help increase marine biodiversity within the UAE (Fig. 11). Participants were split regarding the recognition of the value of oceanic blue carbon helping to improve marine-based food security within the UAE, with 37% strongly disagreeing, 36% neither agreeing nor disagreeing, and 23% agreeing. The majority of participants did not agree that the recognition of the value of oceanic blue carbon could help increase marine-based tourism within the UAE, with 40% neither agreeing or disagreeing, 30% strongly disagreeing, and 20% agreeing. Half (50%) of the participants disagree or strongly disagree that the recognition of the value of oceanic blue carbon would help improve socioeconomic or disagreeing, 10% indicating not knowing, and 15% agreeing or strongly agreeing (Fig. 12).

Participants related a range of other potential co-benefits from the application of oceanic blue carbon, including the following:

- Improving climate change resilience
- Providing additional tools for policy and management
- Supporting the concept of natural capital, which is linked to different initiatives
- Supporting improved biodiversity
- Supporting an aesthetically pleasing environment
- Positively affecting human health
- Understanding additional natural values or benefits of species and will allow improved conservation of marine vertebrate and their habitats
- Improving general environmental conditions leading to nutrient transfer/build-up from and between

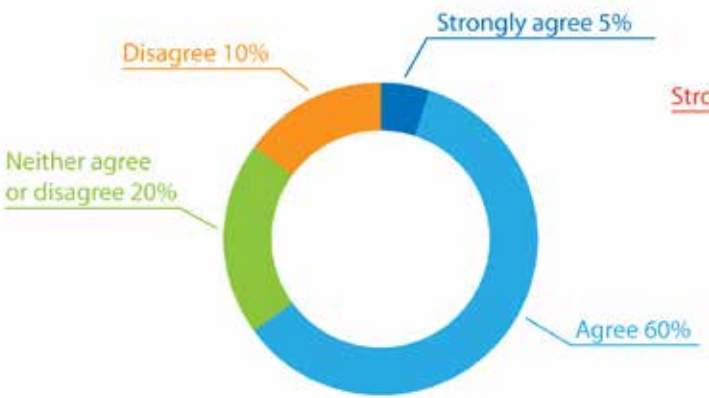


Figure 11. *Perception that recognition of the value of oceanic blue carbon can help increase marine biodiversity within the UAE*

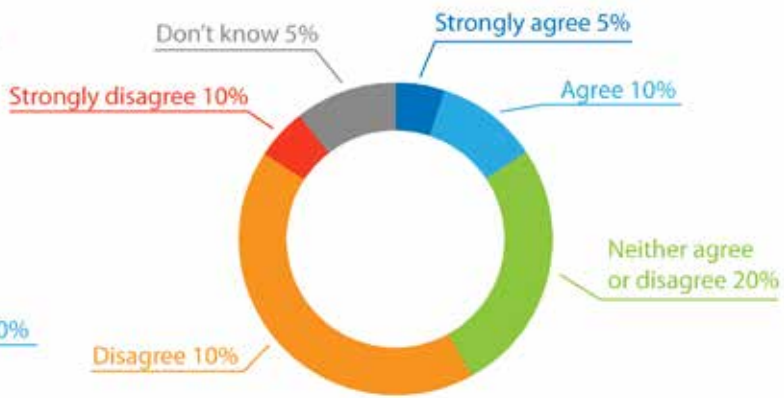


Figure 12. *Perception that recognition of the value of oceanic blue carbon can help improve socioeconomic equality within the UAE*

terrestrial and marine environments
- Improving coastal resilience/security from oil spills or any catastrophic changes
- Making the UAE a global research leader
- Supporting increasing carbon drivers for decision-making
- Supporting improved awareness/outreach of its importance for conservation and better appreciation of the marine environment
- Increasing regional and international awareness on oceanic blue carbon
- Setting an example for other countries to follow

Participants related a range of potential impacts or negative consequences from the potential future application of oceanic blue carbon, including the following:
- Risk, since the full implications of oceanic blue carbon are unknown until it is implemented
- The concept highlights only one ecosystem value, whereas a systems or holistic approach may be better for management and in addressing stressors
- The high need for accurate baseline data
- The difficulty in accounting for the difference between demersal and pelagic species
- Applying oceanic blue carbon may entail short-term economic stress as implementation of policies will likely affect livelihoods, including the practicality of implementation and relevance to fisheries at the local level
- Uncertainty in oceanic blue carbon science and a lack of awareness among stakeholders may cause reduced support for policy
- Difficulty in understanding whether oceanic blue carbon is the highest priority in local policies (other stressors may be more important to address)

FUTURE APPLICATION

This section aimed to identify recommendations for the application of oceanic blue carbon.

The vast majority (95%) of participants agree or strongly agree that international recognition of the value of oceanic blue carbon should be increased (Fig. 13). The vast majority (90%) of participants agree or strongly agree that scientific research on oceanic blue carbon should be supported and funded (Fig. 14). The vast majority (95%) of participants agree or strongly agree that value of oceanic blue carbon should be incorporated into strategies for conservation and climate change mitigation (Fig. 15).

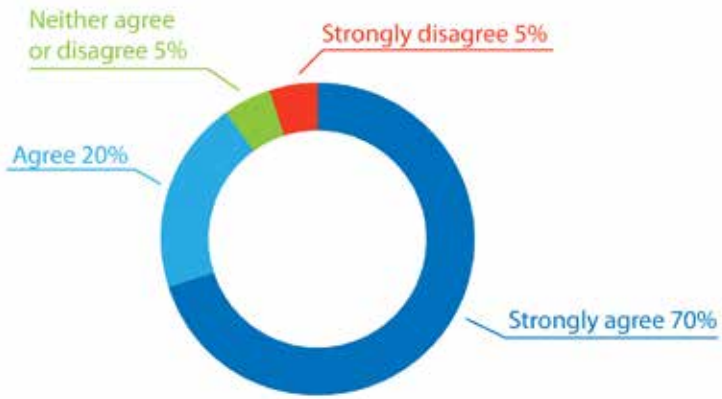


Figure 14. *Perception that scientific research of oceanic blue carbon should be supported and funded*

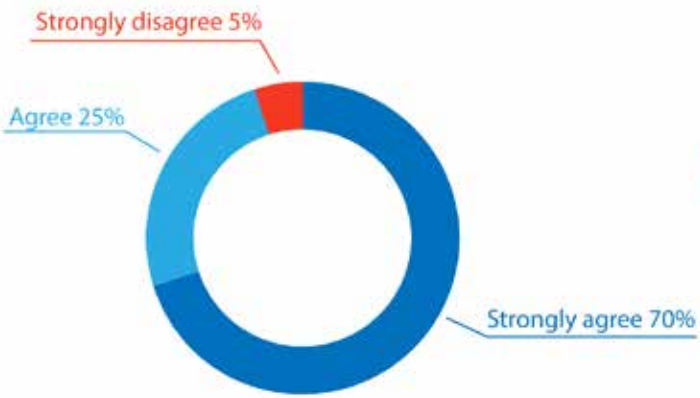


Figure 13. *Perception that international recognition of the value of oceanic blue carbon should be increased*

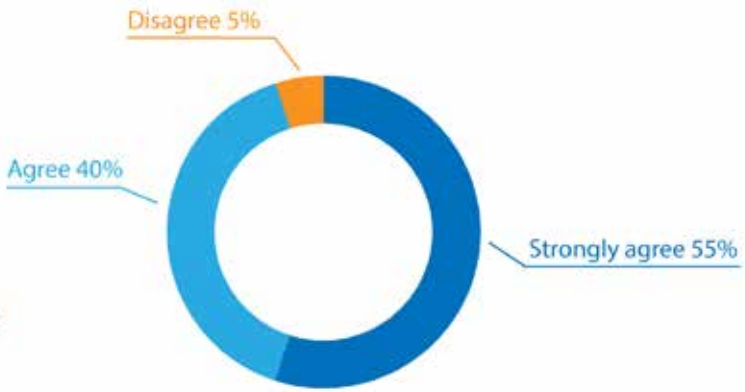


Figure 15. *Perception that the value of oceanic blue carbon should be incorporated into strategies for conservation and climate change mitigation*

Participants related a number of other thoughts or views on oceanic blue carbon including the following:

- The concept seems abstract, it would be important to study and visualize where it could be most impactful
- Important to understand the connection/relevance to migratory species
- Prioritize focus on species with high abundance or megafauna
- Many options potentially exist for the integration of oceanic blue carbon into policies at the emirate and national levels, including possible cross-cutting into other policy areas (CBD, Ramsar, MPAs)
- Research should consider types of data (species, stock amount) already employed in marine management, such as quota setting
- A new idea which will potentially get a lot of criticism and in order to avoid this, methodologies need to be robust and data gaps minimized
- Will this increase the amount of whales' trade-off increase in CO2 emissions? What are the secondary effects of increase in whale populations? There should be a narrative on the benefits of oceanic blue carbon to form strong arguments against sceptics
- Incorporate the concept into positive storylines highlighting how much carbon fisheries and species store and how ecosystems are interconnected
- This concept could serve as a new language and tool to be incorporated into fisheries management
- This concept could improve our understand of marine life and reinforce efforts to protect species and habitats

DISCUSSION

KEY FINDINGS

Overall, the survey's key finding is that the application of oceanic blue carbon policy has significant policy potential in the arenas of climate change, biodiversity conservation, and fisheries management. Key results included the following for each of the study's five themes:

1) The application of oceanic blue carbon is potentially relevant to national policies related to fisheries and climate change:

a. The majority of participants agree or strongly agree that the recognition of the value of oceanic blue carbon could help improve fisheries management within the UAE.

b. Participants agree or strongly agree the potential application of oceanic blue carbon as very relevant to specific marine management and climate policies within the UAE. This includes general fisheries management, the management of threatened and endangered species (including sharks, Hamour, sea turtles, and marine mammals), UAE national policy on biodiversity, Marine Protected Areas (MPAs), and coastal zone management. The vast majority of participants viewed oceanic blue carbon as relevant to national climate change policies.

2) The application of oceanic blue carbon is potentially relevant to international agreements on biodiversity and climate change:

a. The vast majority of participants agree or strongly agree that the recognition of the value of oceanic blue carbon could help the UAE meet its goals in addressing climate change.

b. Participants agree or strongly agree the potential application of oceanic blue carbon to be very relevant to regional and international agreements. This includes national carbon accounting under the Paris Climate Agreement, national climate pledges to fulfil the Paris Climate Agreement, regional fisheries management, actions to fulfil the Convention on Biological Diversity (CBD) and to manage marine biological diversity in waters beyond national jurisdiction, international efforts to manage whales and endangered species, and actions to achieve UN Sustainable Development Goals 13 and 14.

c. Many additional potentially relevant regional and international agreements or treaties were identified. These included the Regional Organization for the Protection of the Marine Environment (ROPME), Ramsar Convention, Convention on Migratory Species (CMS), and others.

3) Infographics were the format in which the majority of participants would prefer to receive data on oceanic blue carbon.

4) Regarding potential co-benefits and impacts from the application of oceanic blue carbon, participants reported a wide range of factors, including:

a. Factors that would help support the incorporation of oceanic blue carbon into policy and management

(beyond the potential mitigation of climate change) included biodiversity conservation, the research sector, and understanding ecological co-benefits.

b. Potential co-benefits from the application of oceanic blue carbon (beyond mitigation of climate change) included increasing resilience to the impacts of climate change and making the UAE a global research leader.

5) Regarding recommendations for the application of oceanic blue carbon, participants reported a wide range of suggestions:

a. The vast majority of participants agree or strongly agree that international recognition of the value of oceanic blue carbon should be increased, that scientific research on oceanic blue carbon should be supported, and that value of oceanic blue carbon should be incorporated into strategies for conservation and climate change mitigation.

b. Participants reported a wide range of other thoughts regarding the application of oceanic blue carbon. Chief among these were priority focus on megafauna, exploring the possible cross-cutting of oceanic blue carbon into other policies, and the importance of spreading awareness.

LIMITATIONS AND DRAWBACKS

This assessment is based on a limited number of survey responses (28 persons surveyed in total) in only one country. Most of the participants have already been involved in the application of or discussions about coastal blue carbon in the UAE.

The majority of respondents believe it would be somewhat difficult or very hard to incorporate the value of oceanic blue carbon into policy and management. They noted many potential barriers, including getting recognition of the concept from the scientific community and collecting enough accurate data to counter scepticism.

Participants related a range of potential impacts or negative consequences from the application of oceanic blue carbon. One chief concern was whether oceanic blue carbon should be a high priority for the UAE given other pressing policy issues. Another concern was whether the application of oceanic blue carbon would entail short-term economic stress.[2]

2. The authors note that similar issues face the current implementation of coastal blue carbon in other countries.

RECOMMENDATIONS

Several important avenues for future policy research that will advance the application of oceanic blue carbon have been revealed by this study:

1) This assessment of oceanic blue carbon policy in the UAE should be considered a first order assessment. Additional data on perceptions and attitudes are needed from an increased number of countries, from a greater number of participants, and from more diverse stakeholders. This would allow for a broader understanding of the potential policy opportunities for oceanic blue carbon, a more robust statistical figure, and the appreciation of different views between stakeholder groups.

2) Scientific research should be placed foremost, prior to the implementation of oceanic blue carbon policy options. Sustainable policy must be based on robust scientific knowledge and there is a critical need to avoid "over-promising" with regard to potential climate solutions.

3) The potential impacts or negative consequences from the application of oceanic blue carbon should be fully explored and incorporated into economic modelling, especially with potential impacts to the fisheries sector. It is important to understand the potential "winners" and "losers" from the application of any policy.

CONCLUSION

Oceanic blue carbon – the natural ways that marine vertebrates can trap and store carbon – is an emerging concept. Yet this study has shown it is relevant to the sustainable management of coastal and marine environmental resources and actions to address global climate change.

This study is a "world's first" in terms of understanding how the ocean can be harnessed to achieve meaningful action at the national and international scales. Our results suggest that it is possible and practical to manage marine fauna for climate mitigation purposes, challenging previous views, such as those advanced by Howard et al. 2017 and Lovelock and Duarte 2019 (introduced in section 3.1).

Much more remains to be accomplished – in science, economics, education and in policy – to enact sustainable and robust science-based actions harnessing the value of oceanic blue carbon to help mitigate the global climate challenge. However, our results suggest that oceanic blue carbon has broad potential implications for the management of marine resources including fisheries, biodiversity conservation, and in addressing the global climate challenge.

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APPENDIX: SURVEY INSTRUMENT

Oceanic Blue Carbon Policy Survey Instrument

Survey #:

Date:

Location:

Interviewee:

Interviewer:

Survey instructions

1. Introduce yourself and the project. Clearly state the project objectives: This survey aims to identify views on the potential application of the concept of Oceanic Blue Carbon in policy and management.

2. Ask consent for interview. Consent given: Yes / No

2. Describe Oceanic Blue Carbon: The concept of 'Oceanic Blue Carbon' refers to how marine animals can help sequester carbon through a range of natural processes that include storing carbon in their bodies, excreting carbon-rich waste products that sink into the deep sea, and fertilizing or protecting marine plants. In particular, scientists are beginning to recognize that vertebrates, such as fish, seabirds and marine mammals, have the potential to help lock away carbon from the atmosphere thereby assisting to mitigate for the impacts of climate change.

2. Show 'Fish Carbon - Exploring Marine Vertebrate Carbon Services' video (4:12 minutes): https://vimeo.com/295991431. This video describes the various Oceanic Blue Carbon mechanisms. The terms 'Fish Carbon' and 'Oceanic Blue Carbon' are synonyms in this context.

3. Implement survey, it should about 20 minutes.

4. Thank participant for their time and contribution.

1 of 6

General Background/Stakeholder Group - *This section identifies the stakeholder group and background of the person being interviewed.*

(G 1) What is your current **occupation**? Government / Non-Government Organization / Fishing industry / Other: _____

(G 2) How many years have you been working in this field? _____

(G 3) Have you been involved in the application of or discussions about **coastal blue carbon** in the U.A.E.? Yes / No

Perception of Marine Environment – *This section identifies a bassline for views on the state of the marine environment.*

(P 1) What is the **general condition** of the marine environment in the Gulf Waters in **Abu Dhabi**? very good / fair / poor / don't know

(P 2) What is the **general condition** of the marine environment in the Gulf Waters throughout the **U.A.E.**? very good / fair / poor /don't know

(P 3) What is the current **level of fishing activity** in the Gulf Waters in **Abu Dhabi**? (Recreational and industrial activity combined)

high / correct level / low / none / don't know

(P 4) What is the **level of fishing activity** in the Gulf Waters throughout the **U.A.E.**? (Recreational and industrial activity combined)

high / correct level / low / none / don't know

(P 5) What are the **top three impacts** to your **local marine environment** and why? (In order of importance, do not prompt)

Impact 1 overfishing / pollution/dumping / marine litter / climate change / severe weather / invasive species / other _____

Impact 2 overfishing / pollution/dumping / marine litter / climate change / severe weather / invasive species / other _____

Impact 3 overfishing / pollution/dumping / marine litter / climate change / severe weather / invasive species / other _____

(P 6) Five years from now, what do you think will be the **largest marine environmental problem** in the U.A.E.?_____

Policy and Management - *This section aims to identify views on the potential importance of Oceanic Blue Carbon to marine and climate policies.*

(5 = strongly agree, 4 agree, 3 neither agree or disagree, 2 disagree, 1 strongly disagree)

(P 1) Recognition of the value of Oceanic Blue Carbon can help improve **fisheries management** within the U.A.E.	5 / 4 / 3 / 2 / 1	Don't know
(P 1) Recognition of the value of Oceanic Blue Carbon can help improve the **management of marine mammals** within the U.A.E.	5 / 4 / 3 / 2 / 1	Don't know
(P 2) Recognition of the value of Oceanic Blue Carbon help improve the **condition of the marine environment** within the U.A.E.	5 / 4 / 3 / 2 / 1	Don't know
(P 3) Recognition of the value of Oceanic Blue Carbon can help the U.A.E. meet its **goals in addressing climate change**	5 / 4 / 3 / 2 / 1	Don't know

Relevant Polices - *This section aims to identify policies relevant to Oceanic Blue Carbon. <u>This section assumes that Oceanic Blue Carbon can be accounted for.</u>*

(RP 1) How potentially relevant is the value of Oceanic Blue Carbon to the following **marine management and climate policies within the U.A.E.**?

a.	**Fisheries management** (e.g., the designation of catch limits, seasonal regulations, etc.)	Relevant / Not relevant / Don't know
b.	The management of **sharks**	Relevant / Not relevant / Don't know
c.	The management of **Hamour**	Relevant / Not relevant / Don't know
d.	The management of **sea turtles**	Relevant / Not relevant / Don't know
e.	The management of **marine mammals** (e.g., Dugongs, whales and dolphins)	Relevant / Not relevant / Don't know
f.	**National policy on biodiversity** (e.g., National Biodiversity Strategy and Action Plan)	Relevant / Not relevant / Don't know
g.	The management of **Marine Protected Areas** (MPAs) within the U.A.E.	Relevant / Not relevant / Don't know
h.	**National climate change policies** (e.g., National Climate Change Plan of the United Arab Emirates)	Relevant / Not relevant / Don't know
i.	**Coastal zone management** within the U.A.E.	Relevant / Not relevant / Don't know
j.	Other national policies & management? _____	Relevant / Not relevant / Don't know

(LP 2) How potentially relevant is the value of Oceanic Blue Carbon to the following **regional and international agreements**?

a. **National carbon accounting** under the Paris Climate Agreement — Relevant / Not relevant / Don't know

b. **National climate pledges** to fulfil the **Paris Climate Agreement** (e.g., actions in Nationally Determined Contributions (NDCs))

Relevant / Not relevant / Don't know

c. **Regional fisheries management** (e.g., Action Plan for the Protection of the Marine Environment and Coastal Areas in UAE and the Arabian Gulf)

Relevant / Not relevant / Don't know

d. Actions to fulfil the **Convention on Biological Diversity** (e.g., 2020 Aichi Biodiversity Targets) — Relevant / Not relevant / Don't know

e. International efforts to manage **whales** (e.g., Resolutions under the International Whaling Commission) — Relevant / Not relevant / Don't know

f. International efforts to manage **endangered species** (e.g., Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES))

Relevant / Not relevant / Don't know

g. International efforts to manage **marine biological diversity** in waters **beyond national jurisdiction** (e.g., discussions currently ongoing at the UN regarding the UN Convention on the Law of the Sea)

Relevant / Not relevant / Don't know

h. International efforts to address **illegal**, **unreported** and **unregulated** (IUU) **fishing** — Relevant / Not relevant / Don't know

i. Actions to achieve UN Sustainable Development Goal 14, to **conserve and sustainably use the oceans, seas and marine resources for sustainable development**

Relevant / Not relevant / Don't know

j. Actions to achieve UN Sustainable Development Goal 13, to **take urgent action to combat climate change and its impacts**

Relevant / Not relevant / Don't know

k. Other regional and international agreements or treaties? _____ — Relevant / Not relevant / Don't know

Application & Data Needs - *This section aims to identify the types of data needed to incorporate the value of Oceanic Blue Carbon into policy and management.*

(AD 1) What **key factors** or **kind of data** is needed in order to incorporate the value of Oceanic Blue carbon into policy and management?
(e.g., annual carbon estimates, specifies specific estimates, geographic data)

_____

(AD 2) Other than the potential mitigation of climate change, what **other factors** would help support the incorporation of Oceanic Blue carbon into policy and management?
(e.g., significant co-benefit, the supporting of other policy objectives)

_____

(AD 3) In your opinion, **how difficult** will it be to incorporate the value of Oceanic Blue carbon into policy and management?

Very hard / Somewhat difficult / Easy / Don't know

(AD 4) Are there any **other issues** that the concept of Oceanic Blue Carbon would need to overcome? _____

Co-Benefits and Impacts - *This section aims to identify potential co-benefits and impacts from the application of Oceanic Blue Carbon*

(5 = strongly agree, 4 agree, 3 neither agree or disagree, 2 disagree, 1 strongly disagree)

(BI 1) Recognition of the value of Oceanic Blue Carbon can help **increase marine biodiversity** within the U.A.E.	5 / 4 / 3 / 2 / 1	Don't know
(BI 2) Recognition of the value of Oceanic Blue Carbon can help **improve marine based food security** within the U.A.E.	5 / 4 / 3 / 2 / 1	Don't know
(BI 3) Recognition of the value of Oceanic Blue Carbon can help **increase marine based tourism** within the U.A.E.	5 / 4 / 3 / 2 / 1	Don't know
(BI 4) Recognition of the value of Oceanic Blue Carbon can help **improve socioeconomic equality** within the U.A.E.	5 / 4 / 3 / 2 / 1	Don't know
(BI 5) Other potential co-benefit? _____	5 / 4 / 3 / 2 / 1	Don't know

(BI 6) Can you think of any **potential impacts or negative consequences** from the application of Oceanic Blue Carbon? _____

Recommendations - *This section aims to identify a few recommendations for the application of Oceanic Blue Carbon*

(5 = strongly agree, 4 agree, 3 neither agree or disagree, 2 disagree, 1 strongly disagree)

(R 1) **International recognition** of the value of Oceanic Blue Carbon should be increased	5 / 4 / 3 / 2 / 1	Don't know
(R 1) **Scientific research** of Oceanic Blue Carbon should be supported and funded	5 / 4 / 3 / 2 / 1	Don't know
(R 3) The value of Oceanic Blue Carbon should be incorporated into strategies for **conservation and climate change mitigation**	5 / 4 / 3 / 2 / 1	Don't know

(R 4) Do you have any other thoughts or views on Oceanic Blue Carbon you would like to share? _____

- Thank you -

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This report presents the results of a survey of 28 coastal and marine environmental stakeholders to assess knowledge, attitudes, and perceptions of the concept of oceanic blue carbon and its relevance to policy. This survey's major finding is that the application of oceanic blue carbon policy has significant relevance to the areas of climate change, biodiversity conservation, and fisheries management in national, regional, and international contexts. These findings are the world's first of their kind and significantly contribute to conversations regarding ocean conservation, sustainable management of marine resources and nature-based solutions in the context of climate change mitigation.

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