Developing a Knowledge Base for Sustainable Ocean Governance in Barbados

Thesis towards the completion of the Nippon Foundation Fellowship Programme for Human Resources Development and Advancement of the Legal Order of the World's Oceans

Kareem Jamal Sabir

United Nations- The Nippon Foundation Fellowship Programme, 2017

OCEANS & LAW OF THE SEA
UNITED NATIONS
DIVISION FOR OCEAN AFFAIRS AND THE LAW OF THE SEA

Nippon Foundation

Disclaimer

ABSTRACT

Barbados is a Small Island Developing State (SIDs) located east of the Lesser Antillean volcanic island arc in the Caribbean region. Its small open economy is sensitive to international macroeconomic shocks. Barbados has over time shifted its focus from inland (monoculture crop production with preferential trade) to coastal (tourism development) and now is beginning to focus its attention beyond the coast and across its EEZ for growth and development opportunities. It is a way of transforming typical small island disadvantages into large ocean-space opportunities. This thesis therefore seeks to support filling an institutional and strategic policy gap in ocean governance in Barbados. This thesis seeks to assist Barbados in codifying and standardizing ways of strengthening, coordinating, and synergizing existing ocean monitoring and facilitating new means of data collection in a sustainable, cost-effective and operational way.

Part 1 assesses a suite of existing frameworks for developing bodies of ocean knowledge to support decision-making and policy support. Part II presents recommendations of good practice (principles and approaches) for Barbados to develop capacities in long-term ocean monitoring and research with a robust enabling environment, as well as a framework for regular integrated marine environmental assessments (using a pressure-state-response framework) as a major constituent of the interface between science and policy. Three main elements of a long-term ocean monitoring framework and seven initiatives for establishing an enabling environment for long-term monitoring were presented. Six guiding principles and practices of a framework for integrated assessments of the marine environment were presented along with key considerations for development of an assessment process. A hybrid framework of sustained monitoring and research feeding into periodic assessments has been recommended for Barbados to develop in support of an ocean policy or blue economy strategy.

ACKNOWLEDGEMENTS

This work is supported by the Nippon Foundation of Japan and the United Nations Division of Ocean Affairs and Law of the Sea through the Fellowship Programme for Human Resources Development and Advancement of the Legal Order of the World's Oceans. Sincere gratitude is expressed to these two organisations for the opportunity to undertake the fellowship programme in professional development and networking in ocean governance. The Government of Barbados and particularly the Coastal Zone Management Unit have been extremely supportive throughout the entire fellowship programme.

Special thanks to Mrs. Valentina Germani and Ms. Simone Dempsey for their coordination, advise, and guidance throughout the programme. Likewise, gratitude is extended to the management and staff of DOALOS for their hospitality in hosting and professional guidance. The 2017 Fellowship cohort have also been a pillar of support and have my sincerest gratitude.

Special thanks to Elizabeth Mendenhall, Robert Thompson and Tracey Dalton at the University of Rhode Island, Department of Marine Affairs for their gracious hosting and academic supervision.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

Barbados is a Small Island Developing State (SIDs) located east of the Lesser Antillean volcanic island arc in the Caribbean region. The country is 425km^2 with its highest point at 340m above sea level, making it comparatively limited in natural resources and exposed to a plethora of natural hazards. The population of Barbados as of the 2010 census is approximately 278,000 residents, making it one of the most densely populated in the world.

The geopolitical landscape of the Caribbean region is well studied and is presented as one of the most complex and diverse in terms of geography, ethnicities, languages, economies and systems of government.[1] Barbados is an active Member State of The Latin American and Caribbean States for the Group of Latin America and the Caribbean (GRULAC) under the UN regional groupings for dialogue and cooperation. This group constitutes approximately 17% of the States of the UN. At the Sub-regional level, Barbados is a member of the Caribbean Community (CARICOM) group through its signature to the Treaty of Chaguaramas in 1973 and its revised treaty in 2002 establishing the intention of a single market and economy in the sub-region.

Barbados celebrated 50 years of independence in 2016. There have been no military disputes or major civil unrest in this time. As such, Barbados has limited military capacity, with only a small defense force and coast guard, and no navy or air forces. This will be discussed further as it relates to the capacity for surveillance and monitoring of the Exclusive Economic Zone (EEZ) of Barbados. Its small open economy is sensitive to international macroeconomic shocks. The common vulnerabilities of SIDs manifest here; small exposed economies, net importer of goods, limited tradable commodities, issues with economies of scale, heavy dependence on coastal and marine resources. The past few decades have seen the economy shift from agricultural exports (sugar) to a services-driven economy (tourism and financial services). This shift saw annual GDP as high as 5% in 2006 but the global financial, energy and food crises during the 2000s resulted in

[1] Fanning, Lucia & Mahon, Robin & McConney, P. (2009). Focusing on Living Marine Resource Governance: The Caribbean Large Marine Ecosystem and Adjacent Areas Project. Coastal Management - COAST MANAGE. 37. 219-234. 10.1080/08920750902851203.

Barbados recovering from negative growth since. The following is summarized from the Barbados Economic and Social Report 2015[2] which represents a major national report from all sectors and Ministries annually to illustrate the macroeconomic vulnerabilities and to support the description of the country's current state of development:

- Return to sustainable growth of 0.8% in 2015 after two years of restructuring and economic rebalancing;
- As mentioned above, tourism recorded its largest growth in 2015 (6.4%) and sugar product recorded its largest decline (32.8%);
- Current account deficit of $483 million or approximately 5.5% of GDP with fuels and food being a major contributor to imports;
- Foreign reserves declined 5.1% to $926 million (13.8 weeks of imports);
- Central government debt at 138.4% of GDP;
- Regarding fisheries, Barbados recorded a 34.3% decline in landings compared to 2014. The major contributor to the landings is the flying fish fisheries which recorded a 71% decrease in landings compared to 2014 making it the second lowest catch on record. Other pelagics such as Mahi Mahi and Tunas are the other significant contributors to total landings. While landings decrease, total registrations to fishing fleets increased.
- Overall tourism contributes 12% to GDP. Cruise tourism reported approximately 580,000 cruise arrivals in 2015, an increase of 4% on 2014;
- In 2015 an estimated 2.1 million barrels of crude oil were in reserve. Production increase by 3.8% to around 236 thousand barrels with oil sales also increasing. Barbados is not a significant oil/gas producer.

This broad economic picture provides the context for Barbados's challenges with declining agricultural production being replaced by tourism, which in turn suffered and is recovering from the global financial crisis. It also illustrates the challenges of food and fuel imports on budget balancing, all of which influenced the strategic decision to transform its economy to a green economy. There is commitment to this transformation at the highest level and this was bolstered in 2009 when the Prime Minister expressed the desire to commit Barbados to becoming the "most

[2] Barbados Economic and Social Report 2015. Prepared by the Research and Planning Unit, Ministry of Finance and Economic Affairs. June 2016

environmentally advanced green country in Latin America and the Caribbean"[3]. This demonstrated and reaffirmed that Barbados is committed to sustainable development. Barbados articulated a definition of a green economy encompassing the unique challenges of SIDs:

> *"an integrated production, distribution, consumption and waste assimilation system that, at its core, reflects the fragility of our small island ecosystem as the basis for natural resource protection policy intervention, business and investment choice, human development programming, and for the facilitation of export market development strategies". Barbados' Green Economy Scoping Study*[4]

This overall strategy, as seen in the above definition, will focus on reduced carbon emissions, resource efficiency, waste reduction and reuse (circular economy), and sustainable consumption and production as avenues for achieving a green economy. These approaches relate in a couple of key ways to the ocean discussions in this research paper. The first is that Barbados desires to reduce its fuel imports by the development of alternative sources of energy production, and by the environmentally and socially sensitive exploitation of its own offshore hydrocarbon resources. Both of these avenues for reducing fuel imports will necessitate the exploitation of marine resources and services. The second however is the commitment to maintaining the natural resources base and the ecosystem services of the island which is central to development and the social well-being. A balanced exploitation of the marine space and its resources will therefore be a major focus of Barbados going forward.

In 2004, Barbados initiated internal discussions on the feasibility of preparing a proposal to the Commission on Limits of the Continental Shelf (CLCS) under the United Nations Convention on the Law of the Sea (UNCLOS). The process of preparing the formal submission began in 2006 and led to Barbados becoming the first SIDs to submit a proposal to the CLCS for a claim of an extended continental shelf beyond 200nm (ECS)[5]. After review and a revised submission, the CLCS made final recommendations to the Secretary General regarding the Barbados submission in April of 2012 leading to the addition of approximately 57,579km^2 of maritime space, the subsoil mineral and hydrocarbon resources of which Barbados will have exclusive rights to exploit. This

[3] Moore, W et. al. 2014. Barbados' Green Economy Scoping Study. Government of Barbados, University of West Indies- Cave Hill Campus, United Nations Environment Programme. 244p.
[4] Ibid.
[5] Pursuant to Article 76 of UNCLOS

substantial investment of finances, time and expertise to exercise sovereignty over its marine resources is a significant indication that Barbados seeks growth opportunities from its marine resources.

Barbados then, by virtue of these observations, has over time shifted its focus from inland (monoculture crop production with preferential trade) to coastal (tourism development) and now is beginning to focus its attention beyond the coast and across its EEZ for growth and development opportunities. It is a way of transforming typical small island disadvantages into large ocean-space opportunities. These opportunities include further developing fisheries, alternative energy production, nature tourism, oil and gas, and increasing benefits from other coastal and ocean services such as carbon sequestration.[6]

Other SIDs experience similar challenges and recognizing the opportunities, have begun formulating strategies to unlock growth opportunities from their oceans and to chart ways to achieve green economic development through blue activities. The Bahamas, for example, recognized the need for a comprehensive marine policy to consolidate a plethora of resource- and sector-specific policies and to seek sustainable growth opportunities from its large marine space. The Bahamas National Maritime Policy was formulated in 2005 along with associated institutional frameworks to improve governance of marine resources[7]. The Organisation of Eastern Caribbean States (OECS) recognized the need for an integrated approach to governance of the collective ocean space of the Eastern Caribbean and has developed the Eastern Caribbean Regional Ocean Policy (ECROP)[8]. It aims to coordinate the growth and development of marine related sectors taking the environmental, social and economic dimensions of sustainable development into account. Likewise, both The Seychelles and Mauritius in the Indian Ocean have articulated blue economy road maps and have implemented a bi-lateral arrangement for joint management of two marine areas. Various initiatives through UNCTAD, UNDESA, DOALOS, UNEP and FAO are underway to support SIDs in these endeavors.

Though Barbados has not yet articulated a written ocean policy, its actions are trending toward this outcome. These actions include among other things, the negotiation with neighbors on

---

[6] UNCTAD 2014. The Oceans Economy: Opportunities and Challenges for Small Island Developing States. United Nations, New York and Geneva. 2014

[7] Commonwealth of the Bahamas, 2015. The Bahamas' National Maritime Policy. Bahamas Maritime Authority, Ministry of Transport and Aviation.

[8] OECS 2013. Eastern Caribbean Regional Ocean Policy. Prepared by the Social and Sustainable Development Division of the OECS and the Special Advisory Services Division of the Commonwealth Secretariat

maritime boundaries, articulation of offshore hydrocarbon legislation and regulations along with undertaking licensing rounds, and pre-feasibility projects for offshore renewable energy production. Given all that has been presented so far of Barbados's evolution of resource management and development in the marine space, two things become apparent:

1. There is a critical need for scientific data and assessments of the state of the marine environment to support an ocean policy formulation and implementation.
2. There already exists a plethora of local, regional and global data related to the marine environment to be harnessed to support ocean governance in Barbados.

There has long been international agreement on the need to collect data and conduct assessments related to the marine environment for better decision-making and management. UNCLOS is often referred to as a constitution for the oceans [9] by way of its comprehensive and overarching framework. Part XI of UNCLOS represents an agreement on the importance of protecting and preserving the marine environment while acknowledging the sovereign rights of states to exploit resources under their jurisdiction. More specifically, article 200 promotes States undertaking and cooperating in conducting scientific research and assessments with a culture of information sharing for the prevent of environmental degradation in the marine environment. Further in article 201 there is a direct encouragement for States to use such data for establishing criteria for "the formulation and elaboration of rules, standards and recommended practices and procedures for the preventions, reduction and control of pollution of the marine environment." This represents a clear commitment at the global level to foster sustainable management of the oceans based on scientific data and understanding.

The global priority for protecting and sustainably using the oceans also manifested itself in Chapter 17 of Agenda 21. This chapter referred to the UNCLOS framework as the basis for further elaboration of a series of programme areas in pursuit of protection and sustainable development of marine and coastal assets. More specifically, in the programme area for integrated management and sustainable development of coastal and marine areas, including exclusive economic zones, States negotiated the following text as it relates to data and information:

> *"Coastal States, where necessary, should improve their capacity to collect, analyse, assess and use information for sustainable use of resources, including environmental impacts of activities affecting the coastal and marine areas.*

[9] Remarks by Tommy T.B. Koh of Singapore and President of the Third United Nations Conference on the Law of the Sea, 6 to 11 December 1982 (Montego Bay) at the final session of the Conference.

Information for management purposes should receive priority support in view of the intensity and magnitude of the changes occurring in the coastal and marine areas…" 17.8. of Agenda 21

The programme area goes on to encourage the development of databases, socioeconomic and environmental indicators, regular assessments of the state of the marine environment and information exchange at all levels. Further commitment was consolidated at the ten-year follow-up of Agenda 21, in the Johannesburg Plan of Implementation adopted in 2002 at the World Summit on Sustainable Development, which concisely stated in paragraph 36:

"Improve the scientific understanding and assessment of marine and coastal ecosystems as a fundamental basis for sound decision-making, through actions at all levels…" WSSD Johannesburg Plan of Implementation

SIDs went further, in view of their particular vulnerabilities and dependence on oceans, with promoting a commitment to coastal and ocean monitoring at the national level in a systematic way to feed into regional and international information sharing and clearing-house mechanisms. These commitments outlined in the Barbados Programme of Action (BPOA)[10] have been continuously reaffirmed in the Mauritius Strategy and SAMOA Pathway ten and twenty years later respectively.

These examples demonstrate a strong global commitment for the establishment and encouragement of a culture of data collection and assessments to support and drive sustainable ocean management. A plethora of examples, of how these commitments translated into practice, exist such as the agreement for UNESCO/IOC to establish the Global Ocean Observation System (GOOS). Other examples in the FAO, UNEP, UNFCCC, WMO and IMO mechanisms referred to in UNCLOS are well established.

Now that the international and national importance of ocean assessment and monitoring has been established, this paper will explore various mechanisms that have been building upon this commitment. A variety of cases will be presented demonstrating international and national mechanisms at various stages of their evolution and with perhaps different objectives and approaches. After an assessment of these approaches, elements of best practice and lessons learned

[10] Established by UN General Assembly resolution 47/189, the UN Global Conference on the Sustainable Development of SIDS was held in Barbados from 25 April to 6 May 1994.

from them can assist in forming a basis for what a similar framework would comprise in the case of Barbados, given its peculiar context.

The rationale is therefore set to establish a comprehensive framework of knowledge about the physical and chemical parameters, living resources, biodiversity, ecosystems and services, mineral and other non-living resources, and uses and interactions (socio-economic aspects) of the EEZ and Continental Shelf (including the ECS) of Barbados to support the sustainable exploitation of these zones. The term 'knowledge' is used in this thesis to encompass more than just coastal and marine data. The intention here is to guide sustained data collection, analysis, trends, and indicators towards the production of models and assessments of the resource base and associated sectors. Therefore, 'ocean knowledge' here refers to data, its synthesis, and the collective increased understanding of marine environments resulting. The process of networking and interaction among scientists, technicians, resource users and decision-makers across multiple disciplines likewise contributes to the growth in knowledge and understanding.

This thesis therefore seeks to support filling an institutional and strategic policy gap in ocean governance in Barbados. The vision is to assist Barbados in codifying and standardizing ways of strengthening, coordinating, and synergizing existing ocean monitoring and facilitating new means of data collection in a sustainable, cost-effective and operational way. So, an ocean knowledge framework will seek to bring long term sustainability to research and data gathering and funnel the resulting knowledge to support decision-making, research direction and public awareness to address societal needs. In this way, a series of guiding principles and approaches will be recommended, but there will be no attempt to formulate an ocean monitoring policy for Barbados since this should be led by national stakeholders and involve extensive consultation between government, research institutions and other players.

Part I: An Examination of Existing Ocean Knowledge and Assessment Frameworks

Part 1 of this thesis assesses a suite of existing frameworks for developing bodies of ocean knowledge to support decision-making and policy support. The term ocean knowledge is used in a deliberately broad sense to not only include primary data but also, models, forecast products, assessments, local/traditional knowledge, surveillance of human uses etc. that all contribute to the increase understanding of the ocean. The intention here is to present best practices and lessons learned from existing initiatives to inform recommendations for Barbados in Part II. A standardized approach to assessing each mechanism is used; looking first at its origins and the rationale for its development; then delving into the main elements, institutional arrangements, stakeholders and beneficiaries, and the way that policy-makers are reached.

The case studies chosen were with the intention of assessment across a spectrum of scope and scale: some global approaches and national initiatives, monitoring programmes versus integrated assessments, and different focuses and objectives. No formal case selection methodology was used here. These examples were highlighted in various recent intergovernmental processes and side events[11] showcasing good practice, progress in implementation of policies, and lessons learned. They were chosen here to highlight their origins, overall frameworks and approaches, or outputs that may be useful for Barbados in developing its own mechanisms.

[11] Preparatory Committee established by General Assembly resolution 69/292: Development of an international legally binding instrument 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; Eighth Meeting of the Ad Hoc Working Group of the Whole; United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea Eighteenth meeting: "The effects of climate change on oceans"; The United Nations Conference to Support the Implementation of Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development will be convened at United Nations Headquarters

1 INTERNATIONAL MECHANISMS

Global ocean monitoring has long been considered as a critical necessity to support management of the oceans. In the late 1980s there have been simultaneous calls from several international fora which led to a comprehensive framework for observing the global oceans to support management. More recently, the development of a regular process for global reporting and assessment of the status of the marine environment, including socio-economic aspects[12] has been initiated. These two mechanisms will be the focus here as they offer two frameworks initiated by the United Nations General Assembly (UNGA), at different stages of their evolution, with different core approaches.

1.1 The Intergovernmental Oceanographic Commission's (IOC) Global Ocean Observing System (GOOS)

At its plenary meeting in December 1988 the UNGA adopted a resolution on the protection of Global Climate for Present and Future Generations of Mankind[13]. This was followed by statements by the International Panel on Climate Change (IPCC) recognizing the need for systematic global ocean observations since the oceans are a critical asset in regulating global climate. The IOC in cooperation with the World Meteorological Organization (WMO) responded to that GA resolution and initiated the development of a comprehensive global ocean observing system through the IOC Assembly resolution[14]. This proposal was then presented to the twenty-third session of the IOC Executive Council, which adopted a resolution reiterating the urgency of such a system and requesting a status report with a needs assessment for implementation[15].

In addition to this, through the technical discussions at the Second World Climate Conference in October 1990, Member States articulated an urgent need to create a Global Climate Observing System(GCOS) to better understand climate changes and variability and to support policy and management of marine activities. This was proposed to be based upon the existing WMO's Weather Watch Global Observing System and the IOC-WMO Integrated Global Ocean Services

[12] A Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects (Regular Process)
[13] United Nations General Assembly 70th Plenary Meeting, 6 December 1988 (A/RES/43/53)
[14] Resolution XV-4 of the 15th IOC Assembly, July 1989
[15] Resolution XXIII-5 of the IOC Executive Council, 1990

System and including both space-based and surface-based observing components. This GCOS was proposed to include the GOOS proposed by IOC as a critical element.

1.1.1 Rationale

What was the urgency in the international diplomatic and scientific community to establish the GOOS? Three major needs of the international community can be extracted from Annex 3 of the report of the Sixteenth Session of the IOC Assembly[16] as the rationale for the development of the GOOS:

1. The for a system to provide products based on data and observations to support the expanding operations and activities in the upper oceans and the coastal oceans. So, several calls in various fora to sustainably manage marine extractive resources such as fisheries, offshore oil and gas, and likewise reduce the impacts non-extractive uses such as shipping have led to the agreement for comprehensive ocean observations and data synthesis to support this management.
2. The need for ocean-scale climate cycle information as highlighted by the scientific community. This included decadal and centennial cycles and their variability. This necessitates the development of long term operational monitoring of certain variables rather than relying on research programmes which may be limited in geographic and temporal scope.
3. Following on from 2 above, the need to use these operational, ocean-scale data to support reliable climate predictions. Long-term monitoring of the upper ocean, the ocean's surface and the interface of the lower atmosphere and the ocean's surface to produce these models and predictions at a global level would need to be done through a system such as GOOS. These climate prediction needs were of course driven by the concerns of global warming and climate change.

Considering this, the goal of the GOOS was to meet the needs of Member States and the international scientific community with respect to long-term, large-scale ocean monitoring to support decisions in ocean operational activities and climatic forecasts.

[16] Intergovernmental Oceanographic Commission (of UNESCO) Sixteenth Session of the IOC Assembly. Annex 3 Toward a Global Ocean Observing System: A Strategy (IOC-XVI/8 Annex 3)

1.1.2 Institutional Arrangements

The Twenty-Third Session of the IOC Executive Council requested the production of a status report on GOOS to be updated annually to report on implementation and development of the system[17]. The first report[18] offers an excellent synopsis of institutional arrangements at the time and existing mechanisms that supported the GOOS framework.

The IOC is the coordinating and lead technical agency of GOOS. The IOC has been recognized as a joint specialized mechanism of the United Nations System in the fields of marine science and ocean services. It is referred to in UNCLOS as "the competent international organization" regarding Marine Scientific Research (MSR)[19]. As mentioned earlier, the WMO and IPCC are key partners in GOOS development along with the United Nations Environment Programme (UNEP), International Council for Scientific Unions (ICSU) and United Nations Food and Agricultural Organisation (FAO).

The Twenty Fifth Session of the IOC Executive Council in 1992 established an Intergovernmental Committee for GOOS and a Joint Technical and Scientific Committee (JGOOS) in partnership with WMO, ICSU and UNEP to guide the development of the system. These committees govern the system and coordinate with Member States. The system encourages voluntary participation by Member States for mutual benefit. The two committees above coordinate the establishment of standard procedures and protocols for data collection which is submitted to international, regional and national centers for data analysis and data exchange.

[17] Resolution XXIII-5
[18] IOC/INF-833
[19] "Law of the Sea Bulletin" Volume 1996, Issue 31, Part III

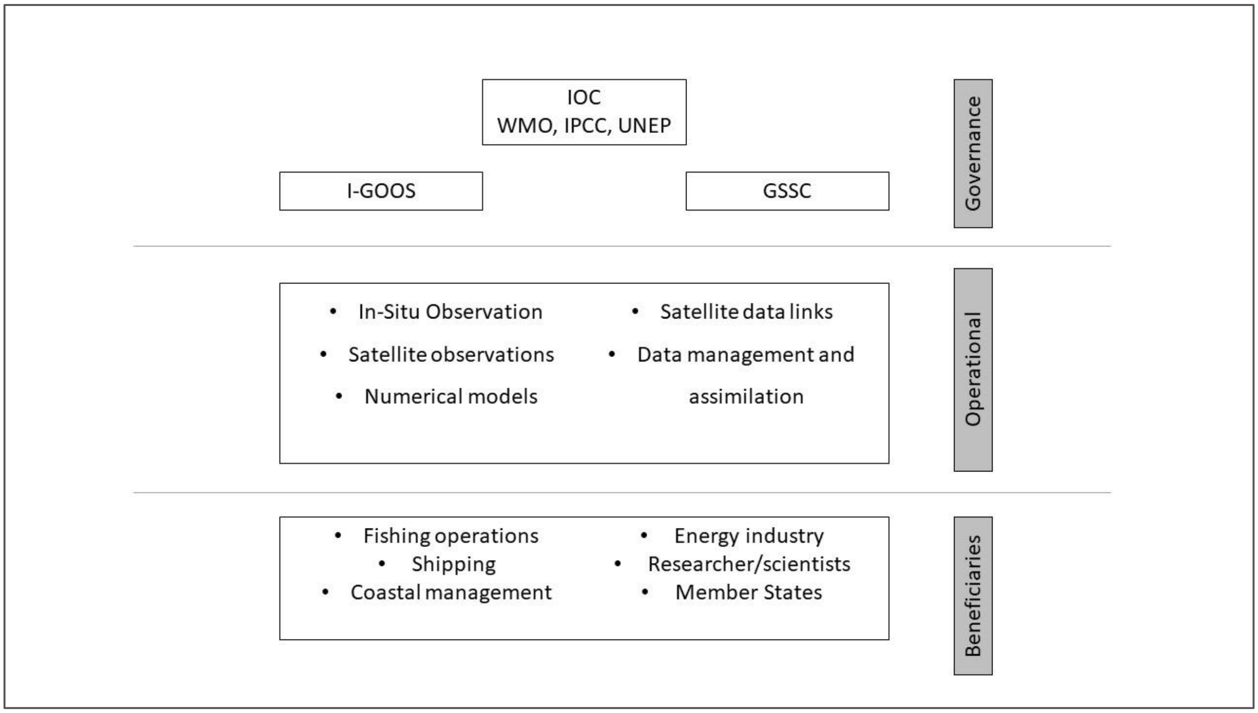

Figure 1: Simplified understanding of GOOS institutional and operational framework as it was established

GOOS institutional arrangements underwent a strengthening and streamlining process by the adoption of a resolution[20] at the twenty-sixth Session of the IOC Assembly in July 2011. Some of the outcomes of that session are presented below:

- The Assembly noted the Framework for Ocean Observations developed by the task team set up by the OceanObs'09 Conference (Venice, 2009);
- Considered the continued importance of ocean observations to various international processes such as the International Convention for the Safety of Life at Sea (SOLAS), the Global Framework for Climate Services (GFCS) and the United Nations regular process for global reporting and assessment of the state of the marine environment, including socio-economic aspects (the UN Regular Process);
- Decided to recommit to GOOS, aligning it with a Framework for Ocean Observing and its Essential Ocean Variable (EOV) approach;
- Decided to dissolve I-GOOS and GSSC while creating a streamlined GOOS Steering Committee with effect from January 2012;

[20] Resolution XXVI-8

This new GOOS Steering Committee comprised 15 members, 5 of which were elected by Member States and 10 scientific and technical experts appointed by the Executive Secretary in consultation with partners. Its main role was to identify and oversee the development of EOVs, their implementation and the level of success of the GOOS in providing end-users with fit-for-purpose data and information products. These changes were proposed by the I-GOOS, at their Tenth Session, as a strategy to increase the engagement of Member States in GOOS governance and thus offered an interface for science and policy in the framework.

1.1.3 Framework of Ocean Observing (FOO)

In 2009, hundreds of ocean observation practitioners and scientists held a global conference with a "common vision for the provision of routine and sustained global information on the marine environment sufficient to meet society's needs"[21]. One of the main outcomes of this conference was to devise a conceptual framework for ocean observing to achieve the above vision. The post-conference task team drafted the framework which was adopted by GOOS as mentioned earlier, with the then new GOOS Steering Committee positioned to be the governing body of the framework globally.

The framework built on best practices from existing ocean observation networks such as JCOMM and GCOS to codify a strategy of supporting the ocean research community. This support is of two types;

1. A way for national governments to inject additional resources and coordinate to expand existing research to meet the demands for information, and
2. Support research observation to transition into long term and sustained observations to meet societal needs[22].

The FOO supports existing mechanisms, facilitates operationalization, promotes standardization of data and broad accessibility to reduce duplication of effort, while promoting free and open data exchange. Across all these principles is a strong focus on capacity building and feedback for improvement.

[21] OceanObs'09 Ocean Information for Society: sustaining the benefits, realizing the potential
[22] IOC/INF-833

The FOO process is one that is needs-driven. The input of the process is a demand or desire for environmental information to address a scientific problem or societal needs. At the global level, these needs are identified by Member States and technical experts of various fora such as the "UN Regular Process", UNEP Regional Seas and Large Marine Ecosystem initiatives, UNFCCC and WMO climate-related data needs, among others. Therefore, the GOOS governance mechanism, through negotiations with its partners can facilitate development, deployment and improvement of observation processes in a long term and sustained way to satisfy those needs. The outputs are the observation data synthesized into products and services to inform research and decisions about the associated needs driving the process.[23]

Ocean observations are known to be costly and thus require large investments to sustain a meaningful spatial and temporal scale of monitoring. A common strategy to address this has been to measure as many variables as possible during observation activities. The danger of this however is to create scenarios of duplication and inconsistent data standards. The Framework of Ocean Observations therefore took an approach of negotiating Essential Ocean Variables (EOVs) as the most cost-effective plan to provide an optimal global view of each variable, and satisfying the principle of "measure once and use many times".[24] The EOV approach does not restrict or limit the observation method used and thus does not stifle innovation and technological advancement. In this way, if the ocean observing element is driven by the requirements, has scientific acceptance and common standards and protocols, it may be incorporated in GOOS to monitor EOVs.[25]

There is, however, an established process in the framework for transitioning new technologies and methods from the idea/innovation stage to the mature sustained monitoring phase. This involves a long process of proof of concept and peer acceptance, agreeing standards internationally, negotiating a governance mechanism and international commitment, with investment and capacity building cutting across all phases until the observation is mature and ready to be incorporated into the framework. It is important to note that EOVs and their associated methods of observation and data analysis must be highly feasible technically and financially, and have a high impact on societal issues and research needs to be sustainable. This process of bringing observation from pilot to maturity can be seen through IOCs commitment to support, through GOOS, the BBNJ[26] and other

[23] IOC/INF-833
[24] Ibid.
[25] Ibid.
[26] Development of an international legally binding instrument 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,

processes by developing a suite of Biology and Ecosystem EOVs currently in concept and pilot stages. These biology and Ecosystem EOVs, once mature, would support the production of baselines, assessments and reports to support the management of biodiversity beyond national jurisdiction.

1.2 A Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects (UN Regular Process)

It will be useful now to examine the UN Regular Process as a case study for a few reasons. First, it is a comprehensive assessment of the status of the marine environment rather than a data collection/provisioning mechanism like GOOS and thus the processes and arrangements also useful best practices. Second, because it is an assessment it will depend heavily on monitoring mechanisms like GOOS to provide the experts with quality, timely and consistent data to conduct the assessment. It is an important bridge between science and policy. Third, the UN Regular Process is a relatively new process that may be useful for Barbados's potential ocean knowledge framework to align itself and develop in tandem with.

1.2.1 Rationale

The UN Regular Process, like the GOOS, was a result of the international community recognizing the importance of oceans to human wellbeing and economic development. The genesis of the Regular Process however was more from a growing concern of the environmental impact human activities are having on the oceans. The World Summit on Sustainable Development held in Johannesburg in 2002 recommended the establishment by 2004 of a regular process under the United Nations for global reporting and assessment of the state of the marine environment, including socio-economic aspects, both current and foreseeable, building on existing regional assessments.[27]

This call also came because of a recognition that there were at the time no comprehensive global assessments of the status of the marine environment that met the requirements. These requirements

pursuant to UNGA resolution A/Res/69/292. The GOOS framework is piloting biology and ecosystem EOVs in anticipation of providing data support for this potential new legally binding instrument.

[27] Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August–4 September 2002 (United Nations publication, Sales No. E.03.II.A.1 and corrigendum).

were that it needed to be global but building on regional assessments, regular and comprehensive to support global policy direction on an ongoing basis. There were many existing assessments that were one-time assessments, regional, sector-specific or thematic in nature and this gap needed to be filled.

United Nations Member States responded to the recommendation and decided at the fifty-seventh session of the General Assembly to accept the above recommendation to establish a global marine assessment process with the above characteristics. The resolution requested the Secretary General to work closely with Member States and relevant competent agencies in the United Nations System to propose modalities for the Regular Process drawing upon experiences from previous assessment processes.[28] Specific reference was made to work of UNEP in its decision in 2001 to pursue, in consultation with its Regional Seas Programme, IOC and the Convention on Biological Diversity (CBD), the possibility of establishing a regular marine assessment leveraging its regional seas conventions.[29] Both the UNEP and UNGA resolutions recalled the report "A Sea of Troubles" of the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) which highlighted "ineffective communication between scientists and government policy makers and the public alike" as a reason for lack of action in addressing environmental problems of the oceans. Therefore, the development of a global marine assessment was important to provide a scientific basis for policy and integrated management as it related to the marine environment.

1.2.2 Modalities

Developing a process was done by soliciting proposals from Member States, United Nations agencies and Non-Governmental Organizations. These proposals were presented by the Secretary General to the fifty-eighth session of the General Assembly.[30] In this report, the GESAMP[31] was highlighted as "the only United Nations inter-agency mechanism with relevant experience in carrying out assessments, with internationally recognized scientific high standing and with a real capacity to take the lead role of the scientific aspects of a GMA mechanism, subject to a successful

[28] A/RES/57/141, para 45.
[29] A/56/25 Governing Council Decision 21/13.
[30] A/58/423
[31] Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) is an advisory body to the United Nations sponsored by nine United Nations organizations

organization of its structure and modus operandi."[32] The report outlined several other important considerations worth summarizing here:

- The assessment proposed to proceed at a basic level to inspire full participation and evolve as capacities improve;
- It was important for the assessment to be global, comprehensive and include socio-economic aspects to improve the science-policy support potential;
- Peer review of the scientific assessments;
- It was important, to preserve the credibility of the assessment, to have factual scientific assessments and the process of formulating policy recommendations as separate and distinct processes done sequentially.

The overarching process, as understood from the report on proposed modalities,[33] would be a five-year cycle with 4 broad steps presented below:

1. Convening of a global stakeholder forum with interested parties to discuss the issues followed by a global design by a scientific panel;
2. Regional implementation of that global design to ensure further regional participation and the use of region-specific information;
3. Synthesis of regional assessments into a global assessment; and
4. Review of the scientific assessment through a policy lens to elucidate policy recommendations.

It must be noted that additional steps were involved in the first assessment cycle. For instance, additional international and regional workshops were convened to discuss modalities, raise capacity and seek support among Member States. Likewise, an assessment of more than 1200 previous marine-related assessments was conducted which resulted in the preparation of best practices and lessons learned to inform the overall process.

1.2.3 Institutional Arrangements

The Regular Process was established under the General Assembly through an Ad Hoc Working Group of the Whole. The summary of the first assessment in 2015, entitled the "First Global

[32] Ibid.
[33] Ibid.

Integrated Marine Assessment: World Ocean Assessment I" (WOA1) summarizes the institutional arrangements under the reporting of organization of work.[34]

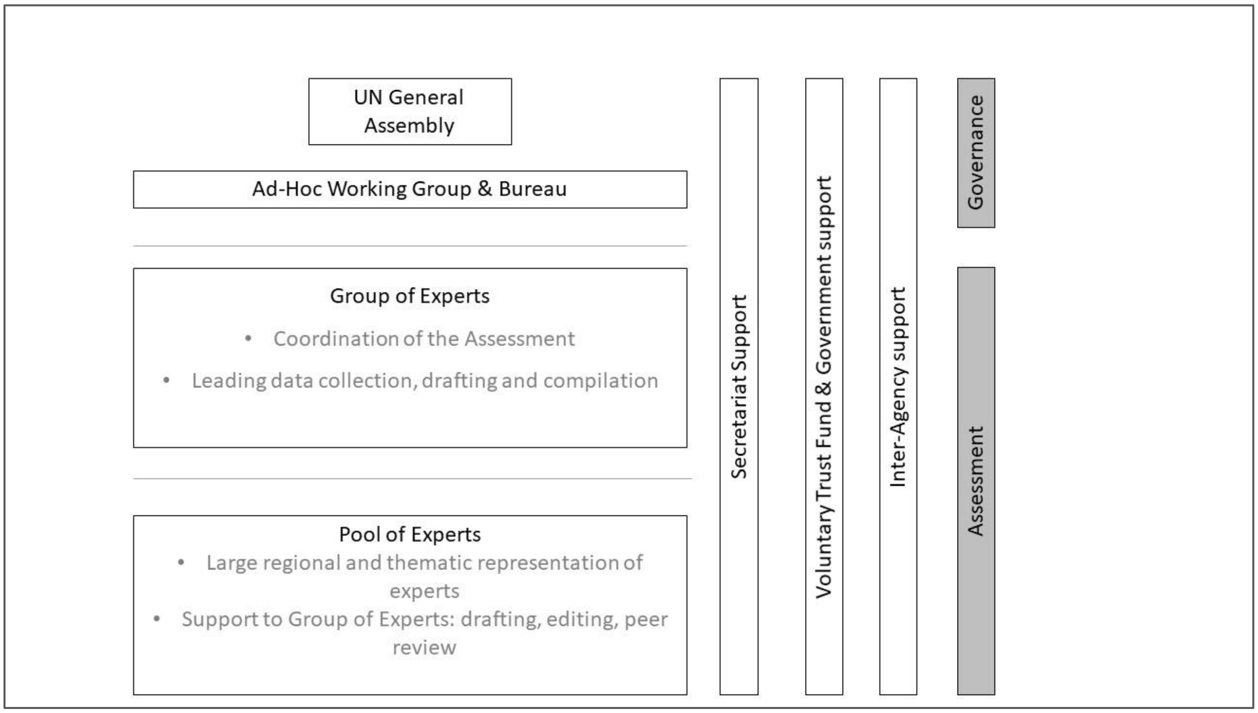

Figure 2: Institutional arrangements for the United Nations Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects

Briefly, the Ad-Hoc Working Group of the Whole established the Bureau in 2011 to implement the decisions made by the Group. The Bureau has two co-Chairs, usually one each from developed and developing Member States. The technical aspects of the work are conducted by the Group of Experts (GoE) and the Pool of Experts (PoE). The GoE comprises 25 experts representing geographic regions and adequate breadth of expertise in ocean disciplines including socioeconomic aspects. They are nominated by the Chairs of the regional groups of the General Assembly pursuant to resolution 64/71.[35] The GoE has the responsibility for conducting any assessments under the framework of the Regular Process at the request and approval of the General Assembly.[36] The group meets at the beginning of the cycle to discuss the issues with global partners, inviting open discussion and participation by all interested parties. The outline and implementation plan are determined by the GoE and approved by the Ad-Hoc Working Group of

[34] A/70/112.
[35] A/Res/64/71 para 180
[36] A/67/87 Annex III Terms of Reference and working methods for the Group of Experts of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment

the Whole. The group then coordinates regional assessments and leads the drafting of the assessment.

The PoE is a larger body of experts reflecting regional and disciplinary diversity like the GoE. They are nominated by Member States to serve in the pool and support the work of the GoE by identifying and compiling data, drafting, editing and peer review. It is important to note that currently all members of the Group and Pool serve in their personal capacity and not as representatives of a Government or external authority and may not have any affiliation (government, academic, private sector etc.). Neither members of the Group or Pool are financially compensated by honorarium, fee or other remuneration from the United Nations for their work in the Regular Process[37].

The entire process is supported in three key ways (Figure 2). The Division of Ocean Affairs and Law of the Sea (DOALOS) serves as the secretariat of the Regular Process.[38] DOALOS hosts all meetings of the Ad-Hoc Working Group, the Bureau, GoE and PoE. They managed the process of membership of the Group and the Pool, ensuring the quality of the membership through the nomination process. Likewise, capacity building workshops and guideline documents[39,40] by the secretariat ensured a quality assurance mechanism and standardization were in place for the assessment process. The second cross-cutting support is provided through a funding mechanism. The secretariat manages a voluntary trust fund to support participation of developing States and to support the various meetings of the Bureau, Group and Pool. The third support mechanism identified in the report on the organization of work is that of competent agencies of the United Nations such as IOC, UNEP, FAO, IMO and others that have given valuable input into the design and supported technically and financially throughout the assessment process.

1.2.4 Outputs and Benefits

The pre-assessment phase of the first cycle of the Regular Process was to conduct an Assessment of Assessments (AoA)[41] with the view to build on existing and draw from best practices and lessons learned. The GoE acknowledged that numerous assessments already existed but none met all the criteria as mentioned earlier. The GoE examined over 1200 assessments of various types

[37] Ibid
[38] A/70/112
[39] A/67/87 Annex III Terms of Reference and working methods for the Group of Experts of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment
[40] A/68/82 Annex II Guidance for Contributors
[41] Pursuant to A/Res/60/30.

(regional, non-recurring, species specific, sector specific etc.) and resulted in a set of conclusions on good practice and recommendations on how an integrated global marine assessment might be accomplished.[42] The AoA report is a tremendous synthesis of best practices and considerations for design and implementation of a marine assessment that will surely be of use in this current body of work. The Assessment of Assessments Report provides useful insight on the ways the Regular Process could contribute to the management of marine resources:[43]

i. The overall benefit of the Regular Process is contributing to a regular and global perspective of the importance of oceans to human wellbeing by provision of information on goods and services of the oceans, inclusive of trends over time.
ii. Offer a truly integrated assessment of all human interactions and their impacts on all components of the oceans.
iii. Promote integrated and ecosystem-based assessments that can be a model for the development of or improving existing national and regional assessments, thus encouraging vertical and horizontal synergy of assessments processes for better policy support at all levels.
iv. Contribute to capacity building in data collection, sharing, analysis, scenario development and science communication which will improve the ability to formulate science-driven policy.
v. Promote stakeholder cooperation at all levels.
vi. Strengthens the link between science and policy

The main output of the Regular Process at this time is the integrated global assessment of the state of the marine environment, or the World Ocean Assessment I (WOA1).[44] It comprises 55 chapters divided into 7 major parts:

- Part I- Summary
- Part II- The Context of the Assessment
- Part III- Assessment of Major Ecosystem Services from the Marine Environment (other than provisioning services)

[42] A/70/112.
[43] UNEP and IOC-UNESCO 2009. An Assessment of Assessments, Findings of the Group of Experts. Start-up Phase of a Regular Process for Global Reporting and Assessment of the State of the Marine Environment including Socio-Economic Aspects.
[44] United Nations (Ed.). (2017). The First Global Integrated Marine Assessment: World Ocean Assessment I. Cambridge: Cambridge University Press. doi:10.1017/9781108186148

- Part IV- Assessment of the Cross-cutting Issues: Food Security and Food Safety
- Part V- Assessment of Other Human Activities and the Marine Environment
- Part VI Section A — Overview of Marine Biological Diversity
- Part VI Section B — Marine Ecosystems, Species and Habitats Scientifically Identified as Threatened, Declining or Otherwise in need of Special Attention or Protection
- Part VI Section C — Environmental, economic and/or social aspects of the conservation of marine species and habitats and capacity-building needs
- Part VII- Overall Assessment

Upon completion of the assessment the Group of Experts elucidated ten important themes to bring to the attention of the General Assembly. Briefly, the themes are: climate change and associated implications, the exploitation of living marine resources, fish production, marine biodiversity, ocean space management, marine pollution, cumulative impacts of human activities on ecosystems, global distribution of benefits accrued form the oceans, cooperation in marine management, and the urgent need for action against threats to the oceans. These ten themes were not presented in any order of priority but are important in supporting Member States and other stakeholders in planning and decision-making. The GoEs, as per instruction of the General Assembly, did not produce a set of policy recommendations for Member States. The outputs nonetheless represent a major undertaking and a first of its kind. The summary of the WOA1 was approved by the General Assembly in December of 2016[45] and the WOA1 itself was launched at the Ocean Conference in June 2017.[46]

Part of the review and evaluation process after the WOA1 was finalized was the production of lessons learned from the first assessment to inform the second cycle. As per GA resolution 70/235 para. 282, the Bureau solicited comments in writing from the GoE, PoE, the Ad-Hoc Working Group of the Whole, Member States and other stakeholders on lessons learned from the first cycle to present to the General Assembly. Comments were sought through 2 informal meetings of the Working Group. The abstract was prepared for discussion at the Seventh Meeting of the Ad-hoc Working Group of the Whole and represents a major output in the development of the Regular Process. This thesis will draw more upon the lessons learned in Part II.

[45] A/Res/70/235 para. 266
[46] The United Nations Conference to Support the Implementation of Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development will be convened at United Nations Headquarters in New York from 5 to 9 June 2017

Pursuant to paragraph 286 of GA Resolution 70/235[47] , the Secretariat compiled an inventory of existing and ongoing regional and global level assessments and other relevant processes to support the first cycle. Again, this output represents a best practice in seeking synergies and building on existing frameworks and assessments for efficiency.

1.2.5 Second Cycle

The GA initiated the second cycle of the WOA through resolution 70/235 requesting the Secretary General to convene the Seventh meeting of the Ad-Hoc Working Group of the Whole to formulate recommendations for of a workplan and resource requirements for the second cycle. One of the main recommendations presented to the GA as a result was for the second cycle to play in important supporting role to 3 ongoing United Nations Processes:

i. Implementation of Goal 14 of the 2030 Agenda for Sustainable Development;
ii. The process for the development of an internationally legally binding instrument under the UNCLOS on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ);
iii. And UNFCCC processes and the Informal Consultative Process on Oceans and the Law of the Sea.

Therefore, the first major output of the second cycle[48] was to produce technical abstracts or handbooks for policy-makers to support the above three processes. The second major output will be the published assessments as necessary, following the determination of the scope and content.[49]

1.3 Trans-Atlantic Assessment of Deep-water Ecosystem-based Spatial Management Plan for Europe (ATLAS)

The Trans-Atlantic Assessment of Deep-water Ecosystem-based Spatial Management Plan for Europe, better known as the ATLAS Project, will be presented here as a case study of regional cooperation in ocean monitoring and research set within a context of regional strategic direction and ocean basin cooperation. The regional context and cooperation make it worthy of being highlighting here as a possible mechanism for Barbados to explore with regional partners or

[47] A/Res/70/235.
[48] As per the Preliminary Indicative Work Programme 2017-2020 for the Second Cycle of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, Including Socioeconomic Aspects, July 2016. Pursuant to GA Resoluton 70/235
[49] Ibid

through CARICOM. The context, work packages and institutional arrangements of ATLAS are summarized outlined below.

The ATLAS project is formulated and funded under the Horizon 2020 European Union Framework Programme for Research and Innovation (H2020). Horizon 2020 represents an 80 billion Euro investment in EU-wide research in innovation and technology over a 7-year period (2014-2020) aimed at driving sustainable economic growth competitiveness and job creation. A sub-call under H2020 began in 2013 for proposals toward "unlocking the potential of seas and oceans" through blue growth initiatives.[50]

The second regional policy direction is the Galway Statement on Atlantic Ocean Cooperation singed in May 2013 by representatives of the European Union, Canada and the United States of America.[51] The three parties recognized the importance of the Atlantic Ocean to prosperity and human well-being while facing similar challenges for management of its resources. Likewise, they recognized the reliance on best available science for decisions and the value of cooperation in ocean science (research and observations) for mutual benefit. The cooperation was formalized to increase knowledge of the Atlantic Ocean dynamics and interlinkages with observations, data sharing, interoperability and coordination as fundamental components to achieving the goal. The Galway agreement seeks to leverage existing bilateral European Union-Canada and European Union-United States science and technology agreements [52] and thus can be seen an implementing instrument for the latter. For example, the EU-US 'Agreement for Scientific and Technical Cooperation' was originally signed by the two parties in 1998 to strengthen and complement existing bilateral agreements between the US and individual EU Member States. The 2008-2013 iteration of the agreement outlined joint large-scale research on North Atlantic Ocean and associated shelf-seas as a planned collaborative research direction.[53]

The ATLAS seeks to provide essential new knowledge of deep ocean Atlantic ecosystems with the following overall objectives:

- Advancing understanding of deep Atlantic marine ecosystems and populations;

---

[50] The H2020 ATLAS Project, & Trans-Atlantic Partnership. Galway Statement Workshop, ISDSC6, Boston 2016. J Murray Roberts

[51] Galway Statement on Atlantic Ocean Cooperation. Launching a European Union-Canada-United States of America Research Alliance. The Atlantic-a Shared Resource, 23-24 May 2013, Galway, Ireland.

[52]Galway Statement on Atlantic Ocean Cooperation. Launching a European Union-Canada-United States of America Research Alliance. The Atlantic-a Shared Resource, 23-24 May 2013, Galway, Ireland.

[53] EC-US Scientific Technological Cooperation Agreement. Road Map Document, July 2009

- Improving capacity to monitor, model and predict shifts in deep-water ecosystems and populations;
- Transform new data, tools and understanding into effective ocean governance; and
- Scenario-test and develop science-led, cost-effective adaptive management strategies that stimulate Blue Growth.[54]

This will be achieved through over 25 research cruises investigating 12 case studies across the Atlantic basin. The data collection efforts will be supported by robust networking and data sharing mechanisms. These data provide input to decision support and policy development work packages such as marine spatial planning and policy integration exercises.[55] The ATLAS project engages 25 multidisciplinary partners from government agencies, research institutions and the private sector across 12 counties. The impact of this work will be a direct injection of new information on deep ocean and other marine ecosystems in the Atlantic to influence marine policy, regulation and blue growth opportunities.

2 NATIONAL MECHANISMS

Some national initiatives for ocean monitoring are presented below. The intention here is to highlight national efforts to increase ocean knowledge for more effective management and as a tool for unlocking Blue Growth opportunities. Cases are presented from developed and developing countries with a variety of objectives and approaches to ocean monitoring that demonstrate the application of ocean monitoring to maritime economic development.

2.1 Norway's MAREANO Programme

Norway's MAREANO (Marine Areal Database for Norwegian Coasts and Sea Areas) Programme is a multidisciplinary benthic habitat mapping programme for the Norwegian North Sea. This programme represents a case study of a central-government-funded, collaborative, multidisciplinary knowledge building programme to support ocean resources management and human-activity regulation through an ecosystem-based approach. The programme was designed

[54] The H2020 ATLAS Project, & Trans-Atlantic Partnership. Galway Statement Workshop, ISDSC6, Boston 2016. J Murray Roberts

[55] ibid

to fill the knowledge gaps regarding seabed conditions, habitats and biodiversity through detailed mapping of depth, sediments, bottom fauna and pollutants in Norwegian waters.[56] The gap existed because traditionally it was easier to sample soft bottom habitats by using sediment grab sample techniques and identifying biodiversity in those samples, thereby leaving hard- and semi-bottom habitats under-sampled. The challenge with this is that habitat-building sedentary species prefer hard bottom and these habitats and centers of diversity, by nature of them being sedentary, were at greater risk of human industrial activity and served as possible indicators of the state of the environment around them. So, it was imperative to fill these information gaps for better management and planning. The Framework Protocol 7 (FP7) Mapping European Seabed Habitats (MESH) project ran concurrently with the first cycle of MAREANO and helped to create data collection, modelling and information product standards for seabed mapping in Europe. The focus here however is the national MAREANO perspective.

The MAREANO launch in 2005 was intended to allow the initial outputs of the programme to support the implementation of 'The Integrated Management Plan for the Marine Environment of the Barents Sea and the Seas off the Lofoten Islands' (BSMP);[57] to be an ongoing support to Norway's national and regional policy input and formulation in general; and provide the scientific basis for regulation of human activities such as the petroleum industry and fisheries.[58]

Regarding institutional arrangements and roles, the MAREANO is coordinated by the Institute of Marine Research which collaborates primarily with the Geological Survey of Norway (NGU) and the Norwegian Hydrographic Service (NHS). These three make up the Executive Group which carry out the scientific work, planning and report to the Programme Group. The Programme Group comprises Head of Department representation of 9 State institutions: Norwegian Environment Agency, Directorate of Fisheries, Institute of Marine Research, Geological Survey of Norway, Norwegian Mapping Authority Hydrographic Service, Norwegian Petroleum Directorate, Norwegian Polar Institute, and the Norwegian Coastal Administration. Direction for MAREANO is given by five Ministries forming the Steering Board: Ministry of Trade, Industry and Fisheries,

---

[56] Institute of Marine Research, 2009. 'MAREANO: Collecting Marine Knowledge' in, Focus on Marine Research Vol 2-2009

[57] L. Buhl-Mortensen et. al, 2015. 'The MAREANO Programme- A full coverage mapping of the Norwegian off-shore benthic environment and fauna' in, Marine Biology Research Vol. 11, No. 1, 4-17

[58] L. Buhl-Mortensen et. al, 2015b. 'Habitat mapping as a tool for conservation and sustainable use of marine resources: Some perspectives from the MAREANO Programme, Norway' in Journal of Sea Research Vol. 100, 46-61

Ministry of Petroleum and Energy, Ministry of Climate and Environment, Ministry of Transport and Communications, and Ministry of Local Government and Modernisation.[59]

The first five-year phase focused on the Barents Sea area. The NHS conducted multibeam surveys to map the topography of the seafloor. This information was then used to plan other sampling activities to map habitats and measure biodiversity and species abundance. These were done by video surveys, sediment infauna samples using grab samplers, and sled and trawl sampling for benthic and demersal megafauna. Data from these multidisciplinary surveys were analyzed to produce maps of bottom type, habitat type, and species distribution and abundance estimates.[60] Backscatter data from sonar surveys were used to produce sediment type and geology maps supported by mulitcorer sediment samples. Information on the chemical characteristics of the sediments were also derived from these samples, ascertaining anthropogenic or natural origin of chemical components and the ability to track change over time as the programme matures.[61] The second phase of MAREANO implemented sampling and mapping in the Norwegian Sea while continuing to refine sampling methodologies to improve information quality and cost effectiveness. Barents Sea area sampling also continued in phase two.

The products and mapping of the programme are published online with the support of an interactive web atlas for the public and specific interest groups to access. Buhl-Mortensen et. al. (2015)[62] outlined the beneficial outcomes and main users of information from MAREANO:

i. As mentioned earlier, the products were critical to the update of the marine spatial planning elements of the BMSP 2010 integrated management tool for the area.
ii. Increased knowledge and identification of ecological sensitive, vulnerable and threatened areas of the seafloor.
iii. Information to help refine definitions for habitat types and methodologies for their identification and mapping. Data from MAREANO were used in support of these improvements.

---

[59] MAREANO: Collecting Marine Knowledge. http://www.mareano.no/en/about_mareano/partners. Published 2007, updated 2016.
[60] Institute of Marine Research, 2009. 'MAREANO: Collecting Marine Knowledge' in, Focus on Marine Research Vol 2-2009
[61] L. Buhl-Mortensen et. al, 2015b. 'Habitat mapping as a tool for conservation and sustainable use of marine resources: Some perspectives from the MAREANO Programme, Norway' in Journal of Sea Research Vol. 100, 46-61
[62] L. Buhl-Mortensen et. al, 2015. 'The MAREANO Programme- A full coverage mapping of the Norwegian off-shore benthic environment and fauna' in, Marine Biology Research Vol. 11, No. 1, 4-17

iv. Contribution to the implementation, and reporting, of regional and international obligations regarding development of strategies for management and protection of marine biodiversity and habitat quality.

v. Outputs have been used by OSPAR[63] in the development of more relevant threatened and endangered habitat categories and to identify their health status. This demonstrates the important role of Regional Seas conventions as both drivers of ocean knowledge and beneficiaries.

vi. Data used widely in national and regional research and other projects.

Core financing is provided by two Ministries from the Steering Board; The Ministry of Trade, Industry and Fisheries; and the Ministry of Climate and Environment. The programme has enjoyed increasing levels of financial contributions by the Government of Norway to support expansion and refinement of the programme. **Figure 3** shows the increases in financial contributions since 2005 (graph A) and percentage changes in levels of investment relative to the previous year (graph B). The data suggest that as the programme develops, a balance is being reached as it relates to the levels of new funding needed to achieve objectives similar to the maturation process in FOO. Funding contributions have also become more stable and predictable over time. Any science-to-policy programme should strive in its sampling methods, frequency and scale to strike a balance between gathering the best information to achieve its objectives while achieving cost-effectiveness. Based on the total area studied thus far and the level of investments, the programme costs around US $520 per km^2 to map bathymetry and habitat characteristics.[64]

[63] United Nations Environment Programme (UNEP) administered Regional Seas programme for the protection and conservation of the North-East Atlantic and its resources (OSPAR Commission and associated convention).

[64] Data presented at the side event "The MAREANO Program SEABED EXPLORER AND MAPPER" hosted by the MAREANO programme and the Permanent Mission of Norway to the United Nations, at the third session of the Preparatory Committee established by General Assembly resolution 69/292: Development of an international legally binding instrument 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 (27 March to 7 April 2017)

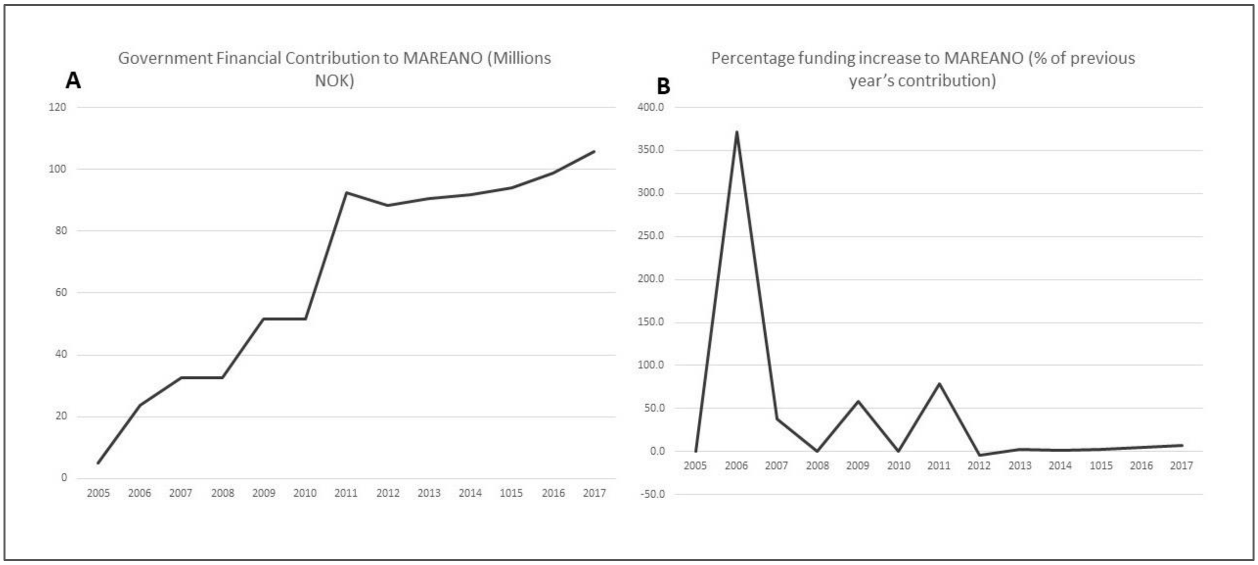

Figure 3: A) Government financial contributions to MAREANO from its start in 2005 to 2017 in Millions of Norwegian Krone. Data sourced from mareano.no/en/about_mareano (B) The same investment levels are presented as percentage increases compared to the previous year.

Norway's approach to integrated ecosystem-based planning and management of marine areas supported by multidisciplinary seafloor mapping provides a useful case study. It's framework of inter-agency coordination; in-situ collection and information sharing to increase ocean knowledge for research, industry regulation, policy direction and planning at the national and regional level is a full science to policy process in practice.

2.2 Indonesia's Satellite Oceanography

Indonesia, being the largest archipelagic State, depends heavily on coastal and marine resources for economic growth and sustainable development. The marine environment has been affected by coastal population growth, fisheries and shipping development resulting in deteriorating water quality and coral reef impacts among others. Indonesia recognized that solutions and management required a robust scientific basis. Likewise, with respect to further growth, Indonesia acknowledged "the need for scientific tools for the exploration of economic benefits that came from the sea like oil and gas, fisheries, but also the economic potential of production of energy from tides, currents and winds"[65] as a major support mechanism in management and decision-making related to coastal and marine resources. Indonesia's operational oceanography will be

[65] Ribotti, A., Sorgente, R., Hanggono, A. et al. Operational Oceanography in Indonesia. Asia Europe J (2008) 6: 277. https://doi.org/10.1007/s10308-008-0185-z

described here along with the development of a Satellite Oceanography programme (INDESO). The investment in satellite ocean observation systems and the development of information products and services in Indonesia represents a useful case study for Barbados considering its apparent direction in hydrocarbon exploration, offshore alternative energy development and general pursuit of sustainable ocean resources management.

The building blocks of the Indonesia Operational Ocean Observation System were defined in 2004 through dialogue between Indonesian and European research institutions along with an overall science and research strategic plan for oceanography. This was followed by the development and implementation of feasibility studies to define roles, infrastructural and technical requirements, and human capacity needs for a sustained monitoring of the seas of Indonesia.[66] The focus would be on the development of routine observations and its derived products (nearcasts, forecasts and hindcasts) to bridge the gap between researchers and information end-users in the areas of physical, chemical, and biological oceanography. The plan also included monitoring impacts of human uses, coastal erosion and dynamics, fisheries, and hazards.

The Indonesian Minister of Marine Affairs and Fisheries, in 2005, launched a national programme under the Declaration of Indonesian Global Ocean Observation System (INA-GOOS).[67] The programme is a national component of the GOOS Framework for Ocean Observation with phases of implementation starting with research and piloting through to sustained operation observations. The goal of INA-GOOS was to consolidate existing observations networks into a comprehensive system and to develop a forecasting and data assimilation system to regular accept and process these data to provide information on the status of environmental health for resource managers and policy makers.[68] The INA-GOOS needed to be supported by relevant policies including fisheries policy, Integrated Coastal Management Policies, and an Operational Oceanography Policy.

A long-term national oceanography would provide timely, quality-assured information as a basis for decisions and to fuel further research. Uses include assessing the state of the environment, national and international treaty reporting, improving sustainable exploitation of resources,

[66] Ibid.
[67] Farhan, A.Riza & Lim, Samsung. (2010). Integrated coastal zone management towards Indonesia global ocean observing system (INA-GOOS): Review and recommendation. Ocean & Coastal Management. 53. 421-427. 10.1016/j.ocecoaman.2010.06.015.
[68] Ribotti, A., Sorgente, R., Hanggono, A. et al. Operational Oceanography in Indonesia. Asia Europe J (2008) 6: 277. https://doi.org/10.1007/s10308-008-0185-z

improving safety of marine operations, improving coastal planning and disaster resilience, and contributing to understanding local climate variability.

Indonesia invested in satellite oceanography as part of its INA-GOOS programme specifically to improve management of fisheries and shipping activities. Fifty million Indonesians earn a living from fisheries related activities and more than a billion dollars is lost annually from illegal, unreported and unregulated (IUU) fishing. The Infrastructure Development of Space Oceanography (INDESO) project was designed to develop a forecasting and management center for marine resources with 7 major applications: reducing IUU fishing, monitoring oil spills, fish stock monitoring, ICZM, aquaculture and seaweed cultivation monitoring, and monitoring the state of coastal habitats such as coral reefs. [69]

The project was funded by the French Development Agency (AFD) with a loan of $30M. The Ministry of Marine Affairs and Fisheries is the main initiator and coordinator of the project with several technical sectoral partners. A subsidiary of the French Space Agency, Collecte Localisation Satellites (CLS), was the main technical partner and supplier of satellite data. CLS have provided the infrastructure for the project, inclusive of satellite data receiving stations, data processing and modelling facilities.

The data center receives daily satellite transmission for various applications:[70]

1. Regarding the monitoring of fishing activity, INDESO combines satellite radar and coastal radar with vehicle monitoring systems (VMS) and Automatic Identification Systems (AIS) to detect and track IUU fishing vessels. These products are distributed to patrol ships and planes to increase the effectiveness of IUU enforcement. INDESO can therefore support the detection and reaction to illegal fishing, as well as provide information for better management of unregulated and reported fishing activity.
2. Using knowledge of ecology and life stage biology of tuna species, INDESO incorporates physical and biogeochemical ocean observations from satellites into the Spatial Ecosystem and Population Dynamics Model (SEAPODYM) to derive a best estimate of the distribution and abundance of fish stock. Fish stock forecasts are distributed to commercial

[69] http://www.indeso.web.id/indeso_wp/index.php/en/home
[70] http://www.indeso.web.id/indeso_wp/index.php/en/home

fleets and fisheries management on a weekly basis for a more sustainable and efficient management of the fisheries.

3. The use of near-real time satellite imagery in conjunction with AIS data results in detection of oil spills and the ability to potentially identify the polluter. Physical and biogeochemical oceanographic data are used to predict the impact areas. This is a crucial application given the high volume of traffic, not only in shipping and fishing vessels but also oil trans-shipment, through the archipelagic waters and straits of Indonesia.
4. INDESO will be a critical support service to ICZM in Indonesia. Satellite data aid in the understanding of coastal hydrodynamics, shoreline changes, vulnerability assessments, and monitoring coastal development. Management and regulation of coastal aquaculture has been improved by monitoring shrimp pond activity. Regarding habitat mapping, mangrove restoration (both natural and anthropogenic) is being monitored through INDESO. Changes in coral reef habitat are being tracked over time to support conservation.

Indonesia presents a good case study for routine ocean monitoring. Similar marine challenges and desire for blue growth exist in Barbados. Indonesia's approach to North-South partnerships, funding arrangements, and innovative approach to monitoring will be explored further in Part II to assess possible application within a Barbados context.

Part I is a compilation of case studies useful to draw best practices and lessons learned in developing ocean knowledge to support ocean governance. Two broad conceptual frameworks at the international level were presented; a framework for sustained ocean data collection and a process for harnessing these and other information to conducted integrated marine ecosystem assessments. An example of regional cooperation for monitoring were also presented as a useful model for consideration for Barbados and its neighbours. At the national level, two initiatives led by government agencies were presented; one in support of environmentally sensitive offshore hydrocarbon exploitation, and one innovative case study of leveraging satellite imagery to support fisheries sustainability given the challenges of in-situ measurement and surveillance. For each case study the strategic direction, objectives, institutional arrangements, outputs, challenges and benefits are presented and by themselves can serve as opportunities for further investigation.

Part II: Considerations for Barbados

3 ELEMENTS OF A POSSIBLE OCEAN KNOWLEDGE FRAMEWORK

Part II presents what the author recommends as good practice for Barbados based on its existing economic and geopolitical circumstances, and the policy landscape. A formulated framework for ocean observation will not be presented here, as this should be a result of national decision-making. Part I provided some of the main cases studies of good practice drawn upon here (being wary of repetition) but does not preclude the use of other examples not presented above.

In the case of Barbados, the urgency of building ocean knowledge has been posited in the introduction, with the desire for energy and food security as a major development priority, and oceans identified as a key part of the solution. Likewise, maintaining and increasing the benefits from coastal and marine ecosystem services requires knowledge of the state of the ecosystems providing those services and the forces impacting these ecosystems. The Framework for Ocean Observations (FOO) and the DPSIR (Drivers, pressures, state, impact and response) framework offer good models on which to base an ocean knowledge development that addresses information gathering for societal needs and a process for environmental assessments respectively. Both options are explored here. They are not mutually exclusive; however, it is likely that an operational observation framework would provide sustained data for assessments taking place in a pressure-state-response framework. Elements of both exist in Barbados's marine governance framework and can be built upon.

Regarding the policy context, an ocean knowledge framework would be nested within an ocean governance framework. A national blue economy, integrated ocean policy or marine spatial plan should be built upon best-available knowledge and would also call for strategies within them to be supported by a body of growing knowledge about the resource and space being managed. This is exemplified by the OECS's Regional Ocean Policy Goals 6.1 and 6.2 which called for an increased understanding of the ocean to support policy and the articulation of a Marine Research Strategy.[71]

[71] OECS 2013. Eastern Caribbean Regional Ocean Policy. Prepared by the Social and Sustainable Development Division of the OECS and the Special Advisory Services Division of the Commonwealth Secretariat

This support would come in the form of information products to assist decisions and overall governance. Typically, from literature reviewed, these four objectives drive a framework for ocean observation and knowledge:

i. Coordinating existing and supporting new mechanisms to increase the understanding of natural resources to support their sustainable exploitation;
ii. Monitoring and assessment of the impacts on, and the state of, the coastal and marine ecosystems and their services using an integrated ecosystem-based approach to assessment;
iii. Supporting local, regional and international obligations and reporting;
iv. Supporting an increase in national research, innovation and ocean literacy.

Other objectives could include supporting maritime security, disaster resilience, marine bioprospecting or other sector-specific support. Recommended guiding principles, institutional arrangements and capacity considerations are presented below.

3.1 Operational Observation

The discussion here is centered around three main elements of a sustained and operationalized set of coastal and marine monitoring based on the FOO: the importance of basing monitoring on clearly articulated needs, the importance of identifying key variables and sustaining quality data collection and analysis, and initiatives for an enabling environment for long term monitoring (Figure 4). The importance of spatial and temporal scale will also be discussed within the context of the three main elements above.

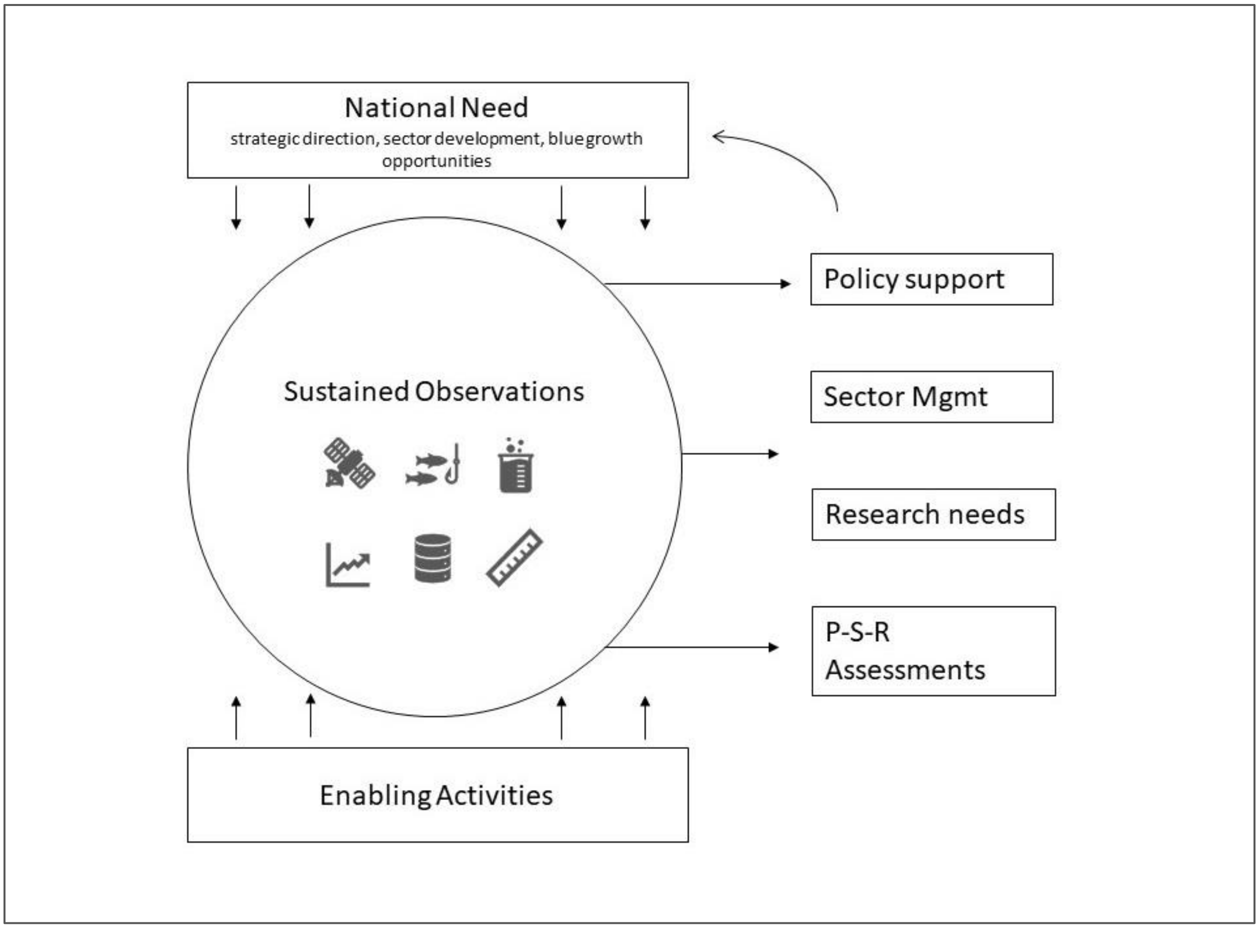

Figure 4: Elements of a sustained coastal/marine observation regime and the processes it supports. Process adapted from the Framework of Ocean Observing (FOO)

3.1.1 Needs driven

A framework for building knowledge must be based on having a specific goal. What has been presented at the outset was a clear call from the international community on the importance of data collection, monitoring, assessments and research for the improvement of management of the natural resource base that countries rely on for growth. This provides a foundation for not only establishing ocean monitoring but also for realizing better environmental management and human wellbeing from it. An investment in ocean monitoring must be based on identification of gaps in knowledge and societal needs.

The FOO model adopted by GOOS exemplifies a needs-driven framework for ocean knowledge. Section 1.1.3 described the development of the FOO to support a global observation where policy-makers and scientists identified global societal needs to base the design of a sustained ocean observation to influence decisions related to those needs. Downscaling this process to a national-level discourse would be a useful exercise. The pursuit of a green economy and the medium- to long-term fiscal strategies to reduce dependency on food and fuel imports presents an important national need that an increased knowledge of the EEZ can help to support. This need is the rationale for this research; formulating a framework for increasing knowledge of Barbados's ocean resources to unlock growth potential and improve management. This overall societal need, can then translate into information needs with reference to the FOO process. Likely areas of mineral resources, potential stock abundance for pelagic fisheries species, sensitive habitats, archeological finds, and areas to harness wind or current energy are some of the important information needs to support decisions related to the overall national goal mentioned above. Planning how to answer these questions in a consistent, high quality and sustained way is done during the requirements phase of the process (Figure 5).

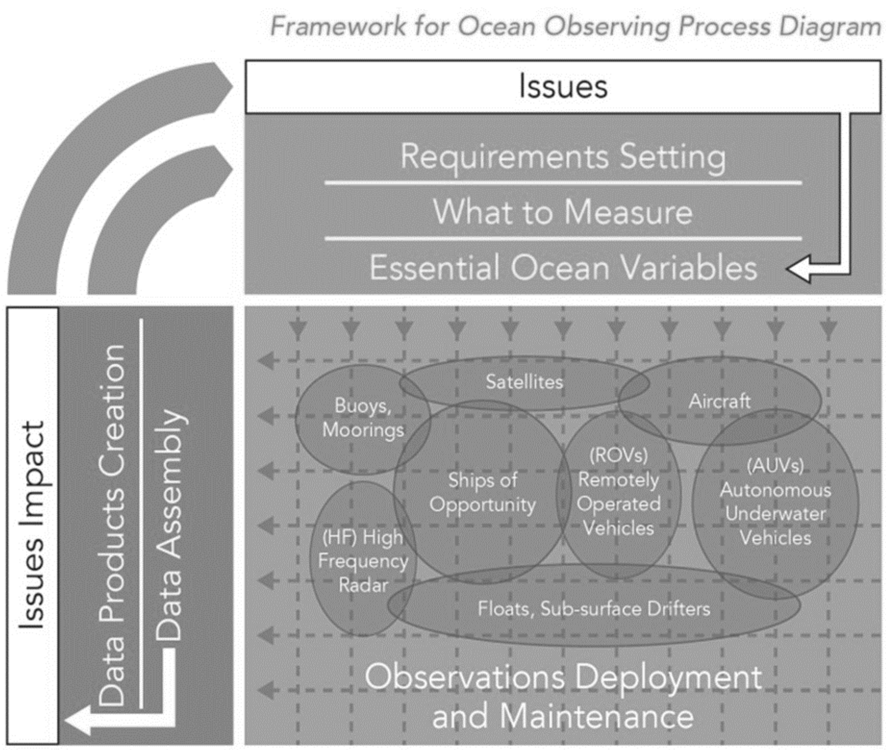

Figure 5: Framework for Ocean Observing. [72]

Knowing what to measure and monitor will determine the mechanisms to employ to efficiently gather the information. Planning ocean observations and assessments would need to take the entire process from needs to information products and forecasts into account to ensure data gathered are

[72] Source: Global Ocean Observing System. http://www.goosocean.org/index.php?option=com_content&view=article&id=125&Itemid=113. Accessed 23 August 2017

effectively used to produce impactful analyses and products to influence decisions and complete the cycle. The FOO Report recommends a team comprising a mix of research experts, resource managers and policy makers to carefully plan and coordinate observing elements. More on sustaining observations and the governance arrangements in the FOO model will come later.

3.1.2 Prioritizing variables and sustaining observations

After establishing the need for information on Barbados's EEZ to support management and decisions, the framework should allow for robust, and sustained gathering of data and output of products and services. Again, drawing on the FOO, planning teams in GOOS recognized the financial and logistical capacity challenges involved in monitoring the vastness of an ocean and thus lean heavily on establishing a set of Essential Ocean Variables to deliver quality and standardized data to analysts and eventually to end-users in an operational way. The process of determining EOVs is participatory and involves researchers, resource managers and field observation practitioners to negotiate and prioritize environmental and socio-economic information needed to address a specific scientific problem or societal need. It is highly recommended that States with capacity challenges take advantage of the negotiations and maturation process that resulted in the identification of EOVs. This way, a sustained regime of observations can commence with already mature variables whose outputs are well understood, standards established, and social benefits proven. The result is a high impact, high feasibility investment scenario, with fewer barriers to cooperation at all levels, and the potential to contribute to (and draw upon) global and regional data collection networks.

The Coastal Zone Management Unit in Barbados has operationalized coastal monitoring for Integrated Coastal Management by (i) the prioritization of a few key variables for sustained monitoring, and (ii) augmenting knowledge with specialized studies. This example will be briefly presented as a replicable model for marine monitoring. The CZMU was formed at the time when the national economy was beginning to shift toward coastal tourism and thus needed a management agency in Government, with accompanying legal and policy frameworks, to ensure the sustainable use of the coastal zone for tourism and recreation. The department was born from recommendations of the 1983 project[73] which conducted diagnostic studies, institutional

[73] Coastal Conservation Project

assessments and pilot conservation projects. The original objective of the resulting CZMU was "…continuing the program of monitoring and implementing restorative and remedial work on the beaches of Barbados" with the following strategic objectives:

- Sustainable use of the coastal zone management area by implementing policies which maintain and, where possible, enhance environmental quality while enabling economic development.
- Through an effective legal, institutional and administrative structure implement integrated coastal management.

In 2016, this author conducted an internal review of all data collection regimes in CZMU with the aim of comprehensively documenting the origin, evolution, standards, challenges, and outputs of each.[74] Information summarized here are extracted from that 2016 report.

Routine monitoring has been prioritized in the draft Integrated Coastal Management Plan as a key factor in its implementation. Four mainstay monitoring regimes have been operationalized by the department: water quality, beach profiles, coral reef surveys, and nearshore dynamics:

i. Quarterly water quality monitoring on fringing and bank reefs around the island began in 2006 using a grab sample methodology for lab tests. In 2009 this was augmented by in situ temperature probes for continuous sampling of reef water temperature.
ii. Beach profiles of select beaches have been measured quarterly since a 1983 project established the regime. These are done by surveying methods to record spot heights along a set profile line to calculate a beach length, height and volume. Sand grain size analysis was also conducted since 1983 coinciding with profile data collection but later reduced to twice yearly collections.
iii. Coral reef monitoring began in 1982 and is conducted every 5 years to document ecosystem characteristics of fringing reefs around the island.
iv. Nearshore wave monitoring was operationalized in 1993 using in-situ instruments collected and redeployed quarterly. The exact location deployments have not been fixed since they are used to inform coastal protection designs but the general locations remain the same. The expansion of the wave monitoring programme will be discussed later within the context of capacity challenges.

[74] Coastal Zone Management Unit. Environmental Monitoring for Integrated Coastal Zone Management in Barbados. Prepared by Kareem Sabir, November 2016, unpublished.

Tidal and sea level monitoring has been met with more challenges and has been interrupted since the establishment of its programme in 1983 with a few attempts to reestablish routine monitoring. These regimes have been identified as priority monitoring programmes in the Barbados Policy Framework for Integrated Coastal Management[75] under the strategic objective "effective framework for implementation" and continue to contribute to the CMZU's mandate, policy input and reporting.

The leadership of the CZMU, through implementation of the Integrated Coastal Management policy have adopted a model of leveraging development partner support for ICZM. This also applies to the operationalization of monitoring to support decisions. The 1983 monitoring regimes commenced through the initial project funded by the Inter-American Development Bank (IDB) to conduct diagnostic studies and institutional assessments which eventually led to the establishment of the CZMU and the formulation of the ICZM Plan for the island. The CZMU has since executed several projects, all with a central model of capital works for erosion intervention, institutional strengthening, and either initial establishment or review and improvement of monitoring regimes. In this way, financial and technical capacity challenges are addressed with the support of development partners to operationalize monitoring and sustain a continued understanding of the coastal and nearshore marine environment. This project cycle approach also allowed the financial and technical space to conduct periodic investigations to further the understanding of the coastal environment that would not be feasible through annual operational budgets. For example, the most recent project[76] executed a few investigations to support routine monitoring:

i. Coral tissue biopsies and skeletal samples to understand the state of coral health and identify stressors;
ii. Modelling current directions and magnitude to further understand sediment transport and wave propagation. Current models were coupled with detailed water quality sampling to understand the main sources of nitrogen pollution and to identify potential point sources based on current patterns;
iii. Sand constituent analysis studies to understand the sources of sand production around the island in support of conservation efforts;

[75] CZMU, 1998. Integrated Coastal Management, The Barbados Policy Framework.
[76] The Coastal Risk Assessment and Management Programme (CRMP) funded by the IDB and commenced in 2011

In summary, this model to sustain knowledge building in the coastal zone via consistent monitoring of key variables through operational budget support, with periodic injections of technical and financial capacity from international donor partners has been a success for ICZM in Barbados and should be considered as a means of expanding monitoring into the EEZ.

The provision of near-real time data from satellite observations can be an important benefit to operational observations. Use of satellite measurement in oceanography has been increasing in importance over the past decade with improvements of technology and data availability.[77] The advances are such that key variables such sea surface temperature, circulation, waves and sea level, water colour/chlorophyll-a, and surface salinity that form the core of operational oceanography can be obtained from satellite services.[78] The capacity challenges for Barbados accessing its EEZ to routinely measure and patrol may also warrant exploring the option of a satellite oceanography. Despite the differences in scale of the marine space and size of shipping and commercial fishing sectors, Indonesia and Barbados share similar capacity constraints. The ambitious and innovative approach taken by Indonesia outlined in section 2.2 to develop an operational oceanography based on satellite observation is worthy of investigating in Barbados or at the regional level under the Caribbean Large Marine Ecosystem (CLME) framework. The INDESO case demonstrates the applicability of robust and readily available oceanographic information products to support efficient and sustainable exploitation of pelagic fisheries resources. INDESO equips commercial fishers and fisheries managers with reliable indicators of position and abundance of pelagic resources, allowing efficiency in fishing effort and adaptive management respectively. These tools in conjunction with improved IUU surveillance, and other fisheries management tools, help to sustainably grow commercial fisheries. The EU-funded ATLANTOS (Optimising and Enhancing the Integrated Atlantic Ocean Observing System) has taken notice and is seeking to adopt the techniques used by the Spatial Ecosystem and Population Dynamics Model (SEAPODYM) used in the INDESO programme to investigate the applicability of producing similar forecast products for Atlantic tuna species.[79]

Mahon, in 1996, posited the importance of Small Island States prioritizing the development of oceanography to support pelagic fisheries management and potentially increase the effectiveness of EEZ fisheries exploitation. He presented that the pelagic fisheries yield of SIDs could be

[77] P.-Y. Le Traon et.al, 2015. Use of Satellite observations for operational oceanography; recent achievements and future prospects. Journal of Operational Oceanography, 8:sup1, s12-s27.
[78] ibid
[79] Developing a forecast system for Atlantic albacore tuna. Phys.org. Aug 30 2017. Accessed 14 Sept 2017

increased if supported by oceanographic information to aid fisheries planning, development and investment. This work presented cases in the southeastern Caribbean where knowledge of eddies, fronts, currents and riverine pulses helped to further the understanding of the potential yield and distribution of tuna and tuna-like species in the sub-region.[80]

3.1.3 Appropriate Scale

Understanding the dynamics of marine environments requires a commitment to long term monitoring and observation. Lessons can be taken from the commitment to provide weather and climate forecasts which necessitated a plethora of measurements to be established over the long term. The same has applied for ocean forecasting, hence the establishment of GOOS at the global and regional level. Regarding coastal and nearshore marine monitoring in Barbados, the Coastal Zone Management Unit has established several programmes of continuous monitoring since the establishment of the department to support integrated coastal management. Understanding appropriate timescales for ocean/atmosphere interactions, coastal dynamics, sea level, fisheries resources and mineral resources is important for planning regimes for monitoring to elucidate trends. The same applies to monitoring the socio-economic activities in the ocean space to answer key management questions. Understanding appropriate timescales will assist in efficiency in monitoring. Daily, automated sea level monitoring is necessary to understanding tidal fluxes and to serve as tsunami early warning, but at least 10 years of monitoring would be required to investigate net sea level changes. Likewise, for the design of engineered coastal defenses, the CZMU monitors wave and beach profile dynamics for at least 12 months to have measured data input into the design process.

The challenges of spatial scale are also important for Barbados. Given the small size of the island, remotely-sensed data and outputs from other regional and global models are usually accompanied by caveats of uncertainties and inaccuracies due to the resolution of the models and satellite data. Accurate, and reliable data need to be collected in-situ for analysis or to validate and downscale global and regional models. This was the experience for several environmental models such as sea-level rise projections, sea-surface temperature, seafloor mapping nearshore wave predictions etc. The choice of data sources must therefore be considerate of the spatial scale it best represents.

[80] Mahon, 1996. Fisheries of Small Island States and their Oceanographic Research and Information Needs in Small Islands: Marine Science and Sustainable Development Coastal and Estuarine Studies, Volume 51, pp 298-322. American Geophysical Union.

This shortcoming will be less significant when establishing monitoring at the level of the EEZ which is substantially larger than the island and nearshore.

Considering the spatial and temporal scale with the objectives of a monitoring regime is essential to ensuring long term sustainability of the programme with respect to allocation of resources. Using the example above, in an area where tidal variance is insignificant it may not be a priority to establish a network of tidal stations whereas simply utilizing regional tidal predictions would be sufficient for management and operational needs. On the other hand, in a location with significant tidal variations with implications for safety of navigation or the harnessing of tidal energy, the investment in accurate and real-time sea level monitoring over the long-term will be important. The former scenario is what presently pertains to Barbados where daily real-time sea level monitoring is not prioritized except for use as part of the regional network of sea level stations for tsunami detection and early warning. Design of a monitoring regime (type of equipment, frequency of sampling etc.) must therefore be done in conjunction with technical expertise or in accordance with existing regional or global standards to ensure sensitivity to scale and interoperability.

3.1.4 Enabling Environment

A suite of initiatives from various literature to reduce barriers and promote sustained monitoring are presented as possible implementation actions for consideration. Implementing these actions over the medium-term will establish a support base for streamlining existing monitoring initiatives and new monitoring regimes by fostering a better enabling environment for planning, partnerships, funding, data sharing and communication.

1. <u>Coordination and oversight</u>

The first is coordination and oversight of research and monitoring efforts. Coordinating efforts by a planning and oversight team of multidisciplinary experts will allow for synergies in measuring and monitoring. The expense and logistical challenges of ocean monitoring necessitates synergistic efforts. The development of standards and protocols, and metadata documentation enhance interoperability and the ability for multiple stakeholder groups to be involved in planning data gathering and using data for various purpose. The outcome is furthering the cost effectiveness of data gathering the more beneficiaries and end-users it has. Such a team would not have oversight over research activity and monitoring regimes but make recommendations at the national level for strategic direction.

2. Inventory of Experts

An inventory of researchers from various disciplines, funding partners, technical assistance partners, analysts, resource managers, end-users, equipment suppliers, technicians etc. should be developed to build a network of ocean-related stakeholders. Some existing resources such as IOC's "Ocean Expert" programme[81] can be utilized. The inventory should be accompanied by a technical capacity assessment to understand where gaps are for capacity improvement planning. Likewise, an inventory and assessment of existing and planned monitoring and research activities will aid in coordination. A set of criteria should be developed to allow monitoring methods and outputs to be assessed for the purposes of quality assurance and interoperability.

3. Forum for dialogue

Fostering dialogue between and among communities of practice can further aid in more coordinated monitoring efforts, increased capacity development, identifying research needs, and sharing best practices. Ocean research and monitoring is interdisciplinary thus having different stakeholder groups. A forum for these groups to dialogue among themselves and with other groups on ocean-related issues and research can take the form of technical conferences, journal publication, working committees or through the function of existing professional associations. Likewise, there is value in facilitating interactions at the regional and international level to exchange experiences and foster partnerships.

4. Knowledge sharing

The importance of measuring once for the benefit of many end-uses, given the difficulty and expense of ocean monitoring has been mentioned above. This is facilitated by effective data sharing. In Barbados, several attempts have been made in the past, and some initiatives currently in development, to provide the technical tools for easier data sharing and collaboration by the development of data sharing platforms of varying type. Despite these efforts, challenges of data misuse, misrepresentation, and lack of proper crediting of sources are among some of the reasons for limited data sharing. Along with supporting existing technical efforts, there needs to be a long

[81] www.oceanexpert.net by UNESCO/IOC Project Office of the IODE

term philosophical shift among practitioners from one where data have high value to a philosophy of dating sharing and usage is far more valuable. A culture where responsible knowledge sharing is encouraged and institutionalized can be supported by: (i) a national legal and policy framework (ii) improving communication and collaboration among practitioners for sharing of knowledge (iii) promoting data quality standards to increase their reusability and cooperation in collection, including metadata standards (iv) and improving data etiquette and ethics.

5. <u>Fund access</u>

Facilitating reliable access to funding is an important enabler. UNESCO/IOC summarizes the funding landscape for ocean science and monitoring in its recent Global Ocean Science Report (GOSR)[82] which would provide a useful starting point for understanding the funding sources and mechanisms. The report suggests national governmental funding is usually the main funder for public research programmes based on research and development (R&D) budgets with many countries, including Trinidad and Tobago, investing between 1 and 5% of their R&D budgets in ocean science.[83] The same applies to Barbados with respect to sugar cane research in the past decades with agriculture being the major GDP contributor of that time. Funding support from international funding mechanisms through instrument procurement, technical cooperation, projects and grants is the more likely scenario to pertain to Barbados. It is important to view ocean monitoring and research with a multidisciplinary approach and seek funding opportunities through thematic and sectoral funding instruments. The importance of development assistance partners has been mentioned earlier as it relates to funding coastal research and monitoring. It would be prudent for negotiations with these partners to revolve around investment in infrastructure for ocean monitoring. Coastal tourism, alternative energy, disaster resilience, climate adaptation and food security are all priority areas for development assistance and thus support for research monitoring regimes can be negotiated under these thematic areas.

6. <u>Maximizing external research</u>

In conjunction with establishing and maintaining a set of routinely acquired data, it is important to consider a means to coordinate the assimilation of data from other sources to feed into a knowledge framework. The focus here will be on improving the process of utilizing the mechanisms of

[82] UNESCO/IOC, 2017. Global Ocean Science Report. The Current Status of Ocean Science around the World. UNESCO Publishing. Paris, 2017

[83] Based on data from 25 countries that answered the GOSR questionnaire that contributed to the GOSR (UNESCO/IOC,2017)

cooperation in Marine Scientific Research (MSR) under UNCLOS[84] to maximize the benefits of foreign research in Barbados's EEZ. The revised guide to the implementation of Part XIII of UNCLOS[85] sets out the importance of effective international cooperation in conducting MSR. It highlights key experiences of States cooperating in marine research. Some of these considerations for maximizing the benefits of MSR include: (i) robust cooperation between the researching and coastal States in the planning stages of research (ii) streamlining the request for consent process, with clarity in communicating conditions or reasons for withholding consent; (iii) coastal States taking advantage of capacity building opportunities and active participation of the coastal State during the conduct of the research; (iv) bilateral negotiations for the sharing of results in a way which is within the capacity of the coastal State to meaningfully benefit from the data and other outputs. It is imperative for Barbados to continue improving on the processes of MSR to be more actively involved in foreign research and to assimilate raw data and research outputs into national knowledge streams.

7. <u>Links to regional/global networks</u>

Linkages to regional and international data collection and sharing mechanisms should be a key part of planning. The opportunities for partnerships, funding, and technical assistance through a networked observation must not be underestimated and is particularly important for SIDs. The fledgling sea level monitoring programme in Barbados contributes through satellite transmission in real time to a network of sea level and seismic monitoring stations coordinated regionally by UNESCO IOCARIBE. The region benefits from funding opportunities for training and new stations, development of standards and sharing expertise quarterly through virtual meetings and annually with in-person meetings. The capacity benefits cannot be understated. There have however been some challenges such as maintenance and other logistics when equipment is procured or donated through regional projects and mechanisms, but the pros outweigh the cons.

[84] Part XIII Marine Scientific Research. United Nations Convention on the Law of the Sea

[85] DOALOS, 2010. Marine Scientific Research. A revised guide to the implementation of the relevant provisions of the United Nations Convention on the Law of the Sea. United Nations, New York 2010.

3.2 Pressure-State-Response Assessment Framework

Assessments play a major role in natural resource governance. They are supported primarily by knowledge generated from routine monitoring as well as research. The trends, data, maps and other forms of knowledge generated from monitoring need to be analyzed and evaluated on a regular basis to add further value in supporting decision-makers (Figure 6).

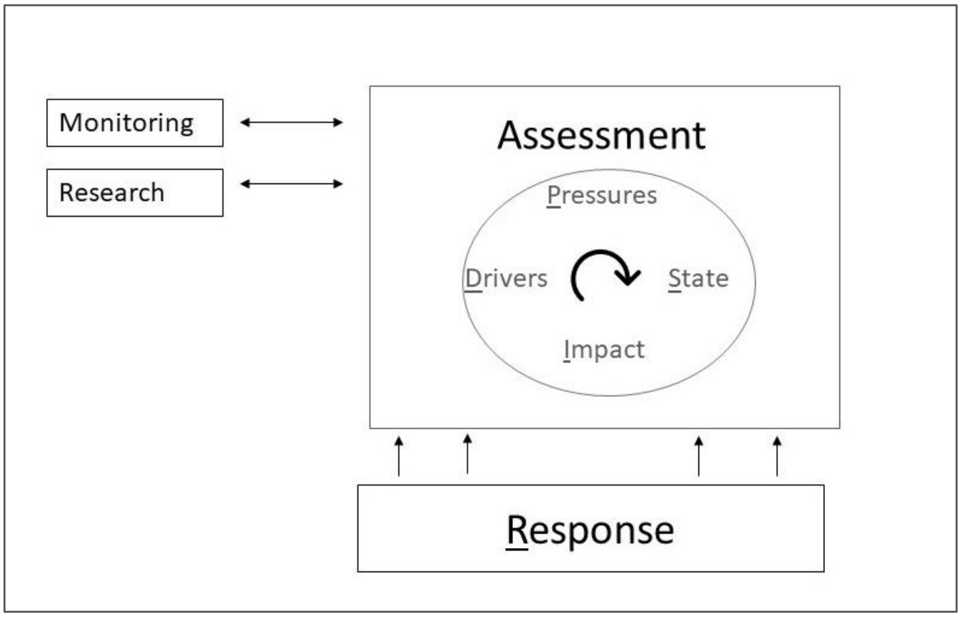

Figure 6: Visualization of an assessment process supported by knowledge from operationalized monitoring and research and used as a tool for management response. Assessment process is based on the DPSIR framework[86]

Integrated Environmental Assessments (IEAs) are particularly useful in that they seek to analyze environmental and socioeconomic data to determine the state of the environment using a Driver-Pressure-State-Impact-Response (DPSIR) approach considering different ecosystem components and their linkages, and in doing so elucidating risk and uncertainty in the analysis, and identifying potential management actions for decision-makers to weigh.[87]

The Driver Pressure State Impact and Response (DPSIR) framework was developed by the European Environment Agency to describe the link between the causes and impacts of environmental problems as a basis for conducting integrated ecosystem assessments. As the acronym suggests, the framework analyses the socioeconomic drivers that place pressure on, and

---

[86] European Environment Agency, 1999. Environmental Indicators: Typology and overview. Technical Report No 25. European Environment Agency

[87] Guidelines for conducting Integrated Environmental Assessments, prepared by UN Environment by Member States request to support the sixth Global Environment Outlook and beyond.

alter, the state of natural resources which in turn can have a negative feedback loop on the same or other drivers.[88] Using this cyclical approach to analyze cause and effect can be useful at thematic, sectoral and integrated levels in crafting responses. An economic or social driver, for example coastal tourism development, can exert specific pressures on the coastal and nearshore marine environment, resulting in increases of pollutants, carrying capacity issues or conflicts in space and land use. These pressures may alter the state of the ecosystems that provide services for the driver in the first place resulting in a decline in the quality of the ecosystem and the associated services. Responses can vary from policy, legal, or direct mitigation actions directed at the drivers, pressure, state or impact, resulting in a positive feedback on the state of the resource.

Routine nearshore water quality and coral reef monitoring, and the resulting policy responses from the Environmental Protection Department and the Coastal Zone Management Unit in Barbados are examples of how existing environmental monitoring regimes were established based on this type of pressure-state-response framework. Understanding and further applying this framework to various coastal and marine-related sectors would provide a strong basis for identifying what should be monitored (Figure 6), and the combination of these sectoral monitoring efforts would fuel integrated assessments and appropriate, prioritized, and measurable responses. It must be noted that many impactful drivers may be extra-national and even extra-regional. These may include climate change and natural disasters, freshwater pulses from the Amazon River affecting the Caribbean Sea, global trade and financial shocks, and other kinds of global drivers that commonly increase the vulnerability of SIDs.

3.2.1 Guiding principles and best practices

The Assessment of Assessment report mentioned in section 1.2.4 is a valuable resource of best practices and guiding principles for the conduct of integrated assessments broadly as well as global marine assessments specifically.[89] The report considered different conceptual frameworks from previous assessments such as the Millennium Assessment and UNEP's Global Environment Outlook process among others. The first cycle of the World Ocean Assessment also produced a compilation of experiences and lessons learned solicited from Member States that serves as a

---

[88] EEA, 1999. Environmental Indicators: Typology and overview. Technical Report No 25. European Environment Agency

[89] UNEP and IOC-UNESCO 2009. An Assessment of Assessments, Findings of the Group of Experts. Start-up Phase of a Regular Process for Global Reporting and Assessment of the State of the Marine Environment including Socio-Economic Aspects.

valuable resource. Some guiding principles and best practices drawing from the AoA and other sources are presented below.

1. Science-Policy interface

Integrated Environmental Assessments exist at the interface between monitoring/research and policy. The difficulty of linking knowledge and action in governance is well known and has resulted in an entire body of work dedicated to understanding the interface or boundary between science and policy. Cash et. al. (2002)[90] posits that while improving credibility of information crossing the science-policy boundary has been an important focus, salience and legitimacy are equally important for policy uptake of assessment results. These three should be equally planned for and balanced from the inception phases of IEAs.

Credibility refers to the perception of information meeting standards of scientific plausibility and technical adequacy by way of trustworthy sources, and sound analysis.[91] The UN Regular Process that produced WOA1 for example had taken several steps to ensure credibility of the assessment. However, some Member States raised concerns, in the compilation of lessons learned, about the low representation of developing states, particularly SIDs and Least Developed Countries (LDCs). These concerns can raise questions of legitimacy, supporting the argument that credibility alone is not sufficient for effective policy uptake.

Legitimacy refers to whether a stakeholder perceives the process in a system as being unbiased and fair. This is judged by considerations of values, interests and circumstances of a broad spectrum of stakeholder groups, i.e. who was engaged in a process and who was not.[92]

Salience refers to the relevance of information for end-users. Information that is timely and informs decision makers about problems that are on their agendas have high salience.[93] This is highly variable however since the needs of stakeholders are different. The Caribbean Institute of Meteorology and Hydrology recently undertook a series of stakeholder engagements to determine

---

[90] Cash, David and Clark, William C. and Alcock, Frank and Dickson, Nancy M. and Eckley, Noelle and Jäger, Jill, Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making (November 2002). KSG Working Papers Series RWP02-046. Available at SSRN: https://ssrn.com/abstract=372280 or http://dx.doi.org/10.2139/ssrn.372280

[91] ibid

[92] Cash, David and Clark, William C. and Alcock, Frank and Dickson, Nancy M. and Eckley, Noelle and Jäger, Jill, Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making (November 2002). KSG Working Papers Series RWP02-046. Available at SSRN: https://ssrn.com/abstract=372280 or http://dx.doi.org/10.2139/ssrn.372280

[93] ibid

the needs of various stakeholder groups for relevant climate forecasts. This approach during development of their Early Warning Information Systems Across Climate Timescales (EWISACTs)[94] led to stakeholders of key sectors becoming co-developers of information and forecast products, increasing salience of the products.

It is important therefore to ensure through planning and communication that a balance between these three is struck to strengthen science policy links and make the assessments as impactful as possible. The first consideration for this balance should be dialogue and negotiation from the early stages of assessment planning in developing the objectives and scope of the assessment to meet the information needs of policy makers. Likewise, the assessment cycle should be adaptive enough to be responsive to changing needs of policy-makers over time. Careful terms of reference and identification of roles of technical and policy actors in the assessment process must be defined. This is essential for legitimacy of the assessment and transparency of the process and its outputs. Though the assessment must be policy relevant, it must not be narrowed or unbalanced by strong agendas which could bias the outcome.

Identification of target audiences and devising strategies for communicating the outputs to each target group will strengthen the likelihood of policy uptake. Regular communication, both formal and informal, increases the likelihood of technical findings being clearly understood by policy makers, and allows communication strategies to adapt. In all forms of communication, the process of arriving at findings and the likelihood and significance of impacts will aid uptake and allow policy makers to prioritize response. Communicating key figures and results is vital to enhance policy-uptake but they must be associated with clear, objective communication of all caveats and uncertainty.

Assessment must relate impacts to human well-being in addition to environmental and ecosystem impacts to be more useful in policy support. This could be indicated with simply a directional impact (e.g. increase of jobs) or detailed ecosystem services valuations could be planned for more quantitative socioeconomic results. Assessments that produce options to address some of the impacts identified have better chances of gaining the attention of policy-makers.[95] Cost-benefit analyses of the options are value-added.

[94] Programme for Building Regional Climate Capacity in the Caribbean (BRCCC)

[95] Guidelines for conducting Integrated Environmental Assessments, prepared by UN Environment by Member States request to support the sixth Global Environment Outlook and beyond.

2. Assessment of existing information

The Regular Process emphasized the importance of building upon existing information to conduct the global ocean assessment.[96] The Assessment of Assessment (AoA) process was a coordinated effort of multidisciplinary teams scanning literature for previous and ongoing marine assessments, acknowledging the opportunity to combine regional, sector-specific and thematic assessments to contribute to an integrated assessment. This approach could be mirrored locally. Barbados is replete with completed and ongoing research, monitoring efforts, instrument deployments, and assessments related to the coastal and marine environment. An examination of the research, operational monitoring and assessments landscape should be the first step towards establishing a framework for harnessing information from various sources to influence policy and researchers. Like the AoA process, a similar exercise locally would have the following potential outcomes:

i. Facilitate a national multidisciplinary dialogue on ocean monitoring and assessments;
ii. Conduct a comprehensive local, regional and international scan of ocean-relating data sets and information sources relevant to Barbados;
iii. The first steps toward a central repository of nationally-relevant ocean information;
iv. Identify good practices and lessons learned regarding all aspects of marine monitoring and assessments;
v. Assess the quality of existing data sets and assessments;
vi. Identify monitoring regimes that can be improved upon or expanded to promote synergies and reduce duplication of effort particularly with regional initiatives;
vii. Support the planning of new monitoring regimes and assessments processes;
viii. Identify gaps and research, and assist in coordinating filling those gaps;

3. Synergy in reporting

Any assessment framework developed for Barbados should be designed to support and be integrated with regional and international mechanisms in terms of both data sharing and reporting. Barbados is party to a plethora of regional and international agreements with reporting requirements and indicators of implementation. These may be in the form of national reporting or

[96] ibid

contributing to a sub-regional or regional report. These important reporting commitments must be considered as beneficiaries or end-users in a framework that ocean monitoring can feed into to ensure their requirements are factored in when designing data collection and information products. The UN Regular Process is a good example of a comprehensive mechanism for marine assessments that can be replicated and downsized locally, with its outputs serving national, regional and global information needs. A robust ocean knowledge framework would increase national capacity to contribute to the Regular Process, even if only focusing first on thematic areas with the most immediate and high priority for Barbados. For example, The state of coastal and nearshore ecosystems, impacts of the land on the sea and fisheries impacts are just 3 themes of national importance with readily available expertise and data. It is important for synergy in reporting to manifest at the department and ministry level where human resource capacity of some departments have often been strained by the request for reports for various national and external reporting. Norway's MAREANO programme provides an example of a UN Environment's Regional Seas convention administration benefitting from the increased understanding derived from MAREANO, with benefits accruing to other States Parties in the OSPAR region. The Caribbean equivalent programme, the Caribbean Environment Programme, is currently undertaking a State of the Convention Area Report (SOCAR) which will review the state of pollution in the region and the implementation of the LBS Protocol.[97]

4. <u>Integrated ecosystems approach</u>

Assessments can be done for species, fish stock, economic sectors, or specific locations. This may result in the potential for fragmented, uncoordinated management responses which may not necessarily equate to an overall improvement of the ecosystem as a whole. A systems approach considers the components of the ecosystem along with a holistic understanding of the relationships and interlinkages of each component. This complexity may be condensed to a simplified diagrammatic model and become the basis for collaborative, interdisciplinary development of

[97] The Protocol Concerning Pollution from Land-Based Sources and Activities (LBS) adopted in October 1999.

indicators, predictive models and other tools. Gross (2003[98] in Bradley and Yee, 2015)[99] highlights 4 key benefits of the use of conceptual models:

1. Formalize current understanding of system processes and dynamics
2. Identify linkages of processes across disciplinary boundaries
3. Identify the bounds and scope of the ecosystem
4. Contribute to communication among and between decision-makers and scientists

Integrated assessments are important supplements to sectoral and species-level approaches and thus should not replace them. They are useful for resource managers to evaluate cumulative impacts of a suite of human activities and likewise assess management response. Levin et. al (2009) [100] defines Integrated Ecosystem Assessments (IEAs) as a "formal synthesis and quantitative analysis of information on relevant natural and socioeconomic factors, in relation to specified ecosystem management objectives". They are further described as an integrated scientific understanding that feeds into management choices.

5. Stakeholder Participation

The multidisciplinary nature of integrated ocean assessments will necessitate the involvement of a diversity of researchers, resource managers, sector specialists, local knowledge holders, among others. Several benefits of broad stakeholder participation have been identified and these are well known[101]. The first is that seeking input from stakeholder groups creates an important sense of ownership and interest in the outcomes. Therefore, careful identification of stakeholders and planning for their engagement is essential in the development stages of a regular marine assessment process. Understanding marine governance in Barbados is a critical need. There is little work to date that documents the major players (public, private and civil society) as well as the institutional and policy landscape of ocean management. After identifying the major

[98] Gross JE. 2003. Developing conceptual models for monitoring programs. DOI-NPS Inventory and Monitoring Program. Ft. Collins, CO, USA. http://science.nature.nps.gov/im/monitor/ docs/Conceptual_Modelling.pdf

[99] Bradley P and Yee S. 2015. Using the DPSIR Framework to Develop a Conceptual Model: Technical Support Document. US Environmental Protection Agency, Office of Research and Development, Atlantic Ecology Division, Narragansett, RI. EPA/600/R-15/154

[100] Levin PS, Fogarty MJ, Murawski SA, Fluharty D (2009) Integrated ecosystem assessments: Developing the scientific basis for ecosystem-based management of the ocean. PLoS Biol 7(1): e1000014. doi:10.1371/journal.pbio.1000014

[101] Van de Kerkhof, M. (2006). Making a difference: On the constraints of consensus building and the relevance of deliberations in stakeholder dialogues: Methodological considerations. Technological Forecasting and Social Change, 72 (6), 733-747

stakeholders, it would be useful to assess their role and potential influence in a marine IEA framework, as well as devising strategies for effective communication and involvement of each.

Van de Kerhof[102] posits that the purpose of stakeholder dialogue in environmental policy and other decision-making must be carefully considered in that most stakeholder engagement is conducted as a kind of negotiation with consensus on issues being the core objective. This process has benefits such as increasing communication, trust and the chances that stakeholders will utilize and assimilate the outputs of the process. These are valuable benefits but there is a risk argued in using this approach whereby the process of reaching consensus may result in stakeholders focusing on the same agreeable issues to reach consensus and not truly identifying the core, difficult issues, thus jeopardizing the quality of the outputs. This is exemplified in focus group sessions on various environmental policy in Barbados where 'low hanging fruit' become the focus of discussions rather than deep technical discussions on core issues. This is not desirable for the legitimacy and credibility of an integrated assessment which is meant to objectively deliver information for management support. Alternatively, a stakeholder process centered around deliberation rather than consensus may be preferable, with more objective analysis, open communication, reflection and argumentation can occur.[103] Therefore, it is essential for stakeholders to be identified and assessed, and engagement plans for each group devised to determine the best timing and method for dialogue, noting that formal technical fora are not always the best means of promoting dialogue.

Section Institutional Arrangements1.2.3 described the mechanisms of stakeholder participation for conducting the first World Ocean Assessment drawing from a multidisciplinary body of experts. The process of forming a team of expert stakeholders to conduct the assessment is a model worthy of exploring. The AoA identifies transparency and criteria in selection of experts, a clear nomination process, balance of public, private and NGO representation as well as representation from a variety of relevant disciplines including socioeconomic experts, clear terms of reference for the experts, and provision for seeking external technical assistance, are some of the notable and relevant best practices for a national level. The feedback from Member States identified long periods of inactivity, difficulty in mobilizing experts, and timing of dialogue as key challenges for the pool of experts. These are relevant for a global assessment but with small numbers of technical

[102] ibid

[103] Van de Kerkhof, M. (2006). Making a difference: On the constraints of consensus building and the relevance of deliberations in stakeholder dialogues: Methodological considerations. Technological Forecasting and Social Change, 72 (6), 733-747

staff in departments and organizations and busy schedules, these difficulties could easily apply to a national assessment in Barbados.

6. Quality and Integrity

Promotion of standards and other data quality provisions should be administered at the research and operationalized monitoring level to ensure quality and accurate data feed into assessments. The second level of quality control is the careful selection of experts and their objective deliberation and analysis mentioned above. This ensures that the assessment process itself is a quality control mechanism for its outputs. Peer review is particularly important for information from local knowledge sources, research using coarse-scale data and models as mentioned in section 3.1.3, and qualitative expert opinion. Information from local knowledge sources or expert judgement that is not backed quantitatively should be met with consensus of the expert groups, otherwise this information should be appropriately and clearly communicated as merely local or expert opinion.

Lack of consensus among experts may arise from disagreement in interpretation, methodologies used or data sources. Decision-makers and other end-users of assessments need to be able to clearly discern information that is met with consensus versus information that is refuted or contentious.[104]

3.2.2 The assessment process

Formulating the details of an assessment process is not within the scope of this thesis. Rather, a few resources and examples will be drawn upon to outline some considerations for steps in the process. These include considerations for setting the scope and objectives, the assessment approaches, financing, and timing. Reflections on institutional arrangements will occur later in a dedicated section.

The scoping phase is the first step of an assessment to determine its boundaries. Regardless of what assessment approach is determined later, it is important to consider the capacity limitations

[104] UNEP and IOC-UNESCO 2009. An Assessment of Assessments, Findings of the Group of Experts. Start-up Phase of a Regular Process for Global Reporting and Assessment of the State of the Marine Environment including Socio-Economic Aspects.

regarding expertise, time and finances to conduct an assessment and therefore a prioritization process must be undertaken to focus the work of the assessment practitioners. The mandate and objectives of the overall assessment framework determine the outer boundary. For example, the assessment's mandate could be to conduct assessments of key ecosystems with respect to one or two key sectors every 3 years. At the beginning of each iteration of this process a collaborative effort should be undertaken to identify the drivers and pressures relevant at the time of the assessment to determine the specific objectives. This process should be adaptive to accommodate the changing national needs and changing drivers/pressures over time.

As mentioned earlier, effective stakeholder participation is crucial even from at the early planning and scoping stages. It is critical to have a balanced representation of expertise, resource users and industry experts, and decision/policy representatives at the stage of identifying and prioritizing referring back to Van de Kerhof's (2006)[105] caution about dialogue for the sake of consensus vs objective deliberation. It is important to objectively identify and prioritize drivers and pressures, and establish causal relationships at this stage to reach legitimate, credible and impactful assessment results and response options. This scoping stage with balanced representation will assist in highlighting gaps in knowledge as well. If drivers, pressures, and causal relationships to impacts are not well understood they should be highlighted for further investigation as a feedback to fill knowledge gaps with monitoring and research design. Improving data and research could assist in revealing a significant relationship that was previously less understood in prior assessments.

Deciding on the extent of the sectoral or thematic scope and the geographic scale could help determine the division of work during the assessment process. The UN Regular Process recognized the extent of undertaking a comprehensive and global assessment of the world's oceans inclusive of socioeconomic considerations. During the initial planning phase, the Group of Experts identified key thematic areas including cross-cutting themes, as well as geographic division of the assessment. Review of the first cycle of the WOA revealed that conducting regional assessments for more detailed and relevant results, followed by a global synthesis of the assessments should be considered. The same could be considered locally with individual integrated assessments based

[105] Van de Kerkhof, M. (2006). Making a difference: On the constraints of consensus building and the relevance of deliberations in stakeholder dialogues: Methodological considerations. Technological Forecasting and Social Change, 72 (6), 733-747

on sectors or ecosystems, followed by cross-sectoral/ecosystem synthesis. This may be more beneficial depending on the existing level of fragmentation in ocean governance locally.

The second step of the assessment is analyzing the magnitude of pressures and the state of the environment that these pressures influence. UNEP guidelines for IEAs[106] outline three main categories of methodological approaches:

i. Assessments based on data and/or the development of indicators;
ii. Assessments based on desktop review of literature, and;
iii. Assessments based on expert opinion and judgement.

The three categories can all be used together in a hybrid approach to take advantage of all three. The entire knowledge management framework of ocean governance should strive to develop to a point where each iteration of assessments uses best available data; meaning timely, quality, easily accessible and sharable, at appropriate scales and locally validated. Key considerations will have to be taken by the experts in choosing data for analysis. Data quality considerations have been addressed earlier in section Operational Observation3.1. Likewise, for the purposes of transparency and credibility, data chosen for assessments should ideally be readily available to end-users (including the public) to allow assessment results and the process of arriving at these results to be clearly understood. Determining data needs for the assessment should feedback into a nationally coordinated monitoring effort to ensure complementarity.

If data are not readily available, then a literature review approach can be employed. The preference here is to utilize peer-reviewed, published research in conjunction with departmental reports and other 'grey literature' which are also useful data sources. In situations where data and peer-reviewed are not accessible, then expert opinion and judgement through facilitated dialogue or questionnaire development can be undertaken.

When the scope, objectives and approaches are decided collaboratively, it is important for practitioners conducting the assessments to formalize the process into a workplan or project document. This assists in determining the resources requirements (time and cost) and general administration of the process. Likewise, supporting mechanism such as a plan for engaging stakeholders, coopting the appropriate experts, and a plan for communicating the results to end-

[106] Guidelines for conducting Integrated Environmental Assessments, prepared by UN Environment by Member States request to support the sixth Global Environment Outlook and beyond.

users should be conducted. Applying project development tools in the planning stages would be essential for administration of the process, particularly in securing financing for the process.

After agreement on the scope and prioritization of sectors/human activities and ecosystems in focus, these can then be applied to the Pressure-State-Response framework where the conceptual model can be developed for each activity/ecosystem combination; i.e. pressures, ecosystem interactions and interlinkages can be identified. It is important for this process to be driven by peer-reviewed research and empirical data to establish clear causal relationships. These interactions must not only include ecological interactions but also, and more importantly, effects that are policy-relevant. Derivation of conceptual models should therefore elucidate pressures of human activities on the state of ecosystems integrity and the resulting impacts on human well-being as a result of ecosystem service impacts.

The second stage of the process is the assessment of the pressures and interaction with ecosystems. The assessment should measure the magnitude and direction of pressures relative to an established baseline or compared to previous assessments. Likewise, the impact of the pressures on the state of the environment should be measured. As mentioned earlier, the ideal situation would be quantitative assessments of pressure and environmental state, however qualitative assessments are useful in the absence of data. These may include weightings and rankings. A combination of the two approaches, whereby empirical evidence is analyzed but applied to support simplified models using weighting and ranking. The assessment of state of the ecosystems and their services impacted by human activity must also consider additional factors. These include the ability of the ecosystem to recover, the frequency and extent of the pressure, management intervention already existing to reduce the effect of the pressure.

The use of indicators in a data-driven approach is essential for distilling data and putting it into context. For example, sea surface temperature (SST) data itself is just a neutral collection of figures. However, after applying scientific understanding, monitoring trends and direction of SST data can be used as one indicator for ecosystem state and of relevant socio-economic impacts such as coastal erosion, coral management, fisheries and coastal tourism. Preference should be given to adopting, and adapting as needed, regionally and internationally developed indicators as appropriate to facilitate synergy in reporting at all levels. Assessing the landscape of existing and in-development indicators regionally and internationally is highly recommended to select a suite of base indicators that can perhaps be built upon to suit national context. UNEP Regional Seas, Agenda 2030, and Sendai Framework for Disaster Risk Reduction, and others, all have suites of reporting and monitoring indicators for consideration. Likewise, tools such as the Ocean Health Index (and OHI+ for down-scaled national assessment tools) represent purpose-built and ready to use assessment toolkits for assessing pressures, the state of ecosystems and their services rendered. Careful selection of indicators is critical as they can influence response options and thus must be carefully developed and the linkages to ecosystem impacts clearly understood.

Though the dynamics of ecosystem cannot be perfectly modelled, expert teams conducting the assessments should make efforts to estimate the probability of changes to ecosystem services occurring and the magnitude or severity of these changes. Again, both quantitative and qualitative methods can be used to represent the scale and magnitude of impacts. Consequences with a moderate to high likelihood of occurring are worthy of further analysis with the potential for formulating responses for said consequences.

The Habitat Risk Assessment model in the InVEST[107] toolkit has been piloted in Barbados[108] as an intermediary tool in coastal ecosystem services assessment whereby the approach of identifying pressures and characterizing their interactions with coastal habitats is implemented in a spatially explicit way leveraging Geographic Information System (GIS) tools. The model relied on collaborative expert characterization of pressures on coastal habitats to map where habitats are most at risk from human activities. These were done by ranking and weightings, however, the model calculations also incorporated of factors such as the level of uncertainty and the quality of data used to perform the rankings. This pilot yielded a suite of maps indicating coastal habitat risk from prioritized pressures, the level of coastal protection services of coral reefs affected by pressures, and tourist visitation and recreation services affected by the state of reefs and beaches. The modelling process employed the same hierarchical approach to data inputs; utilizing best-available from empirical data sources, reports and other literature and finally expert opinion in the absence of robust data. Recommendations from the final report suggest building on the pilot with more widespread data gathering and expert deliberation for calibrating the model, improving the quality of inputs, and developing scenarios.[109]

[107] Integrated Valuation of Ecosystem Services and Tradeoffs
[108] Coastal and Marine Ecosystem Services Assessment for Barbados. Final Report as part of the 'Capacity Building for Ecosystem Services Valuation and Coastal Spatial Planning. Technical Cooperation No.:ATN/OC-13923-BA'. Prepared by Downstream Strategies for the Inter-American Development Bank. August 2015
[109] Ibid.

After analysis of the state of and impacts to ecosystem services and integrity, with estimation of associated risk, a well-balanced assessment team should at this point be equipped to formulate options for responses to further assist policy actors. The selection of experts and their code of conduct in the assessment is particularly important here to ensure unbiased and objective responses without political, research or business agendas interfering. The mandate and limits of the assessments must also be referred to as well. Member States, for example, overseeing the conduct of WOA1 instructed the Group of Experts to refrain from proposing policy response options, seeing this as the sovereign right of each Member State individually. At the national level, formulation of response options by experts empowers users with more information to support decisions. The importance of communicating risk and uncertainty must also be underscored here. As with establishing clear causal relationships and assessing ecosystem state in the previous steps of an assessments, the likelihood and magnitude of each response option to effect change in the state of ecosystems and their services must be clearly communicated.[110] Levin et.al (2009) proposed a further step in IEA processes to evaluate the response options using formal management strategy evaluation (MSE) tools to screen and prioritize response options. [111] Ecosystem services modelling tools such as InVEST are useful in this regard as a platform for scenario development and modelling to support evaluation of options.

Regular and timely iteration of the IEA framework is critical to its success. Therefore, it is important to plan for continuity to allow for identification of trends in the state of ecosystems and services as it relates to changes in drivers and management interventions over time. The frequency and timing should be carefully considered for two reasons. Temporal scale can vary depending on the assessment's objectives and scope. A potential annual assessment process may not offer substantially more than a 5-year assessment relative to the effort. Second, the timing of assessment outputs should be synchronized with their intended target audience such as a state of the ocean report being presented with sufficient time for policy actors to assimilate the outputs ahead of medium-term planning exercises for example. This requires an understanding of the ocean

[110] Guidelines for conducting Integrated Environmental Assessments, prepared by UN Environment by Member States request to support the sixth Global Environment Outlook and beyond.
[111] Levin PS, Fogarty MJ, Murawski SA, Fluharty D (2009) Integrated ecosystem assessments: Developing the scientific basis for ecosystem-based management of the ocean. PLoS Biol 7(1): e1000014. doi:10.1371/journal.pbio.1000014

governance processes locally in addition to relevant regional and international processes. Again, a balanced stakeholder participation is desirable.

Chapter 3 has presented recommendations for two frameworks for sustaining knowledge-driven ocean management: guiding considerations and approaches of a framework for sustained coastal and marine monitoring, and a framework for integrated assessment of the status of marine ecosystem services based on formal decision theory. The two are not mutually exclusive, rather they are more effective when coordinated and synchronized with each other. Elements of both frameworks exist in Barbados, as it relates to coastal and marine related governance, however, the development of institutional arrangements and capacity improvement programmes are essential for maturing these frameworks. Chapter 4 explores capacity development and institutional considerations to support the proposed framework, notwithstanding that any framework or mechanism developed or adopted should be first subject to detailed feasibility assessments inclusive of capacity and institutional assessments.

4 CAPACITY DEVELOPMENT AND INSTITUTIONAL ARRANGEMENTS

Dr. Gunnar Kullenberg in 1998 published a commentary on capacity building in marine research and observations.[112] He was the Executive Secretary of IOC, UNESCO at the time and presented his perspective of challenges for developing countries establishing robust ocean research and monitoring. This work is still poignant and will be a focal point for discussions on capacity building and institutional support for ocean research, long-term monitoring and assessments in pursuit of socio-economic development. Kullenberg noted that substantial assistance to developing countries in increasing ocean science capabilities was needed for the following reasons:

i. To allow States to improve their self-reliance in ocean sciences for the sake of exercising their rights and duties over their maritime jurisdictions for the purposes of sustainable socio-economic development;

[112] Kullenberg G. (1998). Capacity building in marine research and ocean observations: a perspective on why and how. Marine Policy, Volume 22 (3) , pp. 185-195.

ii. To improve the ability of States to respond to the growing number of ocean uses and their associated impacts;
iii. To make more effective scientific input to development activities through multidisciplinary marine science capabilities;
iv. Both developing coastal States and industrialized States need competence in ocean science to responsibly negotiate access to resources in maritime zones and technology transfer;
v. To improve bilateral and multilateral negotiating positions on issues of shared resources and transboundary issues;
vi. To improve capacities to properly develop science-driven marine policies for the development and management of sovereign marine space and resources.

Kullenberg went on to comment on institutional and organizational needs for effective ocean science for developing States citing four key considerations[113]:

i. The importance of increasing the quality and quantity of research institutions, researchers and research vessels for ocean science and monitoring;
ii. The importance of improving the efficiency and effectiveness of existing organizations using national and international support;
iii. The scientific community is enabled to effectively contribute in policy formulation and management interventions as it relates to marine resources management;
iv. The importance of strengthening national interactions between policy, scientific research and services, marine affairs, public awareness and technology stakeholders.

Capacity development and institutional support mechanisms are therefore of critical importance to sustained ocean knowledge generation for sustainable ocean management. It has been a staple of discussions at the global level under UNCLOS and other mechanisms down to the national level and thus will be the focus here separate from other key enablers discussed before. There will be a dual focus on capacities for sustained marine observations and research, as well as capacity for integrated assessments as a major decision-support tool.

[113] Kullenberg G. (1998). Capacity building in marine research and ocean observations: a perspective on why and how. Marine Policy, Volume 22 (3) , pp. 185-195.

4.1 Capacity Development

It is important to contextualize capacity challenges of SIDs for ocean monitoring. These are well-documented but will be presented here with the aid of a local case study from the Coastal Zone Management Unit. The case study will focus on the wave monitoring programme but it must be noted that these challenges manifest in other monitoring programmes across departments. The wave monitoring programme is however one of the longer, more sustained programmes in the CZMU that was subject to a recent expansion to include deep sea monitoring and thus is timely.

Nearshore wave monitoring has been conducted routinely in Barbados since 1993 initially with two S4 Current Meter instruments[114] and soon grew to a total of 7 units at present. The programme is aimed at understanding the wave climate of the island to better inform coastal infrastructure design, erosion control efforts, and coastal development set-back policies. The instruments measured wave parameters, current speed and direction, tide levels, water depth and water temperatures. With their limited number and since they were mainly used for informing coastal engineering designs they have been in areas of intended engineering intervention and not in consistent locations since 1993. In 2010, the programme was augmented with four AWAC units[115] which were primarily used locally to monitor large marina development sites proposed over the years. This represented the first major expansion. The Coastal Risk Assessment and Management Programme is a major project funded by a US 30-million-dollar development IDB loan being implemented between 2011 and 2018. Part of this programme was to review the current wave monitoring regime and procure equipment to expand monitoring to deeper offshore waters. There were a few challenges with procurement, deployment, maintenance and data handling that are important to mention here.

Procurement was successful, despite its delays, there were no significant cost increases. However, once the initial implementation period was over, the buoys were adopted under the regular annual operational budget of the CZMU and represented a substantial increase in the operational budget at a time where government departments were being urged to decrease their operational

[114] S4 suite of current instruments by InterOcean Systems Inc.
[115] AWAC current and wave measuring instruments by Nortek

expenditure due to financial constraints. The national importance of the programme had to be communicated well to justify the increase.

The mere size of the new buoys was a challenge. CZMU does not possess a wench-equipped truck to transport the buoy. Once fully assembled, the width of the buoy was too wide to be transported on many of the roads on the island. CZMU also does not own a boat to support the deployment. Individual boat rental procurement of a fishing boat was normal practice for the S4 and AWAC deployment and retrieval, but the new instruments required a larger vessel to tow the buoys to their deployment locations. The increase in use of support vessels also necessitated that it be done under an annual contract procured through a more rigorous tender process given the increase in costs. These presented unforeseen administrative delays and costs that may seem insignificant for developed economies but are legitimate challenges for small island economies as evidenced by consistent requests for north-south financial and technical support as well as technology transfer in the international policy arena.

Deployment for the first time in the deep Atlantic water off the North coast resulted in further challenges. The harshness and uncertainty of the currents and wave conditions in the area overwhelmed the anchoring mechanism designed for the buoy in the north. On a few occasions soon after initial deployment the buoy was submerged, dragged and broke away from the tethering, prompting a redesign of the anchoring and redeployments. The equipment sends alerts when transmission of data fail, if the instruments are compromised with water intrusion, or if the buoy drifts away from its planned location. Rapid response to these alerts has presented a challenge to the CZMU in mobilizing staff, resources and vessel support to reach the buoys because of the operating hours of the office and the administrative process of triggering unscheduled boat rentals.

The CZMU is currently relying more on partnerships with the Barbados Coast Guard to assist with vessel support to offset the use of incidental boat rental, offering flexibility in time and budget. The involvement of navies and coast guard units are useful and important relationships to develop oceanographic monitoring but in the absence of a formal agreement, logistics and planning challenges inevitably arise. Likewise, a primary role of the Coast Guard is to patrol for and intercept illegal drug traffickers and thus an inherent risk to CZMU staff.

Despite these challenges, the monitoring regimes of nearshore coastal dynamics (waves, currents, beach profiles, sand grain analysis etc.) have been extremely successful in contributing to maturation of integrated coastal management programme in Barbados with exemplary coastal erosion interventions with structures that required comparatively little maintenance because of the data-driven design and construction. Highlighting the challenges of the wave monitoring programme expansion are a means of improvement and lessons learned for other monitoring regimes looking forward. It is clear that monitoring and science in open water requires not only increased technical capacity, but approaching procurement, logistics, and maintenance with more flexibility and reliance on innovative approaches and strengthened partnerships.

The approach used to advance this monitoring regime over the years exemplifies taking advantage of development assistance as a key consideration highlighted by Kullenberg. The partnership of the Government of Barbados, through the CZMU, and the IDB over the past two decades has borne the fruit of rich coastal and marine data, investigations, and management options by way of dialogue and participatory planning of investment strategies. Kullenberg suggests that SIDs may likely never have the resources comparable to larger industrialized States to develop indigenous marine science and monitoring capabilities and thus innovative approaches and north-south support is indeed critical.[116]

Taking advantage of development support is itself a key area for capacity development. Improvement of human resource and institutional capacity to negotiate bilateral and multi-lateral support, synchronize national planning with development intervention planning, and access a plethora of funding mechanisms is vital to developing States. The human resources and institutional platform for improvement is present in Barbados in the form of the Public Investment Unit of the Ministry of Economic Affairs and the international diplomatic personnel of the Ministry of Foreign Affairs. These are important bridging institutions to facilitating north-south and south-south cooperation. Improving dialogue with these stakeholders, the provision of pertinent knowledge from the science-policy boundary, and participatory planning will improve the capacity to negotiate, access and administer development assistance for marine science.

Soegiarto and Stel (1998)[117] commented on Indonesia's journey in the 1980s and 90s to develop national capacity for ocean research and monitoring. The experiences of Indonesia leveraging various sources of technical and financial support is a notable example for Barbados and the Caribbean to contemplate. The first noteworthy point is that the maritime sector development was

[116] Kullenberg G. (1998). Capacity building in marine research and ocean observations: a perspective on why and how. Marine Policy, Volume 22 (3) , pp. 185-195.
[117] Aprilani Soegiarto and Stel, 1998. The Indonesian experience in marine capacity building. Marine Policy, Vol. 22, No.3, pp. 255-267, 1998.

identified as a priority in Indonesia's 25-year development plan (1994-2020) calling for policies on increasing technological capabilities, surveillance and ecosystem monitoring and the improvement of human resource and institutional capacity to support marine development. Therefore, the capacity development process was given legitimacy at the highest national level after identifying the enormous potential the archipelagic waters held for sustainable development.

Ten key efforts that shaped Indonesia's marine research and monitoring capabilities were extracted from the work of Soegiarto and Stel (1998):

1. In 1974, six Universities were requested to develop marine science and technology as their primary programmes. Likewise, two technical institutes were assigned to develop marine engineering and technology programmes. This strategic partnership with local universities and technical institutes formed a critical foundation for human resource capacity development of Indonesia's marine sector workforce and research core.
2. Investment in modern infrastructure and facilities through the State Minister of Research and Technology;
3. The negotiation of north-south bilateral agreements for thousands of students to study abroad in advanced degree programmes in various marine-related fields. Bilateral cooperation was also negotiated with several countries for research programmes and expeditions across the Indonesian archipelago. Indonesia seized the opportunities of these joint research ventures to build in direct hands-on training and transfer of technology[118] in their projects.
4. Active participation in regional and international programmes such as ASEAN[119]-US Coastal Resources Management Programme and sub-regional programmes of the IOC;
5. Infrastructure development through development aid support in the form of French development aid loans and grants to construct suite of research vessels;

[118] One of the innovative approaches described in Soegiarto and Stel (1998) is the support of the Netherlands to establish a suite of transportable marine labs using repurposed shipping containers. This allowed for a shared pool of technology that small academic departments and government institutions could utilize in research projects. Standard 20-foot containers served as biological, physical and chemical oceanography laboratories as well as workshops for equipment maintenance and equipment storage which could be deployed to field stations or research vessels. The same Dutch-Indonesian joint research programme combined a Dutch research vessel and five smaller Indonesian research vessels to conduct research in five thematic areas involving more than 200 Dutch researchers and 250 Indonesian researchers. This programme demonstrated further innovation by hosting 70 Indonesian scientists in the Netherlands after the completion of the expeditions for a special fellowship programme involving training and data analysis. The participants of this fellowship became the core scientists in government institutions, the navy and at universities across Indonesia.

[119] Association of South East Asian Nations

6. Investment in the deployment of a network of SEAWATCH buoys which is an off-the-shelf and customizable solution for ocean parameter monitoring, data transmission and some modelling/forecast services. This was made possible through bilateral cooperation with Norway. The SEAWATCH buoy network was also intended to contribute to the GOOS to assist with several of GOOS specific monitoring objectives such as climate predictions and ocean health assessments.
7. The establishment of a National Research Council in 1984 with one of its core functions being to prepare and monitor the implementation of National Priority Porgrammes on research and technology development;
8. The establishment of the National Committee for Ocean Technology to formulate policy for marine science and ocean technology, coordinate national research programmes and monitor all related research and technology programmes;
9. The establishment of a National Oceanographic Data Centre, and;
10. The establishment of a high-level coordinating council chaired by the President of Indonesia with membership including various marine sector related ministers.

These strategic human resource, infrastructure and institutional investments are useful for consideration for other developing states seeking to develop sovereign capacity in ocean research and monitoring to support marine economic growth and resource management. The more recent example of Indonesia's satellite oceanography platform, INDESO, likewise exemplifies an innovative approach to data-driven ocean management made possible through north-south cooperation.

Member States at the Fifty-Seventh Session of the General Assembly emphasized the need to strengthen the ability of competent international organizations to contribute to regional sub regional and bilateral levels, including through cooperation programmes with Governments, to develop national and local capacity in marine science and the sustainable management of oceans and their resources.[120] The IOC has been a key partner in capacity building. The support of the IOC and other regional and global mechanisms are posited by Kullenberg as a key mechanism for developing States achieving national marine science capabilities. He emphasized the leveraging of existing sub-regional and regional mechanisms to assist in harmonization of national efforts with regional efforts, exchange of information and experiences, joint research design, and in

[120] A/RES/57/141

independent evaluations.[121] The IOC Capacity Development Strategy (2015-2021) outlines an emphasis on regional sub-commissions and committees to effect capacity building tailored to the nuances of each region. The key outputs expected are in human resources development, access to and improvement of physical infrastructure, strengthening mechanisms at all levels, development of ocean research policies, public awareness and sustaining long-term resource mobilization for improved support. In the Latin American and Caribbean region, Barbados has been actively involved in a few key initiatives supported by the IOC including the Caribbean Marine Atlas (CMA) project, Caribbean Large Marine Ecosystem (CLME) Project and Harmful Algal Blooms (HABs) initiative. It will be prudent for Barbados to capitalize on opportunities of the Decade of Ocean Science for Sustainable Development (2021-2030) proposed by UNESCO/IOC and its partners in support of the Sustainable Development Goals (SDGs).

Leveraging regional conventions to facilitate national capacity development is also a useful approach. UNEP Regional Seas conventions call for cooperation in planning and execution in research and monitoring initiatives to promote synergies and efficiency.[122] Pursuant to the Nairobi convention, Member States of the Western Indian Ocean region collaborated to produce the 'Regional State of the Coast Report: Western Indian Ocean'. Part of this process assessed marine related research and development (R&D) in the region to promote a more coordinated regional research strategy and prioritization.[123]

Regarding IEAs, the integrated assessment process identified in Section 3.2 has value in its ability to identify gaps in knowledge and capacity needs during the post assessment evaluation phase. Member State input at regional workshops and input from the Group of Experts converged on knowledge gaps in the production of WOA1. One of the cross-cutting capacity gaps identified was the disparity in capacity across Member States to conduct integrated assessments inclusive of modelling. This section discusses capacity needs for the conduct of integrated assessments; systems thinking, environmental modelling, indicator development and scenario development.

[121] Kullenberg G. (1998). Capacity building in marine research and ocean observations: a perspective on why and how. Marine Policy, Volume 22 (3) , pp. 185-195.
[122] Article 9 OSPAR Convention, Article 14 Nairobi Convention, and Article 13 Cartagena Convention for example.
[123] UNEP-Nairobi Convention and WIOMSA (2015). *The Regional State of the Coast Report: Western Indian Ocean*. UNEP and WIOMSA, Nairobi, Kenya, 546 pp.

Apart from robust data and interdisciplinary dialogue, the success of IEAs with a pressure-state-response framework depends on the derivation of ecosystem models; the capacity to simplify complex human-ecosystem interactions into conceptual frameworks to elucidate causal relationships as the backbone of P-S-R assessments. Improving the understanding of ecosystem relationships and reducing uncertainty is of critical importance to ensure the response phase is targeted and effective. The complexity of modelling one ecosystem compounded by layering several ecosystems and suites of pressures requires sound science and continuous improvement of the understand through research and monitoring. The investments in capacity development of the IPCC for modelling climate interactions and developing scenarios is testament to the importance of reducing uncertainty and improving quality in the products presented to decision makers.

Based on the experience of the CZMU/IDB pilot to model coastal ecosystem services, there is need for further understanding of ecosystem interactions and capacity development in scenario development as part of the assessment toolkit. Capacity was limited in terms of time and financial resources, as well as human resource capacity to develop and model future scenarios based on strategic direction or response options identified in the IEA process.

It is important to note and take advantage of the existence of regional and international resources for capacity development in IEAs such as the training offered by UNEP and the International Institute for Sustainable Development (IISD) in support of expanding States' involvement in the Global Environment Outlook (GEO) process internationally and with the ambition of equipping States to nationalize the GEO process and make vertical linkages. The importance of downscaling established assessment processes to national level has been earlier emphasized as it relates to the potential of WOA to regional and national levels.

4.2 Institutional Arrangements

An important consideration for institutional arrangements in ocean governance more broadly is public support and stakeholder buy-in. Kim (2012)[124] expounded on 4 elements of ocean governance presented by Cho (2006) [125] in exploring the impact of institutional arrangements on

[124] Sung Gwi Kim, The impact of institutional arrangement on ocean governance: International trends and the case of Korea, In Ocean & Coastal Management, Volume 64, 2012, Pages 47-55, ISSN 0964-5691, https://doi.org/10.1016/j.ocecoaman.2012.04.011. (http://www.sciencedirect.com/science/article/pii/S0964569112000816)

[125] Cho, D.O., 2006. Evaluation of the ocean governance system in Korea. Marine Policy 30, 570-579.

ocean governance for Korea using international case studies. Cho suggested that ocean governance comprised (i) ocean policy, (ii) institutional arrangements for implementation of the policy, (iii) mechanisms for coordination and cooperation among actors, and (iv) constituency. Constituency refers to the acceptance of stakeholder groups, policy actors and the public. Kim posited that integrated approaches to institutional arrangements positively impact ocean policy implementation and levels of coordination/cooperation among partners, thus increasing acceptance and buy-in of the public (constituency) for the government's approach to ocean management. Likewise, the reverse can occur where increased buy-in of all stakeholders (constituency) in ocean governance can have a positive influence on coordination and policy implementation overall. It is important therefore to carefully consider all elements of governance in crafting institutional mechanisms for ocean science and broader ocean management. These can take the form of inter-ministerial commissions (e.g. Japan, Australia), administration under a single ministry, or hybrid approaches. Indonesia's approach was the creation of a Ministry of Maritime Affairs and Fisheries, along with the Indonesia Maritime Council comprising membership of 14 Ministers. The United Kingdom established the Marine Management Office under the Department of Environment, Food and Rural Affairs (Defra).[126] The institute of Marine Affairs in Trinidad and Tobago was established in the 1970s, by an Inter-Ministerial Committee on the Law of the Sea, to contribute to marine governance through data collection, implementation of projects/programmes and advice to government headquarters.[127]

Institutional arrangements are an important subset of capacity development for advancing ocean knowledge with its importance featured and exemplified in the case presentations throughout this thesis as a key supporting mechanism for sustained ocean observing and integrated ocean assessments. The value of developing an institutional framework will be underscored here briefly. Care is taken to focus on institutional arrangements for marine monitoring and assessments but commenting on arrangements that also support broader ocean governance is unavoidable. Three institutional capacity needs are: (i) for marine planning, (ii) national-level oversight and

[126] Sung Gwi Kim, The impact of institutional arrangement on ocean governance: International trends and the case of Korea, In Ocean & Coastal Management, Volume 64, 2012, Pages 47-55, ISSN 0964-5691, https://doi.org/10.1016/j.ocecoaman.2012.04.011. (http://www.sciencedirect.com/science/article/pii/S0964569112000816)
[127] Institute of Marine Affairs, Trinidad and Tobago. History. http://www.ima.gov.tt/home/about-ima/history.html. Accessed 14 November 2017

coordination for ocean science and technology, and (iii)advisory services to government. The latter two will be discussed below.

It is instructive to look at the evolution of institutions driving ocean science and monitoring in developed States while cognizant of the differences in scale and circumstances compared to SIDs. Merrell et. al. (2000)[128] expounds on five factors that have driven ocean sciences: the need for basic research, national pride, national defense, economic benefits, and environmental concerns. Merrell et. al.'s chapter delved into the shifting weights of these five factors that have shaped the ocean science landscape in the United States of America in the past 100+ years beginning with the establishment in 1863 of the National Academy Sciences to further the understanding of oceans characteristics critical to the defense of the country. The work of Merrell et.al. went on to chronicle the post-World War II evolution of ocean research institutions such as the establishment of the Office of Naval Research (ONR), National Science Foundation (NSF), National Oceanic and Atmospheric Administration (NOAA), and the Joint Oceanographic Institutions Inc (JOI) established by academic institutions. Juda (2003)[129] explored changes in institutional approaches in the USA, Canada and Australia for the purposes of more effective implementation of UNCLOS and Agenda 21, shifting from fragmented sectoral approaches to more integrated oversight and coordination based on the principle of complexity and interconnectedness of ocean environments and their resources. What can be taken away from these works is that, regardless of development status, changes in national priorities and overall approaches influence institutional arrangements for ocean science. These arrangements may take various forms worth exploring and they change over time through adaptive governance, but are trending to more integrated systems. Likewise, government has a central role to play in driving ocean research for national socio-economic development, environmental protection and sovereignty.

Kullenberg emphasized the importance for developing countries to also establish government-led national oversight mechanisms as part of their capacity development strategy in ocean science and monitoring. This can take the form of technical committees with representation from multiple marine-related sectors to assist in research coordination nationally, interface with similar regional

[128] William J. Merrell, Mary Hope Katsouros, and Glenn P. Boledovich (2000). *Evolving Institutional Arrangements for U.S. Ocean Sciences*; in: Ocean Studies Board & National Science Foundation Division of Ocean Sciences. Content Provider, 2000. *50 Years of Ocean Discovery National Science Foundation 1950-2000*, Washington: National Academies Press

[129] Lawrence Juda, Changing National Approaches to Ocean Governance: The United States, Canada, and Australia, 34 Ocean Dev. & Int'l L. 161, 188 (2003)

and international bodies, and provide technical advice to government.[130] The institutional measures for ocean science capacity taken by Indonesia, chronicled by Soegiarto and Stel (1998), have already been presented earlier where a suite of high-level political as well as technical organizations were established for the advancement of ocean science. So, regardless of development status, combinations of the five factors outlined by Merrell et. al. (2000) will drive the need for developing capacities for ocean science.

There is currently no organization performing these functions on ocean-related matters across sectors in Barbados, perhaps at the sector level there are some bodies performing one of these three roles but not a single, multi-sectoral body overseeing the growth of ocean research and knowledge. The Fisheries Advisory Committee (FAC) for example is a represented by government departments, academia, and fisherfolk groups as a co-management arrangement to advise the Minister responsible for fisheries on fisheries management, conservation and development of the sector.[131] Similar mechanisms in other ocean-related sectors as well as an overarching multi-sectoral, interdisciplinary mechanism is desirous. Likewise desirous is a review of, with the intention of improving, existing governance mechanisms such as the FAC. Barbados sought R&D support for agriculture as its main economic driver in the late 1800s and early 1900s with the establishment of the Barbados Agricultural Society and by hosting regional institutions such as the West Indies Central Sugarcane Breeding Station, the Caribbean Agricultural Research and Development Institute, and more recently the regional office of the United Nations Food & Agricultural Organization. A similar level of leadership and investment in ocean research will be needed for Barbados to effectively and sustainably unlock economic opportunities and resource efficiency from its marine space using best-available knowledge.

Regarding advisory services to government, the process and outputs of IEAs have been presented here as a major constituent of the science-policy interface inclusive of options for management intervention. The guidelines for IEAs present a suite of essential organizational functions to support assessments and the institutional models used by GEO and WOA1. These functions have already been expounded on in section 3.2:[132]

---

[130] Kullenberg G. (1998). Capacity building in marine research and ocean observations: a perspective on why and how. Marine Policy, Volume 22 (3) , pp. 185-195.
[131] McConney, P., R. Mahon and H. Oxenford. 2003. Barbados case study: the Fisheries Advisory Committee. Caribbean Coastal Co-management Guidelines Project. Caribbean Conservation Association, Barbados. 77pp.
[132] Guidelines for conducting Integrated Environmental Assessments, prepared by UN Environment by Member States request to support the sixth Global Environment Outlook and beyond.

1. **Central decision-making**: an overall governing institution given the authority and legitimacy to make decisions on issues such as the structure, composition and roles of other supporting organs, resource mobilization, and facilitating the approval of the assessment and mobilization of its outputs to users.
2. **Scientific advice** for quality assurance and credibility of the assessment, along with effective communication of scientific outputs to policy-makers.
3. **Text management** function necessary to coordinate drafting of assessment outputs
4. A **pool of practitioners** to draw upon for technical coordination and support such as the GoE and PoE mechanism of WOA1.
5. **General communication** of the IEAs to users.
6. **Stakeholder communication** among practitioners and other stakeholders for the purposes of buy-in, capacity building, and interdisciplinary/multi-sectoral integration.
7. **General management** and support in the administrative elements of the IEA including management of time and financial resources.
8. **Expert review** mentioned in the guidelines as an intergovernmental function of the GEO and WOA1 process. A nationalized process can still benefit from external review by support agencies such as IISD in the case of environmental reviews or other regional/international ocean-related bodies.

Two main models were presented in the guidelines to encompass the suite of functions (Figure 7). Institutional model B (Figure 7) pertains more to Barbados's governance framework for most projects and other initiatives where the Cabinet of Ministers approves the formation of a steering committee along with terms of reference to outline its authority and role. These steering committees sometimes have an administrative function or working groups but usually are restricted to decision-making and review with an implementing agency of government identified for management and secretariat functions. The CZMU have in past projects also established independent review and quality assurance boards when robust technical capacity was not available in-house.

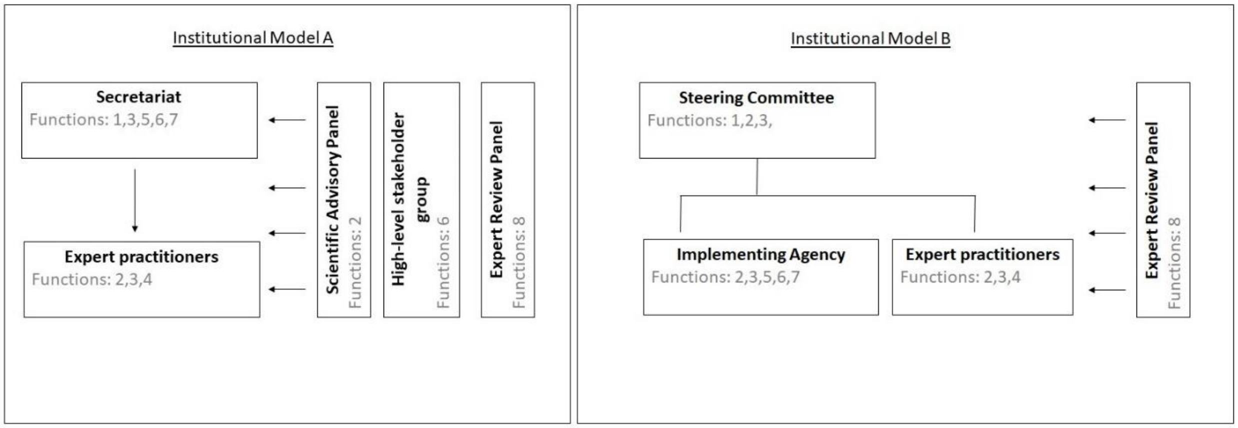

Figure 7: Typical institutional model options to cover core IEA functions listed in Section 4.2 above. Model option A is based on the GEO process focusing on secretariat support while model option B is based on steering committee estabishment which more typifies examples in Barbados. Source: Guidelines for conducting Integrated Environmental Assessments, prepared by UN Environment by Member States request to support the sixth Global Environment Outlook and beyond.

Chapter 4 presented important considerations from the literature regarding capacity building and institutional arrangements as key supporting pillars for an ocean knowledge framework. The importance of government-led investment in ocean science development and supporting institutions is considered a key development strategy for ocean-related socio-economic development by developed and developing countries alike and is strongly recommended for consideration at the national level while proceeding to advance new and existing maritime sectors in Barbados. Likewise, the guidelines for IEAs prepared by UN Environment for Member States is a key reference for institutional options and core functions as it relates to ecosystem assessments.

SUMMARY

Recent developments in Barbados suggest the intention to look toward the ocean for socio-economic development. These developments include delineation of maritime boundaries and extended continental shelf limits, articulation of a green economy strategy with food and energy self-sufficiency featuring heavily, and preliminary steps towards the development of offshore hydrocarbon and alternative energy sectors. To support new maritime activities and improve management of existing ones, governance of marine resources needs to be supported by a robust understanding of the ocean. This encompasses timely and quality data and analyses to inform decision-makers and to improve ocean literacy of all stakeholders including the public.

Case studies revolving around two types of frameworks for ocean knowledge were presented in this thesis: (i)A framework for sustained monitoring of basic oceanographic parameters to support applied research, trend analysis, and assessments, focusing on UNESCO-IOCs GOOS framework (ii) A framework for periodic and comprehensive assessment of the state of the marine environment, including socio-economic considerations, centered around the production of WOA1 under the auspices of the UNGA. Likewise, case studies were presented on various national and regional applications of monitoring frameworks to support socio-economic development and better environmental management at the national level.

These examples were combined with a review of relevant literature to distill a suite of key considerations and approaches to support national discourse in Barbados in the development of legal, policy, and institutional elements of a framework for sustaining ocean knowledge. Three main elements of a long-term ocean monitoring framework and seven initiatives for establishing an enabling environment for long-term monitoring were presented. Six guiding principles and practices of a framework for integrated assessments of the marine environment were presented along with key considerations for development of an assessment process. A hybrid framework of sustained monitoring and research feeding into periodic assessments has been recommended for development in Barbados to support an ocean policy or blue economy strategy.