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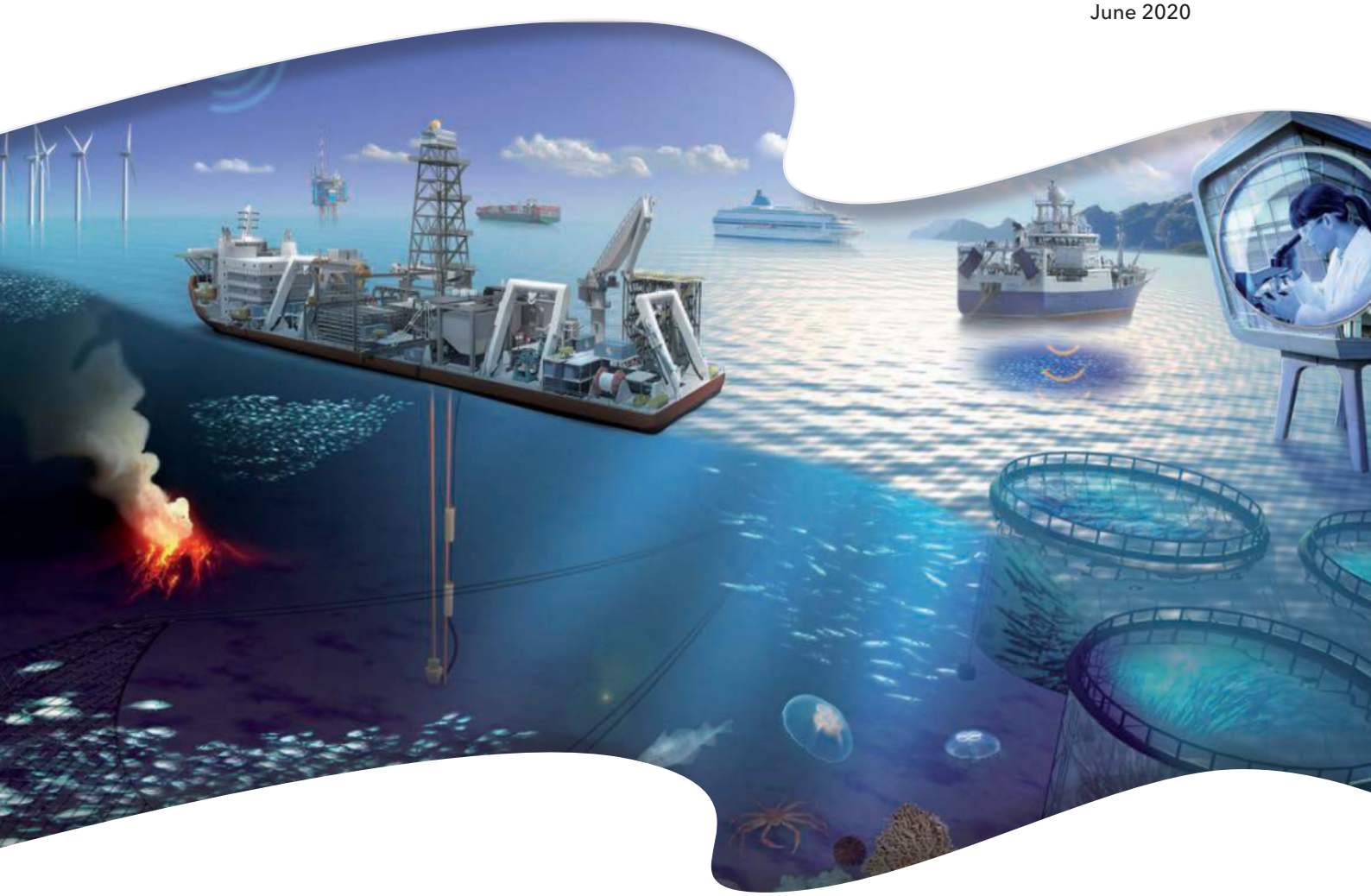
OPPORTUNITIES IN THE BLUE ECONOMY

Global Industrial Trends and Opportunities

Caribbean

Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad and Tobago

June 2020



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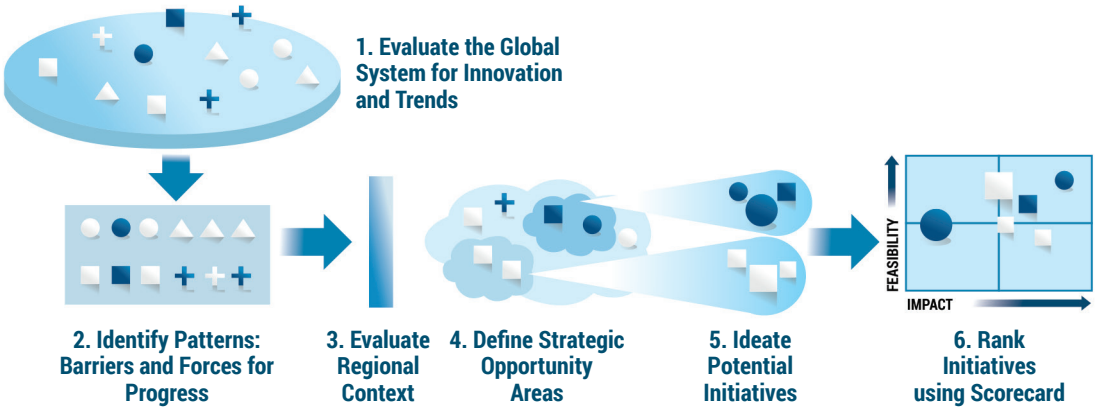
Executive Summary

The promise of the blue economy—a marriage between sustainable development and green growth—cannot be overstated for the Caribbean. The World Bank estimates that the value of the ocean economy in the Caribbean to be US$ 407 billion.[1] For resource-limited SIDS (and SIDS-like coastal countries such as Guyana and Suriname), the ocean provides an unprecedented resource that continues to grow as new technologies provide greater access, and new models allow for smarter management and planning. Yet, in this region named for its sea, the blue economy remains largely uncharted waters.

This project seeks to support the development of blue economy growth in the Caribbean from a promise to a realized present. This report provides findings from Phase 1 of a two-phased approach. In this first phase, a series of foresighting analyses (**Figure 1**) was used to uncover trends in innovation and progress within the blue economy globally, and then apply this knowledge—in combination with regional and country analyses—to identify opportunity areas ripe for development, and specific country-level initiatives for six target countries: Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad and Tobago.

Figure 1: Overview of Six Stages of Foresight Process, including Series of Global and Regional Analyses and Rapid Assessment Tool to Rank Initiatives (see Appendix C for details).



Summary of Key Findings

The results of Phase 1 include a diverse suite of findings, recommendations, and frameworks to support continued advancement of blue economy opportunities in the Caribbean region (**Table 1**).

[1] http://documents.worldbank.org/curated/en/965641473449861013/pdf/AUS16344-REVISED-v1-BlueEconomy-FullReport-Oct3.pdf

Table ES1: Summary of Key Findings from Phase 1 Research on Global Trends that Support Advancement of blue Economy Growth in the Caribbean.

Development Stage	Key Observations
Blue Economy Project Rapid Assessment Tool	**A novel framework for rapidly evaluating blue economy initiatives** to determine their potential impact and feasibility within the Small Island Developing State context
17 preliminary Country-level blue economy Initiatives	**Candidate Blue Economy projects/initiatives have been identified**, with 2-3 each for the six target countries. Each of these initiatives has been selected based on its potential to achieve the following key objectives: • Address immediate livelihoods and employment needs for vulnerable populations, especially those most hard-hit by COVID-19; • Tackle one or more core underlying system barriers to blue economy growth, thereby helping to unlock change for multiple stakeholders; and • Leverage existing assets (including existing local champions wherever possible) and momentum in the region to increase likelihood of success.
Seven Caribbean-specific Opportunity Areas	**Categories of intervention that can guide future project ideation and direct limited resources towards development of initiatives.** These intervention categories are grounded in systemic barriers, which helps avoid the common challenge of chasing "shiny objects" or jumping on the next-big-thing, and instead roots efforts in tackling known, core stuck points using design principles that have proven track records for success.
Regional barriers and assets	**Regional assessment has identified how system barriers manifest in the Caribbean and key forces and conditions that can unlock progress within the region.** Application of this framework can identify future Opportunity Areas that may be ripe for development.
Global trends in innovation in blue economy industry and technology sectors	**Key trends in innovation within eleven industries and nine technology sectors have been evaluated and indicate potential directions for future blue economy growth.** These trends provide insight into forces that block and support blue economy development, including nine Systemic Barriers and eight Drivers, seven Enabling Conditions, and nine Design Principles, the latter three which together create forces for progress.

Opportunity Areas for Caribbean Blue Economy Development and Preliminary Country Initiatives

> *"Opportunity Areas reflect where to focus energy and resources to accelerate and maximize success of blue economy projects that lift up communities, improve local economies, and preserve and protect the underlying ocean ecosystem upon which the entire blue economy depends."*

The project team identified seven areas of opportunity for the Caribbean blue economy (**Table 2**). These intervention categories are compelling because they are ripe for development and responsive to current and future pain points in the system, including the impacts of COVID-19 and climate change. The Opportunity Areas inform discussion and ideation of interventions at the project level, serving as a bridge between the trends at the global level and country-specific capacities on the ground.

Within each Opportunity Area, potential projects that currently exist and new initiatives that could be created have been identified (**Table 2**). Note, some of these project ideas are country-specific; others may work at a regional scale. Specific project ideas, and alignment with Opportunity Areas, is provided in the Country Profiles section.

Table ES2: Summary of Opportunity Areas and Initial Candidate Projects for the Six Countries.

	OPPORTUNITY AREAS						
	Smart Tourism and Hospitality	**Fortifying Local Food Systems**	**Resilient Coastal Infrastructure**	**Turning Ocean Waste and Space into Profit**	**Research Clearing house and Capacity Building**	**Satellite R&D Hubs for Innovation and Biotechnology**	**Advance Waste Management Solutions for SIDS**
Bahamas					Low Carbon Freight Future		Port Waste Reception Facility
Barbados		Tuna Fisheries Sustainable Development		Caribbean Regional Research Clearing House		Offshore Seaweed Production	Sargassum Collection and Processing
Guyana	Barima Mora Passage Special Protected Area Women's Empowerment to Monitor Natural		Barima Mora Ecotourism Development				
Jamaica		Local Community Fishing Practice Improvement				Offshore Seaweed Production	Sargassum Collection and Processing
Suriname	Mangrove Corridor Restoration	Mangrove Honey					
Trinidad and Tobago		Fishers Engine Conversion	Scientific and Educational Ecotourism				

The diversity of candidate projects is both exciting and a challenge: with limited resources, how can governments, practitioners, and funders best determine which projects to progress?

The SIDS Blue Economy Project Rapid Assessment Tool was created to help solve this problem. The tool consists of a robust rubric for evaluating project-level initiatives across five Impact Criteria and five Feasibility Criteria (**Table 3**) in order to compare different kinds of projects according to their potential for change (impact) and their risk (feasibility).

Table ES3: Impact and Feasibility Criteria for Foresight Tool and Weights for Scoring.

Category	Criteria	Weight
IMPACT	Job Creation and Skills Upgrading	30%
	Vulnerable population Livelihoods and Resiliency	20%
	Institutional Strengthening and Sectoral Linkages	20%
	Local Economic Resiliency	15%
	Environmental Sustainability	15%
FEASIBILITY	Demand: Access to Viable Markets	25%
	Competitiveness of Production Factors	25%
	Adequacy of Institutional Factors	20%
	Geographic Vulnerabilities	10%
	Leadership Commitment for Implementation	20%

The Scoring Guide has been purposefully designed to support evaluation of blue economy projects in SIDS, with the ten criteria, and their weightings, reflecting known barriers particularly relevant for SIDS, and also COVID-19 pandemic economic recovery challenges. Consideration for all these challenges, and how an initiative specifically addresses them (the ranking) is critical to effective design and strategy creation (**Table 4**).

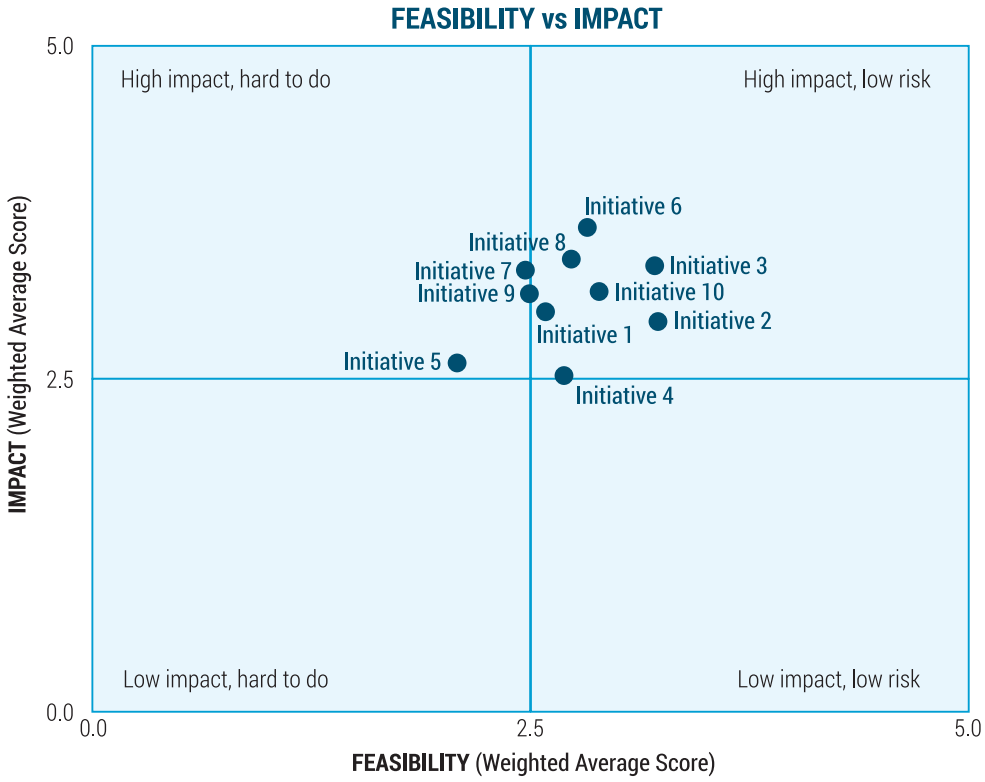
The following **Table 4** and **Figure 2** illustrate a demonstration of a ranking of candidate projects/ initiatives.

Table ES4: Screenshot of Master Scorecard showing Preliminary Test Scores for Eight Projects Generated by the Foresight analysis and currently under evaluation. Each project was scored by 1-4 reviewers independently, based on familiarity and knowledge of the project and country.

ASSESSMENT OF INITIAL CANDIDATE PROJECTS/INITIATIVES										
	Impact Factors	**Weight**	**Barbados C-Combinator**	**Guyana Drones for Mangroves**	**Suriname Mangrove Corridor**	**Barbados Tuna**	**Bahamas Virtual Tourism**	**Jamaica C-Combinator**	**Barbados Research Clearinghouse**	**Trinidad and Tobago Fisher Fuel Initiative**
IMPACT ASSESSMENT	Job creation and skills	30%	4.0	2.0	3.5	2.3	2.7	4.0	3.3	3.0
	Vulnerable population	20%	3.7	4.0	4.0	2.3	2.3	3.8	2.7	4.0
	Institutional strengthening and local linkages	20%	3.8	2.0	3.5	2.3	2.7	3.8	4.0	3.0
	Builds local economic resiliency	15%	2.3	4.0	3.5	2.3	3.0	2.3	3.0	3.5
	Environmental sustainability	15%	4.0	4.0	4.0	3.7	2.7	4.0	3.3	4.0
	Average Score	100%	3.6	3.2	3.7	2.6	2.7	3.6	3.3	3.5
	Weighted Average Score		3.7	3.0	3.7	2.5	2.7	3.6	3.3	3.4
	Number of Evaluators (n=?)		3	1	2	3	3	4	3	1

	Feasibility Factors	**Weight**	**Barbados C-Combinator**	**Guyana Drones for Mangroves**	**Suriname Mangrove Corridor**	**Barbados Tuna**	**Bahamas Virtual Tourism**	**Jamaica C-Combinator**	**Barbados Research Clearinghouse**	**Trinidad and Tobago Fisher Fuel Initiative**
FEASIBILITY ASSESSMENT	Demand	25%	4.2	3.0	3.0	3.0	2.7	4.1	3.0	2.5
	Competitiveness	25%	3.0	3.0	3.0	3.0	2.0	2.8	2.7	2.5
	Adequacy of institutional factors	20%	2.3	3.0	3.0	2.0	2.0	2.3	2.7	3.0
	Geographic vulnerabilities	10%	2.3	3.0	3.5	2.0	3..0	2.3	2.7	3.0
	Leadership	20%	1.7	4.0	3.5	3.0	1.0	2.3	1.3	3.0
	Average Score	100%	2.7	3.2	3.2	2.6	2.1	2.7	2.5	2.8
	Weighted Average Score		2.8	3.2	3.2	2.7	2.1	2.8	2.5	2.8
	Number of Evaluators (n=?)		3	1	2	3	3	4	3	1

Figure ES2: Scatterplot Generated within Master Scorecard Reflecting Impact vs. Feasibility Scores for Different Initiatives.



The rankings also reflect specific enabling conditions that need to be met in order for longer-term, larger-scale blue economy development to occur. For example, within "Job creation and skills upgrading," there are explicit ranking distinctions between projects that provide temporary vs. permanent job prospects vs. those that also provide long-term professional growth opportunities. These rankings reflect the all-too-common systemic barrier of "brain drain," where local talent leaves the region to secure more satisfying, often better-paying jobs that have greater room for growth and development.

By considering how projects are potentially meeting (or failing to meet) the specific milestones provided in each rank, users can more explicitly identify where more resources or better design may be needed in order to maximize potential impact of the proposed project. The scorecard is designed to evaluate initiatives where a discrete purpose and model for implementation has been identified. As this report is Phase 1 of a two-part investigation, the projects identified remain preliminary. Evaluation and prioritization of country-level projects using the tool will occur during Phase 2. However, preliminary test runs of the tool are provided in SIDS BLUE ECONOMY RAPID ASSESSMENT TOOL section.

Regional Analysis: Barriers and Conditions for Progress

The Global Scan identified trends in innovation and growth across eleven industry and nine technology sectors. The first analysis identified the general state of maturity of industry sectors;

a second pattern-finding analysis uncovered the forces that are either blocking or accelerating blue economy growth at a global level. The forces that block progress are System Barriers, and they are by definition, movable or changeable aspects of the system. Forces that help to accelerate progress are categorized as Drivers, Enabling Conditions, or Design Principles, defined respectively as the catalytic forces that launch initiatives, the factors that allow an initiative to take root, and the strategies that allow innovations and initiatives to gain traction or progress.

Following the global scan, a regional analysis was conducted to evaluate the current landscape of blue economy conditions in the Caribbean. Not surprisingly, the blue economy industry sector maturity at the global-level compared with the Caribbean shows that while several industry sectors are mature in the Caribbean, many have been slower to progress, or remain nascent or negligible, compared with the global landscape (**Table 5**).

Table ES5: Maturity of Blue Economy Industries Globally vs in the Caribbean.

Blue Economy Industry Status	Blue Economy Global Scan	Blue Economy Caribbean Scan
Mature	Fishing; Tourism (Cruise, Coastal, Marine); Shipping; Oil & Gas	Fishing; Cruise, Coastal, Marine Tourism; Shipping
Growth Stage	Mariculture: coastal & offshore; Maritime Monitoring & Surveillance; Ports; Renewables: offshore wind, solar	Oil & Gas*; Maritime Monitoring & Surveillance; Ports
Emergent	Coastal Development, Protection & Restoration; Marine Products; Deep-sea mining; Renewables: wave, current, thermal	Mariculture: coastal & offshore; Coastal Development, Protection & Restoration; Marine Products
Nascent/ Negligible		Renewables: offshore wind, solar; Deep-sea mining; Renewables: wave, current, thermal

The lag in blue economy development in the Caribbean can be attributed to the strong manifestation of several System Barriers and gaps in Enabling Conditions that are critical for sector growth, as summarized in **Table 6**.

Table ES6: Summary of Key Findings from Phase 1 Research on Global Trends that Support Advancement of Blue Economy Growth in the Caribbean.

Lack of organizational infrastructure to retain and grow talent

"Brain drain" is a significant barrier to accelerating blue economy growth in SIDS. Technical, analytical, and topical expertise and opportunity for professional growth, are all needed. In addition, although the Caribbean's emerging blue economy entrepreneurial ecosystem is growing with institutions such as the Branson Centre and the UNDP's Blue Economy and Sustainable Management of Ocean Degradation Lab, entrepreneurial support structures are still minimal. Incubators that do exist are largely working in silos and face shortage of experienced, talented entrepreneurs and limited deal flow. Further, there are few major institutions or research clusters in the Caribbean that could support blue economy R&D and commercialization processes, and that have a track record of working with good candidate entrepreneurs.

Lack of Marine Spatial Planning, Uncertain regulatory environment and poor legal frameworks

The lack of clear policies, frequent government turnovers, lack of enforcement, and other factors create uncertainty—and risk—around the rules of engagement and long-term projects. Meanwhile, data needed to map and evaluate marine resources, and plan strategic use, is missing. Finally, legal expertise, tools, and instruments—including environmental impact assessment protocols—are needed to ensure that the interests of stakeholders and the environment are clearly articulated and protected.

Lack of access and high cost of energy

Several of the six target countries have some of the highest debt-to-GDP ratios in the world, driven in part by dependence on fossil fuel imports. "Covering the ever-increasing cost of energy places enormous pressure on countries whose national budgets are already heavily indebted."[2]

Limited Insurance Options & Lack of Risk-Tolerant Financing for Local Enterprises:

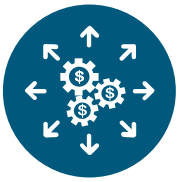
Limited insurance options in a natural disaster-prone region like the Caribbean further erodes the bankability of potential capital-intensive blue economy activities. Creative approaches to build the patient, risk-tolerant capital are critical and currently missing. Given typical market drivers are absent, innovative insurance models that can share risk broadly through the Caribbean should be considered and local governments will likely need to be a stakeholder and potential investor in insurance access to support activities to get off the ground and reach scale.

[2] https://blogs.iadb.org/caribbean-dev-trends/en/the-caribbean-has-some-of-the-worlds-highest-energy-costs-now-is-the-time-to-transform-the-regions-energy-market/

Table ES6: Summary of Key Findings from Phase 1 Research on Global Trends that Support Advancement of Blue Economy Growth in the Caribbean. (cont.)

Fragmented institutions and lack of strong partnerships

Rather than working together, fledgling businesses compete for limited start-up capital and resources; countries work to position themselves as leaders, rather than as partners. Despite the small size of island nations in the Caribbean, and regional groups such as CARICOM, institutions are highly fragmented—both within their own divisions and across the region. The lack of collaboration and partnership leads to data silos, duplicative effort and wasted resources, and an inability to leverage success to accelerate progress across the region. "The existing ocean governance framework in most, if not all, Caribbean countries emphasises a traditional sector-specific approach to management and planning and thus shows symptoms of the problem facing a large number of countries seeking to implement a blue economy approach – ocean governance remains highly 'balkanized'.[3]



Combined Impact of System Barriers on the Investment Climate and Capital Resources

Historically, the Caribbean region has not been noted for sophisticated capital markets or abundant sources of investment capital. In turn, many potential commercial ventures in the region have been constrained by a variety of scalability issues. In addition, the lack of investment capital makes it difficult to overcome the opportunity costs of adopting new technology.

Any one of the critical barriers highlighted alone could derail the feasibility and viability of a blue economy commercial venture. When these barriers are combined, the enormous challenge of the current investment climate becomes even more apparent. As one interviewee succinctly summarized, "the challenge isn't how to find capital, it's how to find bankable projects." These barriers augment the (already numerous, inherent) risks associated with emerging blue economy activities that do not always have long track records of commercial success. Further, accessing capital that has always been scarce in the Caribbean region has become even more difficult in a post-COVID-19 environment.

Although the challenges are significant, the regional analysis also uncovered significant assets that could be pivotal in supporting both regional and country-specific blue economy policy and strategies. Institutions, including CARICOM and the OECS as well as business and industry bodies all could serve as key partners for advancing blue economy activities. There are also significant resources being provided by multilateral development financial institutions that are investing in the Caribbean.

The analysis also highlights ways that small states can be an asset in supporting the blue economy. The small population size in many island nations means momentum can build quickly as personal relationships can set and drive collaborative efforts. In these settings, convening stakeholders and getting support and cooperation for projects or initiatives can be catalytic.

[3] Julian Roberts, "The Blue Economy: From Concept to Reality in the Caribbean Region." Discussion Paper for the Caribbean Regional Dialogue with the G20 Development Working Group, 2015

Likewise, there seems to be increasing interest in understanding how best to use ocean resources for long-term prosperity. This is evidenced through various efforts scattered across the Caribbean including: seagrass, coral and mangrove restoration projects; industry-led initiatives to improve marine environments per SDG and better business practices; the abundance of MPAs and mapping efforts undertaken; and even in the recent creation of the Ministry of Maritime Affairs and the Blue Economy in Barbados in 2018, the first of its kind in the Caribbean. These are seeds of potential growth and demonstrate the interest and opportunity for the blue economy in the Caribbean.

Taken together, the barriers and assets within the Caribbean region create an uneven landscape in the level and quality of enabling conditions across key blue economy industries. The relative readiness for blue economy growth is moderately better for existing sectors than for growth sectors, yet conditions must be upgraded across the board (**Table 7**).

Table ES7: Adequacy of Blue Economy Enabling Conditions within the Caribbean Region for Key Industry Sectors.

Blue Economy Enabling Conditions	Blue Economy Sectors					
	Fishing	Coastal Maritime Tourism	Shipping	Offshore Oil and Gas	Mariculture	Renewable Energy
Local expertise and research capacity						
Strong partnerships among key stakeholder						
Risk-tolerant financing for local enterprises						
Visionary Leadership						
Legal agreements and structures to protect project interests						
Global Standards and Conventions						
Market beyond the region						

High Low

Trends in Industry and Technology to Inspire and Inform

Our global scan analysis of eleven industry and nine technology sectors relevant to the blue economy provided more than the framework of System Barriers and critical forces for progress. This scan also helped identify where multiple technologies and sectors were coming together to foster new and exciting innovations. Based on this analysis, we create a Global Blue Economy Hotspot Matrix that contains representation of the types of innovations we found at the crossroads of industry, technology and science (**Table 8**).

Table ES8: Blue Economy Hotspot Matrix. Selection of Innovations occurring at the nexus of science, technology, and industry. Colors show qualitative scale from scaled, "hot" intersections (red) to those that are still nascent but promising (beige).

Technologies	Mariculture	Coastal Development	Deep Sea Mining	Fisheries	Marine Products	Maritime Surveillance and Safety	Oil and Gas	Ports	Renewable Energy	Shipping	Tourism
AI	(1) Swarm intelligence to detect pollution	(10) Tourist safety	(19) Autonomous mapping and species identification	(28) Increase efficiencies at sea	(37) Seaweed Farming Management	(46) Accident prevention at sea	(55) Mass data analysis for site identification	(64) Machine-based arrival and departure predictions	(73) Managing energy input and flow	(82) Mapping analysis for reduced fuel consumption	(91) Chatbots for personalized experiences
AR/VR	(2) Remote teaching and instructions	(11) Imaging coastal adaptation to sea level rise	(20) N/A	(29) N/A	(38) N/A	(47) Virtual training for maritime enforcement	(56) Underwater equipment training	(65) N/A	(74) Renewable energy training	(83) N/A	(92) AR virtual tours to attract tourists
Biotechnology	(3) Increased productivity and quality	((12) Ecologically active concrete	(21) Environmental DNA	(30) Fish leather alternative	(39) Edible and biodegradable plastic alternatives	(48) Marine mammals for defense	(57) Bioremediation	(66) Biometrics security systems	(75) Synthetic biology for biofuel production	(84) Anti-fouling	(93) Bio-safety; Anti-viral coatings
Blockchain	(4) Rapid and secure sales	(13) N/A	(22) N/A	(31) Addressing IUU with traceability	(40) N/A	(49) Real-time digital insurance	(58) Trading simplification	(67) Secure and real-time information transfer	(76) Tracking biofuel creation and delivery	(85) Tracking and verifying fuel compliance	(94) N/A
Drones	(5) Monitoring and maintenance	(14) *See Robotics	(23) *See Robotics	(32) Mapping remote underwater zones	(41) *See AI	(50) Remote patrolling at sea	(59) Remote project monitoring and surveillance	(68) Surveillance and Security	(77) Remote inspection of offshore platforms	(86) Hull cleaning robots to avoid biofouling	(95) *See AR/VR
GIS and spatial mapping	(6) Mapping for improved management	(15) Calculating exposure to coastal erosion	(24) *See Sensors	(33) Satellite tracking to monitor IUU	(42) Mapping sargassum	(51) *See Blockchain	(60) Asset mapping and management	(69) Locational intelligence	(78) Identification of ideal project locations	(87) *See AI	(96) Ecotourism site selection and management
Nanotechnology	(7) Contaminant removal	(16) N/A	(25) N/A	(34) Fish Rfid for tracking and monitoring	(43) Extracellular synthesis of metallic nanoparticles	(52) N/A	(61) Nanosensor imaging and mapping	(70) N/A	(79) Enhanced bio-availability of plant nutrients	(88) Nanoparticulate hull coastings to combat erosion	(97) Antimicrobial and antifungal Nanocoatings
Robotics	(8) Automated feeding	(17) Unmanned gliders for hurricane warnings	(26) Nodular collection technology	(35) Quality control	(44) Automated urchin removal from kelp beds	(53) Anti-piracy robots	(62) Teleoperated marine operations	(71) *See Drones	(80) Kelp elevators for biofuel	(89) *See Drones	(98) Customer service
Sensors	(9) Autonomous health management	(18) *See Robotics	(27) 3D modeling of seabed	(36) *See Drones	(45) *See AI	(54) *See Robotic	(63) Inspection and maintenance	(72) *See AI	(81) *See Nanotechnology	(90) *See Drones	(99) Bio sensors

Experimental, limited application outside R&D

Commercial application but limited use; start-up companies; pilots

Commercial use in multiple regions, multiple regions, multiple companies or suppliers; POC

The matrix is not a comprehensive evaluation; instead, it is a snapshot based on expert interviews and a high-level scoping analysis to highlight the cutting-edge of tech-based innovations that are being applied to the blue economy space. As such, the matrix offers industry experts guidance regarding up-and-coming technological innovations; it can also offer technologists and entrepreneurs insights into where there may be new growth opportunity areas. A few highlights include:

- Multiple types of technologies are progressing quickly (red) within Marine Products, which could indicate opportunity for accelerated growth in this sector despite it being a more nascent industry for the blue economy;
- Fisheries are undergoing a data technology explosion, with advanced systems for identifying and tracing fish, mapping habitats, and tracking vessels all occurring in both industrial and artisanal fleets;
- Drones and GIS/Spatial Mapping tools are—not surprising—advancing strongly within nearly every industry sector that touches the blue economy;
- Rarely does a technology operate on its own; instead, multiple technologies are often tightly interwoven and need to be embedded in public policy and regulatory frameworks in order transforms themselves in sustainable solutions;
- Do not underestimate nascent technologies; given sufficient starting capital, they can and likely will, evolve to meet demand; and
- Innovations in technology are helping to bring greater access, transparency, and accountability—as well as cost efficiencies—to many of these sectors. These developments can help both the mature and emergent industries meet the full definition of blue economy—to support long term health of the environment along with local economies—if properly applied.

Appendix B houses more detailed descriptions of innovations. In the future, the matrix could easily become a more dynamic tool that continues to incorporate new innovations and visualize the rapidly changing edge of blue economy technology development.

Next Steps

Moving forward, government leaders, civil society organizations, funders, and other blue economy stakeholders will benefit from the regionally-grounded Opportunity Areas to narrow the field of potential blue economy initiatives to those that contribute to larger systems-change and are most likely to succeed given present conditions. The seven distinct opportunity areas specifically incorporate regional assets as important points of leverage; these areas are ripe for development in part because they utilize existing momentum within the region. Within each opportunity area, there are multiple potential commercial ventures and projects that currently exist and new commercial initiatives that could be created.

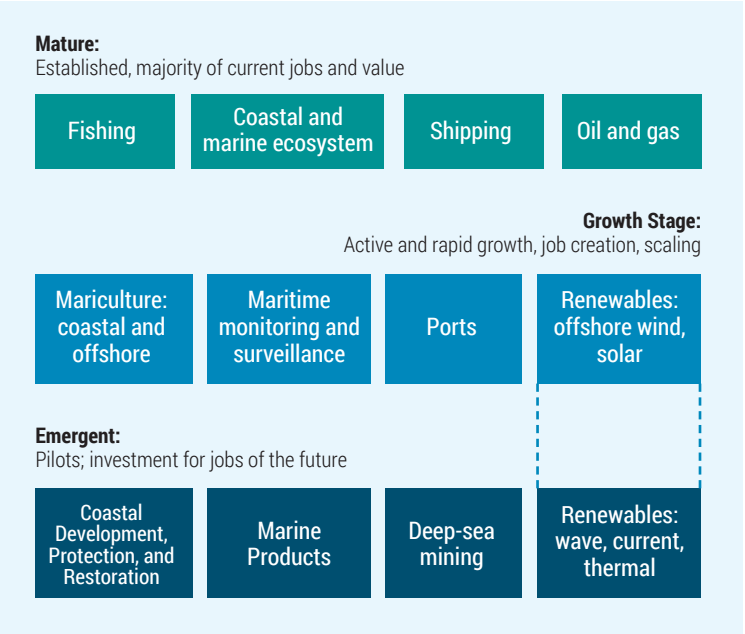
However, for the blue economy to truly grow at any sort of scale in the Caribbean, it will require governments, private sector, and civil society leaders and international organizations to collaborate and provide the necessary funding, expertise, policy reforms and other resources to tangibly address the region's existing barriers and gaps. Taking these actions would support sufficiently "de-risking" the business environment to an extent that entrepreneurs and investors perceive more certainty and have the confidence that there are solid opportunities to achieve the requisite scale and competitiveness that would make new innovative blue economy business models financially viable and sustainable.

In contrast to historic investment into economic activity in ocean environments, the blue economy opportunities identified in this report explicitly consider economic growth balanced with social benefits, equitability, and environmental sustainability. The next phase of this research will focus on validation and refinement of candidate project initiative ideas to develop action plans that can meet this triple impact criteria for true blue economy development. The aim is to provide models and support scaling of initiatives that can help address immediate pain points while creating the enabling conditions and proof of concepts needed to advance successful blue economy growth in the six target countries, and the region as a whole.

Introduction 1

This project identifies trends in successes and challenges in the blue economy in order to increase awareness and craft strategic action plans for accelerating sustainable, equitable, and innovative blue economy growth in six Caribbean countries. Recognizing the vast potential of the Blue Economy to drive improvements in livelihoods, local economies, and the environment, this work synthesizes learnings from blue economy efforts around the world across traditional and emergent industry and technology sectors (**Figure 1**) to inform country-specific strategies grounded in local champions and capacity.

Figure 1: Overview of the Eleven Blue Economy Sectors Analyzed in this Report.

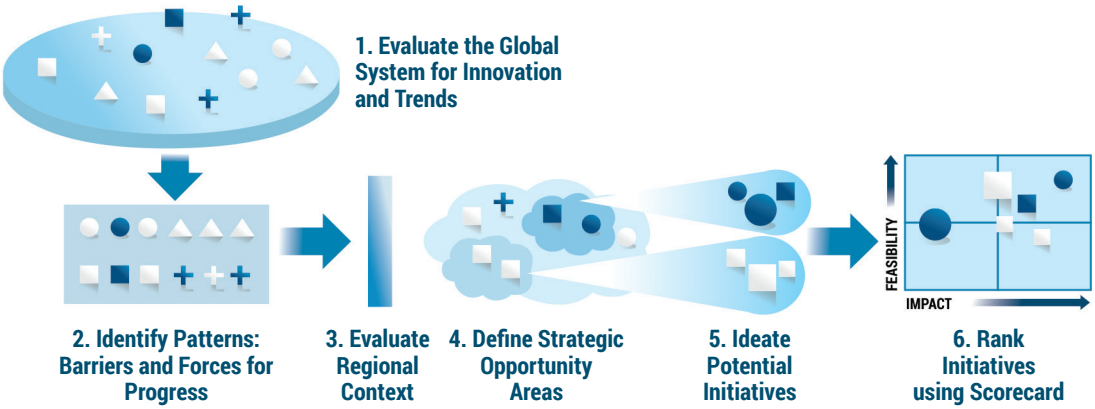


Adapted from *Ecorys et al (2012): Blue Growth Scenarios and Regional Economic and Innovation Dynamics Consulting SPRL (2016): Strategic Cooperation on Blue Growth in the North Sea.*

The analysis categorizes the eleven blue economy sectors into three major buckets, following the convention from Ecorys et al (2012). Mature or established blue economy sectors, such as fishing and shipping, hold the majority of current jobs and economic activity. Growth stage sectors offer opportunities for new job creation within short time horizons—technology and models are proven, and resources can be strategically applied to scale these opportunities to new regions. Emergent sectors include areas where pilots are occurring, and investment today will help build the enabling conditions for jobs in the future.

This report provides findings from a series of foresighting analyses that evaluate the main technological, industrial, and scientific advances and disruptions within the blue economy at a global level, and applies these insights to inform new lines of economic and sustainability risks and returns at the regional level and within specific country contexts (**Figure 2**).

Figure 2: Overview of foresighting toolkit, including series of analyses and scorecard to rank initiatives. Stage 1: Evaluation of innovations in the blue economy space to identify trends, focusing on Breakthroughs, Contradictions, Extremes and Rarities.[4] Stage 2: Identify patterns in common challenges (Systemic Barriers) and forces for progress (Drivers, Enabling Conditions, and Design Principles). Stage 3: Regional analysis to determine how System Barriers manifest and current status of enabling conditions on the ground. Stage 4: identify promising Opportunity Areas that appear ripe for development, factoring in regional context. Stage 5: Ideate potential initiatives within Opportunity Areas, based on country-level investigations. Stage 6: evaluate initiative ideas using SIDS blue economy rapid assessment tool (see Appendix C for details).



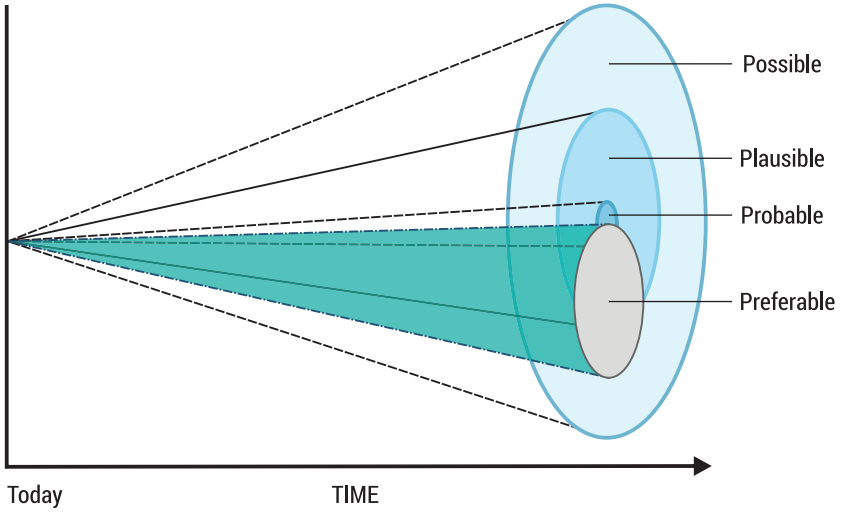
This process can also be mapped to a more typical Futures Cone (**Figure 3**), sensu Voros (2017), but slightly modified.[5] First, analytical foresighting was used to examine current trends in innovation across traditional and emergent blue economy sectors. This first analysis describes the "Possible" future, in terms of what might happen based on the very leading edge of innovation in the blue economy space. This future requires we gain additional knowledge before that future could be truly realized, and therefore it remains broad, and uncertain. The second analysis evaluates the forces that contribute to successful blue economy development (Drivers, Enabling Conditions, and System Design Principles) and the factors that continue to stymie progress (System Barriers). This helps narrow the realm of possible into what is "plausible," what could happen based on current trends. Third, we conduct a regional analysis to understand specific constraints, exploring how system barriers manifest and unique assets that may exist within the region. This analysis informs a discussion of what is most "Probable." The next step is to generate Opportunity Areas; these factor in regional and temporal considerations, including COVID-19 pandemic and country-specific assets. By design, the Opportunity Areas push the system towards a future that is "Preferable" and may include ideas for action that are both probable and perhaps

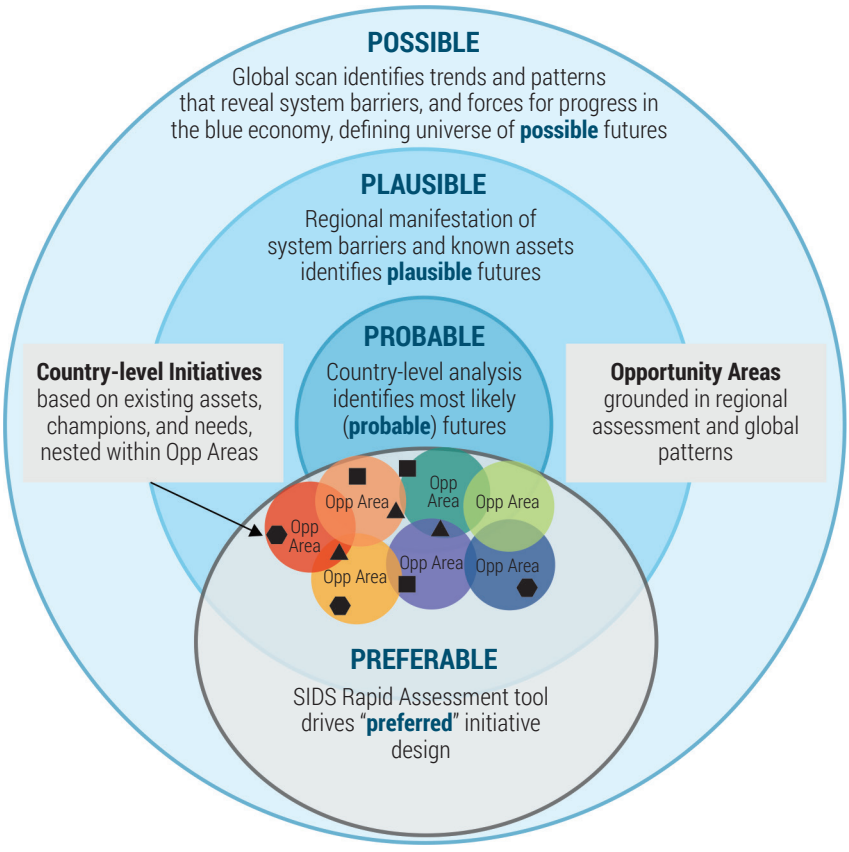
[4] The Future Today Institute. "Strategic Futurist Tools and Frameworks." The Future Today Institute, futuretodayinstitute.com/foresight-tools-2.

[5] Voros, Joseph. "The Futures Cone, Use and History." *The Voroscope*, 24 Feb. 2017, thevoroscope.com/2017/02/24/the-futures-cone-use-and-history.

slightly more risky but still likely (Plausible). *Opportunity Areas reflect where to focus energy and resources to accelerate and maximize success of blue economy projects that lift up communities, improve local economies, and preserve and protect the underlying ocean ecosystem upon which the entire blue economy depends.*

Figure 3: Upper: Typical Futures Cone, modified from Voros, 2017, showing the four traditional categories of futures and degree of uncertainty (size of cone) as function of time. Bottom: modified Futures Cone, showing role of different analyses within this foresighting toolkit to move from ideas and scenarios from Possible to Preferable future state.





Finally, we analyzed existing and potentially new initiatives within the various Opportunity Areas, based on specific momentum and challenges that exist within each country. To compare and assess priority initiatives, we then developed and applied a new SIDS blue economy Rapid Assessment Tool and used this tool to evaluate potential country-specific initiatives. The Rapid Assessment Tool allows practitioners and funders to assess impact and feasibility of initiatives, and thereby determine a robust portfolio of projects that, if supported, can help address short and long-term strategic growth of the blue economy. The potential project initiatives are focused on six target countries in the Caribbean: Jamaica, Bahamas, Barbados, Suriname, Guyana, and Trinidad and Tobago.

Global Scan: Blue Economy Industries and Technologies

2

Overview of the Blue Economy 2020

The "blue economy" reflects a fundamentally new approach to economic development. Marrying sustainable development with green growth, the blue economy explicitly seeks to foster social inclusion, environmental sustainability, and economic growth linked with improved livelihoods. The concept specifically integrates (and depends upon) healthy marine environments with robust coastal zone economies.[6] This dual approach requires a high level of coordination and planning; it also forces equal consideration for conservation—and where needed, restoration—alongside job creation and economic growth. In the balance between sustainability and growth lies enormous opportunity, including the chance to drive more competitive and knowledge-based economies.

The term "blue economy" first emerged as part of the United Nations Conference on Sustainable Development in Rio (Rio+20) in 2012. Not surprising, the concept was pioneered by Small Island Developing States (SIDS), whose economies and cultures are highly dependent upon the sea. But the popularity of this framework for sustainable development has continued to increase, and today, coastal countries around the world are investigating how to best develop their blue economy. And the potential is enormous.

Today, 90% of all internationally traded goods occur by sea; the abundance of fish from wild capture seafood and aquaculture provides 15% of humanity's protein needs. Generating close to seven trillion US$ per year, ocean activities from sectors such as fishing, aquaculture, shipping, and tourism create hundreds of millions of jobs. Meanwhile, the physical and chemical properties of the ocean have absorbed nearly 30% of all carbon dioxide emissions and absorbed 90% of the additional heat trapped in the atmosphere, significantly slowing the rate of climate change. Marine ecosystems such as seagrass beds, mangroves, and coral reefs provide coastal protection from rising seas and storms and generate the coastlines which are coveted by resorts and home-owners alike. Deeper below the surface, new biological and mineral resources are contributing to advanced material science and electronics, and life-saving medicinals.

Especially for resource-limited SIDS, the oceans provide an unprecedented three-dimensional cornucopia of opportunity—a treasure trove that continues to grow as new technologies provide greater access, and new models allow for smarter management and planning.

[6] World Bank and United Nations Department of Economic and Social Affairs. 2017. The Potential of the Blue Economy: Increasing Long-term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Coastal Least Developed Countries. World Bank, Washington DC.

Not all technological trends are positive, and developments such as automation of traditional tasks, must be considered carefully to avoid unsupported job loss. To realize the full potential of the blue economy—including its ability to increase economic opportunity for local communities—will require significant investment across infrastructural, political, knowledge, and cultural dimensions of the complex human-ecological system that forms its foundation. Vigilance to avoid the historical trap of resource extraction at the expense of local community welfare and long-term health of marine ecosystems is also required.

Covid Context

As the COVID-19 pandemic continues to spread across the globe—inflicting severe human and economic costs–so too the highly tourism-dependent Caribbean countries have been hard hit. Most Caribbean countries have taken strong containment measures, such as border closures and lockdowns, to flatten the curve. This sudden stop in tourism is sharply slowing economic activity in the Caribbean, and growth in the region is projected by the IMF to contract by 6.2 percent in 2020. As the COVID-19 pandemic continues to spread across the globe—inflicting severe human and economic costs—so too our Caribbean countries have been hard hit.

Three of our six countries are highly dependent on tourism—The Bahamas, Barbados, and Jamaica—accounting for 30-50 percent of GDP and employment and are hit hard by the collapse of the tourism sector. The global cruise line and airline industries have ground to a halt with major cruise companies canceling sailing through August and most airlines drastically reducing or suspending service to the Caribbean region. On the demand side, North America and Europe are crippled by the pandemic resulting in massive travel and hotel booking cancellations and the shutdown of resorts, restaurants, entertainment, and the entire tourism value chain—putting thousands of people in the service sector out of work.

Meanwhile, the remaining three countries—Guyana, Suriname, and Trinidad and Tobago—are, as primarily commodity exporters (Guyana, oil and gold; Suriname, gold; Trinidad and Tobago, oil and gas), severely impacted by the steep drop in commodity prices as their exports and fiscal revenues have fallen. Energy companies are likely to be cutting back production plans in anticipation of weaker energy demand resulting from a contraction in global manufacturing activity.

Hence, the economies of all six countries targeted for this blue economic opportunity report are brought to their knees, with no foreseeable end in sight. **Table 1** shows negative projected GDP growth rates for five of the six countries, and Guyana projected hyper-growth rate due to oil revenues was significantly reduced to reflect the impact of the pandemic and drop in world price for oil. The UN's Economic Commission for Latin America and the Caribbean (ECLAC) reported that, "The Latin American and Caribbean region will suffer the worst crisis in its history in 2020, with a 5.3% drop in GDP. A contraction of comparable magnitude has not occurred since the

Great Depression of 1930 (-5%) or even since 1914 (-4.9%)."[7] ECLAC projects the following growth rates among the 6 countries.

Table 1: Projected GDP Growth Rate for Six Target Countries of the Caribbean 2020.

Country	Projected GDP Growth Rate 2020
Bahamas	-6.8%
Barbados	-5.8%
Guyana	56.4%
Jamaica	-5.3%
Suriname	-4.4%
Trinidad and Tobago	-5.0%

Note: Guyana's projected growth rate in January 2020 was 86%, and the current 56.4% growth rate may be downgraded due to possible oil price reductions and production delays.
Source: UN ECLAC.

The economies of these countries will be severely impacted during 2020 and into 2021. The exception is Guyana, which may be less impacted due to the recent discovery and development of offshore oil and gas.

In the long term, the pandemic will leave lasting damage on these vulnerable countries through multiple channels, including lower investment, erosion of physical and human capital due to the closure of businesses and loss of schooling and jobs, and a retreat from global trade and supply linkages.[8] Moreover, the scope and speed with which the COVID-19 pandemic and economic shutdown have devastated the poor around the world are unprecedented in modern times. Thousands of already vulnerable people in the Caribbean are likely to be pushed deeper into extreme poverty in 2020.

Whereas the initial aim of this project was to "identify current blue economy technology trends and opportunities and create knowledge and technical capacity for expanding current economic activities and creating new ones for six Caribbean countries," because of the COVID-19 pandemic's major economic impacts on the Caribbean, the IDB and project team have decided to "pivot" the project's objectives toward strongly supporting economic recovery, job creation and attention to vulnerable populations, while addressing blue economy opportunities. Thus, in this report we are focusing on identifying blue economy opportunities and initiatives which contribute to generating employment of and livelihood for vulnerable populations in our six Caribbean countries.

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[7] United Nations. COVID-19 Special Report Measuring the Impact of COVID-19 with a view to reactivation. Economic Commission for Latin America and the Caribbean (ECLAC). No. 2, 2020.

[8] Global Economic Prospects. "Global Economic Prospects, June 2020." *Global Economic Prospects, 2020*, Ch. 3, pp. 133–79. Crossref, doi:10.1596/978-1-4648-1553-9.

Trends within Blue Economy Industry Sectors

The following section provides a high-level landscape of eleven blue economy sectors (Figure 1).

The summaries contain an overview of the sector and trends within it, and a selection of specific initiatives or businesses that serve as examples of leading-edge approaches. A more complete summary for each industry sector, including factors that drive growth and known risks and uncertainties, is provided in **Appendix A**.

Mature, Existing Blue Economy Sectors

Fishing, Tourism (Cruise, Coastal, Marine), Shipping, and Oil and Gas

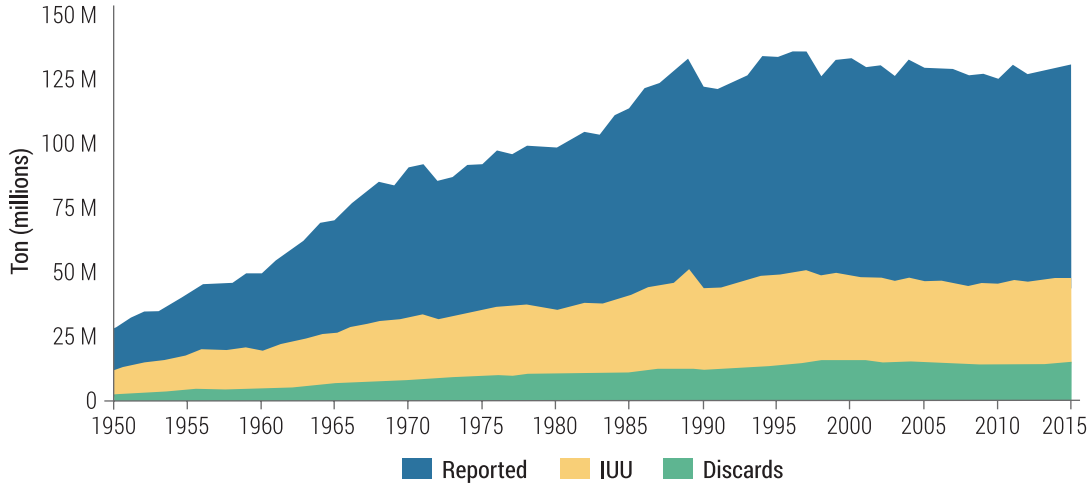
Fishing

Overview

Wild capture fisheries serve an important role in the blue economy, especially in SIDS, as a source of both economic value and food security for communities. At the global level, wild capture fisheries produce approximately 90 million metric tons[9], with a significant portion of that catch unreported, or illegally caught (**Figure 4**).

[9] FAO. The State of World Fisheries and Aquaculture (SOFIA) - Meeting the Sustainable Development Goals, Food and Agriculture Organization, Rome, Italy, 2018.

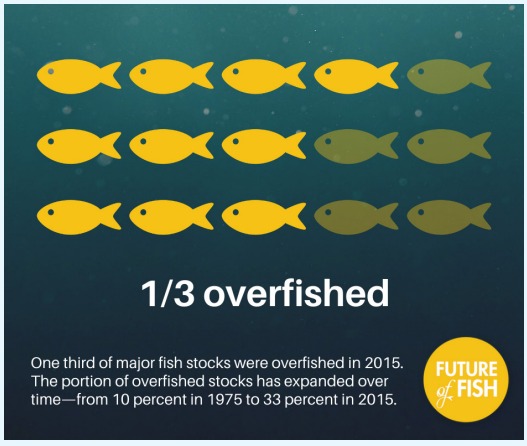
Figure 4: Proportion of Global Wild Capture Fisheries that is Reported, IUU (Illegal, Unreported, and Unregulated), and Discarded.



Data from Watson, Reg A., and A. Tidd. "Mapping Nearly a Century and a Half of Global Marine Fishing: 1869–2015." Marine Policy 93 (July 2018): 171–77 and sourced from OurSharedSeas.

Key Trends

- Rising demand for seafood globally has contributed to overexploitation of fish stocks.
- Significant lack of data affects most fisheries.
- The application of marine GIS and spatial planning allows more streamlined and integrated management by providing detailed information on habitat mapping, species distribution and abundance, the relationship between fish occurrence and oceanographic variables, as well as fishers' activities.
- Increased emphasis on traceability and data-rich supply chains has fueled new business strategies that highlight the origin and even the specific fisher, as part of consumer-facing marketing.
- Interest in more sustainable seafood includes growing pressure to reduce waste and bycatch.



Innovative Models and Initiatives

- Pacifical Tuna Company, Western Pacific Island countries
  A global marketing and distribution company for sustainable tuna (MSC certified) operating within the EEZ of the eight countries of the Parties of the Nauru Agreement (PNA).
- The company operates under 50/50 ownership between PNA and Sustainable b.v. and relies on a combination of novel models for fishery and business management based on:
  - A strictly managed vessel day scheme (VDS) which allocates tradable fishing days among the parties with controlled pricing for access.
  - IFIMS, the world's first database that combines information from data systems from PNA member countries, the fishing industry, and flag states, integrating fisheries management, compliance, and marketing.
  - Blockchain technology for traceability and consumer-facing branding.

- SmartFish Group, Massachusetts, United States of America
  - Hybrid model developed to support local fisheries in Mexico.
  - Non-profit arm provides capacity building and technical training for fishers, mostly focused around quality improvements and basic finance literacy, along with improved environmental performance.
  - The for-profit arm, SmartFish Inc., works to be an honest broker that provides distribution and marketing, paying premium prices to fishers in exchange for reliable, sustainable, and good quality products that can be sold into local restaurants and other outlets. SmartFish Inc. handles promotion and marketing and branding.

- Abalobi Initiative & App Suite, Cape Town, South Africa
  - Social enterprise with traditional fishers taking centre stage, that supports climate-smart, equitable, sustainable small-scale fisheries through integration of ICT.
  - ABALOBI, as a mobile app suite and programme, is aimed at social justice and poverty alleviation in the small-scale fisheries chain. Their program provides training to improve knowledge, stewardship of marine resources, and resilience-building in the face of climate change.
  - The ABALOBI app suite comprises five inter-connected apps – conceptualized in a co-design process and currently in various stages of development and testing. The five apps cover the full spectrum of stakeholders in the small-scale fisheries sector, with services ranging from traceability data analysis to an online marketplace.[10]

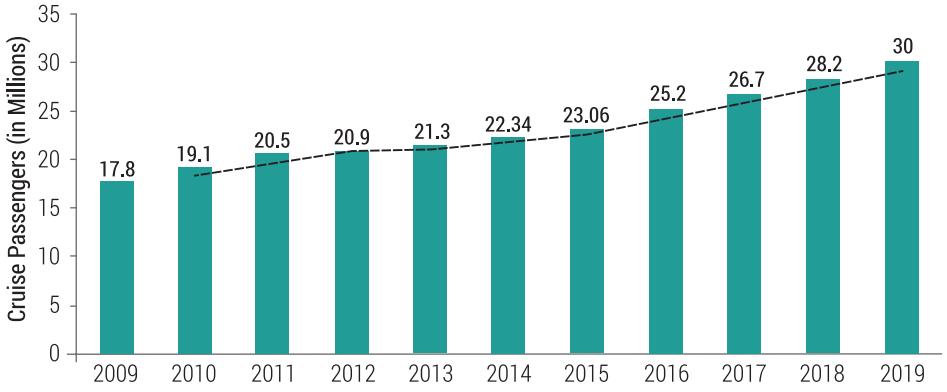
[10] ABALOBI. ABALOBI ICT4FISHERIES, abalobi.info. Accessed 14 June 2020.

Tourism (Cruise, Coastal, Marine)

Overview

Tourism is a major component of the economy of the Caribbean, with 70.3 million tourists in 2016 and an anticipated growth of between 2% and 3% in tourist arrivals for 2018. In 2017, the travel and tourism industry accounted for 20% of GDP and 19% of employment in the region. The sector can broadly be categorized into 3 sub-sectors: 1) Cruise Tourism: Ship-based tourism from vessels making multiple stops in the region and beyond; 2) Coastal Tourism: Hotels and resorts along the shore; 3) Marine Tourism: Recreational, educational, and ecotourism activities.

Figure 5: Global Ocean Cruise Passengers (in millions) 2019-2019.



Source: Global Ocean Cruise (2018). CLIA, 2018. https://cruising.org/news-and-research/-/media/CLIA/Research/CLIA%202019%20State%20of%20the%20Industry.pdf.

Key Trends

- Before the COVID-19 outbreak, coastal tourism was expected to grow significantly and likely at a faster rate than tourism as a whole.[11] However, a rapid recovery is unlikely to happen in 2020.
- Europe was expected to be the region concentrating the most tourist arrivals with over 700 million international arrivals, followed by Asia and the Pacific with over 500 million arrivals in 2030[12].
- Marine tourism is a viable pathway to support conservation of marine biodiversity while maintaining economic value.

[11] World Bank Group, 2030.
[12] OECD (2016), *The Ocean Economy in 2030*, OECD Publishing, Paris, https://doi.org/10.1787/9789264251724-en.

Innovative Models and Initiatives

- Virtual Reality (VR) Tourism, Hawai'i, USA
  - The Vessel at Naupaka Spa & Wellness Centre at Four Seasons Resort Oahu offers a series of "customised journeys", such as Deep Space, Ocean Cove, and Lost Jungle. In the Vessel users can see, hear, smell, feel, and touch their surroundings. All sensory environments are integrated (stereoscopic visuals, spatial audio, scent, vibroacoustics, proprioception, wind and temperature) with real-time, physiological data collection (onboard sensors recording respiration, heart rate, electrodermal activity and electroencephalography) to enable the generation of dynamic, closed-loop experiences.[13]

- Diaspora Repatriation Program, In design
  - The future of foreign exchange earnings in the islands requires a transition from the traditional tourism sector, to a smaller, highly skilled number of people who come and make their home on the islands, bringing their foreign exchange income with them. These opportunities can be capitalized on from the repatriation of island diaspora and rebuilding on the indigenous human capacity.

- Wildsea Europea, Europe
  - Efforts are underway to create Discovery Journeys of Europe's Marine Biodiversity through Water Sports & Coastal Trails. This initiative is working to develop a transnational, sustainable tourism route connecting European coastal destinations with unique marine landscapes and biodiversity, flowing from the Atlantic Ocean to the Mediterranean.

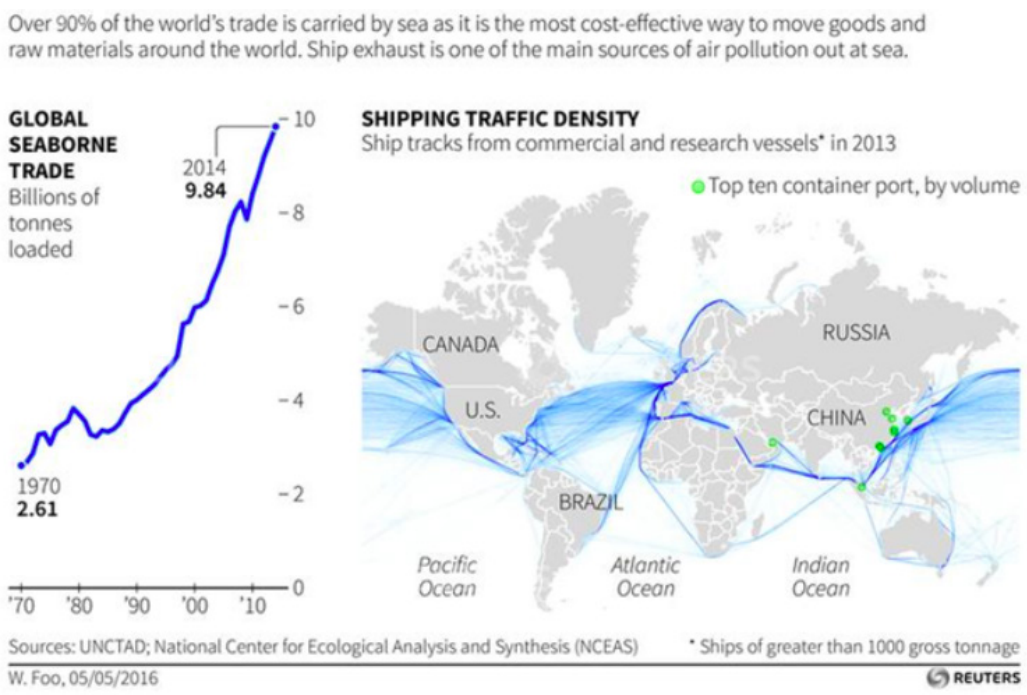
Shipping

Overview

Global seaborne trade has experienced tremendous growth over past decades rising from 2.6 billion tons loaded in 1970 to 9.8 billion in 2014 (**Figure 6**). Access to foreign resources, commodities, and fuels has helped drive economic expansion in recent decades. The significant role of maritime transport in supporting growth of the global economy shows little sign of slowing. Even in the face of the COVID-19 pandemic, it is uncertain that a shift in focus towards localized economies will counteract the world's reliance on international shipping as a necessity for economic growth.

[13] Four Seasons. "Four Seasons Resort Oahu at Ko Olina and Sensync Partner to Introduce the World's First Multi-Sensory Virtual Reality Wellness Experience: The Vessel, Featuring Deep Brain Massage." Four Seasons Press Room, 28 Nov. 2019, press.fourseasons.com/oahu/hotel-news/2019/the-vessel-immersive-sensory-experience.

Figure 6: Global Shipping Density.



Source: UNCTAD, NCEAS.

Key Trends

- Recent years have witnessed a rise in application of digital software technologies to improve coordination, regulation, and efficiencies in the global shipping industry.
- Greening of the global shipping industry is also underway, driven by international regulations, positive incentive programs, and advancements in new technologies, especially regarding decarbonization of shipping and cleaning of air emissions.
- Within the Caribbean region, a growth of the shipping sector coincided with the 2016 widening of the Panama Canal.[14]

Innovative Models and Initiatives

- Transition to Liquified Natural Gas (LNG), Puerto Rico[15]
  - Due to a lack of regulatory legislation regarding fuel quality, the majority of existing cargo ships are significant emitters of pollutants, affecting air quality in port areas or frequently used shipping lanes.

[14] Ewing-Chow, Daphne. "The Caribbean's Share in The Global Cargo Industry Is Growing Rapidly." *Forbes*, 21 May 2019, www.forbes.com/sites/daphneewingchow/2019/05/21/the-caribbeans-share-in-the-global-cargo-industry-is-growing-rapidly/#3413d8ea61a2.

[15] Interview with an expert. Due to privacy policies name has been omitted.

- Switching to LNG is one way to decrease the amount of harmful particulates, volatile organic compounds, and other pollutants (such as ozone) created by the shipping industry.
- Puerto Rico is considering this transition by tapping into the cheap natural gas that is being produced through hydraulic fracturing throughout the US.

- The CargoX Platform for Blockchain Document Transfer (BDT), International
  - CargoX is a secure platform enabling confidential trade information to be securely transferred through a digital environment.
  - A Smart B/L (or SmartBL) is an electronic bill of lading, sent through the CargoX Platform for Blockchain Document Transfer (BDT) or any other electronic platform, and is specifically designed to decrease the paperwork burden for shipping agencies. A smart B/L can be uploaded in the form of PDF (or any other type of document), or created as a structured data document and then sent or transferred on the platform.
  - Ownership of the smart B/L document is transacted to the new owner, who can legally claim ownership rights. Recipients can always validate the original source and prove ownership of their documents, and a comprehensive document repository is available with audit logs.[16]

- TradeLens, International
  - TradeLens is an interconnected group of supply chain partners; including cargo owners, ocean and inland carriers, freight forwarders and logistics providers, ports and terminals, and customs authorities.
  - TradeLens software allows users to access a supply chain and logistics network with data coverage of over half of global container shipping volumes. The program runs on a designated permission matrix and blockchain, ensuring every party to a shipment has access only to their information, as well as a secure audit trail of all transactions. The systems is connected to a global platform built on open-source technology and publicly-available APIs.[17]

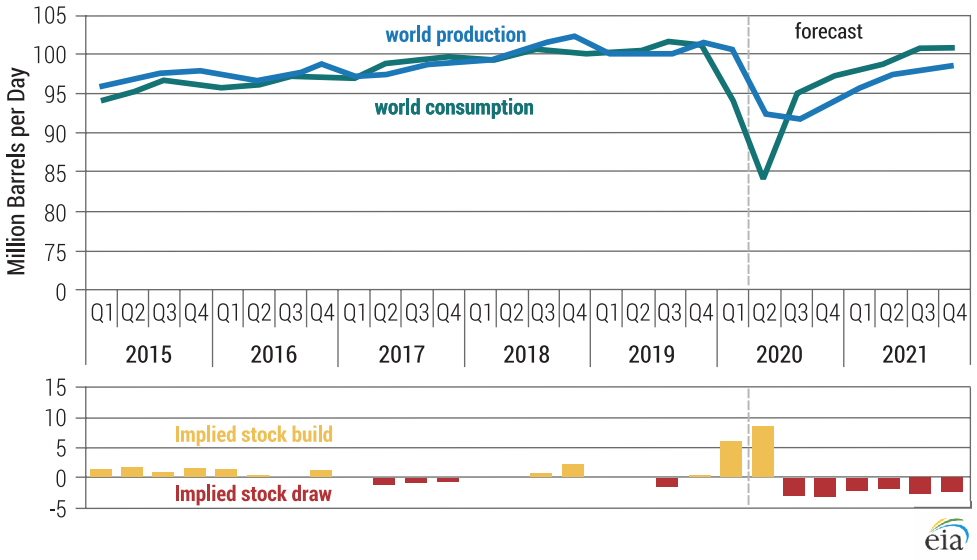
Offshore Oil and Gas

Overview

Offshore oil and gas face numerous challenges ranging from weak market demand and oversupply, to concerns about safety and the ocean environment, to the momentum gathering behind efforts to decarbonize the global economy. COVID-19-related shutdowns have only exacerbated already falling oil prices throughout much of the world. As shown in the **Figure 7**, oil and gas demand and production are forecasted by the US. Energy Information Administration to drop precipitously during 2020 and recover in 2021.

[16] "CargoX for Transport and Logistics." CargoX, cargox.io/solutions/for-transport-and-logistics. Accessed 14 June 2020.
[17] TradeLens - Digitizing Global Supply Chains." TradeLens, www.tradelens.com. Accessed 14 June 2020.

Figure 7: World Liquid Fuels Production and Consumption Balance.



Source: EIA (2020).

Among existing blue economy sectors, the offshore oil and gas industry contributes the highest gross value to the ocean economy.[18]

Key Trends

- Offshore oil production will significantly increase in the upcoming years, with a larger proportion of deep water facilities and a relative decrease in shallow-water fields.[19] Offshore oil is expected to account for about 30 percent of new crude production, with roughly half of the total offshore volume coming from deepwater and higher-cost ultra deepwater resources by 2035.[20]
- While important offshore fields are being exploited in Guyana and Suriname, other Caribbean countries might offer great potential for the industry, including in Cuba, the Dominican Republic, Jamaica, Honduras, Nicaragua and the Bahamas. Meanwhile, Trinidad and Tobago holds one of the most coveted oil and gas basins in the world.[21]
- Offshore oil and gas production represented approximately a third of value added by ocean-based industries, according to the OECD.[22]

[18] OECD (2016), *The Ocean Economy in 2030*, OECD Publishing, Paris, https://doi.org/10.1787/9789264251724-en.
[19] OECD (2016), *The Ocean Economy in 2030*, OECD Publishing, Paris, https://doi.org/10.1787/9789264251724-en.
[20] McKinsey & Company. "Offshore-Drilling Outlook to 2035." *McKinsey & Company*, 30 May 2019, www.mckinsey.com/industries/oil-and-gas/our-insights/offshore-drilling-outlook-to-2035#.
[21] GEO ExPro. "Promising Oil and Gas Opportunities in the Caribbean." *GEO ExPro*, 30 Sept. 2019, www.geoexpro.com/articles/2019/09/promising-oil-and-gas-opportunities-in-the-caribbean.
[22] OECD (2016), *The Ocean Economy in 2030*, OECD Publishing, Paris, https://doi.org/10.1787/9789264251724-en.

Innovative Models and Initiatives

- Government Incentive Structures for Research and Development, France[23, 24]
  - In France, the government has implemented an incentive structure by providing tax credits to the service companies which manufacture and maintain equipment and technology that is used by oil and gas operators and invest in oil and gas research at universities for the continual improvement of technology and processes applied by operators in the field.

- Private Sector Utilizing Oil and Gas Expertise for Expanding Offshore Renewable Energy, Norway[25]
  - While originally a strictly oil and gas operator, Equinor is an international energy company based in Norway that has built offshore renewable energy production, namely wind and solar, into their business model. By using their experience in ocean engineering, they aim to become a leader in the offshore renewable energy field; with operational projects already taking place in and around the North Sea as well as emerging work off of the east coast of the U.S.

- Regional Oil Spill Contingency Plan, ASEAN Member States[26]
  - Member states of the Association of Southeast Asian Nations adopted a cooperation mechanism in 2018 to bolster transparency, understanding, and communication in responding to oil spills in the region. Through this plan, member states can request and provide mutual support in the event of any oil spill, which ultimately aims to address oil spills and their regional impact more effectively.

Growth Industry Sectors

Mariculture, Maritime Safety and Surveillance, Ports, Renewable Energy (Wind and Solar)

[23] OECD (2020), Compendium of Information on R&D Tax Incentives, 2019, OECD. https://www.oecd.org/sti/rd-tax-stats-compendium.pdf

[24] Interview with an expert. Due to privacy policies name has been omitted.

[25] Equinor. Equinor ASA, www.equinor.com. Accessed 14 June 2020.

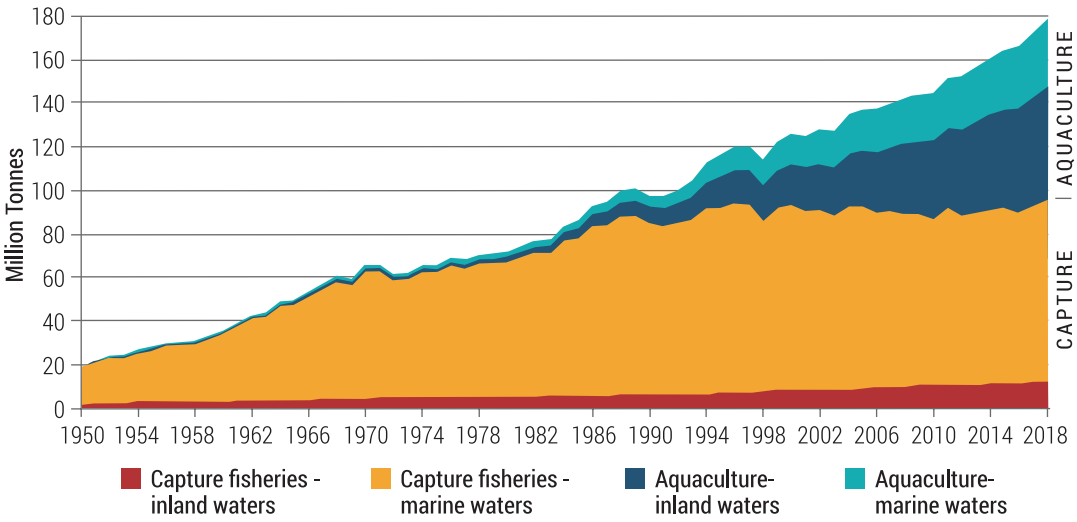
[26] "ASEAN Member States Adopt Regional Oil Spill Contingency Plan." Offshore Energy, Navingo, 3 Dec. 2018, www.offshore-energy.biz/asean-member-states-adopt-regional-oil-spill-contingency-plan.

Mariculture

Overview

Mariculture is the division of aquaculture that is focused on cultivation of marine organisms (i.e. those that live in saltwater) and is a quickly evolving sector within blue economies around the globe (**Figure 8**). Mariculture, in the context of this report, also includes seaweed farming (but note seaweeds excluded from Figure 8). From large-scale operations in China to small-holder farms in New England, USA, there are a diversity of approaches with two major strategies for development: (1) larger-scale, high-capital-cost offshore operations and (2) small-scale, coastal farms, which can be integrated into coastal habitats such as mangroves, or be farther from the coast but still in relatively shallow waters. In some cases, on-shore recirculating systems can include marine species, drawing seawater from nearby, but production from these facilities remains relatively limited to date.

Figure 8: Total Aquaculture and Wild Capture Fisheries Production. Marine Aquaculture (mariculture) Production reached 31 million tonnes in 2018.



Note: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants.
Source: FAO.

Key Trends

- *At the industrial or commercial level, mariculture tends to be single-species in focus, but there is an increasing trend towards integrated multi-species approaches, including finfish, shellfish, and seaweeds.*[27]

[27] Multi-species or more specifically, "multi-trophic" aquaculture (IMTA) is based on the premise that reduced waste and greater efficiencies can arise by integrating different types of animals and plants, whereby one species utilizes the waste product of another. See here for more details: https://www.dfo-mpo.gc.ca/aquaculture/sci-res/imta-amti/index-eng.htm.

- *Diversification beyond food:* Historically, the vast majority of mariculture has focused on raising products for human consumption, including seaweed and finfish, the latter dominated by the lucrative salmon farms and more recently, white fish such as seabass, in the Mediterranean.
- *Research and development for farmed fish health:* A significant amount of research and technological innovation is happening within the aquaculture sector aimed at reducing disease and increasing health of target species.
- *Movement away from fish-based feeds to those that rely on plant or insect-based proteins or utilize scraps from seafood processing.*[28]

Innovative Models and Initiatives

- Green Wave: restorative ocean farming[29]
  - Small-scale farming that integrates seaweeds and shellfish to produce commercial products for food, fertilizer, and bioplastics all without any inputs.
  - Hybrid business model that includes a non-profit training for small holder farmers and hatchery, marketing, and processing businesses. The model includes 25 to 50 regenerative ocean farms in each "Reef" unit, a land-based hatchery and processing hub, and institutional buyers and entrepreneurs developing value-added products. The scale model is to replicate these Reefs up and down coastlines.
  - Blue carbon and nitrogen capture by seaweeds and storm wave protection via seaweed and reef structures.
- JALA water quality monitoring for small-scale shrimp farmers[30]
  - Women-led, Indonesian tech start-up that focuses on affordable water quality monitoring devices to support small-scale shrimp farmers to keep their farms healthy, reducing pressure to cut-down mangroves for new farms.
  - Provides data analysis and decision-support regarding ideal time for harvest, shrimp growth/health, and farm finances.
  - Meta-data from multiple users allows for improved analytics that are then shared back with the community of farmers using the sensors.
- Earth Ocean Farms, Mexico[31]
  - Offshore submersible cages for growing finfish (Red Snapper and Totoaba) that provides skilled jobs and new economic opportunity for local communities

[28] Hasan, Anwar, and Justin Tan. "The Current State of Plant-Based Proteins in Aquaculture Feed." *Biomin*, 10 Feb. 2020, www.biomin.net/science-hub/the-current-state-of-plant-based-proteins-in-aquaculture-feed.
[29] Green Wave: GreenWave.org
[30] JALA. "Jala: Solusi Digital Untuk Kesuksesan Tambak Udang Anda." *Jala*, 13 June 2020, jala.tech/id.
[31] Earth Ocean Farm: EarthOceanFarm.com

- Restocking program helps recover the Totoaba, an endangered species by releasing juveniles grown in hatchery back to the wild
- Cages sit in deep water with strong currents, minimizing impact to environment
- Fully traceable product with use of QR codes from farm to fork.

Maritime Safety and Surveillance

Overview

Maritime safety and surveillance is the protection of vessels, ports and other infrastructure related to the shipping business from intentional damage. Maritime security provides advanced technology to detect hazards and communicate with officials and includes technologies such as surveillance and tracking, communications. It is important because the quality of life on islands and in peripheral maritime regions depends on maritime transport services, which enables trade and contacts between Caribbean ports and provides for Caribbean imports and exports with the rest of the world. The maritime safety and surveillance sector are both an enabler of the blue economy as well a source of traditional economic development. As blue economy industries continue to grow, demand for strong safety and surveillance will help to ensure the longevity, stability, and success of emerging sectors and maritime assets.

Key Trends

- *Regional multinational alliances for surveillance and monitoring*: There is an increasing need for sharing and integrating intelligence, surveillance, and navigation systems into a common operating picture can help Caribbean small states to prepare for, prevent, respond to, and recover from a broad spectrum of potential maritime-related threats, allowing limited resources to be more effectively deployed.
- *Use of big data for better analytics*. The database allows for the storage, exchange and analysis of data on marine casualties and incidents. The shared use of those data will further develop the accident investigation capabilities and contribute to improve maritime safety and the prevention of pollution by ships in the Caribbean region.
- *Smart vessels and ports*: The transportation industry is changing at a rapid pace due to globalization. Increase in international shipping also gives rise to the importance of maritime security. There is an increase in smart boats and advanced facilities and improvement in security and safety regulations is trending in emerging markets.

Innovative Models and Initiatives

- Sea-vision System and Mercury System, Kenya[32]
  - The Regional Maritime Rescue Coordination Center in Mombasa, Kenya, uses a combined security system that provides real-time satellite pictures of vessel movement in the region paired with streamlined communications to naval assets in the western Indian Ocean.
  - A key element of success is the reciprocal relationship between local fishermen and the Centre, as the Centre provides emergency and best business practices training to fishermen, while the fishermen in turn provide human intelligence on illegal activity and illicit threats in the maritime space.

- Stable Seas, International
  - Stable Seas is a program of One Earth Future that engages the international security community with novel research on illicit maritime activities such as piracy and armed robbery, trafficking and smuggling in persons, illegal unregulated and unreported fishing (IUU), and illicit trades in weapons, drugs, and other contraband.
  - The project looks at how a broad array of maritime crimes are able to flourish in environments with limited maritime governance, as well as gaining a better understanding of how these crimes at sea contribute to instability ashore, so that relevant stakeholders can better identify and implement comprehensive solutions.[33]

- Fish-i Africa, East Africa/Western Indian Ocean
  - Fish-i is a partnership of eight East African countries – Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and Tanzania. The group unites national enforcement authorities, regional organisations, and international technical and legal experts to combat large-scale illegal fishing in the Western Indian Ocean through information-sharing and regional cooperation.
  - The partnership is supplemented with the use of technologies that enables the sharing of real-time information and intelligence and coordination of actions taken against vessels suspected of operating illegally.[34]

Ports

Overview

Ports are an integral component of development for the blue economy. As logistically significant nodes for shipping, the point of entry for cruise tourism, and key leveraging tools for international trade capacity and negotiation, the sustainable development of ports in the Caribbean is critical to economic development.

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[32] Robert McCabe (2019) Policing the Seas: Building Constabulary Maritime Governance in the Horn of Africa – The Case of Djibouti and Kenya, African Security, 12:3-4, 330-355, DOI: 10.1080/19392206.2019.1667053

[33] One Earth Future. "Stable Seas." One Earth Future, oneearthfuture.org/stable-seas. Accessed 26 June 2020.

[34] Orbital Design. "FISH-i Africa." Stop Illegal Fishing, 29 Jan. 2020, stopillegalfishing.com/initiatives/fish-i-africa.

Ports are not only hubs of commerce, tourism, and transport, but also essential pieces of infrastructure for SIDS that represent national policies and pride. Yet, their success is dependent on a complex web of relationships with neighboring countries, international trading partners, the private sector, and multilateral institutions. Investments into ports could act as opportunities to set into place new national policies, develop new international partnerships, and promote the development of the surrounding area and country.

Key Trends

- *Increase in understanding and application of the role of ports in relation to illegal activities*: Ports are critical to controlling illegal and unsustainable activities at sea, via surveillance and inspection activities by port authorities. This is especially being applied to fishing through application of the UN Food and Agriculture Organization Agreement on Port State Measures to Prevent, Deter, and Eliminate Illegal, Unreported, and Unregulated Fishing.
- *Digital technology and automation of port operations*: Ports and terminal operations increasingly rely on digital information supplied by sensors and Internet of Things to improve efficiency, reduce costs, improve safety, reduce environmental impacts, etc. Related to this is a trend towards the automation of equipment and operations.
- *Green ports*: There is considerable effort around the world by a growing number of ports to reduce the impacts of ports on public health, local communities, air quality, water quality, marine ecosystem health and local infrastructure.

Innovative Models and Initiatives

- Providing On-Shore Power Through an Increasing Share of Renewable Energy, Amsterdam, Netherlands[35]
  - The port of Amsterdam is focused on decentralizing their energy system through the implementation of a smart grid that allows for flexible power generation between a mix of energy sources and storage mechanisms.
  - To create and support this system, authorities are investing in local renewable energy technologies as early as possible to increase the share of renewable energy used by the port as a way to reduce air pollution and reduce long-term costs of expansion.

- Utilization of Ports as a Hub for Innovation and Entrepreneurship, California, USA[36]
  - The Port of San Diego has developed a "blue economy Incubator," inviting private companies from around the world to apply to have their businesses jump-started in the Port of San Diego with the assistance and capital of the local marine economy experts.

[35] Port of Amsterdam. The Sustainable Port. 2017, https://www.portofamsterdam.com/sites/poa/files/media/havenbedrijf/duurzaamheidsplan_en_digitaal_2017.pdf

[36] Blue Economy Incubator Highlights Q1FY20

- This has resulted in the development of cross-sectoral partnerships with ports:
  - Aquaculture: San Diego Bay Aquaculture is using floating barges with artificial upwelling propellers as a shellfish nursery. Sunken Seaweed grown below the dock is simultaneously piloting the passive growth of carbon sequestering algae.
  - Recreation/Tourism: Swell Advantage is creating a digital logistics platform for all of San Diego's marinas to streamline docking processes and implement a floating boat wash, which will phase out the need for antifouling agents.
  - Coastal Development: ECOncrete is developing biophilic concrete for use in coastal development, a grey-blue initiative that prevents erosion while attracting intertidal zone organisms to act as a natural buffer from flood waters and rising sea levels.

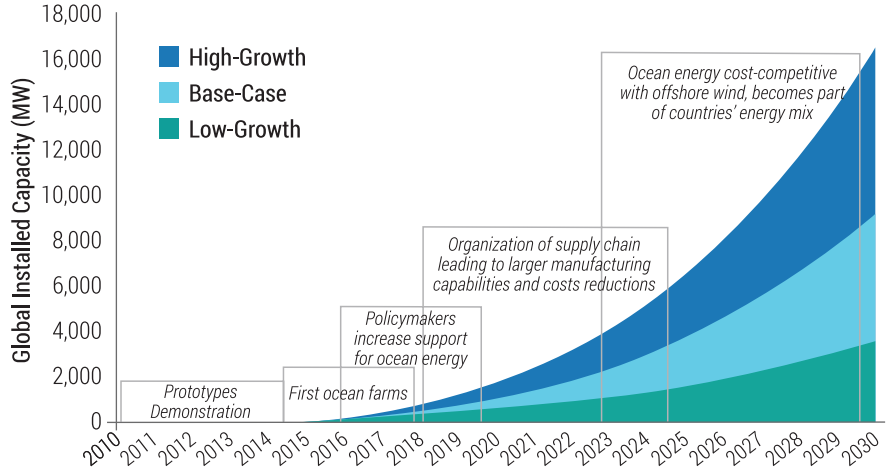
- International Port Collaborative Decision Making Council, International
  - The Port Collaborative Decision Making council (PortCDM) is a global collaboration to create and record the guidelines, processes and procedures required to improve maritime transport in relation to Port operations. The goal is to synchronize approaches and turn-around times in order to improve logistics and planning for visiting vessels by using standardized and secure communication to share data in real-time.[37]

Renewable Energy

Overview

Marine renewable energy is an emerging sector and increasingly recognized enabler of the blue economy. Beyond diversifying energy portfolios and reducing dependencies on fossil fuels, marine renewable energy is a promising mechanism to support blue economy industries by generating local, reliable, and affordable power for regional industry.

Figure 8: Global Ocean Energy timeline.



Source: IHS Emerging Energy Research

[37] IPCDMC. "The International PortCDM Council." International Port Collaborative Decision Making Council, www.ipcdmc.org/about-ipcdmc. Accessed 14 June 2020.

Key Trends

- The marine environment presents a relatively untapped energy source and offshore installations are likely to produce a significant proportion of future energy production.
- Renewable marine technologies are still in their research and development phases, with tidal stream and wave power showing the most promise for future commercial applications in the next five to ten years, respectively.[38]
- Marine renewable energy installations may increase local biodiversity and potentially benefit the wider marine environment when installations have the capacity to act as both artificial reefs and fish aggregation devices.

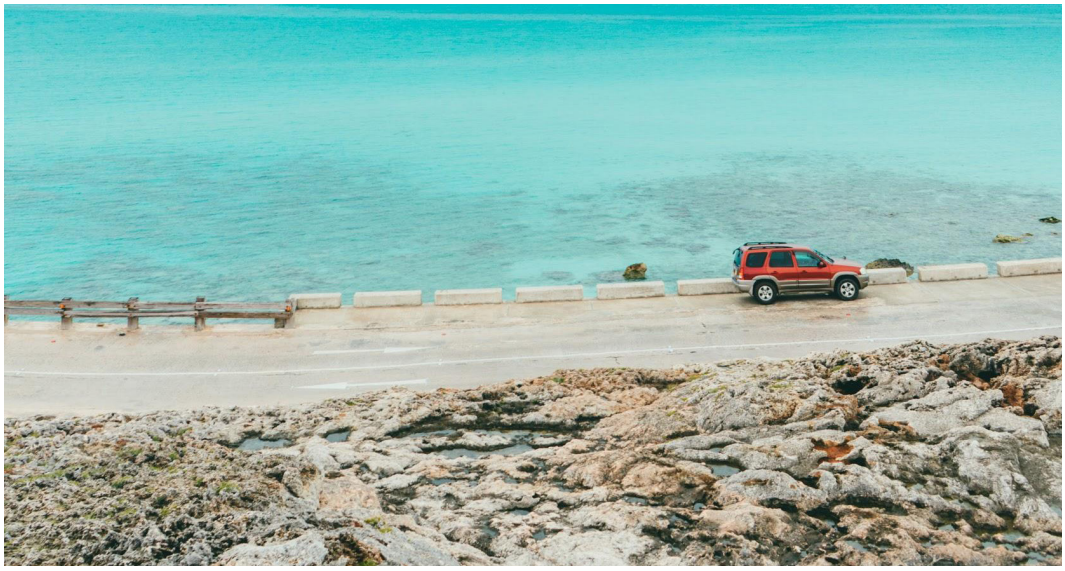
Innovative Models and Initiatives

- Local Community Partnership: Igiugig Village and the U.S. Department of Energy, USA[39]
  - The Igiugig Village is located in remote southwestern Alaska; being heavily dependent on diesel fuels, this community partnered with the Department of Energy to build a resilient and autonomous microgrid via a river turbine system in order to have access to local, sustainable energy.
  - A second system has been commissioned due to the success of the first system in providing clear, reliable, and affordable energy to village residents.[40]
- Multi-Functional Offshore Platform: MARINA Platform Project, EU/International[41]
  - This project was the first EU funded research and development project to analyze multi-purpose offshore renewable energy platforms. Fifteen research institutions partnered to develop a framework and methodology for implementing multi-purpose marine renewable energy platforms, including viable concept designs, survivability tests, and integration of power plans to onshore grids.
  - A new GIS system was created to integrate platforms into marine spatial planning and to identify potential benefits for various maritime stakeholders.
- Accelerating Testing of Prototypes: PacWave, Oregon, USA
  - Built on the Oregon Coast, PacWave is the first grid scale test facility that gives developers access to infrastructure and equipment needed to test small-scale prototypes and technology in real-world environments. The facility is expected to accelerate the research and design process of developing new technology.[42]

[38] Interview with an expert. Due to privacy policies name has been omitted.
[39] Interview with an expert. Due to privacy policies name has been omitted.
[40] Office of Energy Efficiency and Renewable Energy. Environmental Questionnaire: A Resilient and Autonomous Microgrid Powered by Marine Renewable Energy for the Village of Igiugig, Alaska. U.S. DOE, 2020. https://www.energy.gov/sites/prod/files/2020/02/f71/101693.pdf
[41] European Commission. "Final Report Summary Marine Renewable Integrated Application Platform." CORDIS, cordis.europa.eu/project/id/241402/reporting. Accessed 14 June 2020.
[42] PacWave. "Testing Wave Energy for the Future." PacWave, pacwaveenergy.org. Accessed 14 June 2020.

Emergent Industry Sectors

Coastal Development, Protection and Habitat Restoration; Marine Products; Deep Sea Mining; Renewable Energy (Wave, Tide, Current, Thermal) (See Growth Sector)



Coastal Development, Protection and Habitat Restoration

Overview

Coastal protection and habitat restoration are considered emergent sectors of the blue economy, including the concept of nature-based infrastructure (NBI), providing a more holistic approach to engineering solutions that can deliver ecosystem services and social benefits to vulnerable coastal communities.

Key Trends

- Pressures of sea level rise have led to innovative infrastructure design known as blue-gray design, which is a combination of traditional building techniques with nature-based infrastructure.
- Nature-based infrastructure offers more opportunity for return and is likely to offer both significant proven upfront investment opportunities as well as long-term efficiency gains.
- Habitat restoration harnesses the power of ecosystem services by incorporating and supporting the growth of organic coastal protection, such as marshes and mangroves, to allow for natural adaptation to changing conditions.

Innovative Models and Initiatives

- KEEP Coastal Master Plan, Louisiana, USA
  - Following Hurricanes Katrina and Rita in 2005, the Louisiana Legislature created the Coastal Protection and Restoration Agency (CPRA), to coordinate the local, state, and federal efforts towards coastal protection and restoration.
  - To accomplish these goals, CPRA created a master plan to guide work toward a sustainable coast and the actions required to sustain coastal ecosystems, safeguard coastal populations, and protect vital economic and cultural resources. Additionally, the master plan provides context to evaluate other activities in the coastal zone, including: transportation, navigation, and port projects; oil and gas development; ground water management and land use planning[43].

- Jacobs Coastal Infrastructure & Tourism Initiative, Belize[44]
  - As part of the Belize's Sustainable Tourism Program, (STP) Government and IADB commissioned Jacobs to develop a Shoreline Management Plan to improve disaster and climate resilience along an 85-kilometer stretch of coastline in the Corozal District, where there is a strong tourism potential but significant coastal risk from sea level rise.
  - Jacobs utilizes satellite imagery to develop and analyze key data sets, using a diverse set of information including topography, bathymetry, water quality, and land use to create a comprehensive a coastal resilience strategy[45].

- Coral Reef Insurance Program, Quintana Roo, Mexico
  - A healthy coral reef can reduce up to 97% of a wave's energy before it hits the shore, reducing both the effects of storm surge and daily erosion to coastlines. However, coral reefs themselves can also be heavily impacted by hurricane damage, pollution, disease, overfishing, and bleaching.
  - In the Mexican state of Quintana Roo, various stakeholders—the state government, hotel owners, The Nature Conservancy (TNC), and The National Parks Commission—have come together to pilot an innovative conservation strategy based around healthy corals. In 2018, Quintana Roo established the Coastal Zone Management Trust, which collects and manages funds for reef maintenance and repair. The trust has now purchased the first-ever coral reef insurance policy in order to ensure these ecosystems can be repaired after extreme storms.[46]

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[43] Coastal Protection and Restoration Authority. "Our Plan - Louisiana's Coastal Master Plan." Coastal Protection and Restoration Authority, Office of the Governor - Coastal Activities, coastal.la.gov/our-plan. Accessed 14 June 2020.

[44] Jacobs. "How This Top Travel Destination Became More Resilient." Jacobs, www.jacobs.com/projects/Belize-Coastal-Resilience. Accessed 14 June 2020.

[45] Jacobs. "How This Top Travel Destination Became More Resilient." Jacobs, www.jacobs.com/projects/Belize-Coastal-Resilience. Accessed 14 June 2020.

[46] The Nature Conservancy. "Insuring Nature to Ensure a Resilient Future." The Nature Conservancy, 3 Sept. 2019, www.nature.org/en-us/what-we-do/our-insights/perspectives/insuring-nature-to-ensure-a-resilient-future.

Marine Products

Overview

As global demand for naturally derived pharmaceuticals, cosmetics, and food products continues to grow, researchers and innovators have turned to the marine environment for novel compounds able to satiate burgeoning demand. A strong push towards identifying alternatives to fossil-fuel derived solutions is also driving exploration of marine-derived products for alternative uses, such as utilizing chitin from crustaceans or algae derivatives to create plastics.

Key Trends

- The high potential for commercializing ocean products has shaped the development of marine biotechnology.
- Drug discovery from marine natural products has enjoyed a renaissance in the past few years.
- Marine resources have demonstrated great cosmetic prospective having several health benefits like anti-inflammatory, anti-allergic, anti-aging and anti-wrinkling effects.

Innovative Models and Initiatives

- Use of Marine Products in Livestock Feed, in research[47]
  - Studies have found that feed that is supplemented with certain types of algae significantly reduces the amount of methane produced by cattle throughout their digestion process. As the livestock industry comes under continued and persistent scrutiny for its GHG emissions, this finding is not only a promising investment for the meat industry, but also for SIDS that can supply algae for the carbon-sequestering feed.

- Shellworks[48] Crab and lobster shell-derived plastic substitute, UK
  - With some commercial sales, Shellworks is a project by students from London's Royal College of Art and Imperial College London. The team uses waste shells from crustaceans to manufacture biodegradable products, including pots and sheets for packaging. This initiative is one of many around the world seeking to extract the valuable and durable chitin from lobster and crab shells and turn it into a substitute for plastic.[49]

[47] Interview with an expert. Due to privacy policies name has been omitted.
[48] The Shellworks. "Not Your Ordinary Plastic." The Shellworks, www.theshellworks.com. Accessed 14 June 2020.
[49] Biotex SA.

- Marine Pharmaceuticals: Since the mid-1970s, academic, government, industrial, and private research laboratories have devoted varying levels of effort to the discovery of marine-derived pharmaceuticals. Some notable successes to date include the discovery of novel chemicals from marine organisms that have demonstrated potential as new treatments for cancer, infectious diseases, and inflammation. Exploration of deep-sea environments and the isolation and culture of marine microorganisms offer two underexplored opportunities for discovery of chemicals with therapeutic potential.[50]

Deep Sea Mining

Overview

As terrestrial mining resources become increasingly scarce, deep sea mining is being considered as an alternative to supply a seemingly never-ending demand for valuable minerals and metals. While there are concerns for the industry's environmental impacts on the marine environment, deep sea mining is also becoming increasingly recognized as a potentially less harmful mechanism to supply minerals and metals in comparison to terrestrial mining.[51]

Key Trends

- Deep sea mining is currently in its exploratory phase and focused on developing commercial technology for the mineral and metal extraction process.
- The most targeted resources are polymetallic nodules, as they contain nickel, copper, cobalt and other minerals and metals necessary for electrical wiring in high demand commodities like phones and electric vehicles.[52]
- Focus for deep sea mining activities is mostly on international waters.

Innovative Models and Initiatives

- Patania: Prototype Module Collector, Central Pacific Ocean[53]
  - Developed by Global Sea Mineral Resources (GSR), this testing prototype was developed in stages to optimize and improve nodule collector technology. Patania I was tested in 2017 to examine how it can drive along the seafloor while limiting environmental impacts[54], and evolved into Patania II, which will collect nodules but not take them up to the surface and is expected to be tested in late 2020.

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[50] National Research Council (US) Committee on the Ocean's Role in Human Health. From Monsoons to Microbes: Understanding the Ocean's Role in Human Health. Washington (DC): National Academies Press (US); 1999. 4, Marine-Derived Pharmaceuticals and Related Bioactive Agents. Available from: https://www.ncbi.nlm.nih.gov/books/NBK230700/

[51] Interview with an expert. Due to privacy policies name has been omitted.

[52] Richens, James. "Is Deep-Sea Mining Part of the Blue Economy?" *The Economist Newspaper World Ocean Initiative*, 16 Dec. 2019, www.woi.economist.com/is-deep-sea-mining-part-of-the-blue-economy.

[53] Interview with an expert. Due to privacy policies name has been omitted.

[54] Lewis, Barbara. "Belgian Fast-Moving 'caterpillar' in Deep Sea Copper, Cobalt Race." *Reuters,* 27 Feb. 2019, www.reuters.com/article/us-deep-sea-mining/belgian-fast-moving-caterpillar-in-deep-sea-copper-cobalt-race-idUSKCN1QG1B1.

- DeepData database[55], International
  - Created by the International Seabed Authority (ISA) in 2019, this database serves as a centralized repository for marine scientific researchers and contractors to access information regarding exploration activities, data, maps, and relevant publications as they relate to biological, physical, and geochemical parameters of marine ecosystems. The goal of this database is to support the ISA in the most effective management of exploration and exploitation activities, as well as ensuring the protection of the marine environment and equitable sharing of knowledge.

- Deep-Sea Mining, Papua New Guinea (PNG)
  - Since its issuing in January 2011, PNG remains the only country in the world to have granted a mining lease (ML154) for a commercial deep-sea mining project, Solwara 1, to Nautilus Minerals[56]. A highly contested program and partnership between the government of PNG and Nautilus, the project is still in design, and now owned by Deep Sea Mining Finance Limited (DSMF), a privately-owned group aiming to become the first in the world to mine Seafloor Massive Sulphide (SMS) deposits commercially. SMF is a joint venture between international holding group "USM Holdings Limited" and Sultanate of Oman group "MB Holding Company LLC"[57]

Summary of the Blue Economy Industry Sector Trends

The eleven industry sectors reviewed in the previous section all have the potential to contribute to growth of ocean-related economic activity (**Table 2**). However, the blue economy defined herein (and bolstered by conversations with experts in the field) requires that industry sectors contribute not just to economic growth, but to positive development of social and environmental conditions for local communities and natural habitats. Innovations in technology are helping to bring greater access, transparency, and accountability—as well as cost efficiencies—to many of these sectors. These developments can help both mature and emergent industries meet more stringent definitions of blue economy if properly applied. The next section reviews some of the latest technological developments and their application across these different industry sectors.

[55] Marine Scientific Research." International Seabed Authority, www.isa.org.jm/marine-scientific-research. Accessed 14 June 2020.
[56] Childs, John. "Performing 'Blue Degrowth': Critiquing Seabed Mining in Papua New Guinea through Creative Practice." Sustainability Science, vol. 15, no. 1, 2019, pp. 117–29. Crossref, doi:10.1007/s11625-019-00752-2.
[57] Deep Sea Mining Finance. "Sea Floor Massive Sulphides (SMS) - Solwara 1." Deep Sea Mining Finance, dsmf.im/solwara-1. Accessed 14 June 2020.

Table 2: Summary of Blue Economy Industry Sector Trends, Drivers, and Barriers.

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Mature/Existing Blue Economy Sectors				
Fishing	• **Pelagic fishing** • **Reef finfish** • **Crustacean and shellfish fishing** • Fishing • Processing • Marketing and Sales • Logistics • Fisheries science and management	• Rising demand globally and overexploitation • Significant lack of data affecting most fisheries- • Great potential for GIS and spatial • Emphasis on traceability and data-rich supply chains. • Interest in more sustainable seafood includes growing pressure to reduce waste and bycatch	• End-buyer sustainable sourcing commitments • Improved tech for monitoring fleet activity • Need for data • Decreasing stocks and increasing seafood demand	• Fisheries as a "commons" • Rising demand with limited enforcement • Lack of private investment • Science and management missing
Coastal & Marine Tourism	• **Cruise tourism** • **Beach/leisure tourism** • **Adventure and ecotourism** • Water activity rentals and gear • Diving and dive operations • Whale watching and nature viewing at-sea • Marketing, branding • Beach-related tourism • Restaurant and retail related to tourism market	• Before the COVID-19 outbreak, coastal tourism was expected to grow significantly and likely at a faster rate than tourism as a whole. However, a rapid recovery is unlikely to happen in 2020. Europe was expected to be the region concentrating the most tourist arrivals with over 700 million international arrivals, followed by Asia and the Pacific with over 500 million arrivals in 2030. Marine tourism is a viable pathway to support conservation of marine biodiversity while maintaining economic value.	• Rising demand globally and overexploitation • Significant lack of data affecting most fisheries- • Great potential for GIS and spatial • Emphasis on traceability and data-rich supply chains. • Interest in more sustainable seafood includes growing pressure to reduce waste and bycatch	• Fisheries as a "commons" • Rising demand with limited enforcement • Lack of private investment • Science and management missing

Table 2: Summary of Blue Economy Industry Sector Trends, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Shipping	• **Maritime fleet transportation** • **Boat Building** • **Repairs and maintenance of ships and boats** • Transport and trade • National and international permit and policy	• Recent years have witnessed a rise in application of digital software technologies to improve coordination, regulation, and efficiencies in the global shipping industry. • Greening of the global shipping industry is also underway, driven by international regulations, positive incentive programs, and advancements in new technologies, especially regarding decarbonization of shipping and cleaning of air emissions. • Within the Caribbean region, a growth of the shipping sector coincided with the 2016 widening of the Panama Canal.	• Increase in trade volume and trade distance • Cheaper alternatives to air, rail and freight transport	• Ships owners are concerned with the technical risk, capital and hidden costs • Lack of innovative financing solution to overcome the high capital investment • Lower volume of trades since covid-19
Oil and Gas	• **Exploration** • **Extraction** • **Support activities** • Biological and mineral resource mapping and valuation • Extraction • Processing • Transport	• Offshore oil production will significantly increase in the upcoming years, with a larger proportion of deep-water facilities and a relative decrease in shallow-water fields. While important offshore fields are being exploited in Guyana and Suriname, other Caribbean countries might offer great potential for the industry, including in Cuba, the Dominican Republic, Jamaica, Honduras, Nicaragua and the Bahamas. Meanwhile, Trinidad and Tobago hold one of the most coveted oil and gas basins in the world. Offshore oil and gas production represented approximately a third of value added by ocean-based industries, according to the OECD.	• Foreign Drilling companies • Ocean observation technology • Big data analysis	• Growing pushback against further fossil fuel development due to climate change and environmental risk • Recent drop in price • Capital intensive and requires large investment

Table 2: Summary of Blue Economy Industry Sector Trends, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Growth Blue Economy Sectors				
Mariculture	• **Finfish marine aquaculture** • **Shellfish and freshwater aquaculture** • **Offshore aquaculture** • Farm construction and maintenance • Marketing and Sales • Logistics • Feed science • Breeding and selection	• At the industrial or commercial level, mariculture tends to be single-species in focus, but there is an increasing trend towards integrated multi-species approaches, including finfish, shellfish, and seaweeds. • Diversification beyond food • Research and development for farmed fish health • Movement away from fish-based feeds to those that rely on plant or insect-based proteins or utilize scraps from seafood processing	• Improvement programs such as FIPs • Electronic monitoring and reporting systems • Blockchain Traceability • Blended capital solutions	• Need of market expansion beyond US and EU • Important risk for private capital investments • Lack of fisheries data • ineffectiveness of policies and management • Poor access to infrastructure
Maritime Surveillance & Safety	• **Surveillance** • **Monitoring** • **Enforcement** • Biological and mineral resource mapping and valuation • R&D • Technology implementation • Data analytics and response coordination (national and international) • Inspection	• Regional multinational alliances for surveillance and monitoring • Use of big data for better analytics • Smart vessels and ports • At the industrial or commercial level, mariculture tends to be single-species in focus, but there is an increasing trend towards integrated multi-species approaches, including finfish, shellfish, and seaweeds. • Diversification beyond food • Research and development for farmed fish health • Movement away from fish-based feeds to those that rely on plant or insect-based proteins or utilize scraps from seafood processing	• Regional cooperation and coordination • Clear-defined maritime boundaries by surrounding nations • Technologies such as satellite tracking, marine GIS and remote and field sending	• Lack of communication between parties due to security based and economic reasons • Lack of agreement in data-sharing between governments and industry • High upfront investment cost

Table 2: Summary of Blue Economy Industry Sector Trends, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Ports	• **Port Construction** • **Port management** • **Infrastructure maintenance** • **Logistics and cargo Handling** • Construction and infrastructure maintenance • Data capture and verification • Inspection • Warehousing and storage	• Increase in understanding and application of the role of ports in relation to illegal activities • Digital technology and automation of port operations. • Green ports	• Policy incentives • Local investment, technical training and capacity building • Increase in political investment in port safety	• Climate change threatens the water level in ports, sea level rises and extreme weather become more consistent • Social and environmental injustice associated with port-surrounding communities with high levels of air and water pollution
Emergent				
Renewable Energy	• **Offshore wind** • **Wave/tidal energy** • **Ocean driven thermal energy** • **Solar** • Biological and mineral resource mapping and valuation • R&D • Coastal and offshore infrastructure • Prototype testing • Power generation, transfer, storage	• The marine environment presents a relatively untapped energy source and offshore installations are likely to produce a significant proportion of future energy production. • Renewable marine technologies are still in their research and development phases, with tidal stream and wave power showing the most promise for future commercial applications in the next five to ten years, respectively. • Marine renewable energy installations may increase local biodiversity and potentially benefit the wider marine environment when installations have the capacity to act as both artificial reefs and fish aggregation devices.	• Increased energy demand • Cost-effectiveness • Low carbon energy system • Energy security • Indirect economic impact by cutting down reliance on imported fuels	• Large initial investment cost • High operation and maintenance costs • Skilled workforce in this sector is not common • Institutional structure of energy sector in countries may lag behind

Table 2: Summary of Blue Economy Industry Sector Trends, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Coastal Development & Protection	• **Marine related construction (infrastructure development)** • **Nature-based resilient coastal infrastructure** • **Habitat protection and restoration** • **Carbon sequestration** • Permitting • Zoning and planning • Construction of commercial, residential, and industrial use • Habitat protection, restoration • Engineering with nature	• Pressures of sea level rise have led to innovative infrastructure design known as blue-gray design, which is a combination of traditional building techniques with nature-based infrastructure. • Nature-based infrastructure offers more opportunity for return and is likely to offer both significant proven upfront investment opportunities as well as long-term efficiency gains. • Habitat restoration harnesses the power of ecosystem services by incorporating and supporting the growth of organic coastal protection, such as marshes and mangroves, to allow for natural adaptation to changing conditions.	• Increased adaptation planning can help vulnerable groups • Enhance innovative and multifunctional measures • Decrease flood risks and costs	• Fragmentation of knowledge and expertise in multifunctional measures • Local stakeholders in the risk management planning and decision-making practice is dependent on local capacity • Financial capacities
Marine Products	• **Pharmaceutical and cosmetics** • **Food products** • **Fertilizers** • **Chemicals and plastics** • **Other** • Biological and mineral resource mapping and valuation • R&D • Marketing and branding • Processing • Logistics (export and domestic)	• The high potential for commercializing ocean products has shaped the development of marine biotechnology. • Drug discovery from marine natural products has enjoyed a renaissance in the past few years. • Marine resources have demonstrated great cosmetic prospective having several health benefits like anti-inflammatory, anti-allergic, anti-aging and anti-wrinkling effects.	• Opportunity to substitute away from scarce resources • Optimize efficiency and reliability of marine sources	• Current market is still passive towards marine products for use outside of consumption • Availability of reliable suppliers/ products • Initial investment in product is risky • Concerns about quality of products

Table 2: Summary of Blue Economy Industry Sector Trends, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Deep Sea Mining	• **Extraction of minerals** • **Extraction of marine aggregates (sand and gravel)** • **Seabed mining** • Deep-sea habitat mapping and resource valuation • International policy development • R&D of equipment	• Deep sea mining is currently in its exploratory phase and focused on developing commercial technology for the mineral and metal extraction process. The most targeted resources are polymetallic nodules, as they contain nickel, copper, cobalt and other minerals and metals necessary for electrical wiring in high demand commodities like phones and electric vehicles. Monitoring of deep-sea mining activities is split between international waters and national jurisdictions.	• Policy incentives • Local investment, technical training and capacity building • Increase in political investment in port safety	• Climate change threatens the water level in ports, sea level rises and extreme weather become more consistent • Social and environmental injustice associated with port-surrounding communities with high levels of air and water pollution

Technologies in Support of Blue Economy Development

As in many regions of the world, the competition for use of resources is intensifying. At the same time, many raw materials – biotic and abiotic – are becoming scarcer. Both trends call for reconsideration of our current production models and development of new technologies or integrated technologies to resolve real problems. Highly efficient local production that consumes a minimum of materials and energy in an environment people find pleasant to live in is the ideal. A circular flow of materials and energy delivers them back to the start again for a new round of production. There is a considerable potential to support innovation in the blue economy sectors in the Caribbean with existing as well as emerging technologies creating sustainable solutions through technology. Many technologies become increasingly financially and technologically accessible as they advance to the commercial stages in parallel sectors or more developed nations.

In the 21st century key technologies from biotechnology and digital technology, also called Industry 4.0 will meet each other in order to develop sustainable solutions. Both fields provide technologies that allow converging and mutually reinforcing processes which are transforming human activity in its core together with all aspects of sustainability. Fraunhofer[58] defines this as biological

[58] Fraunhofer 2019. Biological Transformation and Bioeconomy.

transformation, a concept that ushers a new way of thinking: connectivity instead of linearity; optimisation instead of maximisation. In short, if biological transformation and digitalization go hand in hand, this creates a Whole in Aristotle's sense of the term, which is more than the sum of its parts. The technologies presented may currently be more nascent than others, this should not necessarily be considered a significant barrier to use or implementation; given sufficient starting capital the majority of these innovations can and will evolve to meet demand. Nor should the described technologies be considered a solution on their own, but part of the solution to resolve current issues in the blue economy.

Regardless of the application, successful use of innovative technologies to support blue economy projects will largely depend on two key elements. First the leveraging of the unique geography of the Caribbean, and some form of community of practice created to address the underlying systemic barriers that inhibit progress. Secondly, successful technological implementation can only occur after the purpose, use, maintenance, data collection, sharing, or analysis related to use of the technology is clearly defined and agreed upon by the users prior to implementation. If these agreements are not reached, there is significant likelihood that resources, uptake and use over time will be minimal to none.

Industry 4.0

The period 1945-2020 has seen strong growth and economic changes, with different results for each continent, country, and industrial sector. While some countries have experienced and maintained a strong economic boom, others went through great growth followed by a more difficult position. In each case the economic development has been influenced by various factors, such as available natural resources, the political system, the functioning of governments, cultural factors, social development, industries and the private world, competitiveness, globalization at the global level. Technological development is one of the factors that has been able to influence, plan and transform into successful economic developments, showing great changes over time: Process automation (80's), Internet (from 90's), telecommunications, to the technological trends of the last three years oriented to the concept of Intelligent Industries. This latest technological trend includes: Internet-of-Things (IoT), M2M, Big Data, Web Services, Telecommunications, and Technology Globalization. These are considered the enabling technologies for new industry, services and products. It is expected that these trends will bring about important industrial and organizational changes in developed or semi-developed countries, generating a growth opportunity for these countries.

The concept of Industry 4.0 originated in Germany between the German Government and German industries initially proposed by Robert Bosch GmbH. Industry 4.0 refers to the fourth step of the Industrial Revolution of 1800, in which there is a convergence between the digital world and industrial manufacturing. Everything is driven by information and communication technology, and includes IoT, M2M, Big Data, sensors, robotization, among other processes, in order for machines to obtain and process knowledge, and thus optimize their own processes (Smart-Manufacturing). As the world's leading high-tech industrial manufacturing country, Industry 4.0 has become

the Technology Roadmap for State and Industry, which includes standardization, norms and regulations, all in cooperation with the State, and the European Community.

For the development of the different sectors in the blue economy, solutions from industry 4.0 can form an opportunity to work more efficiently, to enable activities which before were not economically feasible. With an in-depth revision of Industry 4.0 the following technologies can enable:

Artificial Intelligence (AI)

Technology Overview: There are a wide range of existing definitions for Artificial Intelligence (AI), and while a consensus remains elusive, AI in general can be said to be a task performed by a program or a machine that, if a human carried out the same activity, would be assumed to be accomplished by application of intelligent thought.[59]

Artificial intelligence is dependent on data input for learning and growth" intelligence" is based on decisions programmed to be made by the machine based on the data entered into the system. Within the field of AI, machine and deep learning are frequently used for a wide array of environmental management projects to predict patterns of anything from predicting the future effects of climate change to improved efficiencies at sea. Machine learning refers to feeding a system large amounts of data, which is used to learn how to carry out a specific task, such as identifying a fish at sea or predicting vessel movements at port. Within machine learning lies deep learning, where neural networks composed of interconnected layers of algorithms, (neurons) are expanded into larger, complexly layered networks "trained" using massive amounts of data. It is these deep neural networks that have fueled accelerated progress regarding the AI ability to carry out tasks such as speech recognition[60].

Machine learning can improve port side operations by analyzing data points such as ship arrivals and departures in real time in order to improve forecast accuracy and speed logistics planning. At sea, AI virtual assistants on vessels assist with shipment tracking, delivery booking, and retrieving and translating information. Large industry players as well as small scale fishermen can benefit from AI solutions capable of learning, reading, and scanning and submitting thousands of individual forms to the appropriate officials and departments; decreasing the burden of paperwork while increasing accuracy and freeing additional time for workers[61]. Through AI even CO_2 might be achieved, optimizing offer and demand of space available capacity on freight vessels and the demand for transport.

[59] Heath, Nick. "What Is AI? Everything You Need to Know about Artificial Intelligence." ZDNet, 12 Feb. 2018, www.zdnet.com/article/what-is-ai-everything-you-need-to-know-about-artificial-intelligence.

[60] Heath, Nick. "What Is AI? Everything You Need to Know about Artificial Intelligence." ZDNet, 12 Feb. 2018, www.zdnet.com/article/what-is-ai-everything-you-need-to-know-about-artificial-intelligence.

[61] Ngan, Pham Mai. "AI Applications in the Maritime Industry." FPT Software, 27 Feb. 2020, blog.fpt-software.com/ai-applications-in-the-maritime-industry.

Innovative Uses Related to the Blue Economy

- *Fisheries Management/Combating IUU*: Created by Swedish company Refind Technologies, FishFace is a machine learning device that will use facial recognition technology at sea to automate the collation of information on the species and numbers of fish caught for use in informing management decisions. FishFace is being developed and will be trialed in Indonesia's deep-water snapper and grouper fisheries, with the potential for later expansion.[62]
- *Machine Learning for Management & Climate Change Mitigation*: AI for Earth has partnered with Columbia University and Queens College to support the analysis of data from the Oceans Observatories Initiative (OOI) and data collected from CamHD in the Pacific. Paired with Pangeo's big data analysis and cloud-based solutions from Microsoft Azure, OOICloud gives oceanographers, scientists, and educational institutions access to large datasets which will help improve understanding and management of the oceans and help address climate change.[63]
- *Smart Ports & Vessels:* One Sea member Awake.AI and Silo.AI are developing machine learning solutions to improve situational awareness at ports through analysis of existing freight and logistics chains. In part, the system is based on machine learning regarding transit times, forecasting vessel arrival and departure in advance. This is paired with computer vision-based solution which is constantly analyzing and monitoring vehicles in the port in real time in order to help automate manual analysis, speed up cargo logistics planning, and improve detection of any potentially dangerous.[64]

Drones

Technology Overview: A drone is a form of pilotless craft that operates through a combination of technologies; including computer vision, artificial intelligence, and object avoidance technology. Drone technology is part of a 127 billion dollar industry that uses robots to perform various tasks under the water, on the ground, and in the air; remotely, autonomously, and/or semi-autonomously.[65] In recent years, drone technology has been used by a wide range of players from defense organizations to filmmakers and environmental management professionals. As drones have decreased in price and increased in accessibility, a number of new uses have emerged--from replacing humans in dangerous jobs to making local deliveries or monitoring deforestation patterns in the Amazon.[66]

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[62] The Nature Conservancy. "Indonesia Fisheries." The Nature Conservancy, www.nature.org/en-us/about-us/where-we-work/asia-pacific/indonesia/stories-in-indonesia/indonesia-fisheries. Accessed 15 June 2020.

[63] Microsoft. "OOICloud – Microsoft AI for Earth." Microsoft - AI, www.microsoft.com/en-us/ai/ai-for-earth-OOICloud. Accessed 15 June 2020.

[64] Kaisakaukovirta. "Awake.AI and Silo.AI Collaborate in Bringing Intelligence to Ports and Maritime Logistics." One Sea - Autonomous Maritime Ecosystem, DIMECC Oy, 3 Mar. 2020, www.oneseaecosystem.net/awake-ai-and-silo-ai-collaborate-in-bringing-intelligence-to-ports-and-maritime-logistics.

[65] CB Insights. "38 Ways Drones Will Impact Society: From Fighting War To Forecasting Weather, UAVs Change Everything." CB Insights Research, 9 Jan. 2020, www.cbinsights.com/research/drone-impact-society-uav.

[66] CB Insights. "38 Ways Drones Will Impact Society: From Fighting War To Forecasting Weather, UAVs Change Everything." CB Insights Research, 9 Jan. 2020, www.cbinsights.com/research/drone-impact-society-uav.

Within the maritime sector, drones can be used for tasks such as stock assessments, maritime safety support, or surveillance of MPAs or EEZs, and have the technical capacity to be used in court cases to provide visual or audio records of events. Unmanned aerial vehicles (UAVs) in particular have the potential to combat illegal fishing but are so far rarely used to do so.[67] Additionally, conservationists are combining drone technology with technologies such as GIS to monitor and track animals on land and at sea, or to remotely map potential conservation areas. On a broader scale, new forms of drone-based hardware and software for improved data collection are being leveraged to help study the climate and better predict future changes to global weather systems.

Innovative Uses Related to the Blue Economy

- *Safety at Sea*: FishGuard an initiative focused on technological solutions to prevent illegal fishing in SIDS, initiated by the government of Seychelles to monitor activity in the country's EEZ. It is a cooperative venture run by Atlan Space, TMT and GRID-Arendal, which utilizes long-range drones fit with Artificial Intelligence (AI) to monitor large marine areas as well as short-range, manually controlled drones. The system also taps into satellites with optical and synthetic-aperture radar (SAR) remote sensing equipment, as well as earth observation, automatic identification systems (AIS) and vessel monitoring systems (VMS). This unique integration of different types of data allows the system to detect "dark targets" (unregistered vessels).[68]
- *Monitoring for Management*: The Ocean Alliance's The SnotBot® is a modified consumer drone which flies through the blow of a whale and collects exhaled "snot" on petri dishes. This blow contains a significant amount of valuable biological information including DNA samples, stress and pregnancy hormones, microbiomes and potentially many other biological compounds and indicators of the animal's health and ecology.[69]
- Oceanic and Atmospheric Research: Private company Saildrone designs, manufactures and operates a global fleet of wind and solar powered ocean drones, providing in situ data collection services, global ocean data sets and enhanced weather forecast applications. They have developed an autonomous sailboat that collects oceanic and atmospheric data from the ocean surface, has the capacity to be fitted with a number of additional sensors, and may be rented by users to decrease initial investment and maintenance costs.[70]

Robotics

Technology Overview: Robotics is a specific branch of technology dealing with the creation of physical, programmable machines are able to carry out pre-programmed actions autonomously

[67] Orlowski, A. "Drones Fisheries Enforcement Potential Remains Untapped, Even as Projects Advance." SeafoodSource, 2 Jan. 2020, www.seafoodsource.com/news/environment-sustainability/drones-fisheries-enforcement-potential-remains-untapped-even-as-projects-advance.
[68] GRID-Arendal. "GRID-Arendal: The FishGuard Initiative." *GRID-Arendal*, www.grida.no/activities/275. Accessed 26 June 2020.
[69] https://whale.org/snotbot/
[70] https://www.saildrone.com/

or semi-autonomously, interacting with the world via sensors and actuators.[71] The robotics sector has experienced a period of steady growth since in the 1960s when industrial robotics began to appear in the public eye; predominantly, at first, for industrial use. A second major growth period in the mid-2000s was driven by rapid developments in technologies combined with a global increase in labor costs and global competition. The use of robotics in 2020 is widespread and becoming part of public conversation—from Amazon's delivery drones to Google's self-driving car or even military contracts with Boston Dynamics for use in combat or medicine, the potential use cases are almost limitless.[72] It is worth noting that the unique geography of SIDS may actually be a potential benefit for robots, which are uniquely able to harness environmental factors such as waves, ocean water temperature variance, or sunlight to create, store, or transfer energy and data.

Current trends in marine robotics are centered around autonomous surface vessels, unmanned underwater vehicles/robots, and shipboard robots; with a significant portion of the research increasingly focused on autonomous vessels and their capacity for risk mitigation. Robotic technologies for marine applications are largely leveraged by transportation and defense sectors, with an emphasis on creating robots capable of taking over high-risk tasks from humans. There are robots already being utilized for a wide range of maritime activities, including offshore oil and gas extraction; investigation activities of the ocean, ship, and harbour maintenance; and for defensive marine vessels.[73]

Innovative Uses Related to the Blue Economy

- *Autonomous Vessel Cleaning for Reduced Fuel Consumption*: The Robotic Hull Bio-inspired Underwater Grooming tool (Hull BUG), was created by SeaRobotics and funded by U.S. Navy Office of Naval Research (ONR). It is a small, unmanned vehicle which weighs approximately 40 kg and attaches itself to the underside of ships, using a negative pressure device that creates a vortex between the BUG and the hull, to crawl along the surface and perform frequent cleanings. Sensors provide obstacle avoidance, path cleaning, and navigational capabilities, while a fluorometer detects the biofilm which activates rotary brushes or water-jets to scrub the fouling film off.[74]
- *Autonomous Cargo Ships*: The Maxlimer is a product of SEA-KIT, a maritime technology company based in southeast England. Motivated by potential contracts supporting offshore oil and gas drilling, SEA-KIT created a semi-autonomous robotic support ship with significantly more equipment storage space than a typical vessel, including a flotilla of smaller drone boats and submarines that it can launch and retrieve. The Maxlimer is currently able to travel for up to 22 hours at a time carrying 2 1/2 tons of cargo, using less than 5% of the fuel required to operate a standard ocean-going vessel of the same size.[75]

[71] https://blog.robotiq.com/whats-the-difference-between-robotics-and-artificial-intelligence
[72] https://www.mckinsey.com/~/media/McKinsey/Industries/Advanced%20Electronics/Our%20Insights/Growth%20dynamics%20in%20industrial%20robotics/Industrial-robotics-Insights-into-the-sectors-future-growth-dynamics.ashx
[73] https://www.prnewswire.com/news-releases/emerging-robotic-technologies-for-marine-applications-300539126.html
[74] https://www.marineinsight.com/future-shipping/5-innovative-robotic-technologies-for-the-maritime-industry/
[75] https://www.hellenicshippingnews.com/the-robot-ship-set-to-cross-the-atlantic-and-change-the-world/

- *Anti-piracy Robots for Maritime Safety*: ReconRobotics created a microbot that can provide anti-piracy forces with real-time surveillance information. Enforcement agents often have to board a ship with incomplete information and no visual cues, not knowing exactly what's going on below decks, how many pirates are on board, or if the ship's crew is armed, putting them at a significant disadvantage. To help officers map a situation before boarding, they created a one-pound remote-controlled robot that can be tossed onto a hull or over the side of the boat, with magnetic wheels that allow it to drive in any direction while transmitting a live video stream back to agents, who can then assess the scene before taking action.[76]

Sensors

Technology Overview: A sensor is a physical device used to sense and respond to electrical or optical signals. Sensors are a common technology frequently used for automation, navigation, or to collect information from remote areas. We use different types of sensors daily in our home lives, from the TV remote to automatic garage doors and time-sensitive street lighting systems.

In the ocean environment, physical sensors are frequently used for underwater study and assessment. Ranging from simple handheld devices to complex remote underwater or buoy-based systems, sensors can be used to measure physical changes in the environment, including elements such as temperature, turbidity, transparency, depth, pressure, and water flow.[77] In the past, demand for ocean data was largely driven by customers in the U.S. Department of Defense as well as the oil and gas industry, rapidly expanding in recent years to include a wider range of players, including research communities that wish to better understand ocean environments.[78]

Integrated networks of ocean sensors, buoys, and navigation aids exist to monitor global oceanographic conditions, promote safe navigation, and improve weather forecasts; subsequently increasing our ability to provide early warnings of extreme coastal events.[79] Additionally, sensors can be combined with other technologies such as drones to map underwater topography and health, better informing conservation and fisheries management decisions.

Innovative Uses Related to the Blue Economy

- *Aquaculture*: INNOVASEA is utilizing submersible sensors placed around fish pens and connected to a central database to track water temperature, depth, and other significant environmental indicators of stock health, including dissolved oxygen, salinity, chlorophyll, and algae. This information allows managers to make health-based decisions in near real time, without the need to physically visit the site.[80]

[76] https://www.discovermagazine.com/technology/throwable-robot-can-climb-aboard-ships-spy-on-pirates
[77] https://www.lakescientist.com/physical-sensors/
[78] https://www.energy.gov/sites/prod/files/2019/03/f61/73355.pdf
[79] https://www.energy.gov/sites/prod/files/2019/03/f61/73355.pdf
[80] https://www.innovasea.com/aquaculture-intelligence/

- *Tracking Climate Change*: The international Argo program maintains an array of more than 3,800 floats to track the temperatures and salinities of oceans around the globe, making all data publicly available online. Recently, a number of Argo floats in the Southern Ocean were modified with biogeochemical sensors capable of measuring an array of variables, ranging from pH to oxygen and nitrate levels. This project, named SOCCOM, is focused on increasing scientist's ability to monitor climate change by accurately measuring carbon and carbon flux across seasons at the ice edge, under the ice, and in waters surrounded by ice or other harsh conditions.[81]
- *Seafloor and Ecosystem Mapping*: In order to provide seafloor information necessary to conserve Caribbean coral reef ecosystems, the National Centers for Coastal Ocean Science (NCCOC) uses acoustic multibeam sensors, fish acoustic sensors, oceanographic sensors, LiDAR (light detection and ranging) and remotely operated vehicles to map and characterize the size and shape of physical habitats to help explain and predict fish distribution patterns. Their work targets high priority sites identified by local and regional managers where significant information gaps exist, and where the absence of sufficient biophysical modeling information has so far prevented evaluations of potential management activities.[82]

Geographic Information Systems (GIS) and Spatial Mapping

Technology Overview: A basic GIS program organizes geographic data so that a person reading a map can select information required for a specific project or task, while a more advanced GIS program is able to process geographic data from a variety of sources and integrate it into a single product. Many countries have an abundance of geographic data for analysis, and governments often make GIS datasets publicly available.[83] Rapid progress in computing power, memory and display sizes, and interactive tools have allowed GIS research and development to explore new applications in recent years, including a unique integration of different communication techniques that permits mobile GIS and hand held appliances to interact, process, and exchange data using wireless communications.[84] With more, and better data, these systems can generate more accurate predictive models to anticipate behavior of industry (shipping, fishing), environmental impacts (coastal development, habitat restoration), and health (aquaculture).

GIS in the marine space is quite advanced and used for a variety applications, including: mapping, monitoring, and management analysis; vessel safety and tracking; coastal zone assessment and management; marine geology and geomorphology; environmental and bio-economic characterization of coastal and marine systems; ocean policy and management; climate change and sea-level rise deep ocean mapping; flooding and natural hazard assessment; and the development of environmental sensitivity indices maps.[85]

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[81] https://www.nature.com/articles/d41586-018-03068-w
[82] https://coastalscience.noaa.gov/project/seafloor-characterization-caribbean/
[83] https://www.esri.com/library/bestpractices/geospatial-technology-for-coastal-environments.pdf
[84] https://www.researchgate.net/publication/220737823_A_Contextual_Approach_for_the_Development_of_GIS_Application_to_Maritime_Navigation
[85] http://www.scientificwebjournals.com/JAEFR/Vol3/issue4/JAEFR17021.pdf

Innovative Uses Related to the Blue Economy

- *Shared nautical charts for improved navigation*: The Danish Geodata Agency (GST) partnered with ESRI to convert creation of navigational charts from a file-based system to a database while combining cross-agency chart production into one system. The goal is to reduce the significant amount of time it takes staff to produce charts of all Danish waters, while enabling users to share information across departments and agencies. The data that the agency produces is used for navigation in support of activities such as shipping, fishing, recreational use, and Navy operations.[86]
- *Coastal Mapping for Marine Information*: The ShoreZone coastal habitat mapping program is run by Coastal and Ocean Resources Inc. (CORI), and is an automatic classification system using low-altitude georeferenced aerial imagery to interpret and integrate geologic and biologic features of intertidal zone and nearshore environments. The system's datasets have a wide variety of uses, from resource monitoring, planning, and protection to hazard mitigation and policy formation. The ShoreZone coastal mapping program is comprised of a partnership of scientists, GIS specialists, Web specialists, nonprofit organizations, and governmental agencies.[87]
- *Legislative Atlas*: Created and managed by the Coastal Services Center, Legislative Atlas allows users to view the geography associated with ocean and coastal laws and the relationships that exist between the laws. Users are able to search for and view spatial relationships between legislations and pertinent marine boundaries in order to analyze gaps and overlaps in a region's regulatory framework. The atlas also describes the regions, districts, and planning areas with coastal areas that are managed by the federal government. The ability to separate and visualize federal planning areas is also designed to help resource managers identify specific contacts within federal agencies who may be able to assist with particular areas of interest.[88]

Blockchain

Technology Overview: A blockchain is a secure digital ledger of transactions duplicated and distributed across a network of computer systems. Each block in the chain contains numerous transactions, and every time a new transaction occurs, a record of that event is added to all of the participant's ledgers. A decentralized database managed by multiple participants is known as Distributed Ledger Technology (DLT). Blockchain is a type of DLT in which transactions are recorded with an immutable cryptographic signature, meaning that if one block in one chain was changed, it would be immediately apparent to all users.[89]

One of the major predicted benefits of blockchain within the maritime industry is the potential for a decrease in the burden and bureaucracy of paperwork throughout the supply chain. For international shipments, companies and customs officials are required to fill out and submit numerous documents (most of them paper-based) to be able to transport goods from the exporter

[86] https://gisuser.com/2019/02/danish-geodata-agency-partners-with-esri-to-chart-the-waters-of-denmark-and-greenland/
[87] https://www.esri.com/library/bestpractices/geospatial-technology-for-coastal-environments.pdf
[88] https://www.esri.com/library/bestpractices/geospatial-technology-for-coastal-environments.pdf
[89] https://www.euromoney.com/learning/blockchain-explained/what-is-blockchain

to importer. Unfortunately, the majority of this documentation is inaccessible and provides neither real-time visibility nor significant data quality. Blockchain has the potential not only to make cargo checks faster and more efficient through secure electronic submissions but could minimize the risk of penalties for lack of customs compliance. It's also potentially quite cost efficient–early tests indicate that savings may decrease administrative costs by as much as 15% of the value of shipped goods, equal to approximately 1.5 trillion USD globally.[90]

Innovative Uses Related to the Blue Economy

- *Traceability to Combat IUU & Slave Labor in the Tuna Industry*: In 2018, WWF partnered with global blockchain venture studio ConsenSys, ICT implementer TraSeable, and tuna fishing and processing company Sea Quest Fiji Ltd on a pilot project focused on the Pacific Islands tuna industry. The goal of the pilot was to decrease incidences of IUU and slavery in the supply chain by increasing transparency and data security through secure traceability. To achieve this, fIshers registered their catch on the blockchain through radio-frequency identification (rFID) e-tagging and scanning fish, which traveled with the fresh or frozen fish from harvest to sales. Consumers were then able to scan a barcode located on the can to trace their product's journey back to the point of origin.[91]
- *Blockchain for Shipping Insurance*: The repair state of a ship, the makeup and experience of the crew, the flag under which the ship is registered, and the location of the ship all affect the cost of a ship's insurance in real time. Due to a combination of fluctuating prices as well as the numerous parties required to be involved in insuring container ships, marine insurance tends to be both inefficient and costly. Recently, professional services firm EY worked with Microsoft, network security expert Guardtime, blockchain technology provider R3, and global shipping company A.P. Moller - Maersk to create Insurwave, the world's first blockchain platform for marine insurance. Insurwave runs in Microsoft Azure, and allows marine insurance brokers, insurers, and clients to receive real-time data from the assets they covered to better price risk and facilitate claims processing.[92]
- *Digital Sales for Seafood Supply Chains*: To address fragmented seafood supply chains, Fishcoin created a peer-to-peer network that permits independent industry to use a shared blockchain network. A flow of "tokens" is passed from buyer to seller through the supply chain, rewarding those who capture and communicate data; shifting the economic burden to those who benefit downstream, such as hotels, restaurants and retailers. Unlike traditional blockchain initiatives, Fishcoin is not based on a central system or company but is designed as a decentralized platform that incentivizes data capture for communal use.[93]

[90] https://coinrivet.com/blockchain-at-sea-how-technology-is-transforming-the-maritime-industry/
[91] https://wwf.panda.org/?320232/New-Blockchain-Project-has-Potential-to-Revolutionise-Seafood-Industry
[92] https://customers.microsoft.com/de-de/story/insurwave-insurance-azure
[93] https://fishcoin.co

Biotechnology

Biotechnology is "the use of biological systems found in organisms, or the use of the living organisms themselves to make technological advances and adapt those technologies to various fields".[94] Through cellular and biomolecular processes, scientists can make advances and adaptations to technology in various fields; including the use of living organisms in their natural form, breeding new living organisms, or even modifying their existing genetic makeup. Biotechnological advances have resulted in more effective treatment of diseases, environmental impact reduction, and increasingly efficient use of natural resources. The science of biotechnology is broad, and can be broken down into sub-disciplines of which the following are most related to blue economy:[95]

- Red biotechnology: medical processes, such as getting organisms to produce new drugs and using stem cells to regenerate damaged human tissues
- White (or sometimes seen as gray) biotechnology: industrial processes, including the production of new chemicals or the development of new fuels.
- Green biotechnology: agricultural processes such as creating pest-resistant crops or disease-resistant animals, as well as environmentally friendly development.
- Gold biotechnology (bioinformatics): a cross between biological processes and computing.
- Blue biotechnology: processes in marine and aquatic environments, such as controlling the proliferation of noxious water-borne organisms.
- Yellow biotechnology: food production, the most popular application being the fermentation of alcohol or cheese.

The ocean biosphere represents harsh extremes of temperature, light, and pressure; adaptation to these environments has led to a rich marine bio- and genetic-diversity with a wide range of potential applications.[96] Marine biotechnology includes techniques such as bioprocessing, bio harvesting, bioprospecting, bioremediation, gene, protein, or other molecule-based techniques; while applications may include: health, food, cosmetics, aquaculture & agriculture, fisheries, manufacturing, environmental remediation, biofilms and corrosion, biomaterials, research tools.[97]

Innovative Uses Related to the Blue Economy

- *Pain medication from cone snails*: Ziconotide can be extracted from the poison of cone snails (*Conus spp.*), and belongs to the chemical family of the conopeptides, which are of significant interest to the medical community for their potential use as painkillers. The Irish Elan corporation brought a synthetic version of the drug on the European markets in 2005 under the brand name Prialt, which is intended for use by patients suffering from long-term or neuropathic pain that is

[94] https://www.conserve-energy-future.com/biotechnology-types-examples-applications.php#Examples_of_Environmental_Biotechnologynbsp
[95] https://whatis.techtarget.com/definition/biotechnology
[96] http://aquafind.com/articles/Marine-Biotechnology.php
[97] http://aquafind.com/articles/Marine-Biotechnology.php
[98] http://www.marinebiotech.eu/wiki/Application_of_Ziconotide_as_a_painkiller

not responding effectively to traditional painkillers.[98]

- *Seaweed Cosmetics*: The company oceanBASIS is cultivating the sugar kelp *Saccharina latissima*[99] in an integrative sustainable aquaculture facility in the Kiel Fjord. The company specializes in extracting natural substances from marine organisms for use in health and beauty products. Young algae sporophytes are cultivated on seeding ropes in the laboratory, then launched in the organic open water farm. Post-harvest, fresh algae are fermented into an alcoholic extract and combined with additional marine ingredients such as minerals, iodine, algae sugars and polyphenols for their "NaTrue" cosmetic skincare line.

  Crab Shells for Chitosan Production: Chitosan is a versatile biopolymer with over 400 defined applications in industries such as health care, water treatment, textiles, and agriculture. The company TidalVision is producing chitosan for a variety of purposes, including: to bind with heavy metals, hydrocarbons, debris, and other toxins as mining-water treatment processes; as a hemostatic agent able to bind to red blood cells, for antibacterial and antimicrobial coatings, and to improve crop health and accelerate growth.[100]

Nanotechnology

Technology Overview: Nanotechnology is the application and study of nanomaterials (materials sized between 1 and 100 nanometers), in their atomic, molecular and macromolecular scales, whose properties can differ significantly from larger molecules due to their small size.[101] By controlling shape and size at the nanometer scale, scientist are ably to vary design, characterization, production and application of structures.[102] Nanotechnology has the potential to support a broad array of projects and applies to many disciplines of research that impact blue economy development; including chemistry, marine materials, energy, medicine, biotechnology, agriculture, food, electronics, optics, and information technology.

Innovative Uses Related to the Blue Economy

- *Improved Feeding Efficiencies for Aquaculture*: Traditionally, feeding fish has relied on providing fish with food in the form of a pellet, which is formulated based on the daily nutritional fish requirements for fats, proteins, carbohydrates, minerals and vitamins. Scientists are currently testing the theory that nanoparticles can enhance aquafeeds by increasing the proportion of fish food nutrients that pass across the gut tissue and into the fish, rather than passing directly through the fish digestive system without being used. Theoretically, dietary minerals at the nanoscale size may pass into cells more readily than their larger counterparts and accelerate the uptake process; this technology could reduce the environmental impact of the fish feeding process by increasing absorption and decreasing the amount of unused food discharged from aquaculture facilities.[103]

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99 http://www.marinebiotech.eu/wiki/Seaweed_cosmetics_-_%22Oceanwell%22

100 https://tidalvisionusa.com/chitosan/?gclid=EAIaIQobChMI3cfI78uW6gIVAhLnCh3sawwgEAMYASAAEgKwY_D_BwE

101 https://seanews.co.uk/features/nanotechnology-in-the-shipping-and-maritime-industry/

102 https://seanews.co.uk/features/nanotechnology-in-the-shipping-and-maritime-industry/

103 https://seanews.co.uk/features/nanotechnology-in-the-shipping-and-maritime-industry/

- *Natural Protective Coatings*: Until recently, the antifouling pesticide tributyltin (TBT) was commonly applied to ship hulls to prevent the biological buildup responsible for decreased vessel efficiency. This chemical was banned by the International Maritime Organization (IMO), which has led to investment in a search for sustainable alternatives. Nanoparticles made from copper oxide, zinc oxide, and silica have been found to be strong candidates to replace TBT in paint mixtures--in theory, these nanoparticles provide more surface area as compared to more bulky materials, creating an increased surface area that provides a barrier against organisms attempting to attach to or grow on nano-coated surfaces.[104]
- Disease control: Diseases can cause enormous losses for any aquaculture facility, and while vaccinations are common, a question remains around how to most effectively deliver the vaccine to the fish. Nanoencapsulation is being considered as an alternative to traditional techniques, which is the process wherein a biomolecule is wrapped inside another substance that serves as a protective shell at the nanoscale, allowing it to survive in harsh conditions such as high temperatures or changing water acidity. Currently, a biologically derived compound called chitosan that is able to wrap itself around vaccines is a common carrier used in nanoencapsulation treatment delivery, and researchers have met with some success at developing nanoencapsulated vaccines against the bacterium Listonella anguillarum in Asian Carp and white spot syndrome virus in shrimp.[105]

Industry and Tech Blue Economy "Hotspots"

The global scan also helped identify where multiple technologies and sectors were coming together to foster new and exciting innovations. Based on this analysis, we created a Global Blue Economy Hotspot Matrix that contains representation of the types of innovations we found at the crossroads of industry, technology and science (**Table 3**). Darker shaded cells at the intersection of blue economy sectors and specific technologies indicate more established, scaled, and commercial uses of the technology in the specific sector, while lighter shades indicate nascent/experimental applications that have yet to establish commercial viability/potential. Clicking on a specific cell provides a brief description of the uses of the technology in the corresponding industry sector (full descriptions are also available in Appendix B of each of the innovations featured in the matrix).

[104] http://sustainable-nano.com/2014/02/11/nanotechnology-in-the-aquaculture-industry/
[105] http://sustainable-nano.com/2014/02/11/nanotechnology-in-the-aquaculture-industry/

Table 3: Blue Economy Hotspot Matrix. Selection of Innovations occurring at the nexus of science, technology, and industry. Colors show qualitative scale from scaled, "hot" intersections (red) to those that are still nascent but promising (beige).

Technologies	Mariculture	Coastal Development	Deep Sea Mining	Fisheries	Marine Products	Maritime Surveillance and Safety	Oil and Gas	Ports	Renewable Energy	Shipping	Tourism
AI	(1) Swarm intelligence to detect pollution	(10) Tourist safety	(19) Autonomous mapping and species identification	(28) Increase efficiencies at sea	(37) Seaweed Farming Management	(46) Accident prevention at sea	(55) Mass data analysis for site identification	(64) Machine-based arrival and departure predictions	(73) Managing energy input and flow	(82) Mapping analysis for reduced fuel consumption	(91) Chatbots for personalized experiences
AR/VR	(2) Remote teaching and instructions	(11) Imaging coastal adaptation to sea level rise	(20) N/A	(29) N/A	(38) N/A	(47) Virtual training for maritime enforcement	(56) Underwater equipment training	(65) N/A	(74) Renewable energy training	(83) N/A	(92) AR virtual tours to attract tourists
Biotechnology	(3) Increased productivity and quality	((12) Ecologically active concrete	(21) Environmental DNA	(30) Fish leather alternative	(39) Edible and biodegradable plastic alternatives	(48) Marine mammals for defense	(57) Bioremediation	(66) Biometrics security systems	(75) Synthetic biology for biofuel production	(84) Anti-fouling	(93) Bio-safety; Anti-viral coatings
Blockchain	(4) Rapid and secure sales	(13) N/A	(22) N/A	(31) Addressing IUU with traceability	(40) N/A	(49) Real-time digital insurance	(58) Trading simplification	(67) Secure and real-time information transfer	(76) Tracking biofuel creation and delivery	(85) Tracking and verifying fuel compliance	(94) N/A
Drones	(5) Monitoring and maintenance	(14) *See Robotics	(23) *See Robotics	(32) Mapping remote underwater zones	(41) *See AI	(50) Remote patrolling at sea	(59) Remote project monitoring and surveillance	(68) Surveillance and Security	(77) Remote inspection of offshore platforms	(86) Hull cleaning robots to avoid biofouling	(95) *See AR/VR
GIS and spatial mapping	(6) Mapping for improved management	(15) Calculating exposure to coastal erosion	(24) *See Sensors	(33) Satellite tracking to monitor IUU	(42) Mapping sargassum	(51) *See Blockchain	(60) Asset mapping and management	(69) Locational intelligence	(78) Identification of ideal project locations	(87) *See AI	(96) Ecotourism site selection and management
Nanotechnology	(7) Contaminant removal	(16) N/A	(25) N/A	(34) Fish Rfid for tracking and monitoring	(43) Extracellular synthesis of metallic nanoparticles	(52) N/A	(61) Nanosensor imaging and mapping	(70) N/A	(79) Enhanced bio-availability of plant nutrients	(88) Nanoparticulate hull coastings to combat erosion	(97) Antimicrobial and antifungal Nanocoatings
Robotics	(8) Automated feeding	(17) Unmanned gliders for hurricane warnings	(26) Nodular collection technology	(35) Quality control	(44) Automated urchin removal from kelp beds	(53) Anti-piracy robots	(62) Teleoperated marine operations	(71) *See Drones	(80) Kelp elevators for biofuel	(89) *See Drones	(98) Customer service
Sensors	(9) Autonomous health management	(18) *See Robotics	(27) 3D modeling of seabed	(36) *See Drones	(45) *See AI	(54) *See Robotic	(63) Inspection and maintenance	(72) *See AI	(81) *See Nanotechnology	(90) *See Drones	(99) Bio sensors

Experimental, limited application outside R&D

Commercial application but limited use; start-up companies; pilots

Commercial use in multiple regions, multiple regions, multiple companies or suppliers; POC

The matrix is not a comprehensive assessment of all innovation in the space; instead, it is a snapshot based on expert interviews and a high-level scoping analysis to highlight the cutting-edge of tech-based innovations that are being applied to the blue economy. Several interesting findings emerged from this analysis, including:

- Multiple types of technologies are progressing quickly (red) within Marine Products, which could indicate opportunity for accelerated growth in this sector despite it being a more nascent industry for the blue economy.
- Fisheries are undergoing a data technology explosion, with advanced systems for identifying and tracing fish, mapping habitats, and tracking vessels all occurring in both industrial and artisanal fleets.
- Drones and GIS/Spatial Mapping tools are—not surprising—advancing strongly within nearly every industry sector that touches the blue economy
- Rarely does a technology operate on its own; instead, multiple technologies are often tightly interwoven
- Do not underestimate nascent technologies; given sufficient starting capital, they can and likely will, evolve to meet demand
- Innovations in technology are helping to bring greater access, transparency, and accountability—as well as cost efficiencies—to many of these sectors. These developments can help both mature and emergent industries meet the full definition of blue economy—to support long term health of the environment along with local economies—if properly applied.

Hotspot Matrix Applications

The hotspot tool presents the findings of the report in a way that can be used as a general reference and as a specific tool for a variety of users. Looking across a single technology row can show the maturity of applications of the technology to specific blue economy sectors and could be useful to entrepreneurs and technology vendors. For example, AI has seen established commercial use in the Marine Products and Tourism sectors, compared to only experimental use in Deep Sea Mining and Fisheries.

Moreover, looking at different technology applications across a single industry sector can aid users looking for opportunities to use new technologies to enhance the sustainability and development potential of that sector. For example, a reader looking to use technology to develop fisheries in his or her country would be able to identify the following high-readiness applications of technology to the fishing industry:

- **Fisheries x Blockchain**: Blockchain has potential to significantly decrease illegal activities by supporting secure data transactions for traceability and sales. Blockchain technology can help track the journey of a single fish, recording information regarding where it was caught

and how it was processed and sharing this information with system users as well as the end consumer.[106]

- **Fisheries x Drones/Sensors**: The use of underwater drones allows access to information that would be costly or even impossible to obtain with other methods and provides a unique combination of three-dimensional data and underwater footage/images. From data collected with drones, it is possible to map different areas with contrasting vegetation, to establish connections between fauna/flora species and local water quality conditions, or to observe variations of water quality parameters with water depth.

- **Fisheries x GIS**: International initiatives such as Global Fishing Watch (GFW) use satellite tracking to monitor the activities of ships on the ocean and determine which ones are fishing based on the identity, speed and direction of broadcasting vessels. The tool uses a global feed of vessel locations extracted from Automatic Identification System (AIS) tracking data collected by satellite, revealing the movement of vessels over time, and the system automatically classifies the observed patterns of movement as either "fishing" or "non-fishing" activity.

These findings could then be used to direct investment towards application of more mature technologies to the sector. Conversely, some entrepreneurs or vendors looking for new niches may target relatively underdeveloped sectors for applications of their chosen technologies. Users with a cross-sectoral focus can choose between sectors and technologies based on their individual needs or evaluate the commercial readiness of their specific initiatives. For example, a proposal for funding biotechnology in deep sea mining would be rated as extremely experimental, while one applying GIS to coastal development could be seen as less risky. In this way, the tool can be used by a wide variety of users, from national development ministers, to conservation NGOs and technologists.

[106] https://www.weforum.org/agenda/2020/02/blockchain-tuna-sustainability-fisheries-food-security/

Global Patterns of Innovation within the Blue Economy

3

Introduction

To better anticipate where and how the blue economy will develop over the next few years, our global scan identifies trends and patterns of innovation within the blue economy, and the forces that are either blocking or accelerating blue economy growth. We call the forces that block progress System Barriers, and they are by definition, movable or changeable aspects of the system. Forces that help to accelerate progress are categorized as Drivers, Enabling Conditions, or Design Principles, defined respectively as the catalytic forces that launch initiatives, the factors that allow an initiative to take root, and the strategies that allow innovations and initiatives to gain traction or progress (**Table 4**).

Table 4: System Components that elucidate patterns of innovation in the blue economy. Identification of these forces and conditions provides insight into how to ground interventions so as to tackle core challenges and leverage existing resources to maximize impact and effectiveness.

Blue Economy System Components	Definition
Barriers	Forces, structures, or gaps in the status quo system that prevent or slow progress towards economic, environmental, and socially equitable innovations in the blue economy. By definition, barriers are movable, changeable elements of the system.
Drivers	Catalysts, or "sparks" that give a blue economy sector or initiative the initial momentum required to get off the ground or the additional momentum needed to maintain forward progress. Identifying drivers informs design of solutions that look to launch or propel systems change, and helps practitioners anticipate where that change might come from.
Enabling Conditions	On-the-ground assets that help to nurture and support the progress of an initiative or sector. Enabling Conditions can be thought of as the fertile soil in which the initial seeds (i.e. pilots, programs) can take root and move to a more mature state.
Design Principles	Progressive strategies, tactics, and approaches to problem solving that have either led to success or helps a project gain traction in the blue economy space.

Our research and interviews with blue economy sector and technology experts aimed to capture major industry and technology trends, exploring technological capacities, business and tech challenges and accelerators, market demands and needs, and exciting projects in the research and development stage. We then looked for patterns in how or why certain innovations were progressing or not.

At the global level, the system barriers and design principles help us to identify across sectors where innovation and progress is blocked, and why; and the types of efforts that are gaining traction, and why. This information helps point to what is possible in terms of blue economy growth, if the right conditions are met and challenges overcome.

From this universe of what is possible, we then drill down to identify where there are areas of opportunity to scale or replicate success, based on the Caribbean regional context. For this report, Opportunity Areas were identified by incorporating System Components from the Global Analysis with known challenges and limitations specific to the Caribbean.

In this Global Scan (section 2), we provide a high-level summary of the System-level findings. The next section 4. Caribbean Regional Context then provides in-depth discussion of how these barriers, drivers, enabling conditions, and design principles manifest within the Caribbean and how those insights inform identification of realistic Opportunity Areas for the Caribbean regional, and specific candidate blue economy action initiatives and projects for the six countries.

Based on the global scan, we identified patterns in the types of initiatives that are currently pushing the edge of innovation in the blue economy or those that are seen to hold promise. The following subsections--barriers, drivers, enabling conditions, and design principles--describe the fundamental forces that enable and restrict blue economy innovation.

Barriers

Barriers are surfaced during the Synthesis process as clusters of similar or related stuck points that are experienced by multiple stakeholders in a system, identified via interviews or background research. These are the first-order problems that innovators tend to be focused on—the issue they were trying to resolve, or what has them currently stuck.

By clustering related or similar stuck points together we can then identify the underlying core challenge that is preventing progress across multiple projects and actors. These root-cause barriers—System Barriers (**Table 5**)—are affecting more than just one specific sector. Designing solutions that explicitly address system barriers helps to ensure that resources are driving progress that can unlock change at scale. Grounding interventions to tackle these core challenges also helps avoid the problem of "chasing shiny objects" or jumping on the bandwagon of the latest trend; instead, it forces resources to be driven towards root-cause problems and thereby maximize likelihood of impact.

Table 5: Global, Cross-sector System Barriers to Blue Economy Development.

Lack of organizational infrastructure to retain and grow talent

"Brain drain" is a significant barrier to accelerating blue economy growth in SIDS. Technical, analytical, and topical expertise are all needed; while young professionals are trained in many of the required skills, the nascent and undeveloped nature of the sectors means that talented staff often leave the region for jobs that offer growth opportunities (and better salaries).

Uncertain regulatory environment and loopholes

The lack of clear policies, frequent government turnovers, lack of enforcement, and other factors create uncertainty around the rules of engagement and how long-term projects will be affected. This barrier then increases the risk of any project, reducing likelihood of investment, partnerships, etc.

Lack of access and high cost of energy

Until alternative energy sources to imported fossil fuels are more readily available, the startup and maintenance costs of many blue economy projects become cost-prohibitive simply based on need for reliable power.

Market drivers missing

Without strong demand, many projects face an uphill battle, trying to first build awareness, then build demand.

Unproven value

The economics and technology for mapping and valuing natural resources are advanced on land but are only just now being applied to ocean systems. In addition, models for harvesting or extraction of marine resources remain relatively nascent, with mixed track records. The lack of proof of concepts continues to stymie blue economy growth in multiple sectors.

Competition prevents collaboration

Rather than working together, fledgling businesses compete for limited start-up capital and resources; countries work to position themselves as leaders, rather than as partners.

Table 5: Global, Cross-sector System Barriers to Blue Economy Development. (cont.)

Lack of leadership and political will

Growth of a blue economy sector requires support at all levels: on-the-ground staff, career bureaucrats, and ministry officials. Commitment—in times of plenty and times of need—to see the work through over the long-term is also needed. This combination of will and leadership across levels is rare.

Opportunity costs of new technology prevents uptake

Often, the ROI on new technology or innovation may take several months or even years to realize. The upfront costs are therefore too high for businesses or governments to absorb, slowing uptake of innovations that in the long-run, could greatly pave the way for successful blue economy growth.

Fragmented Institutions within and among countries

Despite the small size of island nations in the Caribbean, and despite regional groups such as CARICOM, in reality, there is a high degree of fragmentation and information silos within and across institutions in the region. This lack of true partnership, coordination, and leveraging of resources is a significant challenge to accelerating progress.

Drivers

Operating in contrast to barriers are forces within the system that push progress: Drivers. These are derived through a similar clustering and pattern-finding process as Barriers. "Drivers" are identified by looking for common catalysts to innovation across sectors (**Table 6**).

Table 6: Catalysts, or "sparks" that give an initiative the initial momentum required to get off the ground or the additional momentum needed to maintain forward progress.

Environmental or Social Responsibility Commitments

Whether they are internal Corporate Social Responsibility (CSR) commitments, or government plans for reaching Sustainable Development Goals (SDGs), the need to meet environmental and social impact goals is helping drive forward projects across multiple blue economy sectors.

Cost Reductions

The need to do more with limited financial resources helps drive innovation in fields such as automation, fuel efficiency and vessel design, and engineering with nature. The desire to save or reduce costs can serve as the catalyst for launching new initiatives within companies or a sector.

Table 6: Catalysts, or "sparks" that give an initiative the initial momentum required to get off the ground or the additional momentum needed to maintain forward progress. (cont.)

Focus on Small Scale and Local

Even before COVID-19 revealed the risks of too much dependence on international markets, there has been a strong trend for increasing local production and consumption. National pride, concern for the environment and social welfare, and desire to support local businesses can all spark interest and action.

Limited Capacity and Increased Complexity

The number of blue economy sectors has grown, as has the number of sub-sectors (i.e. offshore fish farms vs. nearshore). To effectively manage these competing interests' forces planning and use of tools that can serve multiple waves of blue economy growth.

Policy and Regulations

These can be both drivers and enabling conditions. Where leadership is strong and visionary, policies can often catalyze new industries or sub-sectors within the blue economy.

Growing Interest in Marine-based Products

From molecules and rare elements to inspiration for design, there is strong and growing interest in what the ocean can offer for pharmaceutical, fashion, defense, cosmetics and food sectors. Some of this interest is based on consumer association of ocean products as exotic or more natural; some is driven by a desire for novelty; and some is a need for new materials and mechanisms to solve pressing global challenges.

Mitigation Needs

Climate change, increased impacts of pollution and runoff, growing coastal populations—all these push coastal ecosystem to the brink. As communities and countries look to reverse or prevent damage, they are pushing for blue economy-based solutions.

Tourism Sector Demands

Prior to COVID-19, the tourism sector—especially for SIDS—was an important driver for blue economy development, including increased demand on small vessel cargo trade; desire for novel, nature-based experiences; and the need to provide clean beaches and healthy reefs. The role this sector will play in short and long term, the requirements it has, remains to be seen post pandemic.

Enabling Conditions

"Enabling Conditions" are those factors that are repeatedly seen as necessary for solutions to take root or "stick" (**Table 7**).

Table 7: Enabling Conditions are the on-the-ground assets or forces that help to nurture and support the progress of an initiative or sector to take root.

Local expertise and research capacity

Local, on-the-ground technical, scientific, and entrepreneurial expertise, as well as access to facilities to support research and development, is necessary in order to attract interest, to scale projects past the pilot stage, and for new endeavors to blossom.

Strong partnerships among key stakeholders

Robust relationships across public and private sectors, and among regional institutions is necessary to crowd-in the diverse resources that most projects require for success: expertise, funding, infrastructure, data, etc. Projects that help to build these networks of stakeholders can then leverage these relationships for future initiatives. Given limited capacity of individual SIDS- more regional or joint-solutions involving efforts such as streamlined data collection, or sharing expertise, could help "float all boats".

Risk-tolerant financing for local enterprises

All projects need funding, and innovation is inherently risky. Failure is part of the design cycle that all start-up businesses and research projects must endure. The availability of patient, risk-tolerant capital to provide support is critical in order for organizations to identify, test, and refine innovative solutions for the blue economy, no matter the sector.

Visionary Leadership

Stakeholders within the system must feel supported and inspired by a clear and strong vision for the future—an outcome that all can align under. Leaders who can paint this picture, and speak across disciplines, help to set the conditions for successful project execution.

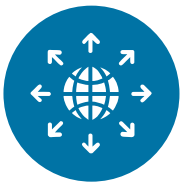
Legal agreements and structures to protect project interests

From filing patents to certifying eco-friendly coastal development projects, legal expertise, tools, and instruments are needed to ensure that the interests of stakeholders are clearly articulated and protected. This is especially important to reduce the risk of abuse of funds or loss of IP.

Table 7: Enabling Conditions are the on-the-ground assets or forces that help to nurture and support the progress of an initiative or sector to take root.(cont.)

Global Standards and Conventions

These efforts help to align stakeholders to common vision and targets, so that resources can be more efficiently and effectively directed. Having these conditions in place raises the bar for sectors such as shipping, fishing, and bioprospecting to help drive innovation while increasing safety and conservation.



Markets beyond the region

Pre-COVID-19, the blue economy space was reliant on markets or demand from outside local regions: cruise ships offered markets for novel seaweed and marine products for their spas; fishers targeted lucrative export markets in the EU, North America, and China for their fish; and for SIDS especially, tourists provided a seemingly stable and steady demand. Consideration for how this enabling condition may shift post-COVID will be critical to designing innovations.

System Design Principles

We call the underlying strategies or tactics related to the success (or promise) of existing or hoped-for solutions, "System Design Principles" (**Table 8**). These principles reflect ways in which multiple stakeholders from different sectors and different parts of the system have problem-solved successfully to advance blue economy growth. The Design Principles are the common principles employed by multiple stakeholders, often to tackle different Barriers. The more we can identify and design specific initiatives to incorporate one or more of these principles, the greater the likelihood that our ideas will leverage momentum in the system and not only gain traction but reach longer-term success.

Table 8: System Design Principles are the underlying progressive strategies, tactics, and approaches to problem-solving that repeatedly emerged as having led to successes or helped a project continue to gain traction.

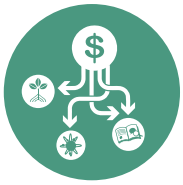
Investment Risk Reduction

Efforts that seek to de-risk a sector or development of the blue economy as a whole. These span technological and process-oriented efforts, in both the private and public sector, that if successful, would help to attract more investment into the space.

Table 8: System Design Principles are the underlying progressive strategies, tactics, and approaches to problem-solving that repeatedly emerged as having led to successes or helped a project continue to gain traction. (cont.)

Leverage new business models to reduce risk and maximize benefits

Co-ownership, staged or phased engagements, unique income generation strategies—all of these can help reduce the risk of a country, organization, or business to engage in a blue economy sector. Implementing solutions that incorporate these new business models can help stabilize and accelerate success of blue economy endeavors.



Diversify infrastructure for non-traditional purposes

Strategic use of infrastructure and skill sets across sectors or functions can help crowd-in additional resources (funding, expertise, data) that are needed for long-term success of a project. From ports serving as modern data and information hubs to 4D simulation rooms serving as both tourist attraction and advanced training grounds, the initiatives in this emergent opportunity area help a sector think outside-the-box to reach scale.

Novel application of renewable energy

Beyond powering homes or typical commercial businesses, renewable energy applications for shipping, freshwater production, and food production offer new ways to lower costs and increase basic security of small island states.

Real time monitoring for planning and decision-making

The technology and capabilities to survey, detect, and monitor above and below the surface, can help SIDS to better protect and more accurately value their marine resources. Also, as economies are dynamic, and the faster, more accurate the data about trade, the more efficient and effective the economy. These approaches help push technology and processes that feed more reliable, detailed information from the ocean to those who have to plan and manage its use. This includes big data and analytics to allow for increased access and strategic use of SIDS's full EEZ—an area too large and remote to be patrolled or mapped by human-power alone.

Aquaculture beyond food production

The fields of biotechnology and materials science advanced significantly in recent years, allowing innovators to turn seaweed and other natural products into fuel, fertilizer, cosmetics, and a host of other valued products (bio-plastics as a more recent focus). Initiatives in this category embrace the ethos that cultivation of marine life can do a lot more than just feed the planet.

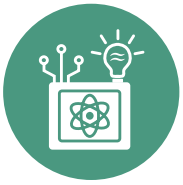
Table 8: System Design Principles are the underlying progressive strategies, tactics, and approaches to problem-solving that repeatedly emerged as having led to successes or helped a project continue to gain traction. (cont.)

Use of ocean products or seawater for environmental mitigation

This emergent strategy includes new technology or innovative application of ocean forces (tide, currents) or biological resources, as a means to mitigate damage to the ecosystem. Use of mangroves and seagrass beds as coastal protection, or mobile shellfish beds as living water filtration systems, are just a few examples.

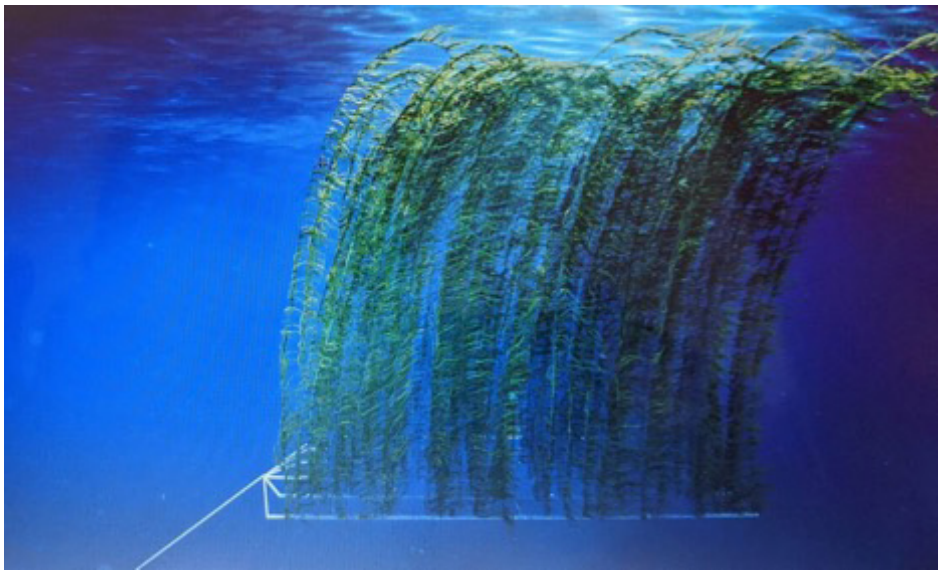
Localize aquaculture production and consumption

There are multiple innovations aimed at reducing costs and sourcing more components locally within the aquaculture space. The goal of these efforts is to allow small-scale, local production of seafood for local consumption.



Science & Technology as core of economy/sector

This emergent strategy includes programs and initiatives that turn the enormous field of research and design (R&D) into income generation for local communities and economies. The defining component of this cluster is an emphasis on the importance and potential of science and technology—as fields of research—to be economic engines within local communities.



Regional Analysis: Blue Economy in the Caribbean Context 4

The regional analysis included background research and interviews with individuals working on blue economy-related efforts in the six target countries or involved with projects and programs in the Caribbean region. The purpose of this regional scan was threefold:

1. To identify how system barriers from the global scan may be manifesting in the region and note any novel barriers;
2. To identify assets (programs, local champions, existing businesses, etc.) that could be leveraged to advance blue economy solutions in the six target countries or region as a whole; and
3. Use insights generated from the regional and global scans to identify promising areas of opportunity that appear ripe for development across the six countries.

Caribbean Context

The economies of the Caribbean have been experiencing weak growth for some time with average GDP growth of 0.8% from 2010 - 2017 as contrasted with 4.7% growth in other small states.[107] Caribbean economies are heavily reliant on the service sector with services making up 62.8% of GDP in CARICOM countries in 2015.[108] Tourism is the primary service sector in the Caribbean with its benefits spilling into the broader sector in many countries. Financial services also provide significant income for several island nations as well. In addition to services, commodities such as agriculture, fishing, and mining also contribute significantly in select countries along with light manufacturing.

Caribbean economies generally are heavily reliant on international trade to sustain their economies. A small portion of trade occurs between islands, thus, economic integration and institutions to promote regional growth is limited. With limited multi- or pluri-lateral cooperation, the economies in the region struggle to take advantage of economies of scale that could benefit industries across the region; or create other institutional assets that larger, more diverse economies are more able to support. Although there are institutions that are established to coordinate regional development, there remains a lack of economic integration, resulting in siloed industries and creating high vulnerability to global shocks and national disasters within individual countries that often affect their primary industries. For example, recent global disruptions include economic contraction in the region during the recession of 2007 - 2009 (hurting global trade and capital flows) and the recent Covid outbreak (which has devastated the tourism industry). And national disasters since 2017 have included hurricanes Dorian, Irma and Maria which, in the hardest hit islands, have caused economic damage greater than their

[107] http://www.oecd.org/dev/americas/LEO-2019-Chapter-6.pdf
[108] https://statistics.caricom.org/Files/Publications/Economic%20Handbook/SelectedEconIndicators_2014.pdf

annual GDP. The OECD states that "The Caribbean is the second most environmental hazard-prone region in the world".[109] Outside of these immediate shocks, the threats posed by climate change also weigh heavily on the economic prospects as well, as the risks and costs of investing to diversify industries continues to increase and work against the competitiveness of the region.

Similarly, the economies of the Caribbean have been supported significantly from foreign direct investment (FDI) with some of the highest levels of FDI in the world.[110] FDI is important for job creation and economic growth; however there are negative consequences to such a high reliance on external capital as it does not always support local wealth accumulation and high-skilled jobs are often not provided to citizens of the countries that host those jobs. Similarly, it can be argued that globalization has increased the vulnerability of many Caribbean countries as those dependent on FDI and foreign business are less resilient as a larger percentage of their economies are dependent on the health and openness of global markets. For example, the reliance on imported food and fuel in many Caribbean countries weakens food and energy security and increases the costs of these goods.

Government finances in many Caribbean countries present a challenge for supporting strong investment and growth. The region generally has low tax receipts with many countries specifically targeting and being sought after by personal and business wealth as tax havens. Additionally, over two-thirds of governments in the region maintain debt-to-GDP ratios above 60%.[111] With low tax revenues and high debts, many governments lack the fiscal space to invest appropriately in social services and economic development. The effects of covid on many countries will significantly exacerbate these challenges.

In regard to the labor force, most countries in the Caribbean are experiencing and trending towards a decrease in the working age population. However, that trend hasn't not resulted in job opportunities for younger generations as the Youth Population is estimated at 25%.[112] This is thought to be due to "clogging" where the aging population is not making way for younger generations; thus resulting in higher youth unemployment with fears of these unemployment trends extending into the future if left unaddressed. Additionally, the Caribbean is significantly challenged by "brain-drain", with most countries seeing more than 50% of their tertiary educated populations migrating to OECD countries in 2000.[113]

Current State of Blue Economy Industries in the Caribbean

Regarding the blue economy in the Caribbean, little comprehensive research has been done to understand its scope for individual blue economy industries across the region or on a country basis. However, through quantitative and qualitative research conducted through this study,

[109] http://www.oecd.org/dev/americas/LEO-2019-Chapter-6.pdf
[110] https://repositorio.cepal.org/bitstream/handle/11362/36620/1/S2014046_en.pdf
[111] http://www.oecd.org/dev/americas/LEO-2019-Chapter-6.pdf
[112] http://www.oecd.org/dev/americas/LEO-2019-Chapter-6.pdf
[113] https://www.ilo.org/wcmsp5/groups/public/---americas/---ro-lima/---sro-port_of_spain/documents/genericdocument/wcms_614940.pdf

it is evident that certain blue economy industries are generally mature throughout the region including fishing and tourism. There are also instances where industries are mature in select countries such as: shipping and ports in Jamaica and The Bahamas; and petroleum products in Trinidad & Tobago. However, most blue economy industries in the Caribbean would need to be considered in the emergent stage or even nascent.

Table 9: Maturity of Blue Economy Industries Globally vs in the Caribbean.

Blue Economy Industry Status	Blue Economy Global Scan	Blue Economy Caribbean Scan
Mature	Fishing; Tourism (Cruise, Coastal, Marine); Shipping; Oil & Gas	Fishing; Cruise, Coastal, Marine Tourism; Shipping
Growth Stage	Mariculture: coastal & offshore; Maritime Monitoring & Surveillance; Ports; Renewables: offshore wind, solar	Oil & Gas*; Maritime Monitoring & Surveillance; Ports
Emergent	Coastal Development, Protection & Restoration; Marine Products; Deep-sea mining; Renewables: wave, current, thermal	Mariculture: coastal & offshore; Coastal Development, Protection & Restoration; Marine Products
Nascent/ Negligible		Renewables: offshore wind, solar; Deep-sea mining; Renewables: wave, current, thermal

* Denotes, in isolated countries. Trinidad and Tobago and Suriname's oil and gas sectors have been operating for decades. However, recent discoveries and production of offshore oil and gas in Guyana are stimulating a massive growth in the entire economy.

It is worth noting that regarding the strengths and ability of Caribbean institutions, that according to the OECD, "The main challenges of Caribbean countries in formulating and implementing development plans include financing, particularly inadequate access to concessional resources and grants; weak technical capacities, especially for production of disaggregated data; insufficient public awareness and political buy-in; and shortcomings in establishing effective institutional mechanisms to implement the plans."[114]

[114] http://www.oecd.org/dev/americas/LEO-2019-Chapter-6.pdf.

In considering the blue economy industries and trying to understand where governments, civil society and businesses should focus, it's worthwhile to consider all of the challenges highlighted herein and that apply to other SIDS. With small economies, there is a challenge in spreading out limited resources to try to build multiple industries. Since many Caribbean islands have isolated economies and do not have tight regional integration, an evaluation of the national resources and assets available should be considered for selecting key industries of focus.

Key Regional Assets

Marine environment and geography

Though the countries of the Caribbean do generally have isolated economies, there are a number of assets regionally that are worth noting. First and foremost, is the sheer volume of marine resources, especially given the disparity in EEZ's for many island nations which far exceed their land area. The World Bank estimates that the value of the ocean economy in the Caribbean to be US$407 billion.[115] This presents a massive opportunity for economic growth that could be transformative for the region. Thus, the oceans provide a bounty of opportunity and the regions key to growth assuming ocean resources can be accessed responsibly and sustainably.

In addition to the marine resources, geographically the Caribbean also lies on major international trade routes benefitting from its proximity and strategic positioning to the Panama Canal. Specifically, the Ports of Kingston, Jamaica and Freeport, Bahamas serve as transit points for major shipping routes between Asia, the EU and the US. These links to the global economy provide assets that can be leveraged for blue economy industries that rely or benefit from international trade.

Institutional Assets

Although institutions focused on economic and social development in the Caribbean are often characterized as working across each other and pursuing similar goals and initiatives within silos, there are several institutions that could be pivotal in supporting both regional and country-specific blue economy policy and strategies including CARICOM and the OECS. Additionally, the UN has a number of agencies including the FAO in the region that are leading initiatives in the blue economy. There are also business and industry bodies such as the Caribbean Association of Industry and Commerce, Caribbean Tourism Organization (CTO), Caribbean Hotel and Tourism Association (CHTA), Florida-Caribbean Cruise Association (FCCA).

There are also significant resources being provided by multilateral development financial institutions that are investing in the Caribbean. These include the World Bank and Inter-American

[115] http://documents.worldbank.org/curated/en/965641473449861013/pdf/AUS16344-REVISED-v1-BlueEconomy-FullReport-Oct3.pdf.

Development Bank (IDB) who provide financing to governments. The IFC, IDB-Invest, and IDB Lab also provide foreign direct investment to support business ventures and industry sectors. Additionally, the Caribbean Development Bank, Development Bank of Latin America (CAF), and other smaller financial and social investment institutions exist within the Caribbean that could be allies in supporting the development of blue economy industries.

Additionally, there are a number of capacity building and support organizations in the Caribbean that are worth noting. The blue economy and Sustainable Management of Ocean Degradation Lab in Barbados is an initiative of UNDP and the Branson Centre's blue economy Program support seed stage businesses in blue economy industries. The Compete Caribbean Partnership Facility, an initiative of several multilateral organizations including the IDB, is focused on supporting private sector development in the Caribbean which includes business opportunities in the blue economy.

Similarly, the region benefits from a relatively small but important collection of educational institutions and research stations, such as the University of the West Indies' Centre for Resource Management and Environmental Studies (CERMES) in Barbados, the Centre for Marine Sciences at the University of the West Indies, the Caribbean Maritime University's Centre for the blue economy and Innovation (CBEI), the Discovery Bay Marine Lab and Alligator Head Marine Lab in Jamaica, the Bimini Biological Field Station in the Bahamas, CARMABI in Curacao and the Smithsonian Tropical Research Institute in Panama.

While it has been mentioned that small states present challenges to establishing and growing industries, that same characteristic can also be an asset in supporting the blue economy. Given the small population size in many island nations, getting champions and communities onboard with development efforts is often much more catalytic and successful as personal relationships can quickly set and drive collaborative efforts. In these settings, convening stakeholders and getting support and cooperation for projects or initiatives can be catalytic.

Through individual initiatives and entrepreneurial efforts currently exploring new opportunities in the blue economy or focused on improving existing businesses benefiting from the resources of the sea, there seems to be increasing interest in understanding how best to use these resources for long-term prosperity. This is evidenced through various efforts scattered across the Caribbean including: seagrass, coral and mangrove restoration projects; industry-led initiatives to improve marine environments per SDG and better business practices; the abundance of MPAs and mapping efforts undertaken; and even in the recent creation of the Ministry of Maritime Affairs and the blue economy in Barbados in 2018, the first of its kind in the Caribbean. These are seeds of potential growth and demonstrate the interest and opportunity for the blue economy in the Caribbean.

Key Regional Barriers and Gaps in Enabling Conditions

Many residents and observers of the Caribbean region are well-aware of long-standing critical barriers that have often hampered the prospects for business and economic growth in the region. Due to the Caribbean's geography, social and cultural history and lingering political and economic fragmentation, many commercial activities have struggled to achieve the requisite scale and competitiveness that would make new innovative business models financially viable and sustainable. Several of the most difficult barriers reflect an absence of key enabling conditions that are needed for robust and equitable economic development. In the context of blue economic growth. Dr Julian Roberts, an Adviser in Ocean Governance at the Commonwealth Secretariat, has provided a detailed review of several of these gaps and challenges in a discussion paper for the Caribbean Regional Dialogue with the G20 Development Working Group.[116]

Building off this body of knowledge, the results of the regional analysis here confirm that these (and other) critical barriers continue to constrain the viability of blue economy business models, the uptake of blue economy technologies, and subsequently, the expansion of blue economy industries. The impact of these gaps in the enabling environment and other existing barriers on the regional investment climate for the blue economy has become even more pronounced following the COVID-19 outbreak, significantly augmenting the already substantial risks associated with numerous blue economy business models, particularly those that are capital-intensive.

A brief summary of the most critical gaps in regional enabling conditions and related systemic barriers and their impact on the investment climate for the blue economy builds on the blue economy innovation ecosystem framework presented in Section 4 and is provided here for context.

Lack of Access and High Cost of Energy

Several of six target countries have some of the highest debt-to-GDP ratios in the world, which are in part, driven by significant dependence on fossil fuel imports. According to the Inter-American Development Bank, "there is an inseparable linkage between the fiscal crisis confronting the Caribbean Region and the reality of paying some of the world's highest per capita energy costs. The countries in the region are encumbered with the necessity of importing increasingly expensive oil products for transportation and electricity generation. Covering the ever-increasing cost of energy places enormous pressure on countries whose national budgets are already heavily indebted."[117]

[116] Julian Roberts, "The Blue Economy: From Concept to Reality in the Caribbean Region." Discussion Paper for the Caribbean Regional Dialogue with the G20 Development Working Group, 2015.

[117] https://blogs.iadb.org/caribbean-dev-trends/en/the-caribbean-has-some-of-the-worlds-highest-energy-costs-now-is-the-time-to-transform-the-regions-energy-market/.

Four of the six target countries (Jamaica, Barbados, Guyana and the Bahamas), have some of the highest energy costs not only in the region, but globally as well, with average tariff rates approximately double the global average tariff rate.

Table 10: Average Retail Tariffs for Six Target Countries.

Blue Economy Industry Status	
Country	**Average Tariff (2012)**
Jamaica	$0.36
Barbados	$0.32
Guyana	$0.32 (2011)
Bahamas	$0.26 (2010)
Global Average (Household Users)	$0.16
Global Average (Business Users)	$0.14
Trinidad and Tobago	$0.06 (2011)
Suriname	$0.05 (2011)

Sources: https://blogs.iadb.org/caribbean-dev-trends/en/the-caribbean-has-some-of-the-worlds-highest-energy-costs-now-is-the-time-to-transform-the-regions-energy-market/ and https://www.globalpetrolprices.com/electricity_prices/

High energy costs not only exacerbate high debt and deficit levels at the national level, but also have a more granular impact on businesses by increasing the operational costs (and the associated risks) related to a number of potential blue economy commercial activities. This is particularly the case for those that require significant energy inputs, such as processing activities. Until alternative energy sources to imported fossil fuels are more readily available and cost-effective, the startup and maintenance costs of many blue economy projects become cost-prohibitive simply based on need for reliable power.

Lack of Marine Spatial Planning and Uncertain Regulatory and Legal Frameworks

Most Caribbean countries' Exclusive Economic Zones (EEZ) are many times larger than countries' land masses—the sheer size, logistical challenges, and financial price tag of underwater surveying means that *very little sea mapping has occurred in the region*.[118] On one hand, the lack of sea mapping impacts awareness and understanding of Caribbean countries' indigenous marine

[118] It is noted that the Global Environment Facility's (GEF) "BE-CLME+": Promoting National Blue Economy Priorities Through Marine Spatial Planning in the Caribbean Large Marine Ecosystem Plus program was recently launched and is intended to enhance marine spatial planning in Barbados, Belize, Guyana, Jamaica, Panama, and St. Lucia. (Source: https://www.thegef.org/project/be-clme-promoting-national-blue-economy-priorities-through-marine-spatial-planning-caribbean.)

assets and as a result, the full potential value of marine resources in most target countries is unknown.

And on the other hand, the types of data are not being generated that are necessary to inform marine spatial planning and integrated coastal zone management activities that could lead to legally zoning and permitting certain blue economy activities. "Knowledge of the marine environment is a critical need for effective decision making. The marine environment, both globally and within the Caribbean, is far from completely understood. There is a paucity of data relating to the offshore waters in the Caribbean Sea."[119]

Regulations, such as permits, are not just needed for access, these legal frameworks are necessary to protect long-term interests of stakeholders, including SIDS governments, who often under-sell their rights to benefit from their natural resources.

The lack of clear policies, regulatory and legal frameworks resulting from inadequate marine spatial planning, coupled with frequent government turnovers, lack of enforcement, and other factors create uncertainty around the rules of engagement and how long-term commercial activities will be affected. This barrier then amplifies the risk associated with any blue economy commercial activity, reducing the likelihood of investment, partnerships, etc.

Dr. Julian Roberts has reinforced that some of the most important priorities for blue economy growth in the Caribbean include, "Integrated cross-sectoral spatial planning, including coastal zone management, would be in place for all sea uses at both the national level and at the level of the Caribbean Sea basin…[such that] surveillance of offshore waters would strengthened through enhanced maritime domain awareness and existing laws would be robustly enforced."[120] The economics and technology for mapping and valuing natural resources are advanced on land but are only just now being applied to ocean systems. Fortunately, efforts to utilize these technologies in ocean systems are already underway in some of the target countries, providing an important technical capacity base from which to build upon.

Limited Insurance Options and Lack of Risk-Tolerant Financing for Local Enterprises

Compounding the issues around inadequate marine spatial planning, limited insurance options in a natural disaster-prone region like the Caribbean that is largely geographically disconnected from both end markets and sources of inputs, only further erodes the bankability of a number of potential capital-intensive blue economy activities.

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[119] Julian Roberts, "The Blue Economy: From Concept to Reality in the Caribbean Region." Discussion Paper for the Caribbean Regional Dialogue with the G20 Development Working Group, 2015.

[120] Julian Roberts, "The Blue Economy: From Concept to Reality in the Caribbean Region." Discussion Paper for the Caribbean Regional Dialogue with the G20 Development Working Group, 2015.

For example, recent research found that several Caribbean countries, including Jamaica and the Bahamas, enjoy favourable conditions for productive mariculture farm sites. Yet with few insurance options available to potential mariculture entrepreneurs and investors, interviewees consulted during the research effort suggested that capital-intensive mariculture activities remain prohibitively risky and the likelihood of significant mariculture development will continue to be minimal going forward.

Creative approaches to build the necessary patient, risk tolerant capital is a critical and currently missing, step. Considering that many typical market drivers are absent, innovative insurance models that can share risk as broadly as possible through the Caribbean might need to be considered and it is likely that local governments will need to be a stakeholder and potential investor initially in insurance access to support blue economy commercial activities to get off the ground and reach requisite levels of scale.

Lack of Local Expertise and Research Capacity

Across the Caribbean, there exist a handful of research stations and associated institutions, such as CARMABI in Curacao, Smithsonian Tropical Research Institute in Panama, Bimini Biological Field Station in the Bahamas, and the Discovery Bay Marine Lab and Alligator Head Marine Lab both in Jamaica. But given the enormity of marine resources and rapid rate of technological development within the blue economy sector, the general impression from stakeholder interviews indicates that by and large there is an overarching lack of professional skills, expertise, and technical capacity within the target countries to effectively support the development and scaling of a number of blue economy activities."

In addition, although the Caribbean's emerging blue economy entrepreneurial ecosystem is growing with institutions such as the Branson Centre and the UNDP's Blue Economy and Sustainable Management of Ocean Degradation Lab, entrepreneurial support structures are still minimal and there are a select few accelerators and other innovation hubs in the Caribbean. And often, the ones that do exist are largely working in silos but on similar business models. All of this is compounded by the shortage of experienced, talented entrepreneurs and limited deal flow. Further, there are few major institutions or research clusters in the Caribbean that could support blue economy R&D and commercialization processes, and that have a track record of working with good candidate entrepreneurs.

As Dr. Julian Roberts noted, there is a lack of organizational infrastructure to retain and grow talent in the region: "the lack of education and training in the wider Caribbean region leads to chronic gaps in the technical capacity for marine research, planning, and decision making. Identifying future skills needs and labour market supply and demand trends and adapting and developing existing education, vocational and professional training programmes to meet them

will be essential if the blue economy is to become a reality in the Caribbean. A more coordinated focus between the existing research and educational facilities may well prove beneficial in terms of addressing key gaps in research skills and capacity building but ultimately a more comprehensive research strategy is likely to be required if the Caribbean is to fully realise the opportunities presented by a blue economy."[121] Roberts goes on to note, "Furthermore, indigenous marine research is not well developed in most Caribbean countries due to a lack of funding and research institutions."

The limited knowledge and skills base to support a number of blue economy activities makes it more challenging to scale up blue economy commercial activities and most likely increases blue economy businesses human resources costs, constituting another key factor that magnifies the risk associated with participating in blue economy activities in the region.

Fragmented Institutions & Lack of Strong Partnerships among Key Stakeholders

Throughout the Caribbean, the blue economy concept has been embraced, at least in part, by some countries., Barbados formed a ministry dedicated to the blue economy; Jamaica is host to the global headquarters of the International Seabed Authority. However, the results of stakeholder interviews indicate that despite the small size of island nations in the Caribbean, and despite regional groups such as CARICOM, in reality, institutions are highly fragmented—both within their own divisions and across the region. The lack of collaboration and partnership leads to data silos, duplicative effort and wasted resources, and an inability to leverage success to accelerate progress across the region.

Several interviewees emphasized that this institutional fragmentation is occurring both within and among countries, with few structures in place to regionally manage marine and coastal resources and help facilitate the prospects for more scalable blue economy activities. The lack of strong regional governance leads to inadequate adherence to global standards and conventions. The lack of compliance further limits blue economy progress in that it increases uncertainty for commercial partners farther upstream—especially in an era of growing SDG and CSR commitments, companies increasingly need to prove they are partnered with legitimate, legal, sources.

Dr. Julian Roberts summarized the blue economy governance challenges posed by the existing levels of institutional fragmentation within the Caribbean region:[122]

> "The existing ocean governance framework in most, if not all, Caribbean countries emphasizes a traditional sector-specific approach to management and planning and thus shows

[121] Julian Roberts, "The Blue Economy: From Concept to Reality in the Caribbean Region." Discussion Paper for the Caribbean Regional Dialogue with the G20 Development Working Group, 2015.

[122] Julian Roberts, "The Blue Economy: From Concept to Reality in the Caribbean Region." Discussion Paper for the Caribbean Regional Dialogue with the G20 Development Working Group, 2015.

symptoms of the problem facing a large number of countries seeking to implement a blue economy approach – ocean governance remains highly 'balkanized'. As a generalization, governmental attempts to mitigate or adapt to particular resource uses on a sector-by-sector basis normally prove ineffective and are unable to respond to the cumulative and synergistic impacts and pressures from human activities. The existing arrangements in most countries are likely to give rise to a number of institutional challenges, such as:

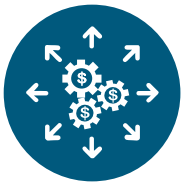
- Lack of connection between the various authorities responsible for individual activities resulting in poor or absent coordination and national oversight for the management and utilization of marine space;
- A spatial and temporal overlap of human activities and their objectives, causing conflicts;
- Impacts from one (or more) activities adversely affecting other users of the marine environment;
- Lack of consideration of the cumulative effects of multiple activities on the marine environment and other users;
- A lack of connection between marine activities and the resource use and onshore communities that are dependent on them;
- Lack of protection of biologically and ecologically sensitive marine areas.

As Caribbean governments encourage economic development of marine areas in the future value-based conflict between competing interests can also be expected to increase. It will be difficult to resolve such conflicts without a more comprehensive and integrated approach to marine planning and decision-making, which recognizes the interactions and the interdependent nature of the various systems on islands.

Clear coordinated institutional mechanisms for integrated coastal and ocean management established and implemented across relevant sectors such as fisheries, tourism, transport, energy, health and environment, will be essential to accommodate and resolve conflicts between the vast range of marine-related interests and values."

This institutional fragmentation and lack of cohesiveness trickles down to the firm level, where fledgling businesses compete for limited start-up capital and resources and countries often work to position their domestic industries as leaders, rather than as partners that could build scale by collaborating with industries in neighboring countries.

Experience with best practice peer regions has shown that coordinated institutional mechanisms for integrated coastal and ocean management and other relevant governance structures are generally prerequisites to significant blue economy growth. And as with the other factors outlined in this section, the existing fragmented institutional and governance structures in the Caribbean region help to elevate the risks associated with pursuing a number of blue economy activities. Growth of a blue economy sector will require support and coordination at all levels: from field staff to the highest levels of government.



Combined Impact of these System Barriers on the Investment Climate and Capital Resources

Historically, the Caribbean region has not been noted for sophisticated capital markets or abundant sources of investment capital. In turn, many potential commercial ventures in the region have been constrained by a variety of scalability issues. In addition, the lack of investment capital makes it difficult to overcome the opportunity costs of adopting new technology.

> "For many Caribbean countries, the challenges to exploiting ocean resources and services for sustainable development lie in the inherent structure of their economies. The small size of many countries limits their capability to fully exploit the economies of scale and price bargaining power that larger countries may have. Sovereignty necessitates certain fixed costs of providing public services, including data collection, policy formulation, regulatory activities and security. The provision of these public goods comes at a high cost per person, limiting the institutions and skills available for policy response. These challenges are inherent and any effective practical approaches to the development of the blue economy must take these factors full on board and be relevant to the Caribbean context."[123]

Any one of the critical barriers highlighted in this section alone could derail the feasibility and viability of a blue economy commercial venture. But when these barriers are combined, the totality of the issues within the investment climate for the blue economy confronting the potential Caribbean entrepreneur and investor becomes even more apparent. As one interviewee succinctly summarized the current state of affairs, "the challenge isn't how to find capital, it's how to find bankable projects." These barriers augment the (already numerous inherent) risks associated with a number of emerging blue economy activities that do not always have long track records of commercial success. Further, accessing capital that has always been scarce in the Caribbean region has become even more difficult in a post-COVID-19 environment.

Some of the six target countries have made more progress addressing one or more of these barriers or building the enabling conditions than others. But still, these challenges and gaps persist as overarching constraints to blue economy growth throughout the region. For the blue economy to truly grow at any sort of scale in the Caribbean, will require the region's public, private, and civil society leaders to strategically address these barriers, even incrementally, in an attempt to "de-risk" the business enabling environment as much as possible and give potential entrepreneurs and investors sufficient confidence and certainty to undertake blue economy activities. Regional development entities will need to be engaged to coordinate with local governments and blue economy industry leaders to not only incubate businesses, but support market development and ecosystem development around chosen industries. And blended finance structures might be required to

[123] Julian Roberts, "The Blue Economy: From Concept to Reality in the Caribbean Region." Discussion Paper for the Caribbean Regional Dialogue with the G20 Development Working Group, 2015.

catalyze nascent blue economy sectors. "Translating new opportunities into productive sectors will require investment in research and development, building technical capacity and creating the right environment to attract and retain outside investment."[124]

Further, with climate change and COVID-19, investment will require business models that further reduce risk and innovate and/or diversify to limit exposure to the fundamental risks that come with SIDS (e.g., climate change, sea level rise, storms, reliance on global markets, etc.). In addition, Pre COVID-19 much of the blue economy space was reliant on markets or demand from outside the Caribbean. From the tourism sector to shipping to newly emergent marine products markets, the demand for blue economy-generated products and services has historically come from the outside. Building local demand and capacity likely will be an important enabling condition in the short-to-medium term as countries work to open up after COVID-19.

To create the enabling conditions that can help unlock the Caribbean's blue economic potential will require strong leadership across the region—from within governments, to academia and research centers, to NGOs, and to the private sector. Key to this condition is the existence of aligned leaders across levels of an organization, to support growth and integration of new models and processes. These leaders must help provide the unifying vision for how the region and individual countries can play a part in blue economy growth; critically, they must also ensure that blue economy development benefits local communities and people and preserves or enhances the marine environment upon which all this rests.

Table 11 provides an initial overview of the uneven levels and qualities of enabling conditions in the Caribbean region across key blue economy industries. The relative readiness for blue economy growth is moderately better for existing sectors than for growth sectors, yet conditions must be upgraded across the board.

[124] Julian Roberts, "The Blue Economy: From Concept to Reality in the Caribbean Region." Discussion Paper for the Caribbean Regional Dialogue with the G20 Development Working Group, 2015.

Table 11: Adequacy of Blue Economy Enabling Conditions within the Caribbean Region for Key Industry Sectors.

Blue Economy Enabling Conditions	Blue Economy Sectors					
	Fishing	Coastal Maritime Tourism	Shipping	Offshore Oil and Gas	Mariculture	Renewable Energy
Local expertise and research capacity	◐	◐	◐	◔	◔	●
Strong partnerships among key stakeholder	◐	◐	◐	◔	●	●
Risk-tolerant financing for local enterprises	◐	◐	◐	◔	●	●
Visionary Leadership	◐	◐	◔	●	●	●
Legal agreements and structures to protect project interests	◔	◔	◔	◔	◔	◔
Global Standards and Conventions	◐	◐	◔	◔	◔	◔
Market beyond the region	◐	◔	◐	◔	●	●

◔ High ● Low

Country Profiles and Preliminary Project Concepts

The following section provides brief country profiles for our six countries, which summarize the economic context, highlight blue economy sectors, and identify preliminary blue economy project concepts. These country profiles serve as a starting point for developing individual country blue economy action plans to be completed in Phase 2 of this project.

Blue Economy Profile

Bahamas

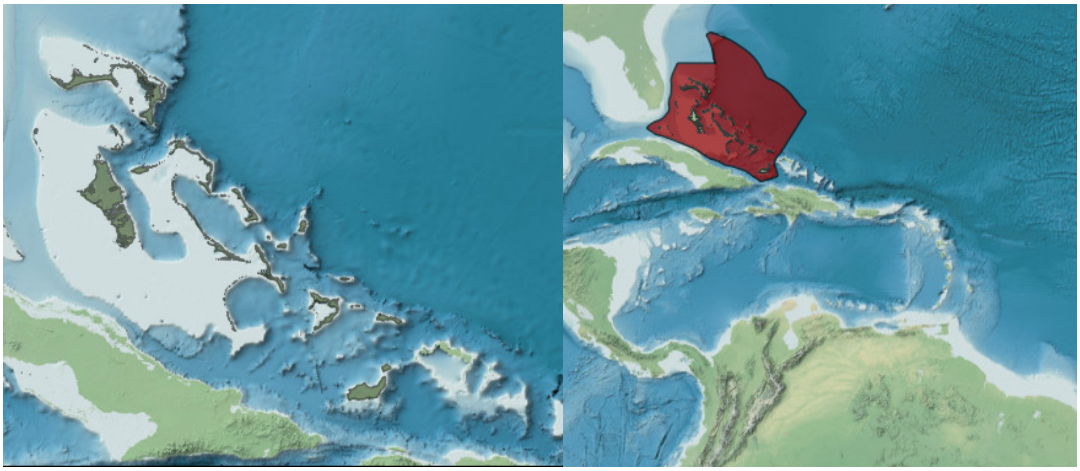


Figure 10: Bahamas official boundaries (left) and Economic Exclusive Zone (right)
Source: Marine Region (2020)

Economic Context

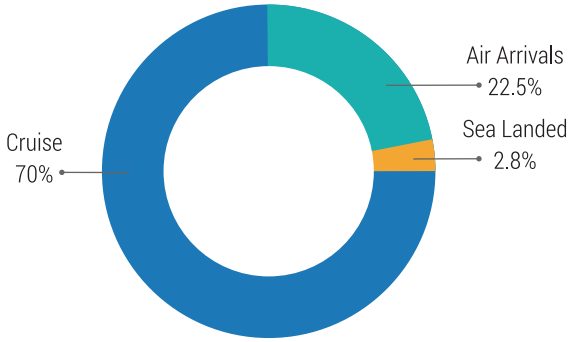
The Bahamas is the wealthiest Caribbean country in terms of GDP per capita (US$ 33,000).[125] The GDP grew by 1.8% in 2019 (US$ 13 billion) against 1.6% in 2018. Due to the outbreak of COVID-19, GDP growth is expected to fall to -8.3% in 2020 and pick up to 6.7% in 2021, subject to the post-pandemic global economic recovery.[126] Even before the COVID-19 pandemic, the public budget deficit increased from 7.4% in 2018 to an estimated 12.8% in 2020, mainly due to the aftermath of Hurricane Dorian, which caused an estimated damage of USD 3.4 billion, about a quarter of the country's GDP.[127] However, the Government established a disaster relief fund as part of a broader strategy for risk reduction policies, which should slightly reduce the impact of Hurricane Dorian on the country's economy.[128]

Tourism and financial services are the driving sectors of the Bahamian economy. With few natural resources and a limited industrial sector, the economy depends heavily on tourism and, to a lesser degree, on financial services. Tourism, together with tourism-driven construction, accounts for approximately 45% of GDP and directly or indirectly employs half of the country's labor force, approximately 102,500 persons. Financial services constitute the second-most important sector of the Bahamian economy, accounting for about 15% of GDP. Manufacturing and agriculture combined contribute less than 7% of GDP and show little growth, despite government incentives aimed at those sectors.[129]

[125] https://www.imf.org/en/News/Articles/2019/07/01/pr19260-the-bahamas-imf-executive-board-concludes-2019-article-iv-consultation
[126] According to the updated IMF forecasts from May 2020, see: https://www.imf.org/en/Countries/BHS
[127] The country's debt-to-GDP ratio was 61.5% of GDP in 2019, and should reach 68.2% in 2020, then decreasing to 67.3% in 2021 (see IMF reference above).
[128] https://www.ccrif.org/news/bahamas%E2%80%99-insurance-policy-ccrif-triggers-following-hurricane-dorian
[129] https://www.cia.gov/library/publications/the-world-factbook/geos/print_bf.html

International tourism visitation in the Bahamas has grown from approximately 5.2 million in 2008 to 7.2 million in 2019. Cruise visitors account for nearly 75% of total visitors, with more than 75% of cruise tourists coming from the US market, creating considerable dependence on one individual market.

Figure 11: Average Annual Tourism Arrivals in The Bahamas, 2010-2019.



Source: Tourism Today, Foreign Arrivals (Air & Sea)

In addition, the Bahamas has been losing market share in the Caribbean because of high operating costs combined with the absence of quality services. Since 2012, tourism growth has been stagnant, attributed partially to natural disasters and interruption in the completion of the mega resort Baha Mar. Before Dorian, hurricane Mathew, which hit the Bahamas in 2016, significantly impacted tourism activity, while Hurricanes Irma and Maria[130] also partially affected the Bahamas in September 2017, showing the countries' vulnerability to natural disasters and external shocks.[131] The COVID-19 crisis will further affect the country as it is estimated that The Bahamas' annual revenue earnings from stopover visitors is expected to plummet from US$ 3.2 billion in 2019, to US$ 548 million in 2020, a drop of some US$ 2.7 billion, which again highlights the potentially catastrophic fall-out from COVID-19 for this nation's largest industry and the wider economy.[132]

In addition to the country's large economic dependency on one sector, the Bahamas is characterized by a strong geographical concentration of economic activities, which results in very unequal income distribution. Production and services are concentrated in Nassau and the larger islands. In contrast, the numerous Family Islands have lagging entrepreneurship and are far from achieving a satisfactory level of agricultural production and of exploiting the opportunities offered by the tourism and services industries, all while having very fragile ecosystems. In addition to a highly concentrated economy, the Bahamian firms face challenges for being competitive and innovative. Only 20% of firms are large (over 100 employees), while only 7% of them export since

130 https://abcnews.go.com/International/wireStory/previous-hurricanes-affected-bahamas-65313981

131 Thus, every year, The Bahamas loses about 2% of its GDP due to climate change shocks, particularly from extreme weather events that cause floods and sea surges

132 See: http://www.tribune242.com/news/2020/apr/01/bahamas-faces-27bn-tourism-shutdown-loss/

they are mainly providing local tourism supporting services and finances. They also face low productivity (17% lower than the Caribbean average), low complexity (existing industries are not closely connected and face challenges in upgrading goods or moving to other industries) and low innovation (only 22% of the firms innovate and innovation is more prevalent in the manufacturing sector while 56% of Bahamian firms are potentially innovative). Furthermore, firms in the Bahamas face high energy costs, low infrastructure availability, high crime, financial limitations as well as a business and innovation climate that needs to be modernized.

Blue Economy Assets[133]

While tourism is the primary blue economic sector in the Bahamas, other sectors contribute to a lesser extent to the blue wealth of the country. Fisheries and maritime transport are among the more important ones, with offshore oil and gas, marine biotechnology, mineral resources and deep-sea mining, offshore renewable energy, and bioprospecting being under-developed and negligible in economic impact. In addition, only 3 islands have significant water resources (Andros, Abacao, Grand Bahama); as a result, since 1960s, water desalination has been growing tremendously, many islands now rely on for water – plants are likely to increase in the future, need regulations to limit environmental impacts and improve energy efficiency of these plants.

The table below provides an overview of blue economy sectors' importance and their development stage in The Bahamas. In the absence of common figures such as value added and jobs generated per sector, information is mainly extracted from stakeholder interviews and from the review done in 2013 by Julian Roberts for the preparation of the National Maritime Policy.[134]

Table 12: Overview of Blue Economy Sectors of Bahamas.

Blue Economic Sector	Economic Importance	Development Stage	Key Observations
Maritime and coastal (island) Tourism	High; accounts for 45% of GDP	Mature	Highly concentrated with a carrying capacity overtaken in popular locations. Expensive overnight-stay destination compared to other neighbouring countries.
Maritime transport	Moderate; merchandise trade accounts for 34% of GDP	Mature	Mainly for importing goods from the USA and to a lower extent for the inter-island connections (suffering from a weak maritime service).

[133] This section is largely excerpted and condensed from: Pierre Failler, Bahamas Strategy for Blue Economy Activities: Draft version for comments, May 2020

[134] See J. Roberts (2013), THE DEVELOPMENT OF A NATIONAL MARITIME POLICY FOR THE COMMONWEALTH OF THE BAHAMAS, A Situation Analysis Prepared for the Ministry of Transport and Aviation on Behalf of the Government of The Bahamas, 110 p.

Table 12: Overview of Blue Economy Sectors of Bahamas. (cont.)

Blue Economic Sector	Economic Importance	Development Stage	Key Observations
Shipbuilding and Ship repair	Moderate	Mature	High cost of labour and goods makes this sector non-competitive against the Florida competitors.
Fishing	Moderate; in 2015, accounted for 1.2% of GDP	Mature	Full or overexploitation of key species (red lobster, groupers, conchs). MSC certified spiny lobster fishery.
Water desalination	Moderate	Under developed	Long history of water desalinisation (started in 1958). Reverse osmosis plants are present in Providence, Exuma, Bimini, Inagua, Long Islands, etc. Recently, plants were installed on Eleuthera and in Reuter Island in 2018. Tourist Resorts usually have their own desalination plant.
Aquaculture and alga-culture	Negligible	Under developed	Governmental aquaculture trials in the past weren't followed by an industrial production phase.

Institutional Blue Economy Assets

The Bahamas National Maritime Policy was adopted in 2015 to support the sustainable development of the maritime sector, protect the marine environment, and effectively use resources within Bahamian water providing a good policy foundation for leveraging the country's blue economy assets. The Prime Minister and Government have identified the blue economy Initiative as a priority for the future development of the Bahamas. The majority of blue economy projects are multi-sectoral, and involve the collaboration between government agencies, such as the Ministry of Tourism, NGOs, and research institutes on the Island, especially as the Government aims to map and identify the country's marine resources.

Per Pierre Failler, "The Commonwealth of the Bahamas has been recognized as a pioneer in the Region for the development of a blue economy vision. The Bahamas National Maritime Policy was adopted in April 2015 to ensure the sustainable development of the maritime sector, protection of the marine environment, and to efficiently and effectively utilise the valuable resources within Bahamian waters. The goals of the Policy were to be accomplished over a period of five years, via a multi-sectoral partnership involving the public and private sectors as well as the Bahamian

community. The primary goals of the National Maritime Policy include supporting ongoing economic activities, such as container port facilities and oil storage; ensuring future economic development and expansion of the maritime sector; safeguarding the marine environment from environmental threats and expanding the sustainable use of marine resources; and, ensuring the safety of vessels at sea transiting The Bahamas."

In addition, Pierre Failler notes that, "With an EEZ of 242,790 square miles (628,823 km^2), the largest of the Caribbean States, and more than 700 islands, the potential for ocean economy activities is considerable. It represents a significant amount of development space in comparison to the country's limited land area , yet the potential of oceans as a sustainable and viable avenue for creating more value and long term economic growth has not been fully explored despite the existence of unique marine biodiversity of marine fauna and flora and non-living natural resources. Thus, the utilization of the ocean space requires an understanding of the resources available and an environmentally sustainable approach to their exploitation, as the need to conserve the fragile resources, even for the current economic maritime activities, is a crucial priority for this sector."

To realize the country's blue economic potential Pierre Failler advises that, "A national framework suitable for the development of these opportunities is key. For The Bahamas, this will require the implementation of a proper blue economy policy, based on the National Maritime Policy, and a regulatory framework as the investment strategy should be made within this frame."

Business/ Regulatory Environment

The World Bank Group 2019 Ease of Doing Business Report ranked The Bahamas 118 out of 190 countries in ease of doing business – down 3 places since 2016. The top four challenges for businesses in The Bahamas are registering property, protecting minority investors, trading across borders, and receiving commercial credit. On the other hand, progress has been made in improving access to credit information through regulation of credit bureaus and paying taxes through the establishment of online filing systems.

In the 2020 Index of Economic Freedom, The Bahamas ranked 69th out of the 186 countries and territories for economic freedom. While contracts are enforced by a British common law-based system, the process can be inefficient and time consuming, money laundering and corruption remain an issue at many levels of government.

Key Stakeholders

- The **Bahamas Maritime Authority** and the **Ministry of Aviation and Transportation** created the National Maritime Policy in 2015 to establish future policy directions needed for the comprehensive and integrated management of the maritime area and associated activities. Future actions include working with local communities and marine industries to implement the Government's prioritized policy goals.

- **Ministry of Tourism** - involved in regional and national initiatives to accelerate sustainable tourism; growing partner for supporting and funding management of marine parks and protected areas
- **The Nature Conservancy** - engaged in sustainable management of fisheries, including the Spiny Lobster Fishery that was first in the Region to meet the Marine Steward Council standards, evaluating Marine Protected Areas, and coral reef restoration. Collaborates with government agencies and NGOs, including the Perry Institute for Marine Science and Bahamas Reef Environmental Foundation, and has worked to establish funding mechanisms for long-term protected area management, including the Caribbean Biodiversity Fund (CBF) and the Bahamian Protected Areas Fund (BPAF)
- **Bahamas National Trust** - national park system focused on biodiversity conservation and environmental education, collaborates with research institutes and NGOs, such as TNC and the National Audubon Society to conduct evaluation of ecosystems and implement community-based initiatives focused on enhancing and protecting biodiversity
- **Cape Eleuthera Institute** - research institute and semester school, one of their primary research areas is sustainability science for fisheries and aquaculture.
- **Cat Island Conservation Institute** - created to drive climate action in the Bahamas by building resilient communities. Hosted workshops and think tanks to bring local community leaders, business wonders, and government departments together to discuss action needed for climate resiliency.

Blue Economy Opportunities: Identification of Candidate Initiatives

- ### SMART TOURISM: Virtual Tourism & Training
  - Creation of virtual tourism experiences on site and online, using ARVR technologies to create immersive videos with webcam streams by Ocean First Education, 360 degree images by The Ocean Agency, exploring shipwrecks without need for scuba certification, diving with turtles, roaming with rays, floating with jellyfish – hypnotic immersive VR, 360 degree dives, narrated and shot for 3D HEADSETS

- ### Port Waste Management Reception Facility
  - Development of pioneer marine waste reception and processing plant that uses cutting edge technologies to contribute to the preservation and protection of the blue economy and ocean environment and the improvement of the livelihoods dependent upon them; it will also improve the water quality and effluent treatment of isolated communities. Clean Marine Group, Limited (CMG) a private early-stage firm, founded in 2017 in Freeport, The Bahamas, has created a business model to adapt an innovative use of cavitational technology for the sustainable management and disposal of liquid and solid waste to the needs of a modern day and efficient MARPOL port reception facility. They have obtained the license from the Grand Bahama Port Authority to operate and will collect and process

all kinds of liquid waste emitted by ships, including black water, grey water, black and grey water, oily water and sludge, thus allowing ships that use their services to comply with MARPOL regulations.

- **Low Carbon Freight Future**
  - Caribbean transition to low carbon transport requires a paradigm shift. (see model from Fiji - Access to clean, affordable reliable transport underpins any transition to a blue/green economy. Opportunity for cleaner, more appropriate, affordable solutions. Transition is a substantive challenge. A long-term strategy is needed but it must begin now. A 'Caribbean' design solution is needed. The initial work occurring in this sector needs to be scaled quickly and as a priority during the Covid-19 economic recovery period in order to create jobs.

Country Stats Context

- Population: **385, 640 (2018)**
- Gross Domestic Product GDP (GDP): **US$ 13 billion**
- Human Development Index (HDI): **0.805**
- Gross National Income (GNI) Per Capita: **US$ 30, 520 (2018)**
- % Blue economy
  - Relative Importance of fishing (ratio fishing/agriculture VA): n.a.
  - Relative Importance of Tourism (Visitor Exp. as % of GDP): **60%** (includes tourism-driven construction and manufacturing)
  - Relative importance of Marine Transportation (Marine transport as % of transport & storage sector): merchandise trade as percentage of GDP: **34%** (average from 2008-2018)
  - Container throughput as % of total Caribbean Container Throughput: **30%** (averaged over years 2010, 2013, 2017)

- Land Area: **6,219 sq miles (10,010 km^2)**
- Coastline: **2,200 miles (3,542 km)**
- Sea Area (territorial waters up to 12 nautical miles): **2,404 sq miles (3,870 km^2)**
- Percentage of coastline with ICM: n.a.
- Marine Protected Area (% of territorial waters): **10%**
- Ocean Health Index: **84**

Blue Economy Profile

Barbados

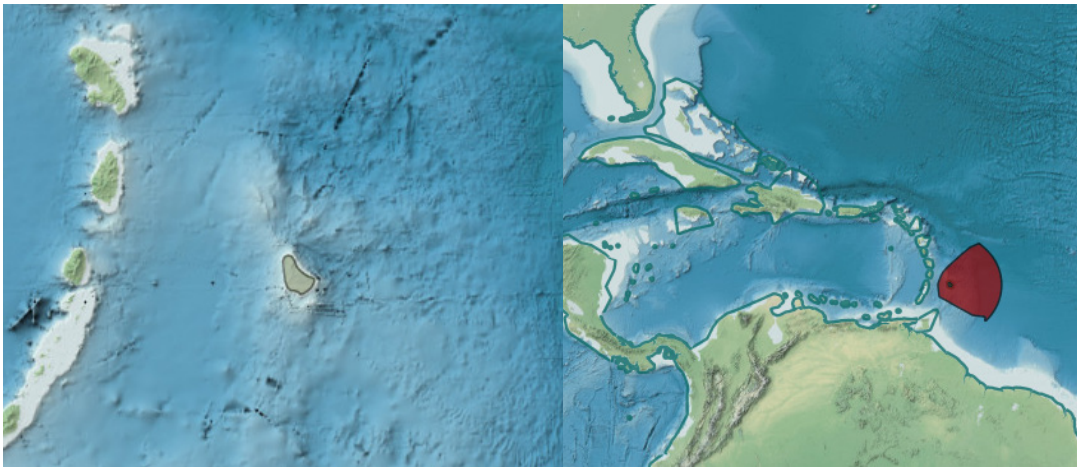


Figure 12: Barbados official boundaries (left) and Economic Exclusive Zone (right)
Source: Marine Region (2020)

Economic Context

Barbados is the most easterly island in the chain of Caribbean islands with a land mass of 432 km^2 and 92 km^2 of coastline with much of the island at or near sea level, making the country highly susceptible to the impacts of climate change.[135] The country is one of the most developed and most densely populated of the Eastern Caribbean islands, with the nation's estimated population of 294,560 enjoying one of the highest per capita incomes in the region.[136] Barbados's economy is largely service driven with the sector accounting for 88.7% of GDP and 75% of employment with visitor expenditures constituting over 22% of GDP.[137] Within the services sector, tourism alone accounts for 17.5% of GDP and more than 12% of direct employment while wholesale and retail is the next biggest component of the services sector, accounting for nearly 10% of GDP.[138] The offshore financial services and international business industry is another important source of foreign exchange.[139]

Since 1972 Barbados has maintained a fixed exchange rate, pegging the Barbadian dollar to the US dollar at BBD$2:US$1. Following the 2008-2009 global financial crisis Barbados has struggled with consistently weak economic growth with GDP growth contracting to -0.2%, by September

[135] http://www2.intracen.org/news/The-unfolding-story-of-Barbadoss-blue-economy/
[136] https://www.cia.gov/library/publications/the-world-factbook/geos/bb.html
[137] Measuring the Blue Economy: The System of National Accounts and Use of Blue Economy Satellite Accounts - CDB Working Paper No. 2019/02 and https://www.cia.gov/library/publications/the-world-factbook/geos/bb.html
[138] CCB Caribbean Country Department, "The Impact of Covid-19 on the Economies Of The Region." Copyright © 2020 Inter-American Development Bank.
[139] https://www.cia.gov/library/publications/the-world-factbook/geos/bb.html

2019.[140] This stagnant growth has caused critical fiscal deficit issues, forcing the country to cut into its international reserves, which has raised its already high public debt to GDP ratio and triggered downgrades of the country's credit rating. In 2018 Barbados had the fourth highest debt-to-GDP ratio in the world and still has the highest debt-to-GDP ratio in the Caribbean region by a long measure at 157.1%, with sufficient international reserves to only cover imports for 19 weeks, making it exceedingly difficult for the country to maintain fiscal sustainability.[141]

Blue Economy Assets

Tourism is the leading sector in the Barbados economy, accounting directly for 17.5% of GDP, and its indirect contribution to GDP is estimated at 40% as illustrated in **Table 13**. The industry provided direct employment for 17,000 people and indirectly supported the jobs of as many as 51,000, which is roughly 40% of the country's total labor force. Cruise tourism's contribution to the broader tourism portfolio depends on the metric: it provided more than half of the country's overall visitors in 2016 at the same time the number of port calls reached a recent historical apex. On the other hand, cruise tourism only accounted for roughly 9% of total tourism employment.

Currently 60% of imported agricultural produce is consumed by the tourism sector, while only 10% of local production is traded within the sector and only 16% of local manufactured goods are consumed by tourism operators.

Table 13: Blue Economic Sector Contribution to Barbados' Economy.

Blue Economic Sector	Economic Importance	Development Stage	Key Observations
Maritime and Coastal (island) Tourism	High; accounts for 17.5% of GDP. Cruise ships delivered over 50% of total visitors in 2015[142]	Mature	Cruise tourism has a large footprint on the island, contributing 54% of the 1.3 million tourists who visited the country in 2015. While the total number of cruise passengers arriving in the Bridgetown port has increased in recent years, the average amount of money they are spending is declining.

[140] Economic growth averaging just 1.4% per year between 1995 and 2013. Source: Private Sector Assessment off Barbados, © 2013 Inter-American Development Bank and https://www.loopnewsbarbados.com/content/barbados-still-struggling-get-out-economic-slump

[141] Financing the Blue Economy: A Caribbean Development Opportunity © Caribbean Development Bank, 2018 - ISBN: 978-976-96037-8-3 and https://www.dw.com/en/drowning-in-debt-barbados-predicament-offers-a-warning-for-small-island-nations/a-44245771 and CCB Caribbean Country Department, "The Impact of Covid-19 on the Economies Of The Region." Copyright © 2020 Inter-American Development Bank.

[142] https://www.ship-technology.com/features/barbados-cruise-trends-crisis/

Table 13: Blue Economic Sector Contribution to Barbados' Economy. (cont.)

Blue Economic Sector	Economic Importance	Development Stage	Key Observations
Maritime transport	Moderate; merchandise trade accounts for 39.4% of GDP (2018)[143]	Mature	Mainly for importing goods from the USA and to a lower extent for the inter-island connections (suffering from a weak maritime service).
Fishing	Minor; in 2015, accounted for 0.15% of GDP[144]	Mature	Total capture production has fluctuated heavily in recent years with the invasions of sargassum seaweeds that has substantial impacts on flying fish catch. The latest available statistics show a production of 1,373 tonnes in 2012 and about 3,000 tonnes in 2013 and 2014.
Aquaculture and alga-culture	Negligible	Under developed	Total farmed fish production in Barbados is estimated at around 20 tonnes in 2014. The slow development in aquaculture is mainly due to the high cost of land, the high investment costs of marine aquaculture installations.

Institutional Blue Economy Assets

From a policy perspective, Barbados has clearly emerged as one of the leading proponents of the blue economic agenda in the Caribbean region. In the context of the country's increasingly dire fiscal conditions, in 2018 the incoming administration of Prime Minister Mia Mottley announced the creation of a Ministry of Maritime Affairs and the blue economy only two days after winning the general election. Barbados was only the third country in the world to establish a ministry dedicated to the blue economy.[145] The creation of this Ministry strongly signaled the GOB's commitment to address the country's anemic economic growth by driving a blue economic agenda that would better leverage the nation's coastal and maritime assets. For example, Barbados maritime space of 183,436 km^2 is over 400 times bigger than its land mass.[146] Yet, the fishing sector's estimated contribution to GDP is only 0.15 %.[147] And although Barbados' tourism

143 https://data.worldbank.org/indicator/TG.VAL.TOTL.GD.ZS?locations=BB

144 The Caribbean Regional Fisheries Mechanism (CRFM) estimated in 2013 that fisheries sector employment was approximately 8,800 or 6.2 % of the Barbados work force.

145 https://medium.com/@acclabs/what-color-is-your-lab-22ef32d3cceb

146 http://www2.intracen.org/news/The-unfolding-story-of-Barbadoss-blue-economy/

147 The Caribbean Regional Fisheries Mechanism (CRFM) estimated in 2013 that fisheries sector employment was approximately 8,800 or 6.2 % of the Barbados work force. Source: Oceans Economy and Trade Strategies (OETS) Project National Stakeholder Workshop, Nikola Simpson Fisheries Consultant, Sustainable Caribbean

industry is significantly dependent on sustainably managed marine and coastal resources, "there have been considerable declines in coral cover on offshore reefs since the 1980s."[148]

According to Minister for Maritime Affairs and the blue economy, Barbados, Kirk Humphrey, "The government is now seeking to consolidate the blue economy to give it a status of important economic significance, underpinned by a philosophy that the ocean matters. In fact, for the first time the island can tackle its many challenges led by a single ministry committed to reversing the fragmented approach that previously existed…Despite that certain aspects of the blue economy, for example fishing and seaport services, have traditionally been part of Barbados's socio-economic landscape, the blue economy as an economic sector remains underdeveloped, fragmented and unexplored."[149] Per Minister Humphrey, "Barbados's blue economy Framework is made up of three pillars: transportation and logistics, housing and hospitality, and health and nutrition. Their goal is to preserve the environment, become 100% renewable energy, ban plastics, and improve marine management policies."[150]

This blue economy Framework is underpinned and supported by a number of institutions, policies and programs. For instance, Barbados's port infrastructure is a primary logistical hub for the entire Eastern Caribbean and also reported 730,900 cruise tourism passenger arrivals during the 2017/18 cruise year.[151]

In addition, the Coastal Zone Management Unit (CZMU) was established in 1996 to manage the country's coastal zone and "the CZMU's efforts in integrated coastal zone management as well as the team's technical expertise are lauded as best practices at both a regional and international level"[152] particularly in terms of marine area management and incorporating climate change resiliency into coastal infrastructure development. For example, the Folkestone Park and Marine Reserve is no-take fishing area that was established in 1981 that has been separated into four separate zones: scientific research, recreational, and two distinct water sports zones."[153]

A separate plan is also underway to establish a new marine management area. But rather than employing a top-down government decree the Global Environment Facility's Community-based conservation of the Barbados Marine Management Area program seeks to utilize a participatory approach to achieve community consensus among various coastal constituencies over zoning and operation of a marine protected area (Barbados Marine Management Area or BMMA) on the west and south-west coasts of the island.[154]

148 https://www.thegef.org/sites/default/files/publications/SGP-Blue%20Economy%20Community%20Solutions-Publication-Digital%20%281%29_0.pdf
149 http://www2.intracen.org/news/The-unfolding-story-of-Barbadoss-blue-economy/
150 https://oceanfdn.org/blue-economy/
151 https://www.barbadosparliament.com/uploads/bill_resolution/60b9659bdba995fe49002564d644c5d6.pdf
152 https://unctad.org/meetings/en/SessionalDocuments/CoastalMarineEnvtServices_Feb21_DRAFT.pdf
153 https://unctad.org/meetings/en/SessionalDocuments/CoastalMarineEnvtServices_Feb21_DRAFT.pdf
154 https://www.thegef.org/sites/default/files/publications/SGP-Blue%20Economy%20Community%20Solutions-Publication-Digital%20%281%29_0.pdf

Apart from the country's physical assets in the maritime and coastal regions and its growing policy of framework in support of a blue economic agenda, Barbados also benefits from a deep reservoir of institutional and scientific expertise indigenous to the island. Barbados hosts a number of important regional and international organizations that bring knowledge and resources to bear in support of the blue economic agenda. These include for example: the Caribbean Development Bank (CDB), the Caribbean Export Development Agency (CEDA), Delegation of the European Union to Barbados, the Eastern Caribbean States, the OECS and CARICOM/CARIFORUM, a number of United Nations offices that oversee programs in Barbados and elsewhere in the Eastern Caribbean, including the United Nations Development Fund (UNDP) and the Food and Agriculture Organization (FAO). The UNDP's blue economy and Sustainable Management of Ocean Degradation Lab is currently supporting a number of innovative ideas and business models that pursue blue economic principles in Barbados and the Eastern Caribbean including ones involving, "tourism, bio-technology and waste management; sustainable financing; renewable energy; blue badge for Blue Certified Businesses; transforming seaweed; blue social impact bonds and solar power on fishing boats."[155] Meanwhile the FAO is supporting a number of initiatives in the fisheries sector to improve fishing practices and explore options for seafood processing. The Compete Caribbean Partnership Facility (CCPF) is another important Barbados-based institution and in February 2020 the Government of Canada announced that it was investing CAD$6 million in CCPF to, "boost private sector growth in the blue economy.[156]

In terms of scientific assets, Barbados hosts University of the West Indies' Centre for Resource Management and Environmental Studies (CERMES) which has driven a variety of blue economy research activities including recent Sargassum Symposiums, "to examine the biodiversity issues on trade and tourism and explore potential opportunities and community solutions created from the influx of sargassum."[157] In addition, other scientific research currently under way in Barbados includes, underwater mapping using drones, habitat classification through remote sensing, corral restoration and community-based participatory maritime mapping. Researchers and entrepreneurs in Barbados have also begun to explore the commercial viability of sargassum collection and processing, sea moss farming and aquaponics, while Barbados-based Ten Habitat, which was selected during the IDB's Blue Tech Challenge, proposes using, "blockchain technology to enhance the tuna supply chain which could both potentially support the expansion of the fisheries sector by reducing imports and increasing exports."[158] [15]

Business/Regulatory Environment

The World Bank Group 2019 Ease of Doing Business Report ranked Barbados 129 out of 190 countries in ease of doing business – down 12 places since 2016. The top four challenges for

[155] https://www.bb.undp.org/content/barbados/en/home/presscenter/articles/2019/introducing-the-barbados---oecs-blue-economy-accelerator-lab.html
[156] https://www.competecaribbean.org/compete-caribbean-channeling-6m-more-to-blue-economy-businesses/
[157] https://medium.com/@acclabs/what-color-is-your-lab-22ef32d3cceb
[158] https://www.nationnews.com/nationnews/news/241019/blue-economy

businesses in Barbados are enforcing contracts, dealing with construction permits, protecting minority investors, and trading across borders. On the other hand, progress has been made in having clear regulations in place, with the Barbados rolling out requirements for electrical code and wiring inspections.

In the 2020 Index of Economic Freedom, Barbados ranked 92th out of the 186 countries and territories for economic freedom. The banking sector is well-developed, property rights are strong, and courts are considered unbiased and efficient. On the other hand, property registration is time-consuming and expensive.

Blue Economy Opportunities—Identification of Candidate Initiatives

Based on our global opportunities scan and local interviews, the following candidate initiatives have been identified, and will be assessed in greater details for the Country Action Plan.

- **Barbados Sargassum Collection & Processing System (C-Combinator)**
  - Sargassum is a problem across the Caribbean yet provides a potential opportunity for profitable business. C-Combinator is a start-up company which has developed a system for collection, transportation, and pilot bio-refinery processing plant in Puerto Rico for production of biostimulant/fertilizer plus advanced products for multiple markets. Business analysis and research on the uses of sargassum and testing the market could de-risk and create viable business models. The potential for these models is great as removal solves a current problem, creates jobs, serves the tourism industry and environment, reduces costs for communities/businesses/ governments, etc.

- **Caribbean Regional Research Clearinghouse**
  - Establishment of a research clearinghouse which serves the entire Caribbean region as a clearinghouse for blue economy research. Companies, research centers, universities interested in conducting ocean research in the Caribbean can coordinate with the clearinghouse and use its services.

- **Tuna Fisheries Sustainable Development Initiative**
  - "Totally Traceable Tuna: Technology & Blockchain Enhancement of the Barbados Tuna Supply Chain for Export" aims to improve traceability of the tuna supply chain and enhance product quality with advanced testing. It will employ a combination of technologies which include portable histamine testing, electronic radio-frequency (RFID) tags, quick response (QR) code tags, and scanning devices to develop better handling methods and collect information about the journey of a tuna at various points along the supply chain.

Key Stakeholders

- The Ministry of Maritime Affairs and the Blue Economy
- The Coastal Zone Management Unit (CZMU)
- The Caribbean Development Bank (CDB)
- The Caribbean Export Development Agency (CEDA)
- Delegation of the European Union to Barbados, the Eastern Caribbean States, the OECS and CARICOM/CARIFORUM
- A number of United Nations offices that oversee programs in Barbados and elsewhere in the Eastern Caribbean, including the United Nations Development Fund (UNDP) and the Food and Agriculture Organization (FAO).
- The UNDP's Blue Economy and Sustainable Management of Ocean Degradation Lab
- The Compete Caribbean Partnership Facility (CCPF)
- The University of the West Indies' Centre for Resource Management and Environmental Studies (CERMES)

Country Stats Context

- Population: **294,560 (94 % Coastal)**
- Gross Domestic Product GDP (GDP): **US$ 5.145 billion**
- Human Development Index (HDI): **0.813**
- Gross National Income (GNI) Per Capita: **US$ 16,280**
- % Blue economy
  - Relative Importance of fishing as a percentage of GDP: **0.15%**
  - Relative Importance of Tourism (Visitor Exp. as % of GDP): **22.4%**
  - Relative importance of Marine Transportation (Merchandise trade as a percentage of gross domestic product): **46.8%**
  - Container throughput as % of total Caribbean Container Throughput: **105,321**

- Land Area: **432 km²**
- Coastline: **92 km²**
- Sea Area (territorial waters up to 12 nautical miles): **183,436 km²**
- Percentage of coastline with ICM: n.a.
- Marine Protected Area (% of territorial waters): n.a.
- Ocean Health Index: **59**

Blue Economy Profile

Guyana

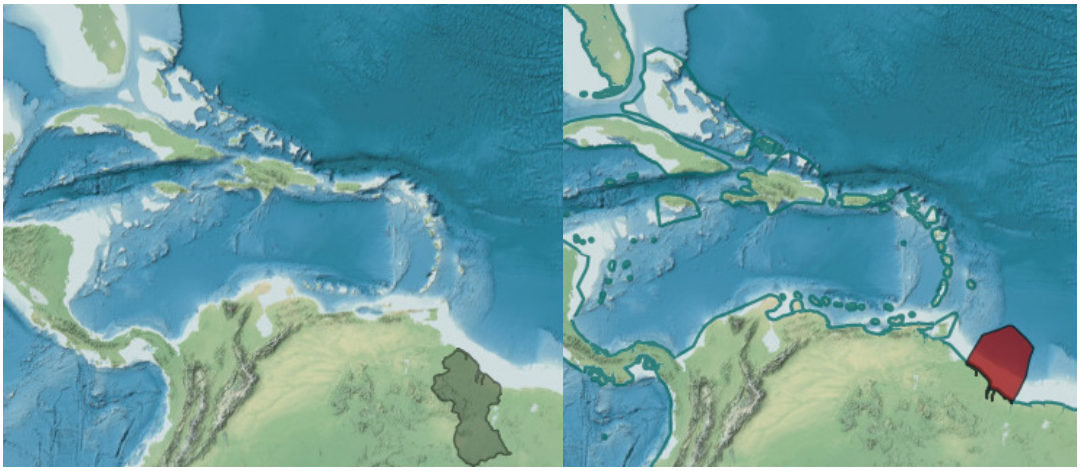


Figure 13: Guyana official boundaries (left) and Economic Exclusive Zone (right)
Source: Marine Region (2020)

Economic Context

The International Monetary Fund predicted that Guyana will be the only country in the Americas to experience any economic growth in 2020 during the COVID-19 pandemic. The IMF expects that Guyana's economy will still grow 53%, down from 86% forecasted in September 2019.[159] Major U.S. and Chinese oil and gas companies recently began investing in Guyana as the coastal nation began offshore oil production in fields expected to contain 8 billion barrels of crude resources.

Guyana has traditionally presented lower GDP per capita (4,979 current US$ in 2018) and lower HDI (0.670, in 2018[160]) than other countries in the Caribbean region. Nowadays, Guyana is an economy under rapid transformation due to exploitation of recently discovered offshore oil and gas reserves. While real GDP increased 4.7% in 2019 and real GDP growth rates have kept positive since 2005 – ranging from 2% to 5.4%-, the growth rate is expected to reach an unprecedented 52.8% in 2020, according to the most recent IMF estimates.[161] This boom is likely to smooth over time as growth is expected to be 6.3% in 2021. Nevertheless, the evolution of these indicators is highly dependent on the global recovery after the COVID-19 pandemic and its repercussions in international oil markets.

Traditionally Guyana's main exported commodities were gold and aluminium ore. Other important exports are rice, woods, sugars and crustaceans (mainly shrimps).[162] This economic profile is

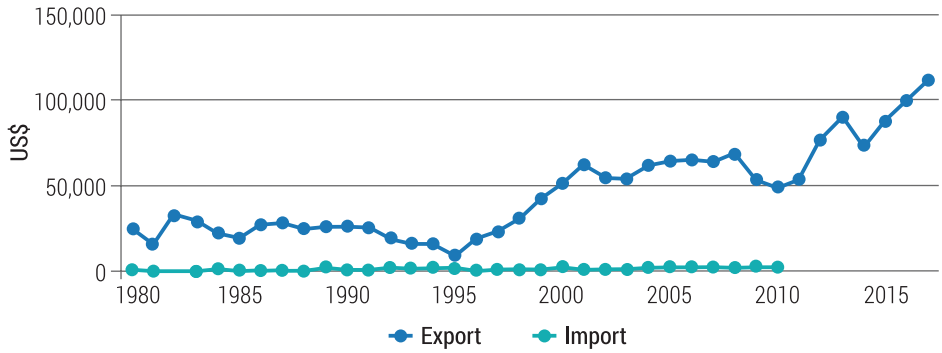
[159] https://www.imf.org/en/News/Articles/2019/09/16/pr19332-guyana-imf-executive-board-concludes-2019-article-iv-consultation
[160] http://www.hdr.undp.org/en/content/human-development-report-2019
[161] https://www.imf.org/en/Countries/GUY
[162] https://www.trademap.org/Product_SelProductCountry.aspx?nvpm=1%7c328%7c%7c%7c%7cTOTAL%7c%7c%7c2%7c1%7c2%7c2%7c1%7c1%7c1%7c1%7c1%7c1

changing rapidly as Guyana turns into an oil exporting country. In this context, the traditional and emerging sectors of the blue economy can play an important role for sustainable development in Guyana.

Blue Economy Assets

Fishing - The share of the fishing industry in GDP was less than 2% in 2016, a value significantly low with respect to other Caribbean countries. Driven by seabob shrimp exports, the fishing industry has developed in recent times even though the average capture production has not significantly increased over the past decade, remaining close to 40,000 tonnes per year. There is, in fact, potential to grow and add value by applying quality controls, sustainability credentials and investment in equipment to harvest deep-water species.

Figure 14: Total Imports and Exports of Fish and Fishery Products in Guyana.



Source: FAO FishStat

Tourism - Tourism sector is less developed in Guyana than in other countries in the region, despite the strong natural assets of the country. While the number of arrivals has increased over the past 10 years, expenditure per visitor has remained very low.[163] Even before COVID-19, growth forecasts were not promising. Low standards of service, limited labor skills and limited road network connecting the coastal and inland regions hinder sector growth.[164]

Oil & Gas - Oil extraction is likely to result in radical changes in Guyanese economy. The size of the offshore Stabroek block oil reserves in Guyana's exclusive economic zone is a least 8 billion oil-equivalent barrels.[165] The IMF estimated in 2019[166] that Guyanese Government would obtain approximately US$ 230 million in revenue under the terms of the 2016 signed between the

[163] https://www.trademap.org/Service_SelCountry_TS.aspx?nvpm=1%7c328%7c%7c%7c%7c%7c%7cS00%7c1%7c3%7c1%7c2%7c2%7c1%7c5%7c1%7c1%7c1 https://www.unwto.org/country-profile-inbound-tourism

[164] Sector Scan by ETG on dropbox

[165] https://corporate.exxonmobil.com/News/Newsroom/News-releases/2020/0127_ExxonMobil-ups-Guyana-recoverable-resources-to-more-than-8-billion-oil-equivalent-barrels

[166] https://www.imf.org/en/Publications/CR/Issues/2019/09/16/Guyana-2019-Article-IV-Consultation-Press-Release-Staff-Report-and-Statement-by-the-48678

Government and private extractors. However, if oil prices remain at relatively low levels in a range from US$ 20 to US$ 35 per barrel, government oil revenue would be between 15% to 40% lower.[167] To mitigate the risks associated with a sudden massive expansion of public spending on inflation and exchange rates, a new Natural Resource Fund (NRF) was created in 2019.

Marine Transport - While the industry is adapting to oil exporting, it is far away from leading countries in the region, i.e. Jamaica, Bahamas or Trinidad and Tobago. The main port of the country is located at Georgetown. Smart ports initiatives and knowledge economy can improve the opportunities in this sector.

Aquaculture - With an average output of 424.4 tonnes a year[168], aquaculture in Guyana lacks the scale for commercial business. Most fish farms are subsistence level, but some also sell their output, mainly in domestic markets. The sector has growth potential linked to exports as international demand and the price of high-quality fish rise. However, the industry has to improve quality certification and standards to gain access to international markets. Better transport infrastructure and easing access to credit to finance domestic scaling up domestic industry can also contribute to aquaculture development.

Table 14: Blue Economic Sector Contribution to Guyana's Economy.

Blue Economic Sector	Economic Importance[169]	Development Stage	Key Observations
Fishing	Moderate 1.7% of GDP	Mature/GDP share declining during 2006-2016, recent data n/a	The share of the fishing industry in GDP is significantly lower than other Caribbean countries. Driven by seabob shrimp exports, the fishing industry has developed in recent times. There is, in fact, potential for further growth.
Marine and coastal tourism	Moderate (Other services including tourism 3.4% of GDP)	Under development	Tourism sector is less developed in Guyana than in other countries in the region. The number of arrivals has slightly increased over the past 10 years, but expenditure per visitor has remained very low.[170]

167 https://publications.iadb.org/en/impact-covid-19-economies-region-caribbean
168 Average for 2014,2015,2016,2017,2018. Source: http://www.fao.org/fishery/facp/GUY/en#CountrySector-Statistics.
169 Data from Guyana's System of National Account in 2017. Share of GDP at constant GDP in local currency with 2016 price index.
170 https://www.trademap.org/Service_SelCountry_TS.aspx?nvpm=1%7c328%7c%7c%7c%7c%7c%7cS00%7c1%7c3%7c1%7c2%7c2%7c1%7c5%7c1%7c1%7c1
https://www.unwto.org/country-profile-inbound-tourism

Table 14: Blue Economic Sector Contribution to Guyana's Economy. (cont.)

Blue Economic Sector	Economic Importance[169]	Development Stage	Key Observations
Maritime Transport	Moderate		Shipping industry is far away from leading countries in the region, i.e. Jamaica, Bahamas or Trinidad and Tobago. The main port of the country is located at Georgetown.
Offshore oil and gas	Very high	Emerging/ Booming	Offshore oil extraction is rapidly changing Guyana's economy. While the Government is expected to obtain huge inflows of revenue, the country also faces important financial and environmental challenges.
Aquaculture	Negligible	Under development	Mainly subsistence level in rural areas and domestic market.

Business/Regulatory Environment

The World Bank Group 2019 Ease of Doing Business Report ranked Guyana 134 out of 190 countries in ease of doing business – down 10 places since 2016. The top four challenges for businesses in Guyana are dealing with construction permits, getting electricity, resolving insolvency, and trading across borders. On the whole, Guyana remains a challenging place to do business.

In the 2020 Index of Economic Freedom, Guyana ranked 124th out of the 186 countries and territories for economic freedom. The Global Index of Economic Openness ranked Guyana 104th out of 154 countries for its ability to enable trade, competition and productivity.

Political uncertainty can also hinder business initiatives. The results of the election held in March 2020 were contested by the opposition and international observers. A recount process was conducted, and the final results were announced in mid-June.

Another factor affecting business in the near future is the COVID-19 pandemic. While less than 200 hundred cases of COVID-19 and only 12 deaths had been reported by May 2020,[171] the government has applied important contentions measures including curfews, restrictions on travels, closure of schools and social distancing. Tax policies have also been used to alleviate the impact of the pandemic, e.g. waiving of VAT for medical supplies, deferral of tax payments for companies and

[171] https://coronavirus.jhu.edu/map.html

individuals or grants to small businesses. The Bank of Guyana has also promoted some alleviation measures for borrowers.

Key Stakeholders

- **Guyana Tourism Authority (GTA)** - Semi-autonomous entity with the mission of promoting sustainable tourism whose Board of Director includes representatives from the Government and the tourism industry. They provide training, licensing, marketing support and other resources for tourist operators.
- **Department of Tourism. Ministry of Business** - Involved in initiatives to promote tourism, with a focus on sustainability and nature-based experiences; growing partner for supporting and funding management of marine parks and protected areas
- **The Guyana Association of Trawler Owners and Seafood Processors (GATOSP)** - Business association representing fishing industries in Guyana. GATOSP applied for the Marine Stewardship Council's Fisheries Standard, obtaining the certification in 2019-
- **Caribbean Regional Fisheries Mechanism (CRFM)**[172] - Inter-governmental organization promoting sustainable utilization of fisheries in the framework of the Caribbean Community Common Fisheries Policy (CCCFP).
- **Fisheries Department. Ministry of Agriculture**
- **Conservation International - Guyana** - Guyana branch of international NGO advocating for the protection of mangrove ecosystems.
- **Global Environment Facility** - Supporting the establishment of Special Protected Areas for Mangrove in Region 1.
- **International Union for Conservation of Nature** - Supporting the establishment of Special Protected Areas for Mangrove in Region 1.
- **Ministry of Natural Resources**

Blue Economy Opportunities—Identification of Candidate Initiatives

Based on our global opportunities scan and local interviews, the following candidate initiatives have been identified, and will be assessed in greater details for the Country Action Plan.

- ### Women's Empowerment & Community-Based Approach To Monitor Natural Resources (Drone Mapping)
  - Empower women and girls through the creation of a sustainable home-based livelihood that employs cutting edge Unmanned Aerial Vehicles (UAV) technology in community monitoring of natural resources. Whilst focus will be on mapping and monitoring the intact strands of mangrove forests as they are a critical element of the communities' natural sea defence it will also build local community resilience. The project will further promote national awareness

[172] https://caricom.org/documents/12304-cccf-policy.pdf

of and value for the natural assets of Guyana's only coastal protected area. Most importantly it will raise awareness of the efforts of its indigenous communities in its monitoring and the well-deserved recognition.

- **Barima Mora Passage Special Protected Area (BMPSPA)**
  - Barima Mora Passage Special Protected Area comprises 45.800+ ha of mangal ecosystem, located near the Venezuelan border in the northern part of Barima-Waini (Region 1). This Special Protected Area will provide ecosystem services to local communities including not only environmental conservation but also economic opportunities, combining coastal protection and carbon sequestration with ecotourism, timber provision, fisheries among other activities. In particular, ecotourism -with a focus on the domestic market in the near future- shows a great potential to harmonize conservation and revenue. Local population, including indigenous communities, will play an important role in the development of the area through participatory management.

- **Barima Mora Eco-Tourism Development**
  - Pilot project to develop educational, birdwatching, and cultural tourism in the Barima Mora Amerindian communities, particularly Warraus. This non-invasive tourism model would be based in the empowerment of the locals, who would receive support and training so that they benefit from potential revenues, for example by offering homestaying experiences. The initial target is the domestic market, less affected by COVID-19 and other international shocks. At this first stage, partnerships with universities and high schools are going to be established to initiate educational and scientific trips.

Country Stats Context

- Population: **787,000 (2020) (90% Coastal**[173]**)**
- Gross Domestic Product GDP (GDP): **US$ 3.88 billion (2018)**
- Human Development Index (HDI): **0.670**
- Gross National Income (GNI) Per Capita: **US$ 15,410 (2018)**
- % Blue economy
  - Relative Importance of fishing (ratio fishing/agriculture VA): **12%** in 2016
  - Relative Importance of Tourism (Visitor Exp. as % of GDP) **3.5%** (average from 2014-2018)
  - Relative importance of Marine Transportation (Marine transport as % of transport & storage sector): n.a.
  - Container throughput as % of total Caribbean Container Throughput **1.3%** (averaged over years 2010, 2013, 2017)

[173] https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/2012_Preliminary_Report.pdf

- Land Area: **196,850 km²**
- Coastline: **459 km²**
- Sea Area (territorial waters up to 12 nautical miles): **10,051 km²**
  Exclusive Economic Zone: **135,060 km²**
  Percentage of coastline with ICM: n.a.
  Marine Protected Area (% of territorial waters): **0%**
  Ocean Health Index: **63**
  Human Development Index (HDI): **0.670**
  Access to safely managed water: **96%**[174] (drinking water)
  Access to safely managed sanitation: **86%**

[174] World Health Organization data for 2017. https://apps.who.int/gho/data/node.main.WSHWATER?lang=en

Blue Economy Profile

Jamaica

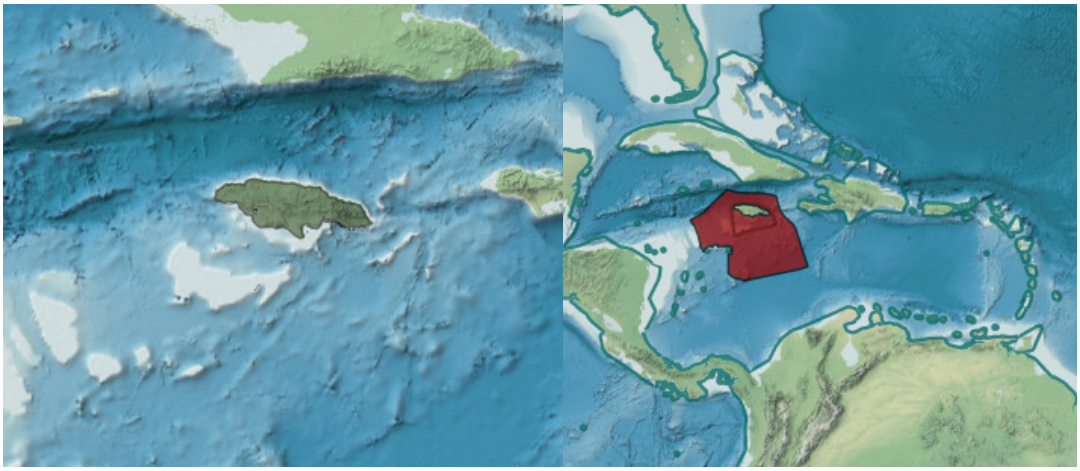


Figure 14: Jamaica official boundaries (left) and Economic Exclusive Zone (right)
Source: Marine Region (2020)

Economic Context

Jamaica is the third largest island in the Caribbean region with a land mass area of 10,991 km^2 and approximately 1,022 km of coastline and is also the largest and most populated island in the English-speaking Caribbean region with a population of 2.93 million.[175] Jamaica is an upper middle-income country and although inequality is lower in Jamaica relative to most Latin American and Caribbean countries, poverty remains a persistent challenge with a 2017 rate of 19%.[176] Further, Jamaica currently sources almost 95% of its energy from imported fossil fuels, which represents approximately 9% of total GDP.[177] Jamaica has been one of the world's slowest growing developing countries over the last few decades with real per capita GDP only increasing by an average of just 1% per year over the last thirty years and the country has been hampered by a consistently high debt-to-GDP ratio.[178]

Despite these impediments to economic growth, Jamaica made important economic advances over the last several years. Between 2012 and 2017 Jamaica successfully reduced its debt-to-GDP ratio from approximately 150% to approximately 115%, which has helped to facilitate positive economic growth for 16 consecutive quarters with a growth rate nearing two per cent.[179] And by the close of 2019 and beginning of 2020 before the Covid-19 outbreak, unemployment had fallen to a historic low of 7.3% from 12.2% in July 2017.[180]

175 http://www.fao.org/fishery/countrysector/naso_jamaica/en and https://www.worldbank.org/en/country/jamaica/overview
176 https://www.worldbank.org/en/country/jamaica/overview
177 SIDS Blue Economy Landscape
178 https://www.lloydsbanktrade.com/en/market-potential/jamaica/economy?vider_sticky=oui
179 https://www.economy.com/jamaica/indicators#ECONOMY and https://www.worldbank.org/en/news/opinion/2019/05/16/jamaica-has-made-an-extraordinary-economic-turnaround
180 https://tradingeconomics.com/jamaica/unemployment-rate

Accounting for more than 70% of GDP the Jamaican economy is heavily reliant on the services sector and is primarily dependent on tourism, remittances and the export of bauxite/alumina for the bulk of the nation's foreign exchange.[181] Although technology-intensive service industries such as business process outsourcing (BPO) are becoming important sources of employment.[182]

Blue Economy Assets

Jamaica's tourism sector in particular is a critical driver of the country's economy. Jamaica, "ranks 16th globally in terms of countries' economic dependence on the sector" and the tourism sector accounts for 34% of GDP and 31% of total employment.[183] Inbound tourism accounts for more than 95% of Jamaica's tourism with tourism receipts alone constituting 20% of GDP and 53% of Jamaica's total exports.[184]

In addition, the port of Kingston is one of the most important logistical hubs in the Caribbean region, "serviced by global container lines connecting three or more continents."[185] The Government of Jamaica has embarked on a program to, "capitalize on economic and trade expansion as well as steep increases in both maritime and inland waterway transport volumes" and position the port of Kingston as the region's, "premier transshipment hub."[186]

In terms of emerging industries, Jamaica's dependence on imported fossil fuels has engendered a growing commitment to achieving enhanced energy security through the development of renewable energy resources such as offshore wind and onshore photovoltaic plants and biomass (from sugarcane, coffee residue). More niche tourism activities such as health and well-being, sports/scuba diving, and Jamaican diaspora tourism are also emerging. In addition, a recent study by the University of California, Santa Barbara found that Jamaica enjoys some of the most favourable conditions for productive mariculture farm sites in the Caribbean.[187] However, culturally, Jamaica's business sector is not noted for a propensity for risk-taking and to date, streamlined regulatory policies or other incentives have not been established that would help encourage mariculture development.

181 https://www.economy.com/jamaica/indicators#ECONOMY

182 http://m.jamaicaobserver.com/sunday-finance/a-better-understanding-of-the-business-process-outsourcing-industry-bpo-_165680?profile=1056&template=MobileArticle#:~:text=The%20Business%20Process%20Outsourcing%20(BPO,more%20than%20US%24400%20million.

183 CCB Caribbean Country Department, "The Impact of Covid-19 on the Economies Of The Region." Copyright © 2020 Inter-American Development Bank.

184 CCB Caribbean Country Department, "The Impact of Covid-19 on the Economies Of The Region." Copyright © 2020 Inter-American Development Bank and Measuring the Blue Economy: The System of National Accounts and Use of Blue Economy Satellite Accounts - CDB Working Paper No. 2019/02

185 https://www.forbes.com/sites/daphneewingchow/2019/05/21/the-caribbeans-share-in-the-global-cargo-industry-is-growing-rapidly/#7b5dadec61a2

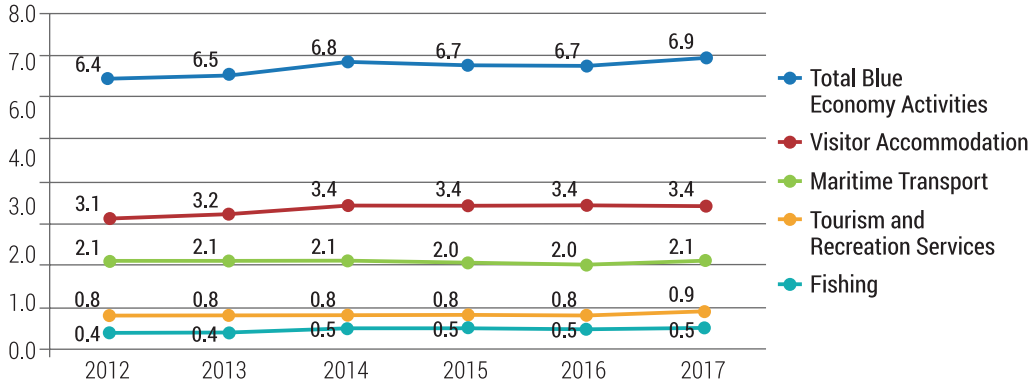
186 https://www.globaltrademag.com/jamaicas-port-of-kingston-strives-for-competitiveness/

187 Lennon R. Thomas 1, Tyler Clavelle, Dane H. Klinger and Sarah E. Lester, "The ecological and economic potential for offshore mariculture in the Caribbean." Nature Sustainability | VOL 2 | 62 January 2019 | 62–70

Jamaica's Exclusive Economic Zone (EEZ) is 274,000 km^2 or approximately 23 times the country's land mass[188] and many of Jamaica's key sectors including tourism, fisheries/seafood processing, maritime works, servicing and transport, logistics and storage and renewable energy are heavily dependent on the nation's coastal and marine resources, which include, "an array of ecosystems including coral reefs, seagrass beds, mangrove forests and wetlands [that] protect the coastline and importantly, provide habitat for several species of fish and other marine life."[189] However, very little sea mapping of Jamaica Exclusive Economic Zone has occurred to date which would allow for heightened understanding of Jamaica's indigenous marine assets and inform marine spatial planning and integrated coastal zone management approaches that could legally zone and permit certain blue economy activities.

Still, the Caribbean Development Bank, (CDB) recently estimated that in 2017 existing blue economy-related activities generated over US$1 billion in Jamaica, accounting for approximately seven per cent of GDP.[190]

Figure 15: Blue Industry Indicators, Percentage of Gross Value Added 2012-2017 (Direct and Indirect).[191]



Measuring the Blue Economy: The System of National Accounts and Use of Blue Economy Satellite Accounts - CDB Working Paper No. 2019/02.

The CDB analysis also demonstrates that tourism-related activities (tourism and recreation resources and visitor accommodation) represented more than an estimated 62% share of Jamaica's ocean economy in 2017 as shown in **Figure 16**.

188 http://www.fao.org/fishery/countrysector/naso_jamaica/en

189 https://cbei.blog/blue-economy-jamaica/

190 http://jamaica-gleaner.com/article/business/20200212/cdb-highlights-blue-economy-contribution-jamaica-projects-41-growth

191 "Gross value added (GVA) measures the nominal value of goods and services produced in an economy less the cost of all intermediate inputs and raw materials." Source: Measuring the Blue Economy: The System of National Accounts and Use of Blue Economy Satellite Accounts - CDB Working Paper No. 2019/02

Figure 16: Jamaica Ocean Economy, 2017[192]

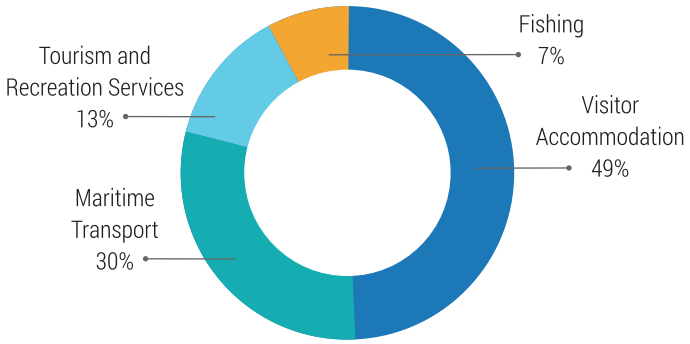


Table 15: Blue Economic Sector Contribution to Jamaica's Economy.

Blue Economic Sector	Economic Importance[169]	Development Stage	Key Observations
Maritime and Coastal (island) Tourism	High; accounts for 34% of GDP (11% direct)[193]	Mature	Traditionally concentrated on North coast near Kingston and Montego Bay; additional development on East coast and push towards cultural-based tourism.[194]
Maritime transport	High; 29 million metric tons of cargo was handled on the island, merchandise trade accounts for 51% of GDP (2018)[195], 3,561 vessels visited its ports in 2018	Mature	Jamaica is already a major center for logistics and transshipments and moves more cargo than any other Caribbean country. In 2018, its logistics industry was worth $728 million, 29 million metric tons of cargo was handled on the island, 3,561 vessels visited its ports.[196]
Fishing	50,000 directly engaged in fishing industry[197]	Mature	Jamaica has one of the highest levels of fish consumption in Americas, although 80% of fish consumed is imported.[198]

192 "Gross value added (GVA) measures the nominal value of goods and services produced in an economy less the cost of all intermediate inputs and raw materials." Source: Measuring the Blue Economy: The System of National Accounts and Use of Blue Economy Satellite Accounts - CDB Working Paper No. 2019/02

193 https://www.statista.com/statistics/874514/jamaica-travel-tourism-total-contribution-to-gdp-by-share/#:~:text=That%20year%2C%20travel%20and%20tourism,Caribbean%20country%20was%2010.56%20percent.

194 https://traveltips.usatoday.com/caribbean-tourism-trends-17985.html

195 https://data.worldbank.org/indicator/TG.VAL.TOTL.GD.ZS?locations=JM

196 https://www.japantimes.co.jp/country-report/2020/01/09/global-insight/jamaica-report-2020/globally-competitive-logistics-hub/#.XvEiYS-z3OQ

197 https://www.caribbeanlifenews.com/jamaica-fisheries-sector-gets-world-bank-aid/#:~:text=The%20World%20Bank%20noted%20that,source%20of%20the%20country%27s%20revenue.

198 http://www.fao.org/fishery/facp/JAM/en

Table 15: Blue Economic Sector Contribution to Jamaica's Economy. (cont.)

Blue Economic Sector	Economic Importance[169]	Development Stage	Key Observations
Water desalination	Negligible	Under developed	Desalination has not been considered for Jamaica because of prohibitive costs, but officials at the Ministry of Economy and Job Creation stated, "We have to talk about it now … the discussions have started.[199]
Aquaculture and alga-culture	Negligible; 800-1,000 directly employed	Under developed	The main species currently farmed in Jamaica is the red tilapia, which is grown primarily in earthen ponds. In 2013, production of tilapia is estimated to be approximately 785.5 tonnes.

Institutional Blue Economy Assets

Prime Minister Andrew Holness has registered Jamaica's continued commitment to leveraging these existing activities and assets and pursuing a blue economic agenda on a number of occasions, including during the High-Level Panel for a Sustainable Ocean Economy in September 2018 where he endorsed "The Ocean Economy, The Urgency of Today, The Possibility of tomorrow, & Charting the Course Ahead."[200] Because of the important socioeconomic advances Jamaica had realized prior to the Covid-19 outbreak the GOJ had been actively pursuing strategies to accelerate the development of Jamaica's blue economy, prioritizing tourism and fisheries as the principal areas of focus.[201]

In addition, Jamaica's Tourism Enhancement Fund (TEF), which is funded through a tax on international cruise passengers and airline visitors, is a critical supporter of the country's coastal and maritime tourism-related initiatives and has invested, "an excess of J$ 36 billion into projects intended to both improve Jamaica's tourist product and to retain more of the earnings from the sector."[202] The country also hosts a small but important nucleus of educational, research and entrepreneurship support institutions including: the Centre for Marine Sciences at the University of the West Indies, the Caribbean Maritime University's Centre for the blue economy and Innovation (CBEI), the Branson Centre's Blue Economy Program, the Discovery Bay Marine Lab and Alligator

199 https://www.fluencecorp.com/jamaica-weighs-decentralized-desalination/
200 https://www.un.int/jamaica/sites/www.un.int/files/Jamaica/mhpm_hlp_sustainable_ocean_economy_unga_20180924-2_2_1.pdf.
201 Measuring the Blue Economy: The System of National Accounts and Use of Blue Economy Satellite Accounts - CDB Working Paper No. 2019/02
202 https://www.stabroeknews.com/2019/08/02/business/jamaicas-tourism-enhancement-fund-helping-to-grow-the-industry/

Head Marine Lab. And importantly, Jamaica hosts the International Seabed Authority, "mandated under the UN Convention on the Law of the Sea to organize, regulate and control all mineral-related activities in the international seabed area beyond the limits of national jurisdiction."[203]

Business/Regulatory Environment

The World Bank Group 2019 Ease of Doing Business Report ranked Jamaica 75 out of 190 countries in ease of doing business – up 8 places since 2016. The top four challenges for businesses in Jamaica are trading across borders, registering property, enforcing contracts, getting electricity service. Violent crime is also an issue in Kingston and Montego Bay.[204] On the other hand, progress has been made in expanding the amount of information collected by credit bureaus and implementing customs data management systems.

In the 2020 Index of Economic Freedom, Jamaica ranked 49th out of the 186 countries and territories for economic freedom. The Global Index of Economic Openness ranked Jamaica 60th out of 154 countries for its ability to enable trade, competition and productivity.

Blue Economy Opportunities – Identification of Candidate Initiatives

Based on our global opportunities scan and local interviews, the following candidate initiatives have been identified, and will be assessed in greater details for the Country Action Plan.

- **Jamaica Sargassum Collection & Processing System (C-Combinator)**
  - Sargassum is a problem across the Caribbean yet provides a potential opportunity for profitable business. C-Combinator is a start-up company which has developed a system for collection, transportation, and pilot bio-refinery processing plant in Puerto Rico for production of biostimulant/fertilizer plus advanced products for multiple markets. Business analysis and research on the uses of sargassum and testing the market could de-risk and create viable business models. The potential for these models is great as removal solves a current problem, creates jobs, serves the tourism industry and environment, reduces costs for communities/businesses/ governments, etc.

- **Offshore Seaweed Production (Marine Permaculture)**
  - 100 hectare offshore marine permaculture (kelp) arrays growing 70 meters under the surface. Low cost, high scalable method of production. Looking at scale for feeds and bio-products but not human consumption. Project being developed by C-Combinator.

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203 https://www.isa.org.jm/news/media-advisory

204 https://www.osac.gov/Country/Jamaica/Content/Detail/Report/1d98b2df-fd4b-485f-aa62-15f4aed245ef#:~:text=Violent%20crime%2C%20including%20sexual%20assault,in%20Kingston%20and%20Montego%20Bay.&text=In%202017%2C%20Jamaica%27s%20homicide%20rate,Latin%20America%20and%20the%20Caribbean.

- **Local Community Fishing Practice Improvements Project**
  - TNC and Alligator Head have been looking at alternative livelihood opportunities for fishers. What models could be viable given covid disruptions that would be immediate and/or longer term.

Key Stakeholders

Importantly, Jamaica benefits from notable core of blue economy institutional stakeholders including:

- Maritime Authority of Jamaica;
- The Tourism Enhancement Fund (TEF);
- International Seabed Authority;
- Caribbean Maritime University's Centre for the Blue Economy and Innovation (CBEI);
- Branson Centre's Blue Economy Program;
- The Centre for Marine Sciences at the University of the West Indies (The UWI), and also The UWI's Blue Economy Program with the United Nations Development Programme (UNDP);
- The Nature Conservancy's marine spatial planning (MSP) and artisanal fisheries programs; and,
- The Alligator Foundation's marine conservation and coastal livelihoods programs.

Country Stats Context

- Population: **2.93 million (70% Coastal)**
- Gross Domestic Product GDP (GDP): **US$ 15.72 billion**
- Human Development Index (HDI): **0.732**
- Gross National Income (GNI) Per Capita: **US$ 4,970**
- % Blue economy
  - Relative Importance of fishing (ratio fishing/agriculture VA): n.a.
  - Relative Importance of Tourism (Visitor Exp. as % of GDP): **20%**
  - Relative importance of Marine Transportation (Marine transport as % of transport & storage sector): merchandise trade as percentage of GDP: n.a.
  - Container throughput as % of total Caribbean Container Throughput: n.a.

- Land Area: **10,992 km²**
- Coastline: **1,022 km**
- Sea Area (territorial waters up to 12 nautical miles): n.a.
- Percentage of coastline with ICM: n.a.
- Marine Protected Area (% of territorial waters): n.a.
- Ocean Health Index: **60**

Blue Economy Profile

Suriname

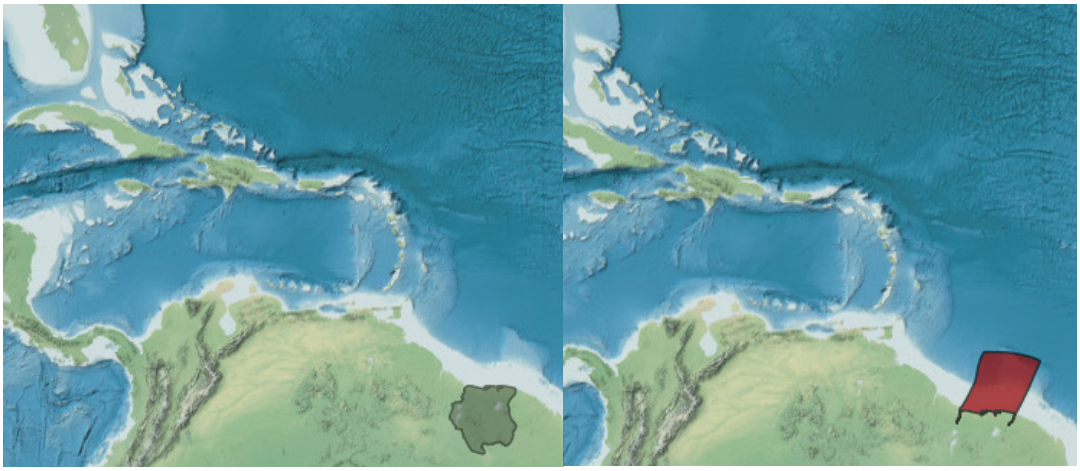

Figure 17: Suriname official boundaries (left) and Economic Exclusive Zone (right)
Source: Marine Region (2020)

Economic Context

Suriname is an upper-middle-income country of 542,000 people with a concentrated economy that is vulnerable to economic shocks. Suriname has abundant natural resources; but as a small state it has limited capacity for economic management. Suriname's economy is highly concentrated in the extractive industries (gold and increasingly oil), which play a dominant role in driving growth, employment, and government revenues while also exposing economic performance to commodity price fluctuations. Historically, extractive industries have accounted directly for around 30 percent of GDP and as much as 90 percent of exports.

Suriname's economy has largely stabilised since 2018 with exchange rate steadied at around 7.5 Suriname dollars (Sur$) per US$ 1 an inflation rate of 4,4% in 2019 down from 22% in 2017. Growth is estimated at 1.9% for 2018, up from 1.7% in 2017 and -5.6% in 2016. The annualised fiscal deficit remained largely unchanged at 7.9% of GDP, as increased revenues were offset by increased expenditure, particularly on subsidies and transfers.

In 2018 Suriname was the number 155 economy in the world in terms of GDP (constant 2011 international USD), the number 132 in total exports, and the number 165 in total imports. In 2018, Suriname exported $2.51B and imported $1.34B, resulting in a positive trade balance of $1.17B.

Trade: The top exports of Suriname are Gold ($1.77B), Precious Metal Scraps ($209M), Rough Wood ($140M), Fish Products ($ 119M) Refined Petroleum($112M), and Bananas ($48M).[205]

[205] OEC - Suriname (SUR) Exports, Imports, and Trade Partners

The Atlas of Economic Complexity[206] includes the service sector as well, considering ICT and tourism which represent about 6% of exports. Nevertheless, the Surinamese economy is almost entirely driven by the exploitation and export of the raw materials gold and oil. Annually it exports about one and a half billion American dollars of gold. In recent years the state-owned oil company 'Staatsolie', the national oil producer, has achieved an annual turnover of one billion dollars each year. New oil reserves have recently been identified offshore which is expected to provide an opportunity in the increase of government spending. It is expected that the economy will continue to grow in the medium term, mainly thanks to large foreign investments in the oil sector. The export of other Surinamese products and services remains very limited to date. The growing fishing industry is a positive exception to this.

Blue Economy Assets

Oil sector: The state-owned company Staatsolie was established in 1980. Thanks to the average production of 17,000 barrels of oil per day, the oil industry has become an important part of Suriname's economy. After Trinidad and Tobago and Cuba, Suriname is the largest oil producer of the Caribbean. State oil accounts for 10% of the GDP, 33% of the total Surinamese exports and no less than 21% of the government income. Oil extraction, on the other hand, makes little contribution to employment. Approximately 0.6% of the labour force is employed in the oil sector. The entire territory of Suriname has been granted a concession to Staatsolie. Investors can only participate in oil extraction by entering into a petroleum agreement, usually a production sharing agreement, with Staatsolie. On the basis of such an agreement, an offshore oil block off the coast or in the exclusive economic zone, for example, can be allocated to a company. Because of the price tag attached to this, only wealthy foreign multinationals are able to invest in the Surinamese offshore oil sector. Off the coast of Suriname, seven multinationals are currently active in an area of 150,000 square kilometers. These are Inpex (Japan), Tullow Oil (Ireland), Kosmos Energy (United States), Petronas (Malaysia), CEPSA (Spain) and Apache (United States). Staatsolie has also invested heavily, one billion US dollars, in the construction of its own oil refinery. Fully operational, the refinery processes 14,000 barrels of crude oil a day into petrol, diesel, sulphuric acid, fuel oil and asphalt.

Port & Logistics: The port facilities of Suriname are reasonably good. The New Port in Paramaribo was proclaimed by the Caribbean Shipping Association both in 2010 and 2011 as 'best multifunctional port terminal in the Caribbean'. Admittedly, access to the port remains an important limitation. Just recently the plan to dredge out the Surinam River has been put into action, mainly to facilitate, so that larger ships with more cargo can reach the port. The country's second port is in Nieuw-Nickerie, from where mainly agricultural products are exported.

Maritime and Coastal Tourism: Over the past twenty years Suriname has slowly started to focus on the development of a tourism industry. It has some impressive assets in its hands: the

[206] https://atlas.cid.harvard.edu/explore?country=undefined&product=undefined&year=2017&productClass=HS&target=Product&partner=undefined&startYear=undefined

tropical rainforest with large natural parks where rare plants and animals live, the unique inner city of Paramaribo with its many wooden buildings - a large part of which has been designated a World Heritage Site by the United Nations - the diversity of cultures, the possibility to stay in traditional villages of Indians or Maroons and the extensive cuisine. An important eye-catcher is the Central Suriname Nature Reserve of 1.6 million hectares, in which 5,000 plant species and 400 bird species live. Due to the importance of Suriname's rivers, much of Suriname's tourism can be considered as "coastal tourism".

Unlike some other countries in the region, Suriname does not yet have an organised, developed tourism sector. In 2015, Suriname received 228,000 visitors. By way of comparison: 4.7 million tourists traveled to Curacao that same year. The economic impact of tourism remains very small. The sector contributes less than one percent to the GNP and provides employment for only 2.4% of the working population. Suriname mainly receives Dutch and Guyanese who come to visit their families, followed by French-Guyanese who come to shop relatively cheaply. Suriname lacks the classic beaches with white sand and clear blue seawater, the classic image of the Caribbean. Nevertheless, between 2011 and 2014 the number of visitors has grown by an average of 9% annually. The establishment of a tourist card in November 2011 for, among others, the Dutch, Americans and South Americans has undoubtedly contributed to this. Visitors from those areas no longer need to buy a tourist visa at a Surinamese embassy or consulate for a trip to Suriname, but since then they have been able to buy a tourist visa for the Caribbean. 20 euros (or 25 U.S. dollars) buy a tourist card that entitles you to a stay of up to three months in Suriname. If the territory of Suriname is left within those three months, a new tourist card must be purchased upon return. Tourist cards can be purchased before departure at Schiphol Airport, upon arrival at Paramaribo airport and at all Surinamese embassies and consulates.

The gradual development of tourism has, among other things, its spinoff in the increase of hotels, eateries, guides, tour operators, travel agents and in the number of tourist resorts in the interior. However, the tourism sector remains very small, which makes travel to and in Suriname expensive.

The only direct air connection to Europe is Amsterdam and recently North America can be reached via Miami. The only destinations in South America are Belém (Brazil), Panamá and the Caribbean via Trinidad & Tobago. In Paramaribo itself is the smaller Zorg en Hoop airport, from where (charter) flights to the interior and the Caribbean depart. There are also airstrips spread all over the country, often unpaved runways that are served by local airlines.

On various fronts, attempts are being made to give tourism a boost. For example, there is a ministry of Transport, Communication and Tourism, although that has been withdrawn. In 2015, barely 250,000 euros will be spent on promoting Suriname as a tourist destination. In addition, there is a Tourism Foundation Suriname, a working arm of the Ministry and the Chamber of Commerce, and the 'Suriname Hospitality and Tourism Training Centre Foundation', which trains personnel for the hospitality industry. In 2016, the Suriname Hospitality & Tourism Association (SHATA) was founded by companies in the sector itself.

Fisheries & Aquaculture: Suriname's most important agricultural export products are fish, bananas and rice. The fisheries sector has shown steady growth export figures and a lot of economic potential. Total exports were $119M in 2018, of which 20% is crustaceans and 80% processed fish. Among other things, tuna and red snapper are found and the seabob shrimp.

Fishing is done by small-scale local and foreign fishermen — often Guiana and Brazilians — as well as by larger companies. Suriname has about ten fish processing companies that export fish and/or shrimp. jvks are around 20 fish processing plants in and around Paramaribo parastatal fishing company SAIL mainly exports to Japan. The Dutch shrimp processing company Heiploeg, which was taken over by Parlevliet & Van der Plas in 2014, has a branch in Commewijne. The Surinamese company Deep Sea Atlantic supplies to the United States, Europe and the Caribbean. The quality of the exported fish is monitored by a fish inspection institute that was established in 2007.

Table 16 provides an overview of blue economy sectors' importance and their development stage in Suriname. In the absence of common figures such as value added and jobs generated per sector, information is mainly extracted from stakeholder interviews and descriptive documents.

Table 16: Blue Economic Sector Contribution to Suriname's Economy.

Blue Economic Sector	Economic Importance	Development Stage	Key Observations
Oil & Gas	Medium, moving to very high	Mature & emerging off-shore	Two recent major off-shore discoveries. Ongoing exploration. Growth as off-shore oil discoveries and developments increase.
Maritime and Coastal Tourism	Low; accounts for <2% of GDP	Under developed	Mostly limited eco-tourism from Holland & EU
Maritime transport	Low	Mature	Mainly for commodity exports (gold, fish, rice) and importing goods
Fishing	Moderate; in accounted for% of GDP	Mature	Full or overexploitation of key species. Frozen fish & shrimp account for 5% of total exports.
Aquaculture	Negligible	Under developed	
IT/Call Centers	Low	Initial development	Growth in call centers industry

Business/Regulatory Environment

- The World Bank Group 2019 Ease of Doing Business Report ranked Suriname 165 out of 190 countries in ease of doing business – down 7 places since 2016. As a result, Suriname is significantly below the weighted average of Latin America and the Caribbean. The top four challenges for businesses in Suriname are enforcing contracts, getting credit, starting a business, and protecting minority investors.

- Starting up a business in Suriname is initially a time-consuming (two months) and expensive process, as is applying for electricity (four months) or a building permit (seven months). Applying for credit from a financial institution is very difficult, shareholders enjoy little legal protection and it is very laborious to apply to a court of law.

- In the 2019 Index of Economic Freedom, Suriname ranked 163rd out of the 186 countries and territories for economic freedom. The Global Index of Economic Openness ranked Suriname 93rd out of 154 countries for its ability to enable trade, competition and productivity.

Blue Economy Opportunities – Identification of Candidate Initiatives

Based on our global opportunities scan and local interviews, the following candidate initiatives have been identified, and will be assessed in greater details for the Country Action Plan.

- **Mangrove Corridor Restoration**
  - Nature-based Protection of Coastline & Fast-Track Creation of Community-based Jobs. Scaling up of proven pilot technology for community-based restoration of mangrove and coastal protection in WegnaarZee area to protect Suriname's coastline and Paramaribo capital region urban infrastructure.
  - Fast-track creation of jobs in developing the green/gray infrastructure using workers from local community
  - Mangrove reforestation preserves local ecosystems while providing additional opportunities for green industries like beekeeping, sustainable fishing, and tourism

- **Mangrove Honey**
  - Scaling up of bee-keeping in mangrove regions as complementary livelihoods for fishers. Mangrove honey is a high-value export that can be used as an additional source of income and as a way of ensuring local buy-in to reforestation efforts.
  - at-based harvesting of beehives can also be used to increase production and participation of local fishermen.

Key Stakeholders

- LVV – Ministry of Agriculture, Husbandry and Fisheries) http://lvv.gov.sr/
- Nationaal Institution for Environment and Development http://www.gov.sr/themas/milieu-en-omgeving/nimos/
- Statistic Bureau of Suriname https://statistics-suriname.org/en/
- Maritime Authority https://www.mas.sr/
- Conservation International Suriname https://www.conservation.org/suriname
- World Wildlife Fund Suriname https://wwf.panda.org/wwf_offices/suriname/
- Green Heritage Fund Suriname https://greenfundsuriname.org/programs/
- Amazona Aquaculture http://www.amazonaquaculture.com/
- Staatsolie https://www.staatsolie.com/en/
- Compete Suriname http://www.surinamecompete.org/
- SHATA – Tourism Association http://www.shata.sr/nl/members/
- University of Suriname https://www.uvs.edu/

Country Stats Context

- Population: **575,991 (2018)**[207]
- Gross Domestic Product GDP (GDP): **US$ 3.59 billion (2018)**[208]
- Human Development Index (HDI): **0.724 (2018)**[209]
- Gross National Income (GNI) Per Capita: **US$ 41,463 (2018)**[210]
- % Blue economy
  - Relative importance of fishing (ratio fishing/agriculture VA): n.a.
  - Relative importance of Tourism (Visitor Exp. as % of GDP): n.a
  - Relative importance of Marine Transportation (Marine transport as % of transport & storage sector): merchandise trade as percentage of GDP: n.a.
  - Container throughput as % of total Caribbean Container Throughput: n.a.

- Land Area: **163,820 km²**
- Coastline: **386 km**
- Sea Area (territorial waters up to 12 nautical miles): n.a.
- Percentage of coastline with ICM: n.a.
- Marine Protected Area (% of territorial waters): n.a.
- Ocean Health Index: **67**

207 https://data.worldbank.org/country/suriname
208 https://data.worldbank.org/indicator/NY.GNP.MKTP.CD?locations=SR
209 http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/SUR.pdf
210 https://data.worldbank.org/indicator/NY.GNP.PCAP.CN?locations=SR

Blue Economy Profile

Trinidad and Tobago

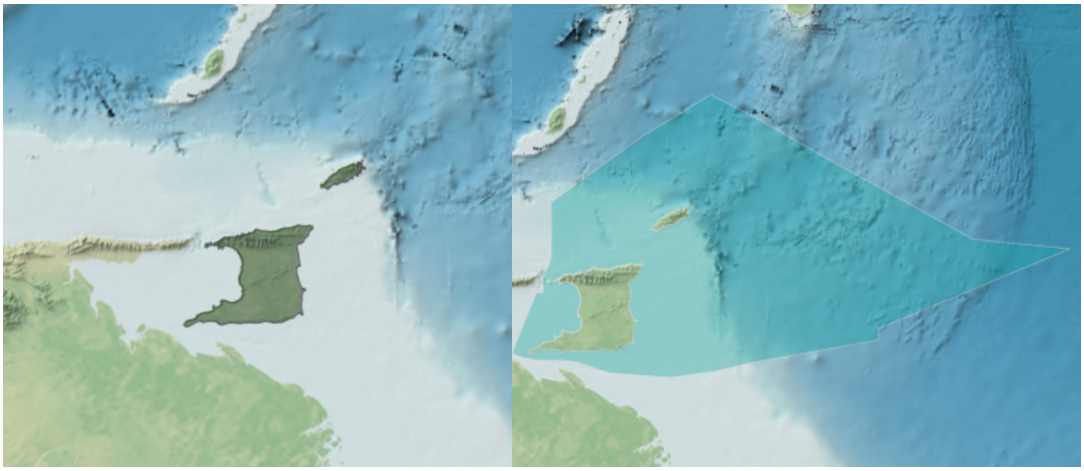

Figure 18: Trinidad & Tobago Official Boundaries (left) and Economic Exclusion Zone (right)
Source: Marine Region (2020)

Economic Context

Trinidad and Tobago is the southernmost island nation in the Caribbean, with Trinidad located off the coast of Venezuela and separated by the Gulf of Paria. Trinidad contains the majority of the country's population and industry, while the smaller island of Trinidad, located 35 km to the northeast, is relatively underdeveloped and features little heavy industry. The combined nation of Trinidad and Tobago is categorized by the World Bank as a high-income country, with the fourth highest GDP per capita in the Americas at $26,913,[211] due primarily to its position as the largest producer of oil and gas in the Caribbean.[212] Along with Barbados, it is viewed as the political and economic leader of the Caribbean. It has positioned itself as a regional hub for business, finance, energy services, transshipment, and investment and the government has removed restrictions on foreign investment while signing trade agreements with countries in the Americas.[213]

Trinidad and Tobago achieved independence from the UK in 1962 and retains a parliamentary democracy modeled on the UK system. The two main parties are the United National Congress (UNC), which draws support from the Indo-Trinidadian community, while the People's National Movement (PNM) normally gains the support of the Afro-Trinidadian population in elections. The current prime minister, Keith Rowley, has led the PNM since 2010 and has been in office since 2015, with new elections scheduled for 2020. The country is politically stable, with no serious cases of violence outside an attempted coup in 1990,[214] when a local Islamist group stormed parliament and held the Prime Minister and other government minister's hostage for six days until surrendering to the army.

[211] https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?locations=TT
[212] https://oxfordbusinessgroup.com/trinidad-tobago-2020/country-profile
[213] https://www.great.gov.uk/markets/trinidad-and-tobago/
[214] https://www.bbc.com/news/world-latin-america-10774647

The economy of Trinidad and Tobago is dominated by the oil and gas industry, with oil and gas exploration representing nearly 40% of GDP and 80% of exports.[215] It is the sixth largest producer of liquid natural gas (LNG) in the world and the world's largest exporter of ammonia and methanol.[216] GDP grew at an annual rate of 0.90% in Q3 2019[217] and is projected to shrink by 6.0%[218] on an annual basis in Q1 2020. Inflation was 1.0%[219] in 2019, while government debt to GDP stood at 63.2%[220] in 2019.

Blue Economy Assets

Overview of Blue Economy Assets - The outsize influence of the petrochemical industry in Trinidad and Tobago, relative to its Caribbean peers, is a unique asset for future blue economic development while also presenting a potential liability for sustainability. On one hand, the extractive nature of the industry presents inherent challenges to moving toward a truly sustainable blue economy. On the other hand, the high level of industrial development and income per capita, if utilized properly, would allow blue economy initiatives to be scaled up and deployed rapidly. The relative underdevelopment of the fishing and marine industries also present low-hanging opportunities for blue economy initiatives, some of which are presented in the blue economy Opportunities section

Oil and Gas - Oil and gas is a key component of any blue Economy plan for Trinidad and Tobago given the size and history of the industry. The domestic hydrocarbon industry dates back over 100 years, with the first commercial oil production beginning in 1908,[221] although a majority of production shifted to natural gas in the early 1990s.[222] Trinidad and Tobago has also expanded into downstream petrochemical activities, with the Port of Savonette housing one of the largest natural gas processing facilities in the western hemisphere.[223] It also has 11 ammonia plants and seven methanol plants[224] and is the third largest exporter of ammonium[225] and the second largest exporter of methanol[226] after Iran. Moving forward, new deep and shallow-water oil discoveries off the coast should contribute to increase in production[227] and economic activity associated with the oil and gas industry.

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215 https://www.cia.gov/library/publications/the-world-factbook/geos/td.html
216 https://www.globalsecurity.org/military/world/caribbean/tt-economy.htm
217 https://tradingeconomics.com/trinidad-and-tobago/gdp-growth-annual
218 https://tradingeconomics.com/trinidad-and-tobago/gdp-growth-annual#:~:text=GDP%20Annual%20Growth%20Rate%20in%20Trinidad%20and%20Tobago%20is%20expected,3.90%20in%2012%20months%20time.
219 https://www.statista.com/statistics/728916/inflation-rate-in-trinidad-and-tobago/
220 https://tradingeconomics.com/trinidad-and-tobago/government-debt-to-gdp#:~:text=Government%20Debt%20to%20GDP%20in,of%209.50%20percent%20in%201958.
221 http://www.energy.gov.tt/historical-facts-petroleum/
222 https://theenergyyear.com/market/trinidad-and-tobago-2/
223 http://www.energy.gov.tt/our-business/oil-and-gas-industry/#:~:text=Trinidad%20and%20Tobago%20has%20been,3)%20billion%20barrels%20of%20oil.
224 http://www.energy.gov.tt/our-business/oil-and-gas-industry/#:~:text=Trinidad%20and%20Tobago%20has%20been,3)%20billion%20barrels%20of%20oil.
225 https://oec.world/en/profile/hs92/62814/#:~:text=The%20top%20exporters%20of%20Ammonia,is%20also%20known%20as%20anhydrous.
226 https://oec.world/en/profile/hs96/290511/#:~:text=The%20top%20exporters%20of%20Methanol,)%20and%20India%20(%24524M).
227 https://www.caribbean-council.org/new-gas-fields-likely-to-spur-trinidads-economic-growth/

Tourism and Fishing - Tourism is 4.6% of the national exports, while fisheries for export is almost non-existent,[228] however the domestic fishing industry is a significant source of domestic consumption, representing 0.3% of GDP (2008)[229] and directly employing 10,720 people (2015),[230] but has attracted international concern for its fishing practices, earning a yellow card from the European Union for illegal, unreported, and unregulated (IUU) fishing in 2017. The fishing industry suffers from a lack of effective monitoring and surveillance, inappropriate fishing equipment, competition from oil and gas exploration, excessively high bycatch rates, and a lack of up to date fisheries legislation,[231] with the primary legislation being the Fisheries act of 1916 and subsequent updates.[232]

Maritime Sector - The Maritime Sector is a major contributor to the economy of Trinidad and Tobago and plays a key role in supporting both the energy and non-energy sectors.

Trinidad and Tobago's connectivity to regional and global markets, healthy export base, educated workforce, energy sector, low fuel rates and political stability are some of the factors that make this country an attractive location for maritime services.[233] Additionally, The Government of Trinidad and Tobago (GORTT) has identified the Maritime Sector as one of the sectors for further development. Although activities in the local Maritime Sector are diverse, the key areas of focus are Port Operations, Ship Repair & Dry Docking, and Marine Services (Off-Shore Bulk Transshipment, Bunkering, Cold Stacking, Maritime Logistics and Open Ship Registry)

Table 17: Blue Economic Sector Contribution to Trinidad and Tobago's Economy.

Blue Economic Sector	Economic Importance	Development Stage	Key Observations
Oil & Gas	Very high	Mature	Energy accounts for 35% of GDP,[234] and T&T is one of the top petrochemical exporters in the world. Possible future expansion of expansion of offshore oil and gas exploration
Maritime Transport	High	Mature	Connectivity to regional and global markets, healthy export base, educated workforce, energy sector, low fuel rates and political stability are some of the factors that make this country an attractive location for maritime services

228 https://atlas.cid.harvard.edu/explore?country=222&product=undefined&year=2017&productClass=HS&target=Product&partner=undefined&startYear=undefined
229 http://www.commonwealthofnations.org/sectors-trinidad_and_tobago/business/fisheries/
230 http://www.fao.org/fishery/facp/TTO/en
231 https://www.seafoodsource.com/features/trinidad-and-tobago-iuu-fishing-yellow-card-from-eu-sign-of-deeper-problem
232 https://www.ima.gov.tt/2018/04/11/the-state-of-the-marine-fisheries-resources-of-trinidad-and-tobago/
233 https://tradeind.gov.tt/commercial-maritime/
234 http://www.energy.gov.tt/our-business/oil-and-gas-industry/#:~:text=Trinidad%20and%20Tobago%20has%20been,3)%20billion%20barrels%20of%20oil.

Table 17: Blue Economic Sector Contribution to Trinidad and Tobago's Economy. (cont.)

Blue Economic Sector	Economic Importance	Development Stage	Key Observations
Fishing	Minor	Developing	The share of the fishing industry in GDP was less than 2% in 2016, a value significantly low with respect to other Caribbean countries. Driven by seabob shrimp exports, the fishing industry has developed in recent times even though the average capture production has not significantly increased over the past decade, remaining close to 40,000 tonnes per year. There is, in fact, potential to grow and add value by applying quality controls, sustainability credentials and investment in equipment to harvest deep-water species.
Marine and coastal tourism	Moderate (Other services including tourism 7.6% of GDP)[235]	Growing / Under development	Government has positioned Tobago as a center for tourism, with its own ministry (separate from Tobago). Was posed for double-digit growth compared to 2019 prior to COVID crisis[236]
Aquaculture	Negligible	Under development	

Institutional Blue Economy Assets

While Trinidad and Tobago lags behind other Caribbean nations such as The Bahamas in developing comprehensive blue economy plans at the national level, its relative wealth and position as a hub of business services and educational institutions give it a strong base of institutional assets. The University of the West Indies campus at Saint Augustine gives Trinidad and Tobago a direct link to UNDP blue economy Initiatives[237] and private institutions such as The Environmental Research institute in Charlottesville are leading local conservation efforts.

235 https://knoema.com/atlas/Trinidad-and-Tobago/topics/Tourism/Travel-and-Tourism-Total-Contribution-to-GDP/Contribution-of-travel-and-tourism-to-GDP-percent-of-GDP#:~:text=In%202018%2C%20contribution%20of%20travel,Trinidad%20and%20Tobago%20was%207.6%20%25.

236 https://www.caribjournal.com/2020/02/07/tobago-sunwing-tourism/

237 https://www.open.uwi.edu/uwi-and-undp-join-forces-promote-blue-economy-caribbean

Business/Regulatory Environments

The World Bank Group 2019 Ease of Doing Business Report ranked Trinidad and Tobago 105 out of 190 countries in ease of doing business – down nine places since 2016. The top four challenges for businesses in Trinidad and Tobago are poor work ethic and low productivity in the national labour force, corruption, government bureaucracy and foreign exchange controls. Crime and security is also a factor. On the other hand, progress has been made in other areas such as the implementation of an online government platform TTBizLink which gives businesses and individuals 24/7 access to applications for government trade and business services.

In the 2019 Index of Economic Freedom, Trinidad and Tobago ranked 112th out of the 186 countries and territories for economic freedom. The Global Index of Economic Openness ranked Trinidad and Tobago 74th out of 154 countries for its ability to enable trade, competition and productivity.

Key Stakeholders

Importantly, Trinidad and Tobago also host several notable blue economy institutional assets including:

- Government of Trinidad and Tobago Institute of Marine Affairs
- Caribbean Fisheries Training and Development Institute
- Environmental Research Institute - Charlotteville
- University of the West Indies UWI - St. Augustine

Blue Economy Opportunities—Identification of Candidate Initiatives

Based on our global opportunities scan and local interviews, the following candidate initiatives have been identified, and will be assessed in greater details for the Country Action Plan.

- **FISHERS ENGINE CONVERSION – Pilot Project in NE Tobago**
  - Conversion of inefficient, polluting two-stroke engines to more environmentally friendly options represents a substantial blue economy opportunity for Trinidad and Tobago. Next to tourism, fishing is the main economic activity in NE Tobago which engages 15 communities and 12,000 residents and provides essential food security. Consistent with the small-scale nature of the industry, fishing is largely conducted using small 4-10m boats, with estimates of 300 operational boats from seven fish landing sites. 95% of these boats use 40-75 hp two stroke engines which are banned in many countries as they are fuel inefficient, produce more emissions and release oil into the oceans. A conversion of these two stroke engines to the use of LPG from cooking gas cylinders would allow for a reduction of fuel cost by approximately 75% and significantly reduced environmental impact.[238] Possible pilot projects could include a) technology and knowledge transfer, b) establishing a pilot project converting 50 boats, c) establishing an easily accessible micro loan facility for conversion with the Agricultural

[238] https://www.researchgate.net/publication/251441784_Direct_Fuel_Injection_of_LPG_in_Small_Two-Stroke_Engines

Development Bank of Trinidad and Tobago, d) training local mechanics, e) partnerships with local hydrocarbon companies. Access to the loan facility and/or grant for conversion could be used as an access point to engage fishers in programs that enable the development of a sustainable fisheries sector in NE Tobago.

- **Scientific and Educational Eco-Tourism in NE Tobago**
  - Potential for promotion of science-based tourism to US and EU universities, with development of niche tourism destination assets and facilities based on citizen science projects. Traditionally NE Tobago, especially in the Charlottesville area, has been the hub for science tourism in Trinidad & Tobago and SIDS in the Caribbean due to its proximity to UWI. While traditionally focused on biological and ecological based tourism, new archaeological sites are being discovered on the island which could enhance tourism opportunities. The capital, Port of Spain, was designated as a UNESCO Creative City in 2019,[239] and further momentum could be used as a springboard for NE Tobago ecotourism opportunities. Potential barriers to the project include a lack of private sector leaders and entrepreneurs.

Country Stats Context

- Population: **1,389,858 (2018)**[240]
- Gross Domestic Product GDP (GDP): **US$ 23.8 billion USD (2018)**[241]
- Human Development Index (HDI): **0.784 (2017)**[242]
- Gross National Income (GNI) Per Capita: **US$112,247 (2018)**[243]
- % Blue economy
  - Relative Importance of fishing (ratio fishing/agriculture VA): n.a.
  - Relative Importance of Tourism (Visitor Exp. as % of GDP): **2.1% (2014-2018)**
  - Relative importance of Marine Transportation (Marine transport as % of transport & storage sector): n.a.
  - Container throughput as % of total Caribbean Container Throughput: **12.6%** (averaged over years 2010, 2013, 2017)

- Land Area: **5,131 km²**
- Coastline: **362 km**
- Sea Area (territorial waters up to 12 nautical miles): n.a.
- Percentage of coastline with ICM: n.a.
- Marine Protected Area (% of territorial waters): n.a.
- Ocean Health Index: **71**

239 https://en.unesco.org/creative-cities/events/unesco-designates-66-new-creative-cities?fbclid=IwAR2O29Ta0o3sRrpPmGtP8Wn6JIKYAWOcEs_7RAPrvFmgmklBV-5Ep4em5MM
240 https://data.worldbank.org/country/trinidad-and-tobago
241 https://data.worldbank.org/indicator/NY.GNP.MKTP.CD?locations=TT
242 http://hdr.undp.org/sites/default/files/Country-Profiles/TTO.pdf
243 https://data.worldbank.org/indicator/NY.GNP.PCAP.CN?locations=TT

Opportunities for Blue Economy Development in the Caribbean 5

Opportunity Areas

The global scan and foresighting analysis identified patterns in drivers, enabling conditions, and strategies for success across the eleven blue economy sectors and trends within technology sectors. The analysis also identified the inter-sectoral barriers that systematically and repeatedly stymie blue economy progress, within traditional, growth, and emergent sectors. These global-level factors and forces help to identify where and how efforts can be designed and targeted to accelerate blue economy growth under different conditions.

The regional analysis examined how global barriers—such as a weak business climate and shortage of experienced entrepreneurs--manifest particularly within the Caribbean, and any additional challenges that must be weighed when designing blue economy growth for this region. This analysis also includes consideration of the unique assets that the Caribbean region holds--such as pristine beaches, healthy marine and coastal ecosystems, proximity to North American tourists and markets—and how these factors could serve to drive or enable larger-scale blue economy growth.

By evaluating the results of the global scan in light of regional analysis, we filtered the universe of potential opportunities into seven distinct areas that we believe are currently most ripe for development. These seven **Opportunity Areas** represent specific intervention themes that share the following qualities:

1. Ripe for development in the near term (Launch within 3 months to a year);
2. Drive projects and initiatives with high likelihood for serving vulnerable populations;
3. Incorporate insight into the rapidly changing landscape of Caribbean economies given recent COVID-19 impacts on key sectors, including tourism and fisheries;
4. Explicitly aim to tackle one or more system barriers and thereby, can direct resources to known challenges that if resolved, could lead to progress across multiple blue economy sectors;
5. Seek to align with existing strengths of the region while addressing key gaps; and
6. Incorporate adaptation for climate change.

Within each Opportunity Area, potential projects that currently exist and new initiatives that could be created have been identified. The Opportunity Areas inform discussion and ideation of interventions at the project level, serving as a bridge between the trends and "hotspots" surfaced from the global foresighting and candidate feasible projects on the ground in specific countries. Note, some of these project ideas are country-specific; others may work at a regional or multinational scale. Specific project ideas, and how they align with Opportunity Areas, is provided in the Country Profiles and Foresight Scoring sections (see Section 6).

The six opportunity areas include:

1. Smart Tourism and Hospitality
2. Fortifying Local Food Systems
3. Resilient Coastal Infrastructure
4. Turning Ocean "Waste" and "Space" into Profit
5. Research Clearinghouse and Capacity Building
6. Satellite R&D Hubs for Innovation and Biotechnology
7. Advance Waste Management Solutions for SIDS

Opportunity Area 1: Smart Tourism and Hospitality

The Push: Prior to COVID-19, technology was already permeating the tourism sector, with self-guided tours, reservations, and even room service all just a click away via apps on smartphones. At the same time, the rapid and often unplanned growth of tourism also created challenges for municipalities and threatened long-term sustainability of the industry. With tourism still reeling but starting to re-open, leaders within the industry are exploring ways to introduce new models that protect the health and safety of travelers, and are more friendly to locals and the environment.[244] Advancements in technology and its application within marine and coastal tourism sector provide enormous opportunity for meeting these goals. With effective design, technology can enhance monitoring for health and safety, provide higher levels of customized service (from hotel rooms with temperature and light controls to virtual SCUBA training), as well as enable new "virtual" tourism (virtual reality wreck dives or hiking tours, for example), that can enhance experiences while maximizing safety and even increasing accessibility to a more diverse clientele.

The Pushback: Application of smart technology and virtual reality/ augmented reality (VR/AR) requires both infrastructure and technical skills that are currently lacking across all the target countries. Development of this sector, and focus on marine applications, will require partnerships with traditional hospitality and tourism stakeholders, who may be reluctant to invest in new technologies, even in the face of enormous challenges posed by the COVID-19 pandemic.

The Potential: The infrastructure and technical skills that can support development of such initiatives provides capacity building with cross-sector applications, including marine spatial planning (e.g. virtual coral reef dives provide insight into nearshore environmental resources), resilient coastal infrastructure (visualizations and models for development and planning), and aquaculture and renewable energy (virtual trainings for hard-to-access environments). Immediate job creation is possible through creation of content—underwater video of nearshore habitats; virtual diver training programs and curricula—which could employ locals hardest hit by the loss of tourism, while building materials for marketing and attraction of new, "Gen-C" travelers.[245]

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244 Dunford, 2020. The Guardian. https://www.theguardian.com/travel/2020/may/28/things-had-to-change-tourism-businesses-look-to-a-greener-future

245 Villa-Clarke. 2020. https://www.forbes.com/sites/angelinavillaclarke/2020/06/11/gen-c-travel-jamaicas-minister-of-tourism-reveals-a-new-type-of-traveller/#729b1f3b321f

Opportunity Area 2: Fortifying Local Food Systems

The Push: One of the strongest signals resulting from COVID-19's impact on SIDS is the inherent weakness of food systems that export nutrient-rich seafood while importing high-cost, often nutrient-poor staples. Growing awareness of the vulnerability that this dependency creates momentum for change, especially within fisheries.[246] And that change is already starting to happen: many new pilots have been launched in response to the COVID conditions across small scale fisheries in response to restrictions on travel, uncertain export markets, and availability of improved technologies to support online and local trade and data management. The momentum is building, as entrepreneurs, community activities, NGOs, governments, and industry look to capitalize on these developments to reimagine the future of food.

The Pushback: Policy and regulatory changes, as well as establishment of new logistics can take time, and may slow progress. Likewise, unlocking financing for small-scale enterprises, such as fisher cooperatives, that may be best positioned to fulfill local demand, remains a challenge due to mismatch in deal size and risk profiles. Developing local markets and building demand can also be a heavy lift given reluctance of people to change habits and tastes.

The Potential: As governments, industry, and civil-society organizations look to rebuild SIDS economies post-COVID-19, there is enormous opportunity to leverage new business models and technology that prioritizes local and diversified food production and consumption within blue economy sectors. Job creation within fisheries, aquaculture, and logistics (coastal infrastructure around cold storage, processing, and marketing) sectors will include both skilled labor and technical training, and more robust, integrated networks that link seafood and land-based food production systems could help strengthen institutions, capacity, and ultimately, food security and livelihoods as robust regional food systems are created. Projects within this opportunity area include a diverse set of potential initiatives from cold chain development to reduce food waste and stabilize supply, to integrating traceability technology to increase data flow for management and business purposes, to solutions that combine local agriculture production and distribution with seafood.

Opportunity Area 3: Resilient Coastal Infrastructure

The Push: Advancements in materials and engineering science, as well as ecosystem restoration, provide new models for designing built habitat and restoring natural habitat along tropical coasts. The idea of embedding natural ecosystems within coastal development projects at scale is quickly becoming a reality, with groups such as the Army Corps of Engineers in the USA beginning to integrate these approaches for more adaptive results. Increasing interest from the private sector to meet SDG and net-zero-carbon commitments also have more companies looking for ways to support habitat restoration projects that offset carbon footprints of industries such as shipping and airline sectors. With proof of concepts and new economic arguments for the long-term benefits

[246] Bennet et al. 2020: https://www.tandfonline.com/doi/full/10.1080/08920753.2020.1766937

and cost-savings of grey-green approaches to coastal protection and beach preservation, the stage is set for Caribbean Islands to leverage these advancements and incorporate resilient infrastructure into coastal development and blue economy growth plans.

The Pushback: Awareness of advancements in this sector remains low among many municipalities and upper level officials. Traditional approaches—bigger, thicker seawalls, continual beach replenishment cycles via dredging—along with fear of resistance to new zoning and building policies, keep innovation at bay. There is also likely to be resistance from embedded construction firms that may not have the expertise to adopt new strategies and want to hold onto their government and development contracts. Strong leadership and well-designed models with clear cost-benefit scenarios are needed to push old thinking and pave the way for more innovation-- in design of both policy and physical and natural structures.

The Potential: The scope of projects and immediate job creation that could occur within this Opportunity Area are significantly large. We see immediate potential for job creation—for both skilled and unskilled labor—through large-scale projects that restore, maintain, and grow natural marine habitats (seagrass beds, mangrove forests, coral reefs) for purposes of: 1) coastal protection and shoreline stabilization; 2) blue carbon; 3) adaptation to climate-change-related impacts; and 4) fisheries enhancement (via provision of nursery and juvenile habitat). This work could encompass projects from large-scale public works-oriented initiatives to private-sector development projects that incorporate engineering with nature (EWN) strategies. Because of the uniquely high water (and coastline) to land ratio of SIDS, there is enough room for resilient infrastructure projects that include wave energy generation and food production to be built at scales that can significantly impact local food security and reduce energy costs.

Opportunity Area 4: Turning Ocean "Waste" and "Space" into Profit

The Push: A diversity of entrepreneurs have launched businesses to explore new ways to turn "excess" marine life into non-traditional goods, from shoes to bioplastics. The over-abundance of sargassum, leftover lobster shells, and even fish skin, are all now raw materials that SMEs are using to create novel products.[247] These companies are creating momentum that, if supported, could continue to drive blue economy growth dependent on sustainable sourcing from the marine environment. Meanwhile, advancements in engineering are allowing businesses and governments to re-imagine the use of the seafloor and water column itself. From underwater data storage facilities to organic gardens growing tomatoes, the way we view ocean "waste" and "space" is changing and presenting opportunity.

The Pushback: To create new products requires significant investment of time and energy as new materials, prototypes, and models must work their way through the design phase. An entrepreneurial mindset is required but may be rare in many locations—as may be access to

[247] See for example AlgasOrganics, SALGAX (Mexico), 7 Leagues Leather, Notpla, and ShellWorks.

resources to get an idea off the ground. Programs that cover the groundwork to teach business basics, and spread awareness of the enormous opportunity ocean product development can hold are often not attractive to funders.

The Potential: Within this opportunity area, there is potential to grow the entrepreneurial and technological skills of local residents. Currently, multiple small-scale enterprises are already converting sargassum into natural fertilizers for local and international distribution; there is great potential to support growth and replication of these businesses. Likewise, learning exchanges among artisans and entrepreneurs could facilitate growth of companies that utilize waste products from fisheries or mariculture farms. Longer-term strategies that link with support for biotechnology and innovation Training, access to financing, and access to lessons learned and models that already exist, could lead to a whole new field of SMEs that turn "waste" and "space" in the oceans into valuable resources for people and businesses.

Opportunity Area 5: Research Clearinghouse and Capacity Building

The Push: Researchers from academia and blue economy industry sectors have already-funded projects that require field testing now. From graduate student theses to new prototypes within the commercial sector, these initiatives often require simple logistical and field support in order to execute short-term field experiments. Yet, this need goes unmet because there is no intermediary to connect the existing projects (and their field requirements) with resources on the ground.

The Pushback: To work, these initiatives require strategic outreach and marketing to attract the attention of universities, companies, and institutions around the globe, which could take some time. Effective match-making also requires extensive coordination and local capacity building, to ensure projects are able to access the physical and human resources required for execution—for some projects these conditions may simply be lacking in the Caribbean (but see Opportunity Area 5). Competition from other regions with similar tropical habitats could also reduce demand.

The Potential: Across traditional and emergent blue economy sectors, and within the technology fields, there are an untold number of existing projects that could be employing local Caribbean residents right now as field assistants, boat drivers, dive support, shore-side support, and research partners to accelerate testing and refinement of new technologies, models, and equipment. Attracting these projects to the Caribbean not only could provide immediate employment opportunities, but it also serves to introduce expertise and offers opportunity for local education and capacity building in blue economy fields. With appropriate design, those capacity building and employment opportunities could be directed at underserved communities, including women. A new entity, or a partnership, could play the role of intermediary, connection academic and industry networks (inside and outside of the Caribbean region) to match existing, funded research projects with the appropriate physical and human labor required to implement field work over short-term time horizons (weeks to months). This match-making entity could also facilitate permitting or logistic arrangements, increasing the accessibility of the Caribbean region for such studies.

Opportunity Area 6: Satellite R&D Hubs for Innovation and Biotechnology

The Push: High-tech institutions continue to push to the frontiers of biotechnology, renewable energy, marine product development, and mariculture (especially feed). These advanced labs do not need replication, but they do need access to raw materials, and local processing and testing facilities in order to advance their missions. This opportunity area identifies the potential for the Caribbean to invest in infrastructure (for example, PacWave in Oregon, USA) and training programs that could integrate and accelerate the region's capacity to advance multiple blue economy sectors. Building off Opportunity Area 4, this opportunity area explores initiatives that focus on infrastructure creation for longer-term in-region projects and partnerships.

The Pushback: Significant investment and partnerships with capacity for scaled work, would be required in order for initiatives within this opportunity to manifest. Coastal and offshore infrastructure are often difficult to progress in terms of permitting and expense. Creating expedited permitting and designated research zones require policy and regulatory shifts that may be difficult to pass, especially without strong national leadership; and, the lift to map habitats and collect environmental information needed for baseline data requires local capacity and support that may be hard to find or fund.

The Potential: This opportunity could serve as a natural stepping stone to help the Caribbean region grow its knowledge economy, focused around the blue economy sectors. The shift would be from mostly hospitality services to research and innovation support. By executing this opportunity as a phased blue economy transition, immediate job creation could occur, with significant potential for long term growth. For example, Phase 1 might include partnerships where raw materials are collected and catalogued, then sent to external institutions that have capacity for more sophisticated analyses; results are then shared for interpretation and co-development. Expedited permitting process and on-going mapping and monitoring of habitats would provide baseline data for visiting scientists. Phase 2 might involve more extensive R& D zones and facilities as part of a more holistic blue economy development plan, with experts able to embed long-term in the region (e.g. via a "Scientists for Passports" type program) to help guide and develop blue economy sectors, especially around biotechnology, renewables, and aquaculture (similar to Fraunhofer Chile model).

Opportunity Area 7: Advance Waste Management Solutions for SIDS

The Push: International regulations, in particular MARPOL, require appropriate disposal of ship-generated waste (SGW); yet, SIDS rarely have the facilities to adequately handle this material.

Refusal to accept SGW increases the risk of illegal dumping of waste at sea, as does the lack of effective monitoring and verification of shipping activities. Meanwhile, the challenge of trash continues to plague SIDS, who have limited space for landfills and limited waste management systems and capacity. Advancements in circular economy models and new waste management technologies offer novel solutions for both large and small-scale approaches to waste management that can generate jobs while also reducing impact on local marine ecosystems. Caribbean-based firms are beginning to tackle this challenge in places such as the Bahamas, sowing the seeds for continued innovation and providing opportunity for lessons learned and scaling up.

The Pushback: Existing and new waste management infrastructure, systems and technologies can be expensive to implement. New approaches could require continued adjustment before they work with efficiency and effectiveness. Unless robust enforcement is in place (which is not the case in the Caribbean), it will always be tempting to simply dump waste at sea.

The Potential: Proper management of ship and land-based waste offers opportunity for job creation, environmental mitigation, and increased economic activity for SIDS. Low and high-tech jobs associated with waste management systems and technologies will be needed as facilities are built to collect, process, and safely dispose of marine-based waste, ideally combined with efforts to address waste streams in coastal cities. More efficient and effective land-based waste reduction is often labor intensive, requiring collection, sorting, cleaning, and processing. Benefits to the marine environment due to pollution reduction, including plastics, will assist the tourism and fisheries sectors; and more eco-friendly, compliant ports and resorts that support improved waste management can attract companies and visitors that are committed to sustainability. Projects within this category can range from direct support of local enterprises that are innovating in waste management (such as in the Bahamas), building waste management systems and infrastructure, to circular economy efforts that redirect waste to reuse. Ultimately, a regional network of adequate port waste reception facilities is required to address the needs of the Caribbean maritime industry to ensure that wastes from vessels are able to be discharged in ports and properly handled, disposed or recycled.

A variety of candidate blue economy action projects/initiatives have been identified based on interviews with both global and country experts, which correspond to the seven opportunity areas and each of the six countries. These action projects/initiatives are reviewed in greater detail in Section 5.

Table 18: Summary of Opportunity Areas and Initial Candidate Projects for the Six Countries.

	OPPORTUNITY AREAS						
	Smart Tourism and Hospitality	**Fortifying Local Food Systems**	**Resilient Coastal Infrastructure**	**Turning Ocean Waste and Space into Profit**	**Research Clearing house and Capacity Building**	**Satellite R&D Hubs for Innovation and Biotechnology**	**Advance Waste Management Solutions for SIDS**
Bahamas					Low Carbon Freight Future		Port Waste Reception Facility
Barbados		Tuna Fisheries Sustainable Development		Caribbean Regional Research Clearing House		Offshore Seaweed Production	Sargassum Collection and Processing
Guyana	Barima Mora Passage Special Protected Area Women's Empowerment to Monitor Natural		Barima Mora Ecotourism Development				
Jamaica		Local Community Fishing Practice Improvement				Offshore Seaweed Production	Sargassum Collection and Processing
Suriname	Mangrove Corridor Restoration	Mangrove Honey					
Trinidad and Tobago		Fishers Engine Conversion	Scientific and Educational Ecotourism				

SIDS Blue Economy Project Rapid Assessment Tool

As part of the foresighting analysis to identify blue economy growth opportunities in the Caribbean, this project developed a tool to facilitate more rapid and effective evaluation of blue economy opportunities for SIDS. The SIDS blue economy rapid assessment tool consists of a robust rubric for evaluating project-level initiatives across five Impact Criteria and five Feasibility Criteria (**Table 19**) in order to compare different kinds of projects according to their potential for change (impact) and their risk (feasibility). We envision that the tool will serve two primary stakeholder groups:

1. **For practitioners (governments, NGOs, companies)** that are launching initiatives, the tool can be used to assess design and scope and determine if there are elements that need to be added or addressed in order to boost a project's potential impact or feasibility. For this group, the tool can also be used to evaluate the same initiative over time, in order see whether or not a program is able to grow its impact or reduce risks.

2. **For funders, government agencies, or other entities** that may be looking to support or implement multiple projects in the blue economy space, the tool can be used to evaluate the overall risk profile of a portfolio of projects, as well as the potential impact.

We believe both functions can help to advance more strategic blue economy project development and design. For details on the structure and a guide to use the tool, please refer to Appendix C.

Table 19: Impact and Feasibility Criteria for Foresight Tool and Weights for Scoring.

Category	Criteria	Weight
IMPACT	Job Creation and Skills Upgrading	30%
	Vulnerable population Livelihoods and Resiliency	20%
	Institutional Strengthening and Sectoral Linkages	20%
	Local Economic Resiliency	15%
	Environmental Sustainability	15%
FEASIBILITY	Demand: Access to Viable Markets	25%
	Competitiveness of Production Factors	25%
	Adequacy of Institutional Factors	20%
	Geographic Vulnerabilities	10%
	Leadership Commitment for Implementation	20%

The Scoring Guide has been purposefully designed to drive an evaluation process appropriate to SIDS. The ten criteria reflect known and anticipated barriers to blue economy growth that are particularly relevant for SIDS. Consideration for these challenges, and how an initiative specifically addresses them (the ranking) is critical to effective design and strategy creation.

The rankings also reflect specific enabling conditions that need to be met in order for longer-term, larger-scale blue economy development to occur. For example, within "Job creation and skills upgrading," there are explicit ranking distinctions between projects that provide temporary vs. permanent job prospects vs. those that also provide long-term professional growth opportunities. These rankings reflect the all-too-common systemic barrier of "brain drain," where local talent leaves the region to secure more satisfying, often better-paying jobs that have greater room for growth and development.

By considering how projects are potentially meeting (or failing to meet) the specific milestones provided in each rank, users can more explicitly identify where more resources or better design may be needed in order to maximize potential impact of the proposed project. For more information about the design and use of the tool, see Appendix C.

Ranking of Candidate Projects: Preliminary Foresight Scorecard Results

The scorecard is designed to evaluate initiatives at the project-level, meaning that a discrete purpose and approach or model for implementation has been identified. As this report is Phase 1 or a two-part investigation, the projects identified remain preliminary and at early design stage. This means some candidate projects are not yet ready to run through the tool; most will benefit from further development before a final scoring is completed.

The project team did, however, run eight projects (**Table 20**) through the scorecard in order to pilot the tool and to create an initial overview of the risk vs. reward profile of the portfolio of ideas that were generated by the foresight analysis.

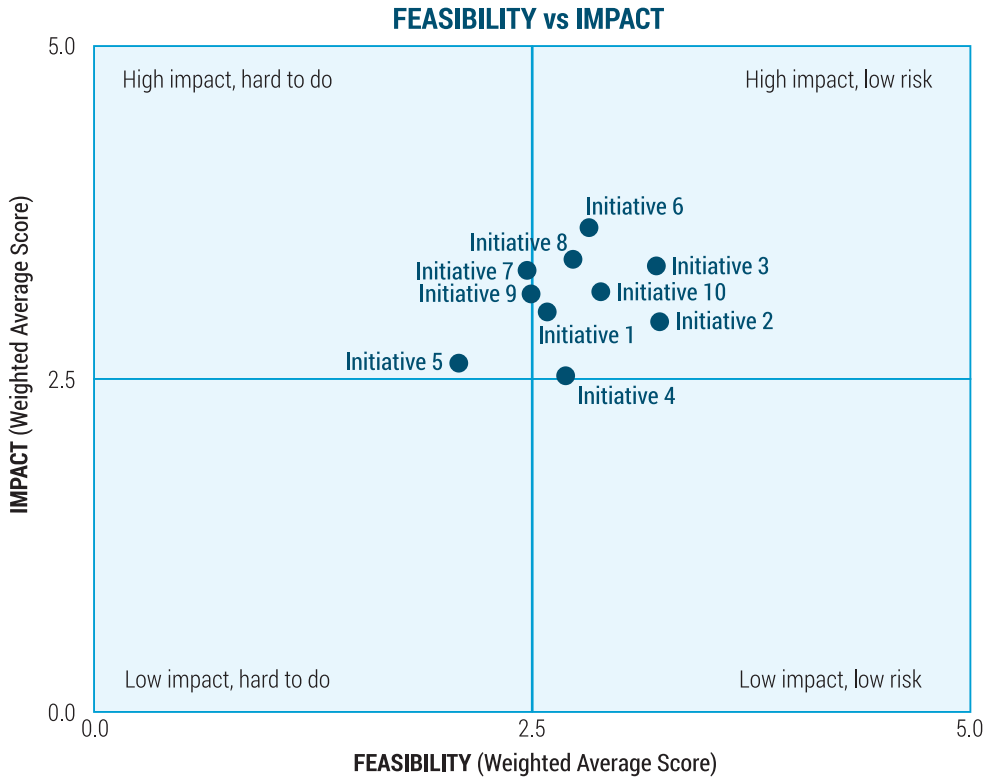
Table 20: Subset of Preliminary Country-level Initiatives included in the Test-run of the Foresight Scorecard.

Country	Project	Opportunity Area
Barbados	Commercial Sargassum (C-Combinator)	Ocean Waste and Space
Guyana	Drones for Mangroves	Resilient Infrastructure
Suriname	Mangrove Corridor	Resilient Infrastructure
Barbados	Tuna	Fortify local food systems
Bahamas	Virtual Tourism	Smart Tourism & Hospitality
Jamaica	Commercial Sargassum (C-Combinator)	Ocean Waste and Space Profit
Barbados	Research Clearinghouse	Research Clearinghouse
Trinidad and Tobago	Fisher Fuel Conversion	Fortify local food systems

The results of this preliminary test run of the scorecard shown in **Figure 19**. The four quadrants represent different trade-offs between risk and reward. Because the project team selected the most promising candidate initiatives that have been uncovered to date, the scorecard results are

biased towards initiatives that are considered "doable" and "impactful". Thus, we see a clustering of projects in the upper right quadrant; however, all of these still have potential to improve in terms of feasibility and impact. These results will help the project team to identify specific areas of weakness across both impact and implementation dimensions of the initiatives, and thus be able to better design solutions within the country action plans that are to be generated in Phase 2.

Figure 19: Scatter Plot of Weighted Average Scores for Impact and Feasibility Criteria from the Eight Preliminary Country-level Initiatives.



Recommendations and Next Steps 6

The universe of global blue economy opportunities is large and expanding as new business models, technological discoveries, and markets are created. The results of Phase 1 include a diverse suite of findings, recommendations, and frameworks to support continued advancement of blue economy opportunities in the Caribbean region (**Table 21**). Each of these findings can help further the pathway for identification and development of blue economy opportunities.

Table 21: Summary of Key Findings from Phase 1 Research on Global Trends that Support Advancement of Blue Economy Growth in the Caribbean.

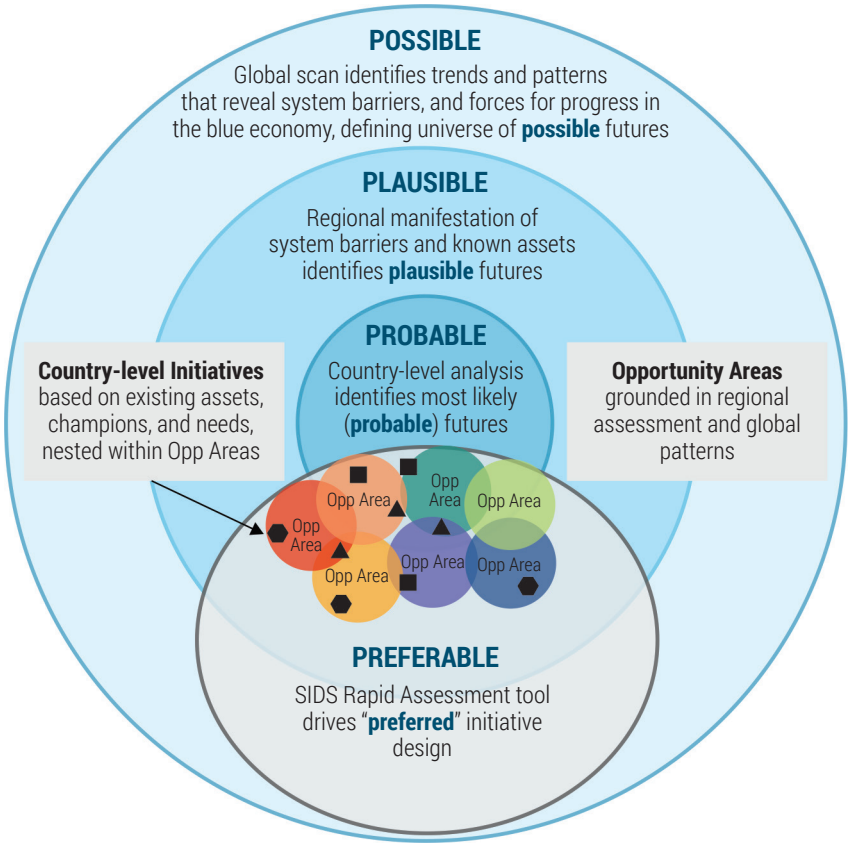
Development or Finding	Description
Blue Economy Project Rapid Assessment Tool	**A novel Tool has been developed** rapidly evaluating blue economy initiatives to determine their potential impact and feasibility within the Small Island Developing State context
17 preliminary Country-level blue economy Initiatives	**Candidate Blue Economy projects/initiatives have been identified**, with 2-3 each for the six target countries. Each of these initiatives has been selected based on its potential to achieve the following key objectives: • Address immediate livelihoods and employment needs for vulnerable populations, especially those most hard-hit by COVID-19; • Tackle one or more core underlying system barriers to blue economy growth, thereby helping to unlock change for multiple stakeholders; and • Leverage existing assets (including existing local champions wherever possible) and momentum in the region to increase likelihood of success.
Seven Caribbean-specific Opportunity Areas	**Categories of intervention that can guide future project ideation and direct limited resources towards development of initiatives**. These intervention categories are grounded in systemic barriers, which helps avoid the common challenge of chasing "shiny objects" or jumping on the next-big-thing, and instead roots efforts in tackling known, core stuck points using design principles that have proven track records for success.
Regional barriers and assets	**Regional assessment has identified how system barriers manifest in the Caribbean and key forces and conditions that can unlock progress within the region**. Application of this framework can identify future Opportunity Areas that may be ripe for development in the future.

Table 21: Summary of Key Findings from Phase 1 Research on Global Trends that Support Advancement of Blue Economy Growth in the Caribbean. (cont.)

Development or Finding	Description
Global trends in innovation in blue economy industry and technology sectors	**Key trends in innovation within eleven industries and nine technology sectors have been evaluated and indicate potential directions for future blue economy growth**. These trends provide insight into forces that block and support blue economy development, including nine Systemic Barriers and eight Drivers, seven Enabling Conditions, and nine Design Principles, the latter three which together create forces for progress.

Together, these findings can help guide resources and energy towards fostering a future scenario (**Figure 20**) for blue economy growth that is not only probable, but preferable in terms of generating desired positive impact for local economies, communities, and the ocean environment.

Figure 20: Modified Futures Cone (adapted from Voros (2017)[248] Futures Cone, use and history) showing system components and how they feed into foresight analyses of what is Possible (most unknown but potential based on trends), Plausible (more likely to occur, based on known limitations and assets in the system), and Probable (most likely to occur based on current momentum in the system). Input from regional and country analyses, along with the SIDS blue economy rapid assessment tool, then shape what is Preferable, via identification of Opportunity Areas and country-specific initiatives.



[248] Voros, Joseph. "The Futures Cone, Use and History." The Voroscope, 24 Feb. 2017, thevoroscope.com/2017/02/24/the-futures-cone-use-and-history.

Through the course of the research, the project team confirmed that the same long-standing barriers that have often constrained business and economic growth in the Caribbean region, are also impacting the uptake of blue economy technologies and the associated viability of a number of blue economy business ventures and restricting the expansion of blue economy industries in the region. These barriers include:

- Access and Cost of Energy;
- Suboptimal Marine Spatial Planning and Regulatory and Legal Frameworks;
- Limited Insurance Options and Risk-Tolerant Financing for Local Enterprises;
- Local Expertise and Research Capacity; and,
- Institutional Cohesiveness and Strong Partnerships among Key Stakeholders

Each of these barriers poses a significant hurdle for blue economy development; tackling all of them presents a formidable challenge that will require strategic and coordinated efforts across multiple dimensions of the system, including infrastructure that: supports greater access to financing, strengthens institutional networks, and that develops local knowledge and capacity. Creation of stronger governance mechanisms to oversee and coordinate such holistic strategy is also necessary.

The global shock of the COVID-19 outbreak has worked to compound these already substantial challenges, increasing the already substantial risks associated with numerous blue economy business models, particularly those that are capital-intensive.

Still, the Caribbean possesses a variety of unique assets that can be leveraged to further blue economic development. Across the Caribbean, the region's maritime area is almost 4.5 times the size of its terrestrial area and countries have already leveraged the enormous potential of this natural resource in several ways.[249] The Caribbean's marine and coastal tourism industry is widely recognized as a global leader, and the region is globally competitive in other industries such as fisheries, marine transportation, and trade.

Further, several key economic and technological trends are coalescing that could potentially position the region to drive or enable larger-scale blue economy growth and become an emerging global leader in blue economic development. For example, the region has been cited for its potential in several emerging commercial areas such as marine renewable energy, mariculture, and bioprospecting (among others).[250]

The seven distinct opportunity areas generated through this foresight research specifically incorporate these assets as important points of leverage; these areas are ripe for development in part because they utilize existing momentum within the region. Within each opportunity area, there are multiple potential commercial ventures and projects that currently exist and new commercial initiatives that could be created.

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249 Measuring the Blue Economy: The System of National Accounts and Use of Blue Economy Satellite Accounts - CDB Working Paper No. 2019/02

250 World Bank (2016) Toward a Blue Economy--A Promise for Sustainable Growth in the Caribbean

However, for the blue economy to truly grow at any sort of scale in the Caribbean, it will require governments, private sector, and civil society leaders and international organizations to collaborate and provide the necessary funding, expertise, policy reforms and other resources to tangibly address the region's existing barriers and gaps. Taking these actions would support sufficiently "de-risking" the business environment to an extent that entrepreneurs and investors perceive more certainty and have the confidence that there are solid opportunities to achieve the requisite scale and competitiveness that would make new innovative blue economy business models financially viable and sustainable.

In contrast to historic investment into economic activity in ocean environments, the blue economy opportunities identified in this report explicitly consider economic growth balanced with social benefits, equitability, and environmental sustainability. The next phase of this research will focus on validation and refinement of candidate project initiative ideas to develop action plans that can meet this triple impact criteria for true blue economy development. Our aim is to provide models and support scaling of initiatives that can help address immediate pain points while creating the enabling conditions and proof of concepts needed to advance successful blue economy growth in the six target countries, and the region as a whole.

Appendix A:
Blue Economy Industry Sector Summaries

Trends Within Blue Economy Industry Sectors

The following section provides a high-level landscape of eleven blue economy sectors (Figure 1). The summaries contain an overview of the sector and trends within it, factors that drive innovation or support progress (enabling conditions), and a selection of specific initiatives or businesses that serve as examples of leading-edge approaches. A list of initiatives within each industry sector, and the technologies that support them, is provided in Appendix A.

Mature, Existing Blue Economy Sectors

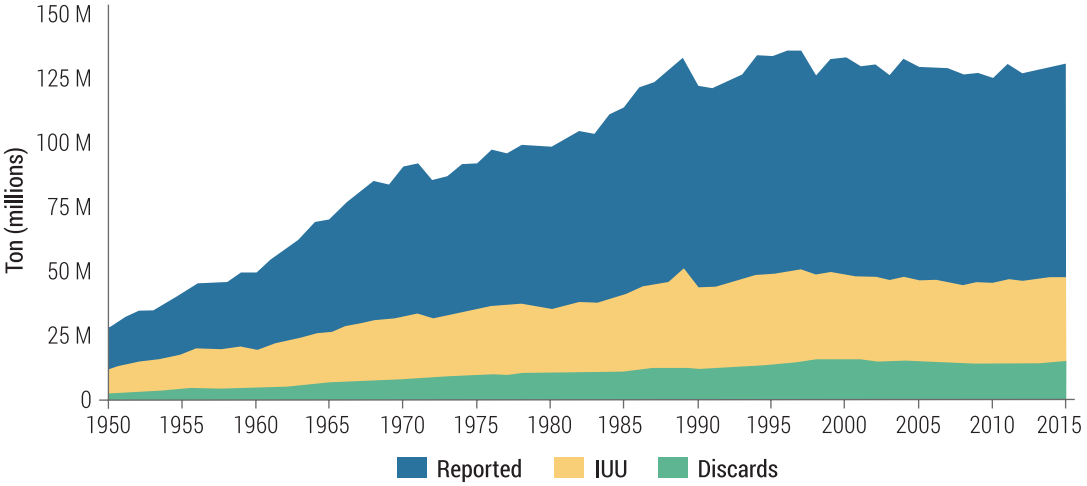
Fishing, Tourism (Cruise, Coastal, Marine), Shipping, and Oil and Gas

Fishing

Overview: Wild capture fisheries serve an important role in the blue economy, especially in SIDS, as a source of both economic value and food security for communities. At the global level, wild capture fisheries produce approximately 90 million metric tons,[251] with a significant portion of that catch unreported, or illegally caught (**Figure 21**).

[251] FAO. The State of World Fisheries and Aquaculture (SOFIA) - Meeting the Sustainable Development Goals, Food and Agriculture Organization, Rome, Italy, 2018, (p. xiii + 210).

Figure 21: Proportion of Global Wild Capture Fisheries that is Reported, IUU (illegal, unreported, and unregulated), and Discarded.



Source: Watson, Reg A., and A. Tidd. "Mapping Nearly a Century and a Half of Global Marine Fishing: 1869–2015." Marine Policy 93 (July 2018): 171–77 and sourced from Our Shared Seas.

The total wild catch provides over 3 billion people with their primary source of protein. And the work to produce this largest globally-traded food commodity provides livelihood for more than 120 million people, about 50% of which are women.[252] In contrast to other food production sectors such as agriculture, over 90% of people who make a living from fishing are involved in small-scale operations. The majority of their catch goes to human consumption.

The global industrial fleets catch species for human consumption as well as for animal feed and other products not directly consumed by people.[253] And the catch comes from all the seven seas. The industrial fishing fleets of the world cover half the world's oceans, creating a footprint four-times that of agriculture.

Despite the importance of local fisheries for food security, more fisheries are turning towards export markets, a trend in part fueled by rising demand for seafood around the world. These markets—typically centered in Europe, North America, and more recently, China—have provided opportunity for economic growth but the diversion of locally caught seafood away from coastal communities has started to raise concerns. Recent studies have highlighted the negative indirect effects of this food diversion, including increased rates of social instability and a lack of micronutrients that are essential to human health.

Key Trends

Rising demand for seafood globally has also contributed to overexploitation of fish stocks. The majority of countries in the world lack the resources needed for fisheries science, management,

252 FAO: http://www.fao.org/voluntary-guidelines-small-scale-fisheries/ihh/en/
253 FAO: http://www.fao.org/3/a0237e/A0237E07.htm

and enforcement required for robust fisheries. Thus, around the world, we find illegal fishing and poor or non-existent management continues to push species beyond their natural capacity to replenish. As of 2015, approximately one third of all fish stocks were considered overfished, and over half were at their limit.[254] Other threats, such as pollution impacts, habitat loss, and global climate change exacerbate these declines. These declines have an economic cost: every year, IUU reduces global fisheries production by US$ 80 billion.[255]

Many of the problems root back to the significant lack of data that plagues most fisheries. Without robust and timely information regarding how many fish are caught, at what size, and when, it is nearly impossible to properly manage stocks. The need for better fisheries data has fueled a growth of technological innovations and applications focused on improving data capture and analytics—to support better business and better management. This includes an increase of electronic monitoring on board vessels and electronic logbooks that allow captains to digitally record and submit records of their catch, sometimes even before making it back to port. To date, these innovations are being trialed mostly in North America, Europe, New Zealand, and Australia, and in high-value international fisheries, such as tuna.

As more and better data become available, however, there is an increasing need for data management and capacity to utilize and incorporate new knowledge into decision-making—in both the business and governance arenas.

In addition to data generated by industry, the application of marine GIS and spatial planning has allowed for more streamlined and integrated management of fisheries by providing detailed information on habitat mapping, species distribution and abundance, the relationship between fish occurrence and oceanographic variables, and fishers' activities. A priority is understanding who is fishing, what is being caught, and the location of fisheries' activity via satellite vessel monitoring data, which can be used to understand the relationship between fishing activity and marine ecosystem health.

Increased emphasis on traceability and data-rich supply chains has also fueled new business strategies that highlight the origin and even the specific fisher, as part of consumer-facing marketing. These initiatives build off the continued trend over the last decade for a growing number of fisheries and supply chain ratings and certification programs, and alignment among these efforts, which guide consumers and end buyers committed to "sustainable" sourcing.

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254 FAO: http://www.fao.org/3/i9540en/i9540en.pdf

255 Agnew et al, 2009. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0004570

Interest in more sustainable seafood includes growing pressure to reduce waste and bycatch. The result is a range of initiatives from new efforts in cold storage and processing, to developing new products and markets for overlooked species and animal parts. A nascent but growing number of researchers, entrepreneurs, and artists are looking at ways of redirecting scraps from seafood processing into new materials, fueled by programs such as the EU's FISHSkin[256] and the FAO's Blue Growth Initiative.[257] By creating materials and markets from the whole animal, these efforts seek to increase economic security and create jobs for coastal fishing communities. This trend includes biochemists and firms looking to shells from crustaceans as potential sources of chiton—a promising natural substitute for plastics.[258] See the Marine Products sector summary for more details.

Innovative Models and Initiatives

- Pacifical Tuna Company: a global marketing and distribution company for sustainable tuna (MSC certified) caught within the EEZ of the eight countries of the Parties of the Naru Agreement (PNA). The company operates under 50/50 ownership between PNA and Sustunable b.v. and relies on a combination of novel models for fishery and business management. In particular, this innovative model includes:
  - A strictly managed vessel day scheme (VDS) which allocates tradable fishing days among the parties with controlled pricing for access;
  - iFIMS: an integrated database that combines information from data systems from PNA member countries, the fishing industry, and flag states, and is the world's first information platform that has integrated fisheries management, compliance, and marketing.
  - Blockchain technology for traceability and consumer-facing branding
- SmartFish Group: hybrid model developed to support local fisheries in Mexico.
  - Non-profit arm provides capacity building and technical training for fishers, mostly focused around quality improvements and basic finance literacy, along with improved environmental performance.
  - The for-profit arm is an honest broker, SmartFish Inc. that provides distribution and marketing, paying premium prices to fishers in exchange for reliable, sustainable, and good quality products that can be sold into local restaurants and other outlets. SmartFish Inc. handles promotion and marketing and branding.
- Abalobi Initiative & App Suite, South Africa: a social enterprise with traditional fishers taking center stage, that supports climate-smart, equitable, sustainable small-scale fisheries through integration of ICT.
  - ABALOBI, as a mobile app suite and program, is aimed at social justice and poverty alleviation in the small-scale fisheries chain. Their program provides training to improve knowledge, stewardship of marine resources, and resilience-building in the face of climate change.

256 https://cordis.europa.eu/project/id/823943

257 See summary of 2018 fashion show featuring fish leather, seaweed, and other products derived from fresh and marine ecosystems. http://www.fao.org/blogs/blue-growth-blog/fish-skin-leather-on-the-catwalks-of-nairobi-could-milan-and-new-york-be-next/en/

258 https://www.sciencenews.org/article/seafood-shells-chitin-plastic-food-waste

- The ABALOBI app suite comprises five inter-connected apps – conceptualised in a co-design process and currently in various stages of development and testing. The five apps cover the full spectrum of stakeholders in the small-scale fisheries sector, with services ranging from traceability data analysis to an online marketplace.[259]

Uncertainties and Risks

Fisheries are inherently risky, with a mobile, difficult to measure resource that, depending on the species, may go through natural boom and bust cycles. Today, these uncertainties are heightened given the dynamic response of ocean ecosystems to climate change. Warming waters, changes in storm cycles and intensity, ocean acidification, and sea level rise are all influencing historical patterns in marine animal movements and abundance. For fisheries, some species that already live at their thermal maximum, are moving further toward the poles, or to deeper waters to remain in preferred temperatures; others are experiencing disruptions in their breeding and reproductive cycles. Loss of habitat, especially in coral reef environments due to increased mass bleaching episodes, threatens long-term survival of species depending on reefs for food, shelter, and spawning sites.

The **majority** of fisheries are currently data poor, and generally underperforming, reducing their ability to absorb these additional impacts, and preventing more adaptive management responses, which would be possible if better information was made available. Data modernization of fisheries, especially within government management bodies, needs to be a priority, but is currently underfunded and prone to pilots that are limited in effectiveness and scale.

A historical lack of resource tenure and the nature of seafood as a "commons" has also created risk that limits the flow of finance and insurance into fisheries, especially small scale fisheries. Without collateral and the ability to control access to the resource, investors remain reluctant to provide the much-needed financing to support best practice on the water, greater efficiencies in the fleets, and improved management.

Drivers and Enabling Conditions

Market drivers have pushed sustainable progress in fisheries via programs such as Fishery Improvement Projects (FIPs), but large-scale success requires significant increases in funding, engagement from industry, and expansion of that market demand beyond North America and the EU. The robust network of NGOs that underpin the sustainable movement serve as a constant driver for industry reform; combined with recent exposés over the past 5 years revealing disturbing frequency and extent of social and labor abuses within the seafood trade, these movements have led to several important initiatives that press industry and governments to adopt new technology and processes to improve performance and practice.

[259] ABALOBI. ABALOBI ICT4FISHERIES, abalobi.info. Accessed 14 June 2020.

Sustainable development in this sector will depend on effective utilization of new data and technologies, which requires investment in all three dimensions of successful technology adoption: hardware, software, and human capacity. Currently, there is momentum via technology-focused pilots, especially electronic monitoring and reporting systems, as well as traceability technology such as blockchain.

There is increasing interest in sustainable fisheries from impact investment with several funds launched in recent years with a focus or inclusion of fisheries in their target portfolios. Investment in the technologies that support seafood sustainability has seen growth over the past few years with a range of technology providers coming onto the scene. However, potential private investments in the production and processing upstream in seafood supply chains have significant barriers that often present insurmountable risks to unlocking private capital. These barriers include: the lack of fisheries data, the absence or ineffectiveness of policies and management; poor access to infrastructure; and a lack of investment-ready businesses. Blended capital solutions, which incorporate grants and concessional capital, are receiving increased attention in fisheries, especially in the Global South, but are still in early stages of piloting.

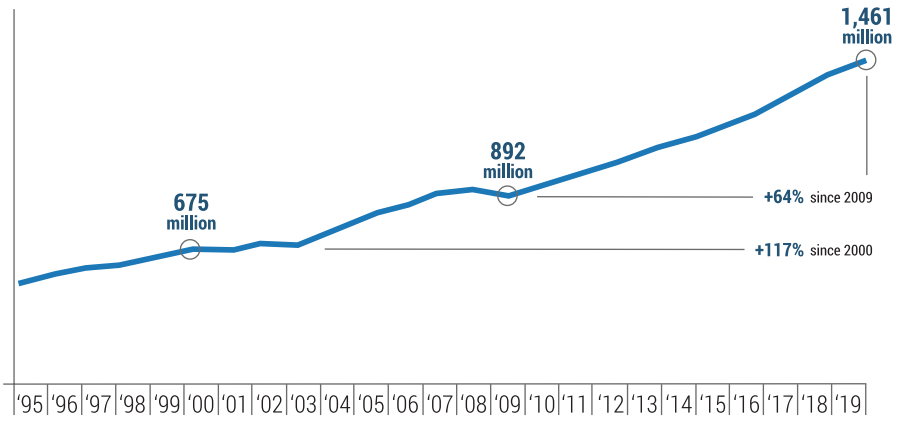
Tourism (Cruise, Coastal, Marine)

Overview: Tourism is a major component of the economy of the Caribbean, with 70.3 million tourists in 2016 and an anticipated growth of between 2% and 3% in tourist arrivals for 2018. In 2017, the travel and tourism industry accounted for 20% of GDP and 19% of employment in the region.

The sector can broadly categorized into 3 sub-sectors: 1) Cruise Tourism: Ship based tourism from vessels making multiple stops in the region and beyond; 2) Coastal Tourism: Hotels and resorts along the shore; 3) Marine Tourism: Recreational, educational and ecotourism activities.

Global international tourist arrivals have increased by 117% since 2000 (**Figure 22**). Coastal, marine and cruise tourism has been one of the fastest growth segments.

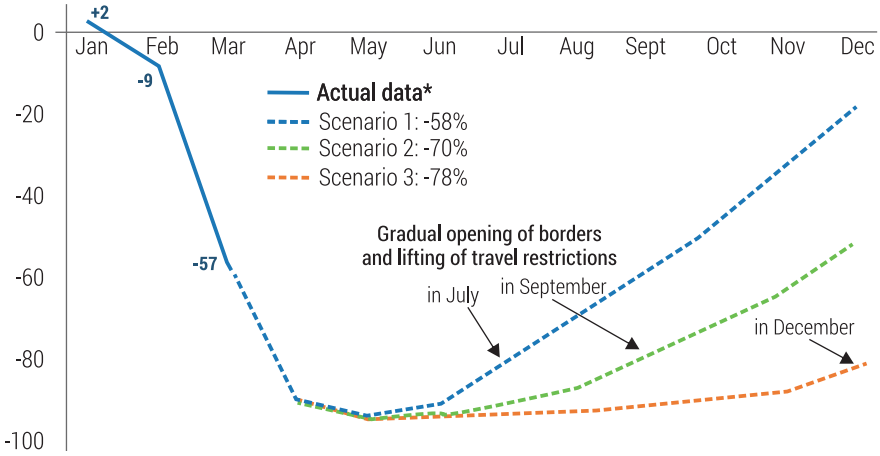
Figure 22: Growth in Global Tourist Arrivals in the Caribbean (1995-2019).



Source: United Nations World Tourism Organization.

However, the COVID-19 pandemic has seriously impacted tourism and travel globally, leading to a precipitous and unprecedented drop in the number of international travelers since February 2020. The prospects for a rapid recovery are not likely, as shown in the UNWTO's scenario analysis below. Clearly, the impact on Caribbean tourism will be severe.

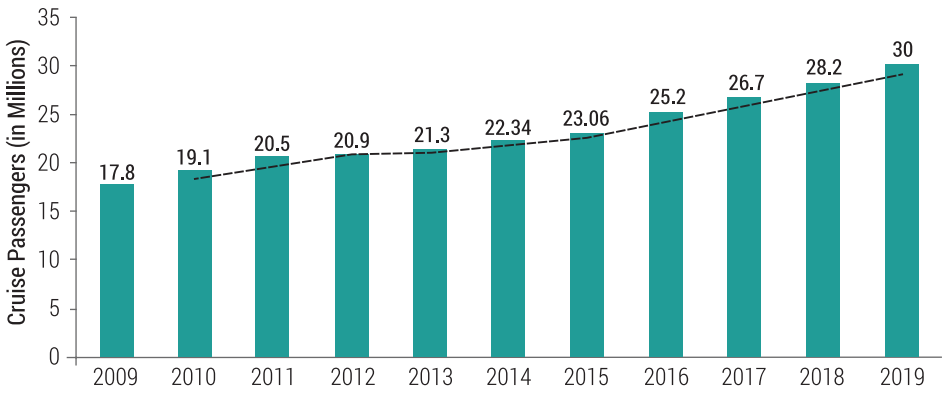
Figure 23: Post-coronavirus Pandemic Tourism Projections.



* Actual data through March includes estimates for countries which have not yet reported data.
Note: The scenarios presented in this graph are not forecasts. They represent alternative monthly change in arrivals based on the gradual opening of national borders and lifting of travel restrictions on different dates, still subject to high uncertainty.
Source: UNWTO

Cruise tourism in the Caribbean now accounts for more than 35% of all such vacations globally. Caribbean island countries are particularly dependent on cruise tourism, where cruise passengers account for over a half of all international arrivals. In Dominica, St Kitts and Nevis, cruises represent the 88%, 79% and 75% of the arrivals total. The Caribbean Tourism Organization (CTO) shows that there were 29.2m cruise ship arrivals into the Caribbean in 2018, a figure roughly equal to the 30.2m long stay visitors who came by air to stay in hotels and other onshore facilities.

Figure 24: Global Ocean Cruise Passengers (in million) 2019-2019.



Source: Global Ocean Cruise (2018). CLIA, 2018. https://cruising.org/news-and-research/-/media/CLIA/Research/CLIA%202019%20State%20of%20the%20Industry.pdf.

For coastal tourism, visitors who arrived by air stayed on average for seven nights in a single location contributing 11.5 times more than cruise passengers to the local economy and to government revenues. Although Caribbean economies rely strongly on tourism, a significant portion of tourism assets are foreign-owned. This is especially relevant for "all inclusive" vacation packages, e.g. with international hotel resorts. Coastal tourism in this region results in water pollution — 85% of wastewater releases are untreated running off from grounds of tourist facilities, such as golf courses, gardens, and agricultural terrains. Other impacts include clearance of natural habitats at the coast due to construction and increase of water consumption.

Marine tourism includes the recreation boating and diving sectors, which are a significant feature of tourist activities in the Caribbean. These activities are often directly linked to the hotel or cruise ship companies which are the home base of the traveller.

Marine ecotourism is designed to minimize ecological impacts and provide recreational learning experiences; while simultaneously promoting local communities' economic and environmental interests. A 2010 study estimated marine ecotourism generated over US$50 billion per year, employing over 1 million individuals.[260] The annual value of coral reef tourism alone (through on-reef and reef-adjacent activities such as diving and snorkeling) is approximately US$36 billion annually.[261]

Marine tourism is also a viable pathway to support conservation of marine biodiversity, and economic studies have begun to show the value of protecting vs. harvesting species. For example, a study by the Australian Institute of Marine Science concluded that a single reef shark presented annual value to the Palauan tourism industry of US$179,000 – or US$1.9 million over its lifetime. In contrast, a single reef shark, killed and sold, would only bring an estimated US$108. Similarly, in Brazil, the value of Brazil's eight great whales was estimated at around $82 BN USD in services provided through carbon sequestration, ocean fertilisation and tourism. By 2030, it is estimated that maritime and coastal tourism will contribute 26% to the total ocean-based economy, while the wider tourism sector is projected to grow at a rate of 3.5%.[262]

Key Trends

- Before the COVID-19 outbreak, coastal tourism was expected to grow significantly and likely at a faster rate than tourism as a whole.[263] However, a rapid recovery is unlikely to happen in 2020.

[260] Cisneros-Montemayor, Andrés M., and U. Rashid Sumaila. "A Global Estimate of Benefits from Ecosystem-Based Marine Recreation: Potential Impacts and Implications for Management." *Journal of Bioeconomics*, vol. 12, no. 3, 2010, pp. 245–68. Crossref, doi:10.1007/s10818-010-9092-7.

[261] Spalding et al., 2017

[262] The Ocean Finance Handbook - https://www.weforum.org/friends-of-ocean-action/increasing-finance-for-a-healthy-ocean

[263] (World Bank Group, 2030)

- Europe was expected to be the region concentrating the most tourist arrivals with over 700 million international arrivals, followed by Asia and the Pacific with over 500 million arrivals in 2030.[264]
- Marine tourism is a viable pathway to support conservation of marine biodiversity while maintaining economic value.

Innovative Models and Initiatives

- Virtual Reality (VR) Tourism, Hawai'i, USA
  - The Vessel at Naupaka Spa & Wellness Centre at Four Seasons Resort Oahu offers a series of "customised journeys", such as Deep Space, Ocean Cove, and Lost Jungle. In the Vessel users can see, hear, smell, feel, and touch their surroundings. All sensory environments are integrated (stereoscopic visuals, spatial audio, scent, vibroacoustics, proprioception, wind and temperature) with real-time, physiological data collection (onboard sensors recording respiration, heart rate, electrodermal activity and electroencephalography) to enable the generation of dynamic, closed-loop experiences.[265]
- Diaspora Repatriation Program, In design
  - The future of foreign exchange earnings in the islands requires a transition from the traditional tourism sector, to a smaller, highly skilled number of people who come and make their home on the islands, bringing their foreign exchange income with them. These opportunities can be capitalized on from the repatriation of island diaspora and rebuilding on the indigenous human capacity. In positioning the Caribbean for the 21st century blue economy, the opportunity lies not in recruiting tourists, but in recruiting collaborators and scientists. Collaborators bring investments, their income, and are less likely to distort the social fabric of the islands.
- Wildsea Europea, Europe
  - Efforts are underway to create Discovery Journeys of Europe's Marine Biodiversity through Water Sports & Coastal Trails. This initiative is working to develop a transnational, sustainable tourism route connecting European coastal destinations with unique marine landscapes and biodiversity, flowing from the Atlantic Ocean to the Mediterranean.

Uncertainties and Risks

Coastal and marine ecosystems, and the tourism opportunities they drive, are extremely vulnerable to a number of factors. In light of the recent global shock from COVID-19, the tourism sector is likely to remain unpredictable for several months to a few years. Solutions for the tourism industry will likely require implementation of new technology and protocols to support greater health and safety—lack of technical capacity to support these developments could prove problematic over the short and medium-term.

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264 (OECD, 2030)

265 Four Seasons. "Four Seasons Resort Oahu at Ko Olina and Sensync Partner to Introduce the World's First Multi-Sensory Virtual Reality Wellness Experience: The Vessel, Featuring Deep Brain Massage." *Four Seasons Press Room*, 28 Nov. 2019, press.fourseasons.com/oahu/hotel-news/2019/the-vessel-immersive-sensory-experience.

With regard to climate change, the Caribbean is ranked as one of the most vulnerable regions, with sea level rise, ocean temperature increase, and changing ocean acidity all threatening natural and human systems. Long-term impacts are still emerging and will continue to increase in severity due to delayed environmental responses to global temperature change. Meanwhile, coral bleaching and species range shifts are already occurring due to ocean temperature and acidity change. These shifts and especially the degradation of coral reefs, directly harm diving, recreational fishing, snorkeling, and beach-related tourism sub-sectors. While solving climate change is a global challenge, it is possible to bolster island resiliency, but it requires investment and leadership and large-scale initiatives that look to integrate nature-based solutions with traditional coastal protection. Currently, COVID stimulus packages fail to push for these more grey-green solutions.

For many other coastal changes, the impacts of climate change are difficult to separate from human-related drivers (e.g., land use change, coastal development, pollution).[266] Investing in coastal zones is potentially high risk and high reward. At the moment, most business models in the Caribbean focused on restoration or marine management are driven by an industry that is currently under siege due to the COVID-19 virus.

- Lack of existing digital infrastructure
- Rural communities and more mature workers skeptical of new tech such as AR/VR – possible resistance to retrain in these ways
- COVID-19 stimulus to grey infrastructure
- Brain drain if no suitable or available job at the end of new training opportunities.

Drivers and Enabling Conditions

The future of the tourism industry as a whole will be shaped by multiple forces, including new protocols for health and safety,[267] continued interest in more "niche" tourism markets such as health or culture-based tourism, desire for customized, technology-driven experiences, and likely, more local or regional-based tourism—at least in the short term. To best leverage these drivers, policymakers need to consider taking natural capital valuation into account as part of their economic development strategies to determine where maritime tourism may be most appropriate and viable. Once that data is available, it is possible to then create detailed development planning and coordination to boost eco-friendly, economically viable, and socially responsible marine and coastal tourism. New modeling tools, such as those created by Mapping Ocean Wealth, provide the kinds of data-driven decision-making tools to support such efforts.

As people do begin to travel again, countries should re-design the flow of capital to better preserve, protect, and manage the natural habitats that fuel their local coastal and marine tourism activities. Different models for financing marine protected areas, habitat restoration, and other restorative or adaptation-based projects could be linked to this new era of tourism.

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266 file:///Users/fionamulligan/Desktop/WGIIAR5-Chap5_FINAL.pdf

267 https://www.forbes.com/sites/angelinavillaclarke/2020/06/11/gen-c-travel-jamaicas-minister-of-tourism-reveals-a-new-type-of-traveller/#13232653321f

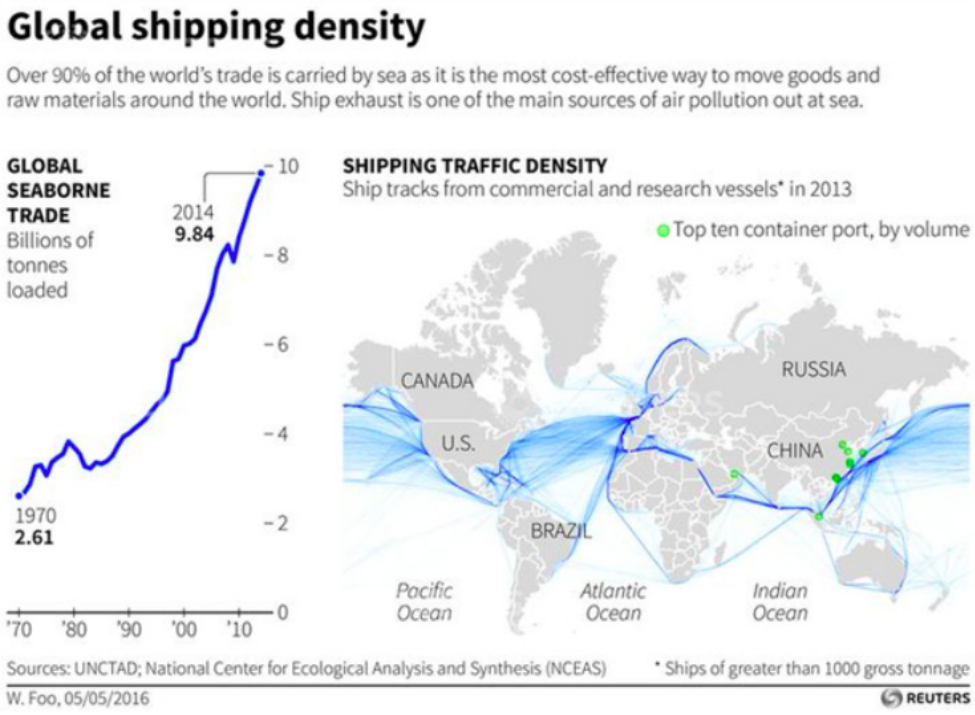
Significant benefits would also arise from more mature insurance instruments, that reinforce the value of healthy, in-tact marine ecosystems for businesses--whether they are on land or at sea.

- Blue tourism option for blue-green funding, eg. Coral restoration and mangrove planting – aimed at future responsible tourist
- Allows for short to medium term work schemes to stave off coastal erosion caused by hurricane damage.
- Caribbean provides companies wanting to test NBI and governance strategies a unique case study with 40 different territories in a compact area.
- UN (Decade of the Ocean) commitments towards sustainability could lead to increase in training and science inclusion for vulnerable communities.
- Dedicated insurance for nature-based infrastructure/coral reefs.
- Blue finance flow expected to be uninterrupted post COVID.
- Need to build hurricane resilience gives energy to investments in coastal protection.
- Enforcement and monitoring jobs creation by integration infrastructure with MPAs.
- Low to moderate skilled job opportunities that are 'ready to go'.

Shipping

Overview: Global seaborne trade has experienced tremendous growth over past decades rising from 2.6 billion tons loaded in 1970 to 9.8 billion in 2014 (**Figure 25**). Access to foreign resources, commodities, and fuels has helped drive economic expansion in recent decades, due in no small part to the shipping industry. The significant role of maritime transport in supporting growth of the global economy is certainly not a new concept, but the scale of global trade has grown exponentially in recent years, showing little signs of slowing. Even in the face of the COVID-19 pandemic, it is uncertain that a shift in focus towards localized economies will be able to counteract the world's reliance on international shipping as a necessity for economic growth.

Figure 25: Shipping Traffic Density Worldwide.



Source: UNCTAD.

The resilience of the global shipping sector is complex and interdependent, made up of a web of private sector companies, international treaties, relationships between national ports, and overseen by a range of multilateral agencies; most notably the International Maritime Organization (IMO). As a result, effective actions to make the global shipping industry more efficient, equitable, and resilient in the face of threats such as climate change, pandemics, and conflict, must involve all of the relevant stakeholders—often a time and resource intensive process given the range of actors and interests.

Key Trends

Recent years have witnessed a rise in application of digital software technologies to improve coordination, regulation, and efficiencies in the global shipping industry. From electronic documentation of trade data, to improved security capacities, the use of digital systems continues to grow. See applications in the Innovations sub-section here, and within AI and blockchain summaries within the Technology Sector Summaries, below.

Greening of the global shipping industry is also underway, driven by international regulations, positive incentive programs, and advancements in new technologies. The IMO has already set aggressive standards to push reductions in sulphur and GHG emissions. Meanwhile, ports are looking to meet GHG emissions standards by offering reduced fees to "greener" ships based on international ranking systems.[268] Innovations in alternative and hybrid energy technologies are also underway.

Within the Caribbean region, a growth of the shipping sector coincided with the 2016 widening of the Panama Canal.[269] Sitting at the strategic intersection of both east-west and north-south shipping routes, the Caribbean's unique geography provides enormous opportunity for regionally-based growth in shipping-related fields.

Innovative Models and Initiatives

- Transition to Liquified Natural Gas (LNG), Puerto Rico[270]
  - Due to a lack of regulatory legislation regarding fuel quality, the majority of existing cargo ships are significant emitters of pollutants, leading to significant decreases in air quality around port areas or frequently used shipping lanes. Switching to LNG is one way to decrease the amount of harmful particulates, volatile organic compounds, and other pollutants (such as ozone) created by the shipping industry. Puerto Rico is considering this transition by tapping into the cheap natural gas that is being produced through hydraulic fracturing throughout the US.
- The CargoX Platform for Blockchain Document Transfer (BDT), International
  - CargoX is a secure platform enabling confidential trade information to be securely transferred through a digital environment. A Smart B/L (orsmartBL) is an electronic bill of

[268] https://www.itf-oecd.org/sites/default/files/docs/reducing-shipping-greenhouse-gas-emissions.pdf
[269] https://www.forbes.com/sites/daphneewingchow/2019/05/21/the-caribbeans-share-in-the-global-cargo-industry-is-growing-rapidly/#3413d8ea61a2
[270] Interview with an expert. Due to privacy policies name has been omitted.

lading, sent through the CargoX Platform for Blockchain Document Transfer (BDT) or any other electronic platform, and is specifically designed to decrease the paperwork burden for shipping agencies. A smart B/L can be uploaded in the form of PDF (or any other type of document), or created as a structured data document and then sent or transferred on the platform. Ownership of the smart B/L document is transacted to the new owner, who can legally claim ownership rights. Recipients can always validate the original source and prove ownership of their documents, and a comprehensive document repository is available with audit logs.[271]

- TradeLens, International
  - TradeLens is an interconnected group of supply chain partners; including cargo owners, ocean and inland carriers, freight forwarders and logistics providers, ports and terminals, and customs authorities. TradeLens software allows users to access a supply chain and logistics network with data coverage of over half of global container shipping volumes. The program runs on a designated permission matrix and blockchain, ensuring every party to a shipment has access only to their information, as well as a secure audit trail of all transactions. The systems are connected to a global platform built on open-source technology and publicly-available APIs.[272]

Uncertainties and Risks

The shipping industry is primarily driven by the private sector, where the resources exist to adapt quickly to changing market signals and the advent of new technologies. However, there is no guarantee that these investments will lead to sustainable or equitable practices, a concern that has created agencies such as the IMO to oversee larger policies that directs the growth of the sector, such regulating fuel types or emissions volumes.[273] Furthermore, the shipping industry is particularly vulnerable to climate change, as evidenced by recent water shortages in the Panama Canal restricting container ship traffic through the Caribbean.[274]

Drivers and Enabling Conditions

The Caribbean's proximity to the Panama Canal places many islands directly in the path of major shipping lanes. Given the critical role of the region for maritime trade, there is significant opportunity to leverage this position to push for sustainable industry development, however, holistic and simultaneous progress in the shipping and port sectors will be required to effectively move either industry forward.

In addition, the need for greater efficiencies—to reduce fuel consumption, paperwork burdens, and pollution—drive continued adoption of new digital communication, tracking, and reporting systems. For these technologies to have maximum effect, however, requires private industry

271 https://cargox.io/solutions/for-transport-and-logistics/
272 https://www.tradelens.com/
273 Interview with an expert. Due to privacy policies name has been omitted.
274 Interview with an expert. Due to privacy policies name has been omitted.

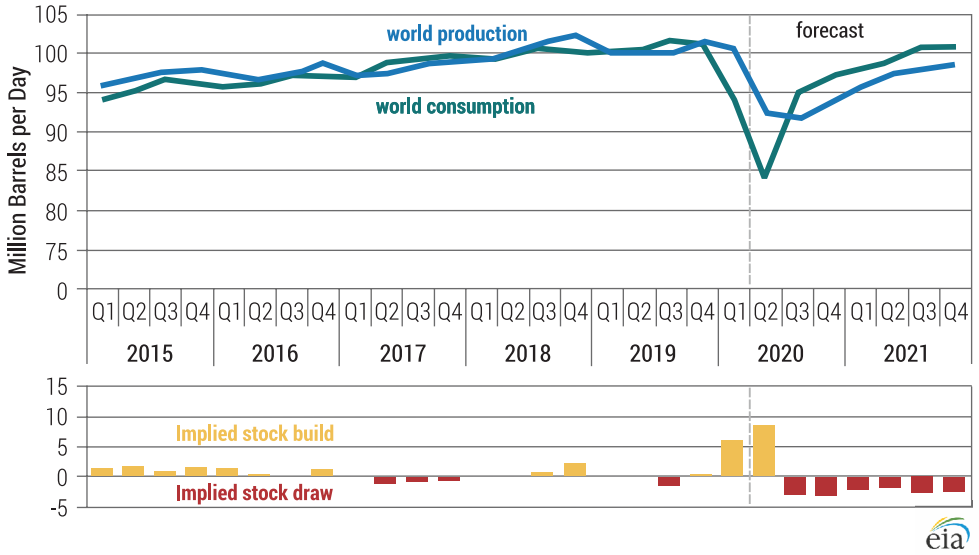
coordination with local and regional governments, to ensure systems are interoperable and coordinated. Capacity training for in-country support personnel, as well as maritime sector employees is paramount in order for local residents to be able to participate in any new growth of the industry.

Investments in the shipping industry involve a wide range of stakeholders, are costly, multi-sectoral, and may take a long time to implement due to the massive network of container ships out on the seas.[275] That being said, it is likely, given ever-increasing globalization, that demand for more efficient, cost-effective, and sustainable shipping solutions will continue to increase. In order to address environmental as well as economic concerns moving forward, all investments made to improve the Caribbean shipping industry will need to involve ports, national governments, private sector actors, and the IMO. Importantly, the transitions and solutions created will need to be adapted and applied to smaller vessels in addition to larger cargo ships, given the vast number of small-scale cargo trade that occurs around and between islands in the region.

Offshore Oil and Gas

Overview: Offshore oil and gas faces numerous challenges ranging from weak market demand and oversupply, to concerns about safety and the ocean environment, to the momentum gathering behind efforts to decarbonize the global economy. COVID-19-related shutdowns have only exacerbated already falling oil prices throughout much of the world. As shown in **Figure 26**, oil and gas demand and production are forecasted by the US. Energy Information Administration to drop precipitously during 2020 and recover in 2021.

Figure 26: Oil and Gas Production and Consumption 2015-2021 (forecast).



Source: EIA (2020).

[275] Interview with an expert. Due to privacy policies name has been omitted.

Among existing blue economy sectors, the offshore oil and gas industry contributes the highest gross value to the ocean economy.[276]

Given its significant influence on the ocean economy, the oil and gas industry has served as an important driver of innovation; namely, ocean observation and mapping technology. However, the industry itself is reliant on finite resources associated with significant environmental risk; whether or not offshore oil and gas fits into the blue economy landscape is still debated by scientists and industry leaders.[277]

Innovative Models and Initiatives

- Government Incentive Structures for Research and Development, France[278, 279]
  - In France, the government has implemented an incentive structure by providing tax credits to service companies, which manufacture and maintain equipment and technology that is used by oil and gas operators, that invest in oil and gas research at universities for the continual improvement of technology and processes applied by operators in the field.
- Private Sector Utilizing Oil and Gas Expertise for Expanding Offshore Renewable Energy, Norway[280]
  - While originally a strictly oil and gas operator, Equinor is an international energy company based in Norway that has built offshore renewable energy production, namely wind and solar, into their business model. By using their experience in ocean engineering, they aim to become a leader in the offshore renewable energy field; with operational projects already taking place in and around the North Sea as well as emerging work off of the east coast of the U.S.
- Regional Oil Spill Contingency Plan, ASEAN Member States[281]
  - Member states of the Association of Southeast Asian Nations adopted a cooperation mechanism in 2018 to bolster transparency, understanding, and communication in responding to oil spills in the region. Through this plan, member states can request and provide mutual support in the event of any oil spill, which ultimately aims to address oil spills and their regional impact more effectively.

Uncertainties and Risks

The volatile nature of the oil and gas market, the increasing risk of oil spills from more extreme weather patterns,[282] and the potential negative impacts on vital Caribbean industries like fishing and tourism, threatens the stability and longevity of the offshore oil and gas industry in the

276 http://www.oecd.org/environment/the-ocean-economy-in-2030-9789264251724-en.htm
277 Interview with an expert. Due to privacy policies name has been omitted
278 https://www.oecd.org/sti/rd-tax-stats-compendium.pdf
279 Interview with an expert. Due to privacy policies name has been omitted.
280 https://www.equinor.com/en/about-us.html#sustainability
281 https://www.offshore-energy.biz/asean-member-states-adopt-regional-oil-spill-contingency-plan/
282 https://www.southernenvironment.org/uploads/publications/SELC_Hurricane_Report_F.pdf?utm_source=News%20Feed&utm_medium=social&utm_campaign=selc_hurricane_report

region. Moreover, the depletion of shallow water reservoirs has pushed the industry to explore deep water drilling, in which the environmental effects and risk mitigation strategies are far less understood and established.

Although a key investor in oil and gas developments in the region, foreign drilling companies further exacerbate social and economic inequality, as the local workforce is largely disengaged from the production process.[283] Foreign companies who stand to gain the most from drilling extract the region's resources without building localized infrastructure or industry, while local populations are left to deal with the risks and fallout. The development of the offshore oil and gas industry may impose significant economic costs to the fishing and tourism industries in the Caribbean--with increased drilling activities, the fishing industry must fight for physical space in onshore infrastructure, such as ports, and face the risk of being displaced by rigs in their offshore fishing zones.[284]

Drivers and Enabling Conditions

The key driver of offshore oil and gas exploration in the region are foreign drilling companies; without the resources to explore and systematically map oil and gas reservoirs in their territorial waters, most Caribbean governments are currently forced to partner with the international private sector. The growing application of ocean observation technology and big data analysis will be vital for SIDS to effectively leverage their resource-rich environment for economic benefit, while clearly calculating the potential environmental trade-offs involved. Most Caribbean governments are lacking seafloor observations, maps, and ecosystem/habitat models to fully understand the ecological effects of drilling in their EEZs. Collecting, analyzing, and sharing this information through remote sensing and marine geospatial mapping can better advise these governments as to how to manage both the economic and conversation interests involved in extraction activities.[285]

Guyana and Suriname are engaging with foreign drilling companies to exploit untapped offshore oil and gas reservoirs that were discovered in the region in 2015. Ongoing exploration is confirming massive oil finds and early stage oil production is taking place in Guyana. See country profiles for more information.

283 Interview with an expert. Due to privacy policies name has been omitted.
284 https://www.tandfonline.com/doi/full/10.1080/23308249.2018.1436521
285 http://journal.frontiersin.org/article/10.3389/fenvs.2016.00058/abstract

Growth Industry Sectors

Mariculture, Maritime Safety and Surveillance, Ports, Renewable Energy

Mariculture

Overview: Mariculture is the division of aquaculture that is focused on cultivation of marine organisms (i.e. those that live in saltwater) and is a quickly evolving sector within blue economies around the globe. Mariculture, in the context of this report, also includes seaweed farming. From large-scale operations in China to small-holder farms in New England, USA, there are a diversity of approaches with two major strategies for development: (1) larger-scale, high-capital-cost offshore operations and (2) small-scale, coastal farms, which can be integrated into coastal habitats such as mangroves, or be farther from the coast but still in relatively shallow waters. In some cases, on-shore recirculating systems can include marine species, drawing seawater from nearby, but production from these facilities remains relatively limited to date.

Key Trends

- *At the industrial or commercial level, mariculture tends to be single-species in focus, but there is an increasing trend towards integrated multi-species approaches, including finfish, shellfish, and seaweeds.*[286] These approaches range from large-scale operations such as salmon farms in Canada, to small-holder farms in Long Island sound.
- *Diversification beyond food:* Historically, the vast majority of mariculture has focused on raising products for human consumption, including seaweed and finfish, the latter dominated by the lucrative salmon farms and more recently, white fish such as seabass, in the Mediterranean. Growing interest in the use of seaweeds for biofuel, fertilizer, and other applications, however,

[286] Multi-species or more specifically, "multi-trophic" aquaculture (IMTA) is based on the premise that reduced waste and greater efficiencies can arise by integrating different types of animals and plants, whereby one species utilizes the waste product of another. See here for more details: https://www.dfo-mpo.gc.ca/aquaculture/sci-res/imta-amti/index-eng.htm.

is driving new investment in seaweed farming. Likewise, concerns regarding wild harvest of species for the aquarium trade is also fueling research into how to cultivate—rather than capture—the most popular species, which largely tend to be tropical reef fish.[287] Similarly, a desire to help reverse widespread damage to coral reefs due to the triple impact of overfishing, pollution, and climate change, has spurred numerous coral farming and restoration efforts around the world, many of them within SIDS.

- *Research and development for fish farm health*: A significant amount of research and technological innovation is happening within the aquaculture sector aimed at reducing disease and increasing health of target species. Increased use of environmental sensors, and a trend towards automated feeding are helping to reduce costs and pollution and increase efficiencies of farm operations for both large and small-scale stakeholders.[288] Meanwhile, AI is tracking individual fish behavior to help with early detection of illness.
- *Movement away from fish-based feeds to those that rely on plant or insect-based proteins or utilize scraps from seafood processing*.[289] As feed costs represent a significant majority of farm operation budgets, advancements in more sustainable and economical feed could open up accessibility of mariculture to a much more diverse set of actors and regions.

Innovative Models and Initiatives

- Green Wave: restorative ocean farming[290]
  - Small-scale farming that integrates seaweeds and shellfish to produce commercial products for food, fertilizer, and bioplastics all without any inputs
  - Hybrid business model that includes a non-profit training for small holder farmers and hatchery, marketing, and processing businesses. The model includes 25 to 50 regenerative ocean farms in each "Reef" unit, a land-based hatchery and processing hub, and institutional buyers and entrepreneurs developing value-added products. The scale model is to replicate these Reefs up and down coastlines.
  - Blue carbon and nitrogen capture by seaweeds and storm wave protection via seaweed and reef structures
- JALA water quality monitoring for small-scale shrimp farmers[291]
  - Women-led, Indonesian tech start-up that focuses on affordable water quality monitoring devices to support small-scale shrimp farmers to keep their farms healthy, reducing pressure to cut-down mangroves for new farms.
  - Provides data analysis and decision-support regarding ideal time for harvest, shrimp growth/health, and farm finances.

287 https://onlinelibrary.wiley.com/doi/abs/10.1111/raq.12381
288 Interview with an expert. Due to privacy policies name has been omitted.
289 Hasan and Tan. Biomin. 2020. https://www.biomin.net/science-hub/the-current-state-of-plant-based-proteins-in-aquaculture-feed/
290 Green Wave: GreenWave.org
291 JALA: https://jala.tech/id/

- Meta-data from multiple users allows for improved analytics that are then shared back with the community of farmers using the sensors.

- Earth Ocean Farms, Mexico[292]
  - Offshore submersible cages for growing finfish (Red Snapper and Totoaba) that provides skilled jobs and new economic opportunity for local communities.
  - Restocking program helps recover the Totoaba, an endangered species by releasing juveniles grown in hatchery back to the wild.
  - Cages sit in deep water with strong currents, minimizing impact to environment.
  - Fully traceable product with use of QR codes from farm to fork.

Uncertainties and Risks

High capital costs upfront and lack of clear policies limit growth of offshore operations in much of the world; high feed costs associated with growing the more lucrative finfish species (which tend to be fish-eaters) is also a deterrent. The track record and chance for catastrophic disease outbreaks or other accidents have also created a barrier for small holders. Insurance remains limited in the sector, except for the largest operations, in part due to the continued lack of proof of concepts for long-term viability of operations.

Another common barrier within mariculture development is the problem of waste products. Operations often produce high levels of organic waste that can be difficult to manage and at times impose negative impacts on other sectors. The movement towards integrated multi-trophic farms, and a focus on growing species lower on the food chain, such as herbivorous fish or shellfish, are current strategies seeking to overcome the waste issue.

Climate change also introduced uncertainty to the mariculture space. Many species are farmed below their thermal optimum, so they may actually benefit from increased growth rates. However, stronger storms and changes in disease virulence and transmission could be catastrophic and pose significant threat to tropical mariculture.[293]

Drivers and Enabling Conditions

Marine spatial planning is helping to identify suitable sites for aquaculture operations based on the complex physical, biological, social, and political factors that influence the growth of this sector. By elucidating how aquaculture sites potentially complement (i.e recreational fishing can benefit from presence of offshore fish farms) or compete with other sectors, such as offshore wind farms and resort properties, marine spatial planning analysis can strengthen aquaculture stakeholders' advocacy and requirements for the space needed to operate in the marine environment.[294]

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292 EarthOceanFarm.com

293 Interview with an expert. Due to privacy policies name has been omitted.

294 https://link.springer.com/chapter/10.1007/978-3-319-51159-7_6

The continued rise in demand for seafood will have to be met by a growing number of aquaculture and mariculture operations. Rapid development for mariculture has been observed in developed countries such as the U.S., Norway, and China, which is suspected to be a result of adequate infrastructure and hospitable regulatory environments. The presence of clear laws and regulations decrease risks and timeframe to launch projects, decreasing costs and uncertainties.

Advancements in engineering are also seeking to expand where farms can be located in terms of wave, current, and depth conditions, as well as integrating renewable energy sources for operations. These innovations could lead to new models for operations that might benefit small-scale holders, as well as SIDS, who have diverse ocean habitats to work with.

Maritime Safety and Surveillance

Overview: Maritime safety and surveillance is the protection of vessels, ports and other infrastructure related to the shipping business from intentional damage. Maritime security provides advanced technology to detect hazards and communicate with officials and includes technologies such as surveillance and tracking, communications. It is important because the quality of life on islands and in peripheral maritime regions depends on maritime transport services which enables trade and contacts between Caribbean ports and provides for Caribbean imports and exports with the rest of the world. The maritime safety and surveillance sector is both an enabler of the blue economy as well a source of traditional economic development. As blue economy industries continue to grow, demand for strong safety and surveillance will help to ensure the longevity, stability, and success of emerging sectors and maritime assets.

National governments are largely concerned with addressing threats to ships and maritime assets, enforcing laws and regulations for environmental management, and protecting human livelihoods through integrated surveillance and marine spatial planning. While defense planning and, later, non-profit environmental organizations were the original drivers of enhanced marine knowledge through Geographic Information Systems (GIS) and surveillance technology, industry actors ranging from fishers to commercial oil and gas drilling companies have now adopted this approach for more targeted, efficient, and safer operations.

In SIDS, the expansion of national jurisdictions over maritime spaces and the heightened awareness of valuable marine resources has diversified the role of maritime security.[295] Beyond bolstering naval defenses, coastal states in particular are looking to expand maritime surveillance to protect offshore activities and marine resources through public and private sector partnerships. Furthermore, this expansion of maritime security priorities, coupled with the dense geography of SIDS in the Caribbean, exposes the need for strong regional alliances to reinforce and support national priorities.

[295] Maritime Security and the Blue Economy.

Key Trends

- *Regional multinational alliances for surveillance and monitoring*: There is an increasing need for sharing and integrating intelligence, surveillance, and navigation systems into a common operating picture can help Caribbean small states to prepare for, prevent, respond to, and recover from a broad spectrum of potential maritime-related threats, allowing limited resources to be more effectively deployed.
- *Use of big data for better analytics*. The database allows for the storage, exchange and analysis of data on marine casualties and incidents. The shared use of those data will further develop the accident investigation capabilities and contribute to improve maritime safety and the prevention of pollution by ships in the Caribbean region.
- *Smart vessels and ports*: The transportation industry is changing at a rapid pace due to globalization. Increase in international shipping also gives rise to the importance of maritime security. There is an increase in smart boats and advanced facilities and improvement in security and safety regulations at marine is trending in emerging markets.

Innovative Models and Initiatives

- Sea-vision System and Mercury System, Kenya[296]
  - The Regional Maritime Rescue Coordination Center in Mombasa, Kenya, uses a combined security system that provides real-time satellite pictures of vessel movement in the region paired with streamlined communications to naval assets in the western Indian Ocean. A key element of success is the reciprocal relationship between local fishermen and the Centre, as the Centre provides emergency and best business practices training to fishermen, while the fishermen in turn provide human intelligence on illegal activity and illicit threats in the maritime space.
- Stable Seas, International Program
  - Stable Seas is a program of One Earth Future that engages the international security community with novel research on illicit maritime activities such as piracy and armed robbery, trafficking and smuggling in persons, illegal unregulated and unreported fishing (IUU), and illicit trades in weapons, drugs, and other contraband. The project looks at how a broad array of maritime crimes are able to flourish in environments with limited maritime governance, as well as gaining a better understanding of how these crimes at sea contribute to instability ashore, so that relevant stakeholders can better identify and implement comprehensive solutions.[297]
- Fish-i Africa, East Africa/Western Indian Ocean
  - Fish-i is a partnership of eight East African countries – Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and Tanzania. The group unites national enforcement authorities, regional organizations, and international technical and legal

[296] Policing the Seas: Building Constabulary Maritime Governance in the Horn of Africa – The Case of Djibouti and Kenya
[297] https://oneearthfuture.org/stable-seas

experts to combat large-scale illegal fishing in the Western Indian Ocean through information-sharing and regional cooperation. The partnership is supplemented with the use of technologies that enables the sharing of real-time information and intelligence and coordination of actions taken against vessels suspected of operating illegally.[298]

Uncertainties and Risks

Effective maritime safety and surveillance depends not only on increased capacity for data collection, but also the open communication of this data between parties. Unfortunately, this information is frequently considered proprietary for either security-based or economic reasons. Agreements around data sharing between governments and industry in particular may be challenging and time-intensive to craft, most likely benefiting from the assistance of an unbiased intermediary. Additionally, a significant barrier faced by SIDS in particular is the high up-front investment cost necessary for technology acquisition and personnel training. Capacity building through international assistance, via training programs or funding for acquiring technology will most likely be needed to improve marine surveillance in the region.

Drivers and Enabling Conditions

In the Caribbean, regional cooperation and coordination is the bedrock of strong maritime safety and surveillance for individual nations. Namely, clear maritime boundaries, currently defined through regional forums, will be required to organize countries' claims to marine assets. With resolved maritime boundaries, Caribbean nations have the potential to gain substantial legal clarity regarding resource allocation, as well as uniting enforcement powers to implement and maintain policies for the sustainable management of their marine resources.[299]

For the majority of SIDS, already climate-vulnerable coastal zones are focal points of human development, tourism, transportation, and industry activities; as a result, these areas are highly vulnerable to environmental degradation and natural resource exploitation. Therefore, ocean observing with remote and field sensing, satellite tracking, and marine GIS is crucial not only for greater national security, but also for ecosystem protection and management in coastal zones. Beyond the capacity and political will to obtain and apply ocean observing technology, multi-sectoral partnerships between the government and industries will be vital for the sustainable management of coastal zones and protection of livelihoods that depend on these areas.

Ports

Overview: Ports are an integral component of development for the global blue economy. As logistically significant nodes for the increasingly important maritime shipping industry, a common point of entry for tourists, and key leveraging tools for international trade capacity and

[298] https://stopillegalfishing.com/initiatives/fish-i-africa/
[299] Caribbean nations prepare for maritime boundary talks with Commonwealth support

negotiation, the sustainable development of ports in the Caribbean has the potential for major economic contribution.

Ports are not only hubs of commerce, tourism, and transport, but also essential pieces of infrastructure for SIDS that represent national policies and pride. Yet, their success is dependent on a complex web of relationships with neighboring countries, international trading partners, the private sector, and multilateral institutions. Investments into ports could act as opportunities to set into place new national policies, develop new international partnerships, and promote the development of the surrounding area and country. However, low technical capacity in emerging economies and high construction costs in remote areas stand as a barrier to the adaptability of this sector. Investments into ports are long-term, expensive, multi-sectoral initiatives with the potential to cause a multiplier effect on the development of the country. To be successful and continue to adapt to international shipping markets, investments will require international coordination and multilateral support that is driven by national policy.

Ports are hubs for employment, innovation, and economic growth. Through their ability to increase economic output across a diverse range of sectors, innovative investments into ports can attract diverse commodity exchanges, bolster entrepreneurship, and invite new streams of revenue (i.e. diversifying Caribbean ports away from a reliance on cruise tourism). The demand for ports that support the globalized economy, cause minimal environmental harm, and embrace the digital age is on the rise due to globalization.[300] Although the costs to invest in ports are high with complex governance factors, investing in Caribbean ports has the capacity to turn this demand into an environmental, social, and economic asset for SIDS.

Innovative Models and Initiatives

- Providing On-Shore Power Through an Increasing Share of Renewable Energy, Amsterdam, Netherlands[301]
  - The port of Amsterdam is focused on decentralizing their energy system through the implementation of a smart grid that allows for flexible power generation between a mix of energy sources and storage mechanisms. To create and support this system, authorities are investing in local renewable energy technologies as early as possible to increase the share of renewable energy used by the port as a way to reduce air pollution and reduce long-term costs of expansion.
- Utilization of Ports as a Hub for Innovation and Entrepreneurship, California, USA[302]
  - The Port of San Diego has developed a "Blue economy Incubator," inviting private companies from around the world to apply to have their businesses jump-started in the Port of San Diego with the assistance and capital of the local marine economy experts.

300 Interview with an expert. Due to privacy policies name has been omitted.
301 https://www.portofamsterdam.com/sites/poa/files/media/havenbedrijf/duurzaamheidsplan_en_digitaal_2017.pdf
302 Blue Economy Incubator Highlights Q1FY20

This has resulted in the development of cross-sectoral partnerships with ports, namely within aquaculture, recreation/tourism, and coastal development:

- Aquaculture: San Diego Bay Aquaculture is using floating barges with artificial upwelling propellers as a shellfish nursery. Sunken Seaweed grown below the dock is simultaneously piloting the passive growth of carbon sequestering algae.
- Recreation/Tourism: Swell Advantage is creating a digital logistics platform for all of San Diego's marinas to streamline docking processes and implement a floating boat wash, which will phase out the need for antifouling agents.
- Coastal Development: ECOncrete is developing biophilic concrete for use in coastal development, a grey-blue initiative that prevents erosion while attracting intertidal zone organisms to act as a natural buffer from flood waters and rising sea levels.

- International Port Collaborative Decision Making Council, International
  - The Port Collaborative Decision Making council (PortCDM) is a global collaboration to create and record the guidelines, processes and procedures required to improve maritime transport in relation to Port operations. The goal is to synchronize approaches and turn-around times in order to improve logistics and planning for visiting vessels by using standardized and secure communication to share data in real-time.[303]

Uncertainties and Risks

Increasing the productivity and connection of ports within the Caribbean through traditional means poses a challenge to the sustainability goals of the blue economy. Shipping is currently the fastest growing global emitter of greenhouse gases (GHGs), and ships notorious air and water polluters.[304] Additionally, climate change threatens the sustainability of ports in the region as the Panama Canal faces water shortages,[305] even as sea level rise and extreme weather events become more consistent. For small island states, there are additional limitations due to the lack of large ports capable of holding cargo ships, and the fact that smaller ports are more difficult to innovate. Demand from the shipping industry drives port development, frequently in directions that are both socially and environmentally destructive.

Currently, ports are heavily linked to social and environmental injustice concerns. Low-income communities are commonly clustered near ports for the inexpensive land located in areas of high levels of air and water pollution, while the emphasis on connectivity for port services simultaneously isolates nearby communities.[306] Through innovations like "Smart Ports," making ports digital powerhouses that serve as data hubs, provide reliable access to broadband, strong environmental infrastructure, and high-value jobs; there is hope that benefits could directly reach the immediate communities. Additionally, by reducing the need for idling engines, increasing logistics efficiency, and promoting private sector innovation into climate and waste mitigation, there is a massive potential for ports to reduce their carbon and environmental footprint.

303 https://www.ipcdmc.org/about-ipcdmc
304 https://blogs.ei.columbia.edu/2019/09/17/port-sustainability-index/
305 Interview with an expert. Due to privacy policies name has been omitted.
306 https://blogs.ei.columbia.edu/2019/09/17/port-sustainability-index/

Drivers and Enabling Conditions

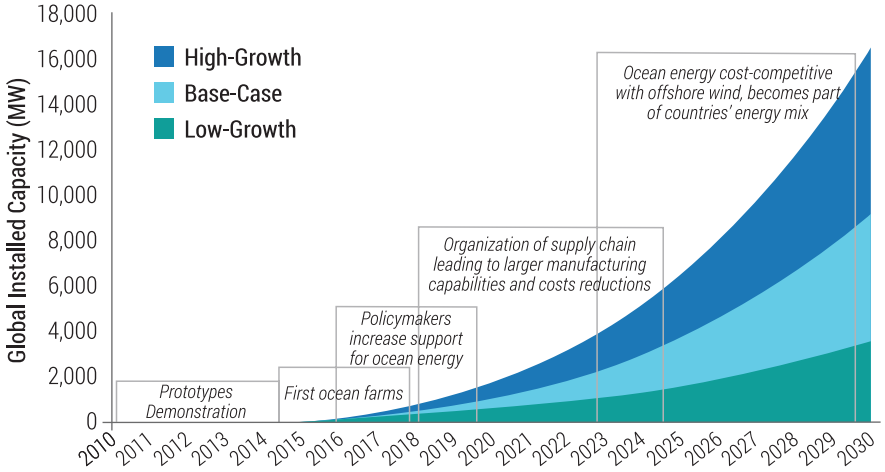
In order to drive this development, national governments will need to act as central players in implementing ambitious policies, incentivizing private sector engagement, and cooperating among nearby states to develop regional strategies that accommodate ports of all sizes in the Caribbean. Additionally, the creation of and investment in local energy sources, technical training and capacity building, and an increased political investment in port safety and health will be required for long term success.

Renewable Energy

Overview: Marine renewable energy has both growth and emerging subsectors and is increasingly recognized as an enabler of the blue economy. Beyond diversifying energy portfolios and reducing dependencies on fossil fuels, marine renewable energy is a promising mechanism to support blue economy industries by generating local, reliable, and affordable power for regional industry.

As an emerging sector, most renewable marine technologies are still in their research and development phases, with tidal stream and wave power showing the most promise for future commercial applications in the next five to ten years, respectively.[307] The power generated from marine energy systems can supply both local microgrids as well as wide-scale power grids when combined with a broader mix of energy sources, generally more applicable to developed countries requiring steady amounts of large power. While grid operators can be resistant to accepting power from renewable sources,[308] with increasing economies of scale and government incentives to reduce the costs of renewable energy facilities the levelized cost of electricity of renewables becomes increasingly competitive with or event beats out conventional energy sources.[309]

Figure 27: Global ocean energy recast.



Source: IHS Emerging Energy Research

307 Interview with an expert. Due to privacy policies name has been omitted.
308 Interview with an expert. Due to privacy policies name has been omitted.
309 https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

Renewable energy can not only support the decarbonization of the world's economies, but also decrease the cost of energy in the long-term.[310] IHS has forecast the growth of global ocean energy to reach from between 4,000 MW to 17,000 MW by 2030.

The majority of existing marine renewable energy systems exist in larger and more developed countries. While islands generate and use less energy than large nations, as island populations grow and industry develops the domestic demand for energy will increase,[311] and, as SIDS currently depend on imported fossil fuels for energy, there is a recognized need for resilient and sustainable energy sources. In 2012, the Barbados Declaration was established for several countries in the Caribbean to commit to achieving energy-related targets; so far, the expansion of the renewable portfolio has mainly been through terrestrial systems, with marine renewable energy installation still in pilot stages.[312]

In the Caribbean, marine energy could prove particularly useful for powering local coastal communities, improving climate resiliency while decreasing dependency on foreign fuel sources, and supporting the growth of emerging industries. However, for the equitable development of this sector, any project development will need to be based on open, trusted partnerships between technology operators and energy end users to reconcile the needs of all stakeholders and the potential loss of space from marine energy systems.

Wave & Tidal Energy:

Ocean waves hold tremendous power and can be converted to energy and generate electricity. In fact, harnessing tidal and wave energy from the surfaces of an ocean is projected to be the most sustainable source of energy. The technologies that are required to generate electricity from wave and tidal energy are at the promising stage, but commercial projects are still under development. In the Caribbean region, despite having abundant tidal and wave potential, the region is expected to grow slowly, as governments channel investments towards proven technologies with lower costs and risks to meet renewable generation targets.[313]

Offshore Wind Energy:

Offshore wind energy refers to the use of wind farms constructed in bodies of water to harvest wind energy to generate electricity. The Caribbean regions have enormous potential for offshore wind development. A study conducted by Uppsala University in 2019 suggested that a massive use of the Caribbean Sea for Offshore Wind Power applications could be enough to cover almost three times the energy needs of the LAC region by 2020.[314] Yet, the offshore wind potential of the Caribbean Sea has barely been exploited. Currently, the offshore wind power industry in Latin America and the Caribbean region is still at very early stages, leaving aside an

[310] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf?la=en&hash=99683CDDBC40A729A5F51C20DA7B6C297F794C5D
[311] Marine Renewable Energy, Commonwealth Series, No. 4.
[312] Marine Renewable Energy, Commonwealth Series, No. 4.
[313] Frost & Sullivan, Global Renewable Energy Outlook, 2018, P52.
[314] https://uu.diva-portal.org/smash/get/diva2:1336039/FULLTEXT01.pdf

important resource that otherwise could contribute to satisfy the growing energy demand of the zone. Despite several countries in the region, including Jamaica and Bermuda, have already had plans to develop offshore wind farms in the following year, more investments shall be diverted into the development of offshore wind as the technologies are mature and they can create jobs in the Caribbean region.

Floating Solar PV:

Floating solar PV plants are an emerging form of PV systems that float on the surface. This technology is creating major new opportunities to scale up solar energy around the world, particularly in countries with high population density and competing uses for available land. Since the first floating solar project in the Caribbean region began construction at the end of 2019, more countries have joined the race.[315] Jamaica has recently awarded the development rights for a 45 megawatt floating solar photovoltaic (PV) plant with battery energy storage system (BESS), marking a significant step in Jamaica's ambition to generate at least 50% of its energy from renewable sources by 2030. This project will also be the first utility-scale floating solar PV development in the Caribbean region.

Salinity Gradient Energy (SGE):

Salinity gradient power is the energy created from the difference in salt concentration between two fluids, commonly fresh and saltwater.[316] This renewable energy source is directly linked with Earth's complex water cycle. The total technical potential for salinity gradient power is estimated to be around 647 gigawatts (GW) globally, which is equivalent to 23% of electricity consumption in 2011.[317] River mouths are locations with high theoretical potential for harvesting SGE since waters of different salinities are abundant in these places.[318] It is estimated that 29% of river mouths with adequate energy density to harness SGE are located in the Caribbean Sea and Gulf of Mexico. However, despite the SGE potentials in the region, this technology is still fairly new and little study has been done to estimate its market potentials.

Innovative Models and Initiatives

- Local Community Partnership: Igiugig Village and the U.S. Department of Energy, USA[320]
  - The Igiugig Village is located in remote southwestern Alaska; being heavily dependent on diesel fuels, this community partnered with the Department of Energy to build a resilient and autonomous microgrid via a river turbine system in order to have access to local, sustainable energy. A second system has been commissioned due to the success of the first system in providing clear, reliable, and affordable energy to village residents.[321]

315 http://newenergyevents.com/first-floating-solar-project-in-the-caribbean-to-be-built-before-the-end-of-2019/
316 https://www.irena.org/documentdownloads/publications/salinity_energy_v4_web.pdf
317 https://www.irena.org/documentdownloads/publications/salinity_energy_v4_web.pdf
318 https://tethys-engineering.pnnl.gov/publications/effects-water-pretreatment-extractable-salinity-gradient-energy-river-mouths-case
319 https://www.stiftung-klima-umwelt.org/assets/Practical-global-salinity-gradient-energy-potential_2016.pdf
320 Interview with an expert. Due to privacy policies name has been omitted.
321 https://www.energy.gov/sites/prod/files/2020/02/f71/101693.pdf.

- Multi-Functional Offshore Platform: MARINA Platform Project, EU/International[322]
  - This project was the first EU funded research and development project to analyze multi-purpose offshore renewable energy platforms. Fifteen research institutions partnered to develop a framework and methodology for implementing multi-purpose marine renewable energy platforms, including viable concept designs, survivability tests, and integration of power plans to onshore grids. Most notably, a new GIS system was created to integrate platforms into marine spatial planning and to identify potential benefits for various maritime stakeholders.
- Accelerating Testing of Prototypes: PacWave, Oregon, USA
  - Built on the Oregon Coast, PacWave is the first grid scale test facility that gives developers access to infrastructure and equipment needed to test small-scale prototypes and technology in real-world environments. The facility is expected to accelerate the research and design process of developing new technology.[323]

Uncertainties and Risks

Although the advantages of harnessing ocean energy are clear, there are significant barriers that hinder development and deployment in this sector. The harsh ocean environment poses a significant design challenge with a need for resilient equipment and technology; survivability of devices is a primary concern, as natural disasters such as hurricanes, can easily damage technology operating at sea. Access to capital is difficult, limiting tests to real environments as opposed to simulations, feeding a negative feedback system whereby commercial deployment is impeded due to high capital costs, long-term nature of investments and unproven technology.[324]

Drivers and Enabling Conditions

The key drivers of this sector have largely been research organizations and academia; however, an increasing number of government agencies and industry operators have identified the need for reliable energy at sea to power autonomous assets used for ocean maritime security, spatial planning, and activities related to offshore oil and gas drilling.[325] In order to efficiently take advantage of marine renewable energy, key environmental and regulatory conditions must be analyzed. Namely, deployed technology should match the environmental conditions specific to a geographic location; for example, in areas closer to the equator with minimal tides, tidal range technology would not generate usable power. Moreover, establishing grid management and equipment needed to manage the power that is generated highlights regulatory decisions needed to either feed the power into the main energy grid, or solely power local or rural communities. As the generated power can be very intermittent and dependent on weather conditions, wide-scale storage availability of renewable energy is also a key factor in stabilizing a current risk of renewable systems. Given system complexity, persistent political will and government investments in marine energy projects will be key for the acceleration and uptake of technology and the growth of this sector.

322 https://cordis.europa.eu/project/id/241402/reporting
323 http://pacwaveenergy.org/
324 Interview with an expert. Due to privacy policies name has been omitted.
325 Interview with an expert. Due to privacy policies name has been omitted.

Emergent Industry Sectors

Coastal Development, Protection and Habitat Restoration; Marine Products; Deep Sea Mining

Coastal Development, Protection and Habitat Restoration

Overview: Coastal protection and habitat restoration are considered emergent sectors of the blue economy, within which is contained the developmental concept of nature-based infrastructure (NBI), providing a more holistic approach to engineering solutions that can deliver ecosystem services and social benefits to vulnerable coastal communities.

In the Caribbean, resilience is heavily tied to the ability to adapt to climate change, as global sea level rise poses a particular threat to these small and low-lying states. Traditionally, this sector has been dominated by gray infrastructure (traditional engineering projects utilizing materials such as steel and concrete), but added pressures of sea level rise have led to innovative solutions utilizing the blue-gray design, which is a combination of traditional building techniques with nature-based infrastructure. This approach harnesses the power of ecosystem services by incorporating and supporting the growth of organic coastal protection, such as marshes and mangroves, to allow for natural adaptation to changing conditions.

Nature-based infrastructure is increasingly gaining attention for protection against coastal flooding and erosion during severe storms. While investments in traditional infrastructure types are common and considered attractive due to their proven risk and return profile, nature-based infrastructure currently offers more opportunity for return. As the sector matures, it is likely to offer both significant proven upfront investment opportunities as well as long-term efficiency gains.[326]

Forward thinking, planning, and investment in coastal infrastructure is crucial for the economic well-being and sustainability of economies in the Caribbean, as increased storm frequency and severity

[326] (Dennis Fritsch, 2020)

paired with sea level rise pose major threats to the most valuable properties and industries. There are potentially applicable learnings from the United States regarding the development of integrated environmental planning, in terms of both management techniques as well as the use of emerging technologies. Louisiana and Miami's long-term coastal management strategies, in particular, demonstrate applications and benefits of engineering with nature;[327] focusing on the sustainment and growth of naturally occurring ecosystems to stabilize coastlines in a cost-effective fashion.

Innovative Models and Initiatives

- KEEP Coastal Master Plan, Louisiana, USA
  - Following Hurricanes Katrina and Rita in 2005, the Louisiana Legislature created the Coastal Protection and Restoration Agency (CPRA), to coordinate the local, state, and federal efforts towards coastal protection and restoration. To accomplish these goals, CPRA created a master plan to guide work toward a sustainable coast and the actions required to sustain coastal ecosystems, safeguard coastal populations, and protect vital economic and cultural resources. Additionally, the master plan provides context to evaluate other activities in the coastal zone, including: transportation, navigation, and port projects; oil and gas development; ground water management and land use planning.[328]
- Jacobs Coastal Infrastructure & Tourism Initiative, Belize[329]
  - As part of the Belize's Sustainable Tourism Program, (STP) Government and IADB commissioned Jacobs to develop a Shoreline Management Plan to improve disaster and climate resilience along an 85-kilometer stretch of coastline in the Corozal District, where there is a strong tourism potential but significant coastal risk from sea level rise. Jacobs utilizes satellite imagery to develop and analyze key data sets, using a diverse set of information including topography, bathymetry, water quality, and land use to create a comprehensive a coastal resilience strategy.[330]
- Coral Reef Insurance Program, Quintana Roo, Mexico
  - A healthy coral reef can reduce up to 97% of a wave's energy before it hits the shore, reducing both the effects of storm surge and daily erosion to coastlines. However, coral reefs themselves can also be heavily impacted by hurricane damage, pollution, disease, overfishing, and bleaching. In the Mexican state of Quintana Roo, various stakeholders—the state government, hotel owners, The Nature Conservancy (TNC), and The National Parks Commission—have come together to pilot an innovative conservation strategy based around healthy corals. In 2018, Quintana Roo established the Coastal Zone Management Trust, which collects and manages funds for reef maintenance and repair. The trust has now purchased the first-ever coral reef insurance policy in order to ensure these ecosystems can be repaired after extreme storms.[331]

327 https://ewn.el.erdc.dren.mil
328 http://coastal.la.gov/our-plan/
329 https://www.jacobs.com/projects/Belize-Coastal-Resilience
330 https://www.jacobs.com/projects/Belize-Coastal-Resilience
331 https://www.nature.org/en-us/what-we-do/our-insights/perspectives/insuring-nature-to-ensure-a-resilient-future/

Uncertainties and Risks

There are relatively few uncertainties and risks associated with sustainable coastal development and habitat restoration, in large part because the central idea is simply allowing the natural environment to recover and thrive, rather than dramatically altering or destroying the existing ecosystemic balance. Implementation barriers include an initial cultural resistance to engineering with nature, difficulty in visualizing complex projects that can lead to a failure to obtain sufficient investment, and lack of necessary data-sharing. There is also a distinct need for long-term leadership and sufficient resources, as sustainable models based on natural growth and management take time and constant care.

If there is interest in engaging in a Payments for Economic Services (PES) scheme, the potential for increased income should be balanced against potential complications. Mangrove PES projects have been under design for years in countries such as Vietnam, but continue to be plagued by issues such as lack of agreement regarding the wide range of potential mangrove use and corresponding administrative classifications, a diversity of buyers and sellers who are often difficult to define/identify for which services, and the open access nature of mangrove systems themselves.[332]

Drivers and Enabling Conditions

Successful projects will require significant funding and multidisciplinary collaboration for comprehensive planning. Data inputs for these plans may already exist, but are likely siloed from one another, making it difficult to build a meaningful picture. In order to initiate this integration and ensure its longevity and success, there is a need for a leadership model that brings local and global stakeholders together to create a formal collaboration of regional actors. An important discipline to incorporate into this model is expert communicators and designers, as plans of this nature tend to require complex diagrams and visuals to make content understandable and engaging for a variety of audiences.

Marine Products

Overview: As global demand for naturally derived pharmaceuticals, cosmetics, and food products continues to grow, researchers and innovators have turned to the marine environment for novel compounds able to satiate burgeoning demand. A strong push towards identifying alternatives to fossil-fuel derived solutions is also driving exploration of marine-derived products for alternative uses, such as utilizing chitin from crustaceans or algae derivatives to create plastics.

The high potential for commercializing ocean products has shaped the development of marine biotechnology. In order to discover novel compounds, proteins, and organisms that can be commercialized across industries, gene sequencing and protein discovery technologies have so far been the primary focus of blue biotechnology innovation.[333] If marine products are developed in

[332] https://www.iucn.org/sites/dev/files/import/downloads/4__payment_for_ecological_services__pes__progress_in_vietnam__cf_.pdf

ways that fairly share benefit with the countries in which their chemicals were derived from, this industry has promising outlooks on building the resilience of SIDS.

Innovative Models and Initiatives

- Use of Marine Products in Livestock Feed, In research[334]
  - Studies have found that feed supplemented with certain types of algae significantly reduces the amount of methane produced by cattle throughout their digestion process. As the livestock industry comes under continued scrutiny for its GHG emissions, this finding is not only a promising investment for the meat industry, but also for SIDS able to supply algae for the carbon-sequestering feed.
- Shellworks[335] Crab and lobster shell-derived plastic substitute, London, England
  - With some commercial sales, Shellworks is a project by students from London's Royal College of Art and Imperial College London. The team uses waste shells from crustaceans to manufacture biodegradable products, including pots and sheets for packaging. This initiative is one of many around the world seeking to extract the valuable and durable chitin from lobster and crab shells and turn it into a substitute for plastic.[336]
- Marine Pharmaceuticals: Since the mid-1970s, academic, government, industrial, and private research laboratories have devoted varying levels of effort to the discovery of marine-derived pharmaceuticals. Some notable successes to date include the discovery of novel chemicals from marine organisms that have demonstrated potential as new treatments for cancer, infectious diseases, and inflammation. Exploration of deep sea environments and the isolation and culture of marine microorganisms offer two underexplored opportunities for discovery of chemicals with therapeutic potential.[337]

Uncertainties and Risks

This industry faces a unique threat from climate change and ocean acidification due to the precipitous decline in biodiversity being observed around the world, particularly in the Caribbean. In addition, there is a risk of bio-prospecting activities further destroying ocean ecosystems, where the potential long-term consequences remain undetermined. In addition, as with any new product development, there is risk of the manufacturing process relying on toxic or harmful chemicals, which contribute to environmental pollution. As is the case for a number of other sectors, research costs in the Caribbean can be extraordinarily high, due in large part to lack of access to local and affordable energy sources. Additionally, traditionally low levels of cooperation and knowledge sharing between Caribbean states to increase their bargaining power will need to be addressed in order to leverage the role of SIDS in the marine products industry.

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333 Hartmann et al., 2014. Proteomics Meets Blue Biotechnology: A Wealth of Novelties and Opportunities.
334 Interview with an expert. Due to privacy policies name has been omitted.
335 https://www.theshellworks.com/
336 Biotex SA
337 https://www.ncbi.nlm.nih.gov/books/NBK230700/

The most significant barrier for the Caribbean remains patenting and the associated costs of funding the proper research to catalog the biodiversity and marine biological resources found in the Caribbean; a region which has been historically exploited for biologically derived compounds to patenting law favoring developed nations.[338] Access to international registrars or research about the Caribbean remains largely restricted, either for proprietary or academic purposes, and international disputes over the ownership of marine resources could lead to complications for benefit sharing agreements.

Drivers and Enabling Conditions

Developing marine products is a complex process, requiring careful coordination between research institutions, private firms, and international agencies to oversee patenting. As the most important component of this process is ownership, prioritizing legislation and frameworks that allow for Caribbean states to retain control of their biodiverse resources should be the first priority.[339] This process most notably involves building the capacity of local researchers to formally submit biodiversity findings to international registrars; making national governments the most important stakeholders in developing these policies.

To ensure that these policies are followed, private company stakeholders and nearby national actors will need to be present. Marine products do not follow national boundaries, making the utilization of joint-ventures and/or regional coordination integral to the success of patenting.[340] Additionally, the private sector will need to be brought into all investments because fears exist that in the Caribbean that by enforcing strict access regulations to bio-prospectors that companies will look elsewhere.[341]

Deep Sea Mining

Overview: As terrestrial mining resources become increasingly scarce, deep sea mining is being considered as an alternative to supply a seemingly never-ending demand for valuable minerals and metals. While there are concerns for the industry's environmental impacts on the marine environment if this industry can even fit into the blue economy, deep sea mining is also becoming increasingly recognized as a potentially less harmful, wasteful mechanism to supply minerals and metals in comparison to the terrestrial mining industry.[342]

An emerging sector, the industry is currently in its exploratory phase and focused on developing commercial technology for the mineral and metal extraction process.[343] The most targeted resources are polymetallic nodules, as they contain nickel, copper, cobalt and other minerals and metals necessary for electrical wiring in high demand commodities like phones and electric

338 Interview with an expert. Due to privacy policies name has been omitted.
339 Interview with an expert. Due to privacy policies name has been omitted.
340 Interview with an expert. Due to privacy policies name has been omitted.
341 Interview with an expert. Due to privacy policies name has been omitted.
342 Interview with an expert. Due to privacy policies name has been omitted.
343 Interview with an expert. Due to privacy policies name has been omitted.

vehicles.[344] Monitoring of deep sea mining activities is split between international waters and national jurisdictions. The International Seabed Authority, an intergovernmental body based in Jamaica, regulates mining in international waters outside of country Economic Exclusive Zones (EEZs), while national governments are responsible for regulating activities in their EEZs.

Innovative Models and Initiatives

- Patania: Prototype Module Collector, Central Pacific Ocean[345]
  - Developed by Global Sea Mineral Resources (GSR), this prototype was developed in stages to optimize and improve nodule collector technology. Patania I was tested in 2017 to examine how it can drive along the seafloor while limiting environmental impacts,[346] and evolved into Patania II, which will collect nodules but not take them up to the surface and is expected to be tested in late 2020.
- DeepData database,[347] International
  - Created by the International Seabed Authority (ISA) in 2019, this database serves as a centralized repository for marine scientific researchers and contractors to access information regarding exploration activities, data, maps, and relevant publications as they relate to biological, physical, and geochemical parameters of marine ecosystems. The goal of this database is to support the ISA in the most effective management of exploration and exploitation activities, as well as ensuring the protection of the marine environment and equitable sharing of knowledge.
- Deep-Sea Mining, Papua New Guinea (PNG)
  - Since its issuing in January 2011, PNG remains the only country in the world to have granted a mining lease (ML154) for a commercial deep-sea mining project, Solwara 1, to Nautilus Minerals.[348] A highly contested program and partnership between the government of PNG and Nautilus, the project is still in design, and now owned by Deep Sea Mining Finance Limited (DSMF), a privately-owned group aiming to become the first in the world to mine Seafloor Massive Sulphide (SMS) deposits commercially. SMF is a joint venture between international holding group "USM Holdings Limited" and Sultanate of Oman group "MB Holding Company LLC".[349]

Uncertainties and Risks

Due to the significant amount of investment capital required for research and development, equipment, and implementation, individual countries often lack the capacity to fund and execute mining projects on their own, forcing partnerships with privately funded companies. Currently, the

344 Is Deep Sea Mining Part of the Blue Economy?
345 Interview with an expert. Due to privacy policies name has been omitted.
346 https://www.reuters.com/article/us-deep-sea-mining/belgian-fast-moving-caterpillar-in-deep-sea-copper-cobalt-race-idUSKCN1QG1B1
347 https://www.isa.org.jm/marine-scientific-research
348 https://link.springer.com/article/10.1007/s11625-019-00752-2
349 https://dsmf.im/solwara-1/

majority of industry interest is limited to the Pacific Islands region; the closest exploratory leases to the Caribbean exist in the Mid-Atlantic ridge.[350] Moreover, the existence of mining resources remains largely unknown in the Caribbean; with more systematic mapping and examination of the seafloor in the region, interest in mining activities from the private sector may grow.

Although viewed as a more environmentally sound alternative to terrestrial mining, there are growing concerns among the scientific community for the effects of seabed mining on surrounding ecosystems, water quality, and potential biodiversity loss. As environmental impacts are incompletely known, further analysis will be vital to fully understand the scope of environmental degradation incurred by seabed mining, as well as how these issues can be mitigated to fit into the blue economy context.[351] Furthermore, the perceived environmental risks influence stakeholder perception and potential funding and investment opportunities for commercial operations; thus, completely and thoroughly illuminating environmental impacts from extraction processes is key for increasing investment in the industry. Additionally, there is a substantial financial risk due to the large funds required for the whole extraction process from beginning to end.[352]

Drivers and Enabling Conditions

The key driver for commencing exploitation activities is the increasing push to recognize seabed mining as an environmentally sound alternative to terrestrial mining.[353] Terrestrial mining can not only produce toxic by-products that have significant impacts on biodiversity and human health,[354] but also has significant social inequality concerns, such as displacing local communities for new extraction sites.[355] In the marine environment, targeted minerals and metals are often located within the same extraction site, while terrestrial sources tend to be more isolated, requiring increased extraction time, labor, and physical destruction for each resource extracted.[356] Although profit is a key driver from both industry and country perspectives, the growth of the deep sea mining industry as a whole has largely stemmed from the opportunity to minimize terrestrial mining effects while still producing high-demand metals.

Knowledge regarding the existence, location, and quality of nodules or vents in a country's EEZ is needed to commence exploitation, and it requires a colossal amount of capacity to conduct deep sea surveys and general exploration activities. Additionally, pragmatic regulations and binding agreements will need to be developed to both protect the host country while ensuring that extraction activities are technologically and economically feasible.[357]

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350 Interview with an expert. Due to privacy policies name has been omitted.
351 Is Deep Sea Mining Part of the Blue Economy?
352 Interview with an expert. Due to privacy policies name has been omitted.
353 https://www.reuters.com/article/us-deep-sea-mining/belgian-fast-moving-caterpillar-in-deep-sea-copper-cobalt-race-idUSKCN1QG1B1
354 https://www.isa.org.jm/marine-scientific-research
355 https://link.springer.com/article/10.1007/s11625-019-00752-2
356 https://dsmf.im/solwara-1/
357 Interview with an expert. Due to privacy policies name has been omitted.

To date, the ISA has licensed 30 exploration contracts, largely to private companies and a few state entities, and is working to establish exploitation regulations so that exploration can commence.[358] Although the technology for deep sea mining continues to progress, it is not yet available or ready for large-scale commercial extraction.[359] Momentum in this industry will depend on the establishment of concrete regulations, research and development for extraction technology, and the adoption of a precautionary approach towards exploitation in the face of incompletely understood environmental impacts and degradation.

Summary of the Blue Economy Industry Sector Trends

The eleven industry sectors reviewed in the previous section all have the potential to contribute to growth of ocean-related economic activity (**Table 21**). However, the blue economy defined herein (and bolstered by conversations with experts in the field) requires that industry sectors contribute not just to economic growth, but to positive development of social and environmental conditions for local communities and natural habitats. Innovations in technology are helping to bring greater access, transparency, and accountability—as well as cost efficiencies—to many of these sectors. These developments can help both mature and emergent industries meet more stringent definitions of blue economy if properly applied. The next section reviews some of the latest technological developments and their application across these different industry sectors.

358 Interview with an expert. Due to privacy policies name has been omitted.
359 Interview with an expert. Due to privacy policies name has been omitted.

Table 21: Summary of Blue Economy Industry Sector Activities, Drivers, and Barriers.

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Mature/Existing Blue Economy Sectors				
Fishing	• **Pelagic fishing** • **Reef finfish** • **Crustacean and shellfish fishing** • Fishing • Processing • Marketing and Sales • Logistics • Fisheries science and management	• Rising demand globally and overexploitation • Significant lack of data affecting most fisheries- • Great potential for GIS and spatial • Emphasis on traceability and data-rich supply chains. • Interest in more sustainable seafood includes growing pressure to reduce waste and bycatch	• End-buyer sustainable sourcing commitments • Improved tech for monitoring fleet activity • Need for data • Decreasing stocks and increasing seafood demand	• Fisheries as a "commons" • Rising demand with limited enforcement • Lack of private investment • Science and management missing
Coastal & Marine Tourism	• **Cruise tourism** • **Beach/leisure tourism** • **Adventure and ecotourism** • Water activity rentals and gear • Diving and dive operations • Whale watching and nature viewing at-sea • Marketing, branding • Beach-related tourism • Restaurant and retail related to tourism market	• Before the COVID-19 outbreak, coastal tourism was expected to grow significantly and likely at a faster rate than tourism as a whole. However, a rapid recovery is unlikely to happen in 2020. Europe was expected to be the region concentrating the most tourist arrivals with over 700 million international arrivals, followed by Asia and the Pacific with over 500 million arrivals in 2030. Marine tourism is a viable pathway to support conservation of marine biodiversity while maintaining economic value.	• Rising demand globally and overexploitation • Significant lack of data affecting most fisheries- • Great potential for GIS and spatial • Emphasis on traceability and data-rich supply chains. • Interest in more sustainable seafood includes growing pressure to reduce waste and bycatch	• Fisheries as a "commons" • Rising demand with limited enforcement • Lack of private investment • Science and management missing

Table 21: Summary of Blue Economy Industry Sector Activities, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Shipping	• **Maritime fleet transportation** • **Boat Building** • **Repairs and maintenance of ships and boats** • Transport and trade • National and international permit and policy	• Recent years have witnessed a rise in application of digital software technologies to improve coordination, regulation, and efficiencies in the global shipping industry. • Greening of the global shipping industry is also underway, driven by international regulations, positive incentive programs, and advancements in new technologies, especially regarding decarbonization of shipping and cleaning of air emissions. • Within the Caribbean region, a growth of the shipping sector coincided with the 2016 widening of the Panama Canal.	• Increase in trade volume and trade distance • Cheaper alternatives to air, rail and freight transport	• Ships owners are concerned with the technical risk, capital and hidden costs • Lack of innovative financing solution to overcome the high capital investment • Lower volume of trades since covid-19
Oil and Gas	• **Exploration** • **Extraction** • **Support activities** • Biological and mineral resource mapping and valuation • Extraction • Processing • Transport	• Offshore oil production will significantly increase in the upcoming years, with a larger proportion of deep-water facilities and a relative decrease in shallow-water fields. While important offshore fields are being exploited in Guyana and Suriname, other Caribbean countries might offer great potential for the industry, including in Cuba, the Dominican Republic, Jamaica, Honduras, Nicaragua and the Bahamas. Meanwhile, Trinidad and Tobago hold one of the most coveted oil and gas basins in the world. Offshore oil and gas production represented approximately a third of value added by ocean-based industries, according to the OECD.	• Foreign Drilling companies • Ocean observation technology • Big data analysis	• Growing pushback against further fossil fuel development due to climate change and environmental risk • Recent drop in price • Capital intensive and requires large investment

Table 21: Summary of Blue Economy Industry Sector Activities, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Growth Blue Economy Sectors				
Mariculture	• **Finfish marine aquaculture** • **Shellfish and freshwater aquaculture** • **Offshore aquaculture** • Farm construction and maintenance • Marketing and Sales • Logistics • Feed science • Breeding and selection	• At the industrial or commercial level, mariculture tends to be single-species in focus, but there is an increasing trend towards integrated multi-species approaches, including finfish, shellfish, and seaweeds. • Diversification beyond food • Research and development for farmed fish health • Movement away from fish-based feeds to those that rely on plant or insect-based proteins or utilize scraps from seafood processing	• Improvement programs such as FIPs • Electronic monitoring and reporting systems • Blockchain Traceability • Blended capital solutions	• Need of market expansion beyond US and EU • Important risk for private capital investments • Lack of fisheries data • ineffectiveness of policies and management • Poor access to infrastructure
Maritime Surveillance & Safety	• **Surveillance** • **Monitoring** • **Enforcement** • Biological and mineral resource mapping and valuation • R&D • Technology implementation • Data analytics and response coordination (national and international) • Inspection	• Regional multinational alliances for surveillance and monitoring • Use of big data for better analytics • Smart vessels and ports • At the industrial or commercial level, mariculture tends to be single-species in focus, but there is an increasing trend towards integrated multi-species approaches, including finfish, shellfish, and seaweeds. • Diversification beyond food • Research and development for farmed fish health • Movement away from fish-based feeds to those that rely on plant or insect-based proteins or utilize scraps from seafood processing	• Regional cooperation and coordination • Clear-defined maritime boundaries by surrounding nations • Technologies such as satellite tracking, marine GIS and remote and field sending	• Lack of communication between parties due to security based and economic reasons • Lack of agreement in data-sharing between governments and industry • High upfront investment cost

Table 21: Summary of Blue Economy Industry Sector Activities, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Ports	• **Port Construction** • **Port management** • **Infrastructure maintenance** • **Logistics and cargo Handling** • Construction and infrastructure maintenance • Data capture and verification • Inspection • Warehousing and storage	• Increase in understanding and application of the role of ports in relation to illegal activities • Digital technology and automation of port operations. • Green ports	• Policy incentives • Local investment, technical training and capacity building • Increase in political investment in port safety	• Climate change threatens the water level in ports, sea level rises and extreme weather become more consistent • Social and environmental injustice associated with port-surrounding communities with high levels of air and water pollution
Emergent				
Renewable Energy	• **Offshore wind** • **Wave/tidal energy** • **Ocean driven thermal energy** • **Solar** • Biological and mineral resource mapping and valuation • R&D • Coastal and offshore infrastructure • Prototype testing • Power generation, transfer, storage	• The marine environment presents a relatively untapped energy source and offshore installations are likely to produce a significant proportion of future energy production. • Renewable marine technologies are still in their research and development phases, with tidal stream and wave power showing the most promise for future commercial applications in the next five to ten years, respectively. • Marine renewable energy installations may increase local biodiversity and potentially benefit the wider marine environment when installations have the capacity to act as both artificial reefs and fish aggregation devices.	• Increased energy demand • Cost-effectiveness • Low carbon energy system • Energy security • Indirect economic impact by cutting down reliance on imported fuels	• Large initial investment cost • High operation and maintenance costs • Skilled workforce in this sector is not common • Institutional structure of energy sector in countries may lag behind

Table 21: Summary of Blue Economy Industry Sector Activities, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Coastal Development & Protection	• **Marine related construction (infrastructure development)** • **Nature-based resilient coastal infrastructure** • **Habitat protection and restoration** • **Carbon sequestration** • Permitting • Zoning and planning • Construction of commercial, residential, and industrial use • Habitat protection, restoration • Engineering with nature	• Pressures of sea level rise have led to innovative infrastructure design known as blue-gray design, which is a combination of traditional building techniques with nature-based infrastructure. • Nature-based infrastructure offers more opportunity for return and is likely to offer both significant proven upfront investment opportunities as well as long-term efficiency gains. • Habitat restoration harnesses the power of ecosystem services by incorporating and supporting the growth of organic coastal protection, such as marshes and mangroves, to allow for natural adaptation to changing conditions.	• Increased adaptation planning can help vulnerable groups • Enhance innovative and multifunctional measures • Decrease flood risks and costs	• Fragmentation of knowledge and expertise in multifunctional measures • Local stakeholders in the risk management planning and decision-making practice is dependent on local capacity • Financial capacities
Marine Products	• **Pharmaceutical and cosmetics** • **Food products** • **Fertilizers** • **Chemicals and plastics** • **Other** • Biological and mineral resource mapping and valuation • R&D • Marketing and branding • Processing • Logistics (export and domestic)	• The high potential for commercializing ocean products has shaped the development of marine biotechnology. • Drug discovery from marine natural products has enjoyed a renaissance in the past few years. • Marine resources have demonstrated great cosmetic prospective having several health benefits like anti-inflammatory, anti-allergic, anti-aging and anti-wrinkling effects.	• Opportunity to substitute away from scarce resources • Optimize efficiency and reliability of marine sources	• Current market is still passive towards marine products for use outside of consumption • Availability of reliable suppliers/ products • Initial investment in product is risky • Concerns about quality of products

Table 21: Summary of Blue Economy Industry Sector Activities, Drivers, and Barriers. (cont.)

Sector	Subsectors/ Activities	Future Trends	Sector Drivers	Sector Barriers
Deep Sea Mining	• **Extraction of minerals** • **Extraction of marine aggregates (sand and gravel)** • **Seabed mining** • Deep-sea habitat mapping and resource valuation • International policy development • R&D of equipment	• Deep sea mining is currently in its exploratory phase and focused on developing commercial technology for the mineral and metal extraction process. The most targeted resources are polymetallic nodules, as they contain nickel, copper, cobalt and other minerals and metals necessary for electrical wiring in high demand commodities like phones and electric vehicles. Monitoring of deep-sea mining activities is split between international waters and national jurisdictions.	• Policy incentives • Local investment, technical training and capacity building • Increase in political investment in port safety	• Climate change threatens the water level in ports, sea level rises and extreme weather become more consistent • Social and environmental injustice associated with port-surrounding communities with high levels of air and water pollution

Appendix B: Technological Applications in Blue Economy Industries

Mariculture

Table 22: Summary of Blue Economy Technologies and their Applications to Mariculture.

No.	Industry	Technology	Readiness	Description
1	Mariculture	AI	Low	Robotic fish utilize AI swarm intelligence (SI), to detect pollution underwater, operating as a group able to navigate their environment, avoid obstacles, recharge themselves at charging stations and make decisions autonomously of humans. The introduction of AI can reduce overexploited fish species through camera and data collection systems that use AI to identify species and enable greater accountability of harvesting practices.[360]
2	Mariculture	AR/VR	Medium	One of the most promising ways to incorporate AR into the aquaculture industry is for use in teaching and instructional purposes. As one example, the Norwegian University of Science and Technology (NTNU) designed an aquaculture simulator using virtual reality and AR, incorporating Oculus Rift's technologies. The program has been designed to teach about fish welfare, disease prevention, escaping fish and dangerous working conditions.[361]
3	Mariculture	Biotechnology	Medium	Biotechnology can be used to identify and combine traits in parental fish and shellfish to increase productivity and improve product quality. Additionally, it can improve existing productivity through feed additives, vaccines, and other pharmaceutical agents.[362]
4	Mariculture	Blockchain	Medium	Blockchain in aquaculture is used to encourage transactions between suppliers and purchasers to occur immediately and safely. Electronic trade can save the added expense of transaction and currency exchanges. Furthermore, information about individual harvest and production methods can be stored here and made accessible to other producers and consumers; and fish that is claimed as sustainably produced can be verified.[363]

[360] https://www.alltech.com/blog/8-digital-technologies-disrupting-aquaculture
[361] https://www.alltech.com/blog/8-digital-technologies-disrupting-aquaculture
[362] https://www.alltech.com/blog/8-digital-technologies-disrupting-aquaculture
[363] http://www.fao.org/3/ca8751en/CA8751EN.pdf

Table 22: Summary of Blue Economy Technologies and their Applications to Mariculture. (cont.)

No.	Industry	Technology	Readiness	Description
5	Mariculture	Drones	High	Drones offer applications for aquaculture both above and below the water. They can be utilized for monitoring offshore fish farms and can take on any number of tasks that currently require costly specialized human intervention, such as visual evidence of fish health, or inspecting underwater cages for damage or holes.[364]
6	Mariculture	GIS & Spatial Mapping	High	GIS-based planning tools can be used to assess and map a range of overlapping indicators; including economic, environmental, inter-sectoral and socio-cultural risks and opportunities for proposed aquaculture systems. In projects like Aquaspace, shared datasets allow for detailed reports and graphics, allowing key stakeholders such as planners or licensing authorities to evaluate and communicate alternative planning scenarios and to make more informed decisions.[365]
7	Mariculture	Nanotechnology	Medium	Nano–enabled technologies can be used for the removal of contaminants from water. In the form of activated materials like carbon or alumina, with additives like zeolite and iron containing compounds, nanomaterials can be used for holding aerobic and anaerobic biofilm for the removal of ammonia, nitrites and nitrate contaminants. Likewise, ultrafine nanoscale powder made from iron can be used as an effective tool for cleaning up contaminants such as trichloroethane, carbon tetrachloride, dioxins and polychlorinated biphenyl.[366]
8	Mariculture	Robotics	High	Robot feeders were developed to overcome labor concerns and introduce a semi-automatic process for the sake of efficacy. Dried food can be dispensed in various forms such as pellets, sticks, tablets or granules into tanks or ponds in a controlled manner for a set amount of time. The automatic fish feeder is controlled by a digital timer and is capable of feeding fish in accordance with a predetermined time schedule without the presence of an operator.[367]
9	Mariculture	Sensors	Medium	Biosensors in aquaculture can help to create efficiencies through the analysis of oxygen levels and water temperature; pH levels, heart rate and metabolism. Some sensors are even capable of detecting the hunger level of the fish and can then feed them accordingly.[368]

364 https://www.alltech.com/blog/8-digital-technologies-disrupting-aquaculture
365 https://www.sciencedirect.com/science/article/pii/S0048969718301554
366 https://www.longdom.org/open-access/nanotechnology-a-novel-tool-for-aquaculture-and-fisheries-development-2150-3508.1000016.pdf
367 https://www.researchgate.net/publication/268285832_Development_of_Automatic_Feeding_Machine_for_Aquaculture_Industry
368 https://www.alltech.com/blog/8-digital-technologies-disrupting-aquaculture

Coastal Development

Table 23: Blue Economy Technologies and their Application to Coastal Development.

No.	Industry	Technology	Readiness	Description
10	Coastal Development	AI	Low	AI can improve tourist safety by detecting sharks and other potential threats using real-time aerial imagery. The system analyses streaming video from a camera attached to a drone to monitor beaches for sharks, issue alerts, and inform rescues. The program uses deep learning to identify all objects in the scene and provides both a visual indication on the computer screen and an audible alert to the operator.[369]
11	Coastal Development	AR/VR	Medium	Coastal communities face numerous challenges caused by sea level rise, many of which are hard to visualize. Virtual reality technology is being used to show residents and city planners what will happen to their community if they do not take steps to mitigate the effects of climate change. Users can visualize communities and shorelines from a bird's-eye view,as well as being able to control virtual sea level rise as narration explains what the viewer is seeing and what will happen to the area in question.[370]
12	Coastal Development	Biotechnology	Medium	Modifying the composition and surface texture of concrete can improve the capabilities of concrete based coastal and marine infrastructure (CMI) to support enhanced marine fauna and flora growth. Additionally, there is the potential to provide valuable ecosystemic and economic services such as elevated water quality, increased operational lifespan, structural stability, and absorption of hydrodynamic forces.[371]
13	Coastal Development	Blockchain	--	N/A
14	Coastal Development	Drones	High	*See Robotics
15	Coastal Development	GIS & Spatial Mapping	High	GIS can be used as a land-use planning tool for coastal areas, helping to calculate exposure to coastal erosion of buildings and infrastructure. The approach not only produces current and future images of buildings and infrastructure exposed to erosion, but also provides an original land-use planning and intervention tool for coastal zones.[372]

369 https://theconversation.com/sharkspotter-combines-ai-and-drone-technology-to-spot-sharks-and-aid-swimmers-on-australian-beaches-92667

370 https://miamibeachtimes.com/politics/new-virtual-reality-project-shows-threat-of-sea-level-rise-in-coastal-communities/

371 https://www.researchgate.net/publication/275886767_Ecologically_Active_Concrete_for_Coastal_and_Marine_Infrastructure_Innovative_Matrices_and_Designs

372 https://www.tandfonline.com/doi/full/10.1080/19475705.2017.1294114

Table 23: Blue Economy Technologies and their Application to Coastal Development. (cont.)

No.	Industry	Technology	Readiness	Description
16	Coastal Development	Nanotechnology	--	N/A
17	Coastal Development	Robotics	High	Water temperature and salinity can provide clues to hurricane severity--warmer surface waters lead to stronger hurricanes, and salt content can affect the temperature of the ocean surface. Robotic, unmanned gliders can be equipped with sensors to measure salt content and at different depths. The gliders, which can operate in hurricane conditions, collect data during dives and transmit it to satellites upon surfacing; providing predicted hurricane data based on temperature differentiation and salinity levels.[373]
18	Coastal Development	Sensors	High	*See robotics

Deep Sea Mining

Table 24: Blue Economy Technologies and their Applications to Deep Sea Mining.

No.	Industry	Technology	Readiness	Description
19	Deep Sea Mining	AI	Low	Multi-functional autonomous robots are frequently paired with technologies such as AI to increase capabilities and efficiencies. In the case of projects such as the ARIM (Autonomous Robotic sea-floor Infrastructure for bentho-pelagic Monitoring) AI is used to guide and control an autonomous mobile seafloor crawler system; which includes navigation, autonomous obstacle avoidance and automatic identification of species. These monitoring activities provide spatial-temporal data for the scientific evaluation of marine ecosystems and are the basis for meeting environmental standards required for subsea activities such as deep-sea mining, offshore oil and gas, and ocean renewables.[374]
20	Deep Sea Mining	AR/VR	--	N/A
21	Deep Sea Mining	Biotechnology	--	N/A
22	Deep Sea Mining	Blockchain	--	N/A

[373] https://www.noaa.gov/stories/robots-probe-ocean-depths-in-mission-to-fine-tune-hurricane-forecasts
[374] https://krakenrobotics.com/kraken-awarded-900000-contracts-for-evaluation-of-seavision-sensors-and-artificial-intelligence-software/#.

Table 24: Blue economy Technologies and their Applications to Deep Sea Mining. (cont.)

No.	Industry	Technology	Readiness	Description
23	Deep Sea Mining	Drones	Low	*See Robotics
24	Deep Sea Mining	GIS & Spatial Mapping	Low	*See Sensors
25	Deep Sea Mining	Nanotechnology	--	N/A
26	Deep Sea Mining	Robotics	Low	Polymetallic nodules, also called manganese nodules, sit on top of the seabed and can be collected without drilling or having to move rocks or dirt. They are made of almost 100% usable minerals, compared to ores mined from the land which have increasingly low yields (some close to 1%). In comparison, nodule collection generates 99% less solid waste and generates no known toxic waste.[375]
27	Deep Sea Mining	Sensors	Low	GIS mapping combined with advanced sensor technologies such as 3D sonars, 3D lasers, chemical sensors and gravity gradiometers allows scientists to generate a highly detailed geo-referenced 3D model of areas above and below the seabed. Combining these sensors into modular payloads provides for a single vehicle that can be reconfigurable to adapt to changing requirements through the life of ocean mining operations from initial surveys to operations to decommissioning.[376]

Fisheries

Table 25: Blue Economy Technologies and their Applications to Fisheries.

No.	Industry	Technology	Readiness	Description
28	Fisheries	AI	Low	AI in fisheries may be used in the future to offset the declining number of workers. AI systems can consider market demand and advise fishermen on how to adjust their catch accordingly to prevent fish prices falling due to overfishing. This can reduce both the working hours of fishermen and the fuel costs of fishing, stabilizing income while reducing waste to better protect natural resources. Image recognition with AI can also support greater traceability and fisheries science by identifying species.[377]
29	Fisheries	AR/VR	--	N/A

375 https://deep.green/nodules/
376 ftp://ftp.soest.hawaii.edu/bhowe/outgoing/IEEEOES_2013/papers/130401-001.pdf
377 https://medium.com/syncedreview/ai-provides-solutions-for-the-japanese-fishing-industry-9865cc15cc2f

Table 25: Blue Economy Technologies and their Applications to Fisheries. (cont.)

No.	Industry	Technology	Readiness	Description
30	Fisheries	Biotechnology	Low	Fish leather, like traditional leathers, is made by tanning animal skin, generally from salmon, cod, perch, and wolfish. Fish leather is thin, extremely strong for its size, and is highly sought by garment designers for its unique textures and finishes.[378] John Galliano, Prada, Christian Dior, Louis Vuitton and Salvatore Ferragamo have all sourced fish skin from Atlantic Leather for their collections and fashion shows at premium prices. Producers of luxury leather goods are increasingly turning to eco-alternatives, due to shortages in quality available leather and significant global demand.[379]
31	Fisheries	Blockchain	High	Blockchain has potential to significantly decrease illegal activities by supporting secure data transactions for traceability and sales. Blockchain technology can help track the journey of a single fish, recording information regarding where it was caught and how it was processed and sharing this information with system users as well as the end consumer.[380]
32	Fisheries	Drones	High	The use of underwater drones provides information that would be costly or even impossible to obtain through other means and provides a unique combination of three-dimensional data and underwater images. Using drone-collected data, it is possible to map different areas with contrasting vegetation, establish connections between fauna/flora species and local water quality conditions, or to observe variations of water quality parameters with water depth.[381]
33	Fisheries	GIS & Spatial Mapping	High	International initiatives such as Global Fishing Watch (GFW) use satellite tracking to monitor the activities of ships on the ocean and determine which ones are fishing based on the identity, speed and direction of the vessels. The tool uses a global feed of vessel locations extracted from Automatic Identification System (AIS) data collected by satellite, tracking the movement of vessels over time and automatically classifying the observed patterns of movement as either "fishing" or "non-fishing" activities.[382]

[378] https://www.fiskurleather.com/about-us.html
[379] https://www.wired.co.uk/article/fish-leather-shirts-sustainability-leather-demand
[380] https://www.weforum.org/agenda/2020/02/blockchain-tuna-sustainability-fisheries-food-security/
[381] https://www.researchgate.net/publication/340882094_Innovative_Water_Quality_and_Ecology_Monitoring_Using_Underwater_Unmanned_Vehicles_Field_Applications_Challenges_and_Feedback_from_Water_Managers
[382] http://www.globalfishingwatch.org

Table 25: Blue Economy Technologies and their Applications to Fisheries. (cont.)

No.	Industry	Technology	Readiness	Description
34	Fisheries	Nanotechnology	Medium	A radio frequency ID (Rfid) chip contains a radio circuit incorporating nanoscale components with an identification code embedded in it. These tags can hold different information as needed, be scanned from a distance, embedded in products for automatic identification, and used as a tracking device or as health monitors, tracking the metabolic rate, swimming patterns and feeding behaviors.[383]
35	Fisheries	Robotics	Low	Robots may be tasked with testing the quality of seafood in a standardized process. Currently, workers pick up fish and decide whether it meets food quality standards by smell, texture, and softness. A lab at Northeastern University in the U.S. has been developing algorithms for a robotic hand called Sawyer, which could be programmed to identify the ideal fish texture and softness with the goal of helping workers process more fish faster.[384]
36	Fisheries	Sensors	High	*See Drones

Marine Products

Table 26: Blue Economy Technologies and their Applications to Marine Production.

No.	Industry	Technology	Readiness	Description
37	Marine Products	AI	High	Drones used to monitor seaweed farms collect video which is stored into a cloud system and analyzed through image processing. Through this process, AI can identify locations of disease outbreaks and the red tides that affect seaweed production. AI can also utilize ICT buoys to collect data on local sea water qualities to try to understand causality between environmental factors, disease outbreaks, and red tides.[385]
38	Marine Products	AR/VR	--	N/A
39	Marine Products	Biotechnology	High	Seaweed based plastics products offer both an edible and biodegradable alternative to traditional plastics. Companies such as Notpla, in particular, focus on packaging for beverages and sauces that are made from a unique combination of seaweed and plants. Their products biodegrade in 4-6 weeks or can be eaten with the product inside (e.g. water pods).[386]

383 https://www.longdom.org/open-access/nanotechnology-a-novel-tool-for-aquaculture-and-fisheries-development-2150-3508.1000016.pdf
384 https://www.therobotreport.com/fish-project-robots-local-fisheries/
385 https://www.aiforsdgs.org/all-projects/ai-seaweed-aquaculture-saga-prefecture
386 https://www.notpla.com/products-2/

Table 26: Blue Economy Technologies and their Applications to Marine Production. (cont.)

No.	Industry	Technology	Readiness	Description
40	Marine Products	Blockchain	--	N/A
41	Marine Products	Drones	--	*See AI
42	Marine Products	GIS & Spatial Mapping	High	The Sargassum Watch System (SaWS) is designed to use satellite data and numerical models to detect and track sargassum in near real-time. Satellite data are provided by the U.S. NASA and USGS, then downloaded and processed through a Virtual Antenna System using both standard and customized algorithms. Of particular importance are the two customized data products, namely the floating algae index (FAI) to detect floating algae and other materials on the ocean surface, and the color index (CI) to trace ocean circulation features.[387]
43	Marine Products	Nanotechnology	Low	Algae belonging to the class *Cyanophyceae, Chlorophyceae, Phaeophyceae* and *Rhodophyceae* have been used as nano-machineries through intracellular and extracellular synthesis of gold (Au), silver (Ag) and several other metallic nanoparticles. Algae are a natural platform for the production of diverse nanomaterials (NMs), primarily due to the presence of bioactive compounds such as pigments and antioxidants in their cell extracts that act as biocompatible reductants. *Chlorella spp.* and *Sargassum spp.* have been extensively explored for the synthesis of nanoparticles with antimicrobial properties, which can potentially provide a substitute conventional antibiotic.[388]
44	Marine Products	Robotics	Low	Kelp forests provide up to 70% of the planet's oxygen as well providing natural mitigation against the intensity of incoming storms. Due to global climate change and overfishing, urchins are now disrupting the balance of underwater ecosystems and destroying the kelp forests. In response, companies are prototyping autonomous vehicles that can operate underwater for longer periods of time and identify targets — like urchins — for collection. As an additional benefit, the urchins may then be distributed for consumption or as an additional income source to local community members.[389]
45	Marine Products	Sensors	High	*See AI

387 https://optics.marine.usf.edu/projects/saws.html
388 https://www.sciencedirect.com/science/article/pii/S0167701218307863
389 https://hypepotamus.com/companies/marauder-robotics/

Maritime Safety and Surveillance

Table 27: Blue Economy Technologies and their Applications to Maritime Safety and Surveillance.

No.	Industry	Technology	Readiness	Description
46	Maritime Safety & Surveillance	AI	Medium	AI can analyze past accidents and come up with solutions to prevent future incidents, as well as alerting crew and sending warnings that an accident is likely or imminent. This same type of AI can also analyze large amounts of data to create the most risk-free navigational routes possible. AI may also be useful in tracking maintenance on ships and predicting when parts may fail or cause accidents or injuries.[390]
47	Maritime Safety & Surveillance	AR/VR	Medium	There is a significant investment being made in VR learning by companies utilizing this technology for jobs in complex and dangerous environments. VR provides a level of gamification that engages employees and makes the learning interactive and easier. Additionally, organizations can increase productivity and lower cost by making operations safer and more efficient. VR can also be used to test equipment and products in a virtual environment before they are produced, increasing quality and flexibility.[391]
48	Maritime Safety & Surveillance	Biotechnology	Low	The U.S. Navy Marine Mammal Program (NMMP) studies the military use of marine mammals - principally bottlenose dolphins and California sea lions - and trains animals to perform tasks such as ship and harbor protection, mine detection and clearance, and equipment recovery. The program is based in San Diego, California, where animals are housed and trained on an ongoing basis. NMMP animal teams have been deployed for use in combat zones, such as during the Vietnam War and the Iraq War.[392]
49	Maritime Safety & Surveillance	Blockchain	Medium	A blockchain platform can be used to establish a digital insurance value chain, connecting participants in a private network to a shared database in real time. Transactions that otherwise can take days can be processed automatically in minutes using computer algorithms with no need for third-party verification and can be paired with GIS to make insurance adjustments in real time based on vessel location.[393]

390 https://www.maritimeinjurycenter.com/2019/07/31/how-ai-and-automated-shipping-could-improve-maritime-safety/
391 https://safety4sea.com/visual-reality-transforming-training/
392 https://tethys.pnnl.gov/organization/us-navy-marine-mammal-program
393 https://www.ledgerinsights.com/blockchain-marine-insurance/

Table 27: Blue Economy Technologies and their Applications to Maritime Safety and Surveillance. (cont.)

No.	Industry	Technology	Readiness	Description
50	Maritime Safety & Surveillance	Drones	Medium	Drones have the capacity to extend the capacity of fisheries enforcement officials farther into the open ocean. Initiatives such as the FishGuard project aims to pair long range drones with artificial intelligence to allow the patrol of open ocean with minimal human supervision.[394]
51	Maritime Safety & Surveillance	GIS & Spatial Mapping	Medium	*See blockchain
52	Maritime Safety & Surveillance	Nanotechnology	--	N/A
53	Maritime Safety & Surveillance	Robotics	Low	Anti-piracy robots are under development, utilizing the already existing Recon Scout Throwbot platform used by military and law enforcement personnel. These robots are tiny, rugged, and versatile; able to survive throws of up to 120 feet while equipped with cameras or sensors needed to provide enforcement personnel with the information required to carry out safe operations.[395]
54	Maritime Safety & Surveillance	Sensors	Low	*See Robotics

Oil and Gas

Table 28: Blue Economy Technologies and their Applications to Oil and Gas.

No.	Industry	Technology	Readiness	Description
55	Oil & Gas	AI	Medium	The UK's first oil and gas National Data Repository (NDR), launched in March of 2019; containing 130 terabytes of geophysical, infrastructure, field and well data covering more than 12,500 wellbores, 5,000 seismic surveys and 3,000 pipelines. The NDR uses AI to interpret this data, to try to uncover new oil and gas prospects and enable more production from existing infrastructures.[396]

394 https://www.seafoodsource.com/news/environment-sustainability/drones-fisheries-enforcement-potential-remains-untapped-even-as-projects-advance
395 https://www.discovermagazine.com/technology/throwable-robot-can-climb-aboard-ships-spy-on-pirates
396 https://www.offshore-technology.com/features/application-of-artificial-intelligence-in-oil-and-gas-industry/

Table 28: Blue Economy Technologies and their Applications to Oil and Gas. (cont.)

No.	Industry	Technology	Readiness	Description
56	Oil & Gas	AR/VR	High	Augmented reality (AR), virtual reality (VR), and mixed reality (MR), can be combined to increase efficiency, improve safety compliance, and lower maintenance costs for oil and gas projects. Engineering and construction teams can visualize potential roadblocks before they arise, and experience projects before they are built. Re-creating various operating environments and conditions which are otherwise complex, remote, and potentially unsafe can help engineering and construction teams to function quickly and safely.[397]
57	Oil & Gas	Biotechnology	High	Biotechnology has been applied for environmental cleanup of oil spills and biological treatment of refinery wastes (bioremediation). Other emerging applications include oil exploration, microbial enhanced oil recovery (MEOR), biodesulfurization and bio denitrogenation of distillates, bio demetallation, bio upgrading of heavy crudes and refining residues, valorization of refining wastes, bioconversion of residual oil to methane, control of oil field souring and corrosion, and the formulation of petrochemicals.[398]
58	Oil & Gas	Blockchain	Low	Trading in petroleum (gasoline, diesel, jet fuel), is often challenging because the product is highly regulated, valuable, completely standardized, quality sensitive, and bulky. It passes through many hands (tank farms, barges, tankers, and pipelines) and title changes frequently mid-journey. A European consortium including BP, Shell, ABN-AMRO, Equinor, Total, Mercuria launched a pilot in 2016 that created VAKT, a blockchain-enabled reimagining of the trade relationship that serves as a digital ecosystem for physical post-trade processing. . In this use case, identity, contract, ownership, asset and money are involved.[399]
59	Oil & Gas	Drones	High	Drones are primarily used in the oil and gas industry for remote monitoring and surveillance, including infrastructure, equipment, tankers and trucks, and other assets. Drones can provide a 360-degree view to monitor field operations, observe construction progress, and provide encroachment detection. Remote monitoring using drones is also enabling oil and gas companies to inspect unmanned production platforms.[400]

397 https://www.stantec.com/en/services/oil-gas-digital-reality
398 https://www.frontiersin.org/articles/10.3389/fmicb.2017.00833/full
399 https://energynow.ca/2019/09/roundup-of-oil-and-gas-blockchain-developments-geoffrey-cann/
400 https://www.offshore-technology.com/comment/drones-oil-gas-applications/

Table 28: Blue Economy Technologies and their Applications to Oil and Gas. (cont.)

No.	Industry	Technology	Readiness	Description
60	Oil & Gas	GIS & Spatial Mapping	High	The Oil and Gas industry is driven by an estimated 80% of data that has a spatial component. This is the only industry that harnesses spatial information at every stage of the life-cycle, beginning with opportunity analysis and exploration, through appraisal and production, right up to the abandonment phase.[401] GIS can help enable efficient management of production processes and environmental assessments, while providing spatial data that can be used to incorporate future environmental changes and their impact on oil plans.[402]
61	Oil & Gas	Nanotechnology	Medium	Nanoparticles can be used for advanced imaging techniques during oil reservoir exploration, where they are able to function under the high temperatures and pressures and unknown chemical environments that pose problems for normal sensors. Nanosensors sent through the wellbore and then recovered as "nanodust" with extracted oil can provide data on the reservoir's characteristics and the nature of the fluid flow. Similarly, when extracting shale gas, nano-computerised tomography (an X-ray based imaging technique) can be used to create images of shales and pore structures. Nano-characterisation and nano-sensing technologies can also be used to determine the mineral composition and petrophysical properties of formations.[403]
62	Oil & Gas	Robotics	High	Robotics are applied to the oil and gas industry for a wide range of largely autonomous purposes, including the teleoperation of unmanned drilling and production platforms, under-water welding, welding robots for double hulled ships and under-water manipulators are key robotic technologies which have facilitated the transition of offshore rigs from shallow waters to open ocean.[404]
63	Oil & Gas	Sensors	High	Drones can be customised to include ultrasonic sensors and visual inspection technologies, such as video cameras and thermal imagers. These are used for carrying out close-range inspections of oil and gas assets to detect flaws or defects. Merging drone data with advanced data analytics also allows companies to predict the current health of the equipment and project potential malfunctions over time.[405]

401 https://www.gislounge.com/gis-in-oil-and-gas/
402 https://www.researchgate.net/publication/330566682_THE_ROLE_OF_GIS_IN_OIL_INDUSTRY_MANAGEMENT
403 https://nano-magazine.com/news/2018/5/30/the-role-of-nanotechnology-in-the-oil-and-gas-industry
404 https://www.sciencedirect.com/science/article/abs/pii/S0921889015002018
405 https://www.offshore-technology.com/comment/drones-oil-gas-applications/

Ports

Table 29: Blue Economy Technologies and their Applications to Ports.

No.	Industry	Technology	Readiness	Description
64	Ports	AI	Low	Machine learning can be used to improve situational awareness at ports by analyzing freight and logistics chains to reliably forecast vessel arrival and departure times. Additionally, computer vision can be applied to analyze and monitor cargo and vehicles in the port in real time to automate manual analysis, speed up cargo logistics planning, and improve detection of exceptional situations.
65	Ports	AR/VR	--	N/A
66	Ports	Biotechnology	Medium	Allowing and tracking port access can be time and resource intensive. Utilizing biometric systems such as hand scanners combined with smart chip cards with unique identifiers, it's possible to largely automate the entry process. Unlike badges or credentials, which can be forged, lost or stolen, and require personnel to man access points, a biometric system uses a unique human characteristic such as finger, eye or hand to verify identity quickly and automatically. All entries can later be referenced for legal purposes as needed.[406]
67	Ports	Blockchain	Medium	Blockchain permits multiple trading partners to collaborate by establishing a single shared view of a transaction without compromising details, privacy or confidentiality. Port and terminal operators, shipping lines, freight forwarders, and customs authorities can interact more efficiently through real-time access to shipping data and shipping documents, including IoT and sensor data ranging from temperature control to container weight.[407]
68	Ports	Drones	High	The geographical location and distribution of port areas increases their vulnerability. Drones can play a pivotal role in surveillance and security of port installations, capturing pictures and videos from a variety of angles in many locations. By combining drone data with stationary cameras, and even equipping drones with additional capabilities like facial recognition, port management could become dramatically more efficient.[408]

406 https://us.allegion.com/content/dam/allegion-us-2/web-documents-2/Article/Biometrics_at_Ports_109048.pdf
407 https://newsroom.ibm.com/2018-08-09-Maersk-and-IBM-Introduce-TradeLens-Blockchain-Shipping-Solution
408 https://www.ideaforge.co.in/blog/drones-in-port-operations/

Table 29: Blue Economy Technologies and their Applications to Ports. (cont.)

No.	Industry	Technology	Readiness	Description
69	Ports	GIS & Spatial Mapping	Medium	Port productivity may be increased through the use of location intelligence (LI), the visualization and analysis of geospatial data to improve understanding, insight, decision-making, and prediction. By adding layers of data—such as demographics, traffic, and weather—to a smart map, users gain location intelligence that describes why things happen where they do.[409]
70	Ports	Nanotechnology	--	N/A
71	Ports	Robotics	High	*See Drones
72	Ports	Sensors	Medium	*See Blockchain

Renewables

Table 30: Blue Economy Technologies and their Applications to Renewables.

No.	Industry	Technology	Readiness	Description
73	Renewables	AI	Low	AI can help with the integration of microgrids and managing distributed energy. When the community-level renewable energy generation units are added to the primary grid, it becomes hard to balance the energy flow within the grid. Given enough data, AI-powered predictions of energy input and flow could play a vital role in solving quality and congestion issues.[410]
74	Renewables	AR/VR	Medium	AR/VR is already used for wind farms and could easily be expanded to marine and/or solar resources. Using a AVR platform, students and trainees can simulate performing construction or repair of turbines. Hands on training helps students transfer learning concepts to practical application, solving one of the biggest issues training limited by cost and accessibility.[411]

409 https://storymaps.arcgis.com/stories/09f876480ffb49bbb3c0dcd7176f98df
410 https://www.imaginovation.net/blog/artificial-intelligence-in-renewable-energy/
411 https://eonreality.com/understanding-renewable-energy-with-ar-and-vr/

Table 30: Blue Economy Technologies and their Applications to Renewables. (cont.)

No.	Industry	Technology	Readiness	Description
75	Renewables	Biotechnology	Low	Synthetic biology can be applied to biofuel production by either developing more efficient enzymes to break down solid biomass or by engineering robust microbes that produce usable biofuel directly. Microbes are being engineered with synthetic DNA to produce novel enzymes—special proteins that accelerate chemical reactions—able to increase the rate at which biomass is broken down. Microorganisms can also be modified to produce renewable hydrocarbon fuels identical to petroleum-based gasoline, diesel, or jet fuel.[412]
76	Renewables	Blockchain	Low	Recent regulations require ships to incorporate more energy-efficient designs and utilize lower-sulfur fuels. Shipowners are testing and adopting an array of cleaner alternatives including hydrogen fuel cells, marine batteries, biofuels, and spinning metal sails. Blockchain can securely trace, batches of biofuels as they are created, processed, blended, and delivered; regardless of the number or geographic location of the stakeholders involved in this supply chain.[413]
77	Renewables	Drones	High	Conventional inspection typically requires a team of engineers to board the platform and use a series of ladders to climb up. Using drones, a maintenance team is able to deliver more detailed information without the risks associated with climbing, improving safety and increasing access to critical infrastructure data.[414]
78	Renewables	GIS & Spatial Mapping	High	Utilizing GIS technology and mapping, policymakers and planning commissions can more easily determine the optimal location for renewable energy projects GIS allows for deep analysis of wind potential, solar potential, distance to cities, population size, and cover type. Additionally, there is ability to inform planners of predicted social and environmental impacts in the area, offering a clear picture of which locations would be best to implement renewable energy resources.[415]

412 https://www.energy.gov/eere/articles/harnessing-biotechnology-accelerate-advanced-biofuels-production
413 https://grist.org/article/shipping-industry-takes-a-page-from-bitcoin-to-clean-up-its-act/
414 https://www.renewableenergymagazine.com/wind/drone-technology-improves-inspection-of-us-offshore-20181016
415 https://mapline.com/role-gis-renewable-energy/

Table 30: Blue Economy Technologies and their Applications to Renewables. (cont.)

No.	Industry	Technology	Readiness	Description
79	Renewables	Nanotechnology	Low	Nanotechnology can be applied to biomass production to enhance the bioavailability of plant nutrients, detect and treat diseases using smart sensors, and increase the efficiency of herbicide and pesticide application.[416]
80	Renewables	Robotics	Low	Prototypes of "kelp elevators" are currently being tested-- long tubes covered in seaweed that can be moved up and down in the water to access sunlight and nutrients. Company Marine BioEnergy wants to use similar technology with robotic submarines to begin kelp farming for conversion into carbon-neutral biocrude that could be used to make gasoline or jet fuel.[417]
81	Renewables	Sensors	Low	*See Nanotechnology

Shipping

Table 31: Blue Economy Technologies and their Applications to Shipping.

No.	Industry	Technology	Readiness	Description
82	Shipping	AI	Medium	AI software is capable of predicting the most economical route available in terms of fuel consumption by utilizing a combination of GIS and additional inputs. Factors such as weather, currents, and other variations are taken into account, and then the most efficient route is recommended, with initial tests indicating that this process can provide fuel savings of up to 3%.[418]
83	Shipping	AR/VR	--	N/A
84	Shipping	Biotechnology	High	Biopaint for ships is under development, valuable for an antifouling effect based on the direct contact of a fouling organism with biocide that resides within the coating itself.[419] Paint can be designed with natural biocides, which, rather than killing off marine growth, temporarily stimulate the octopamine receptor in the larvae of mollusks; causing them to be harmlessly repelled from the hull.[420]

416 https://www.longdom.org/open-access/nanotechnology-as-a-tool-for-enhanced-renewable-energy-application-in-developing-countries-2090-4541-1000e113.pdf
417 https://www.fastcompany.com/40458564/could-these-robotic-kelp-farms-give-us-an-abundant-source-of-carbon-neutral-fuel
418 https://www.ship-technology.com/features/ai-in-shipping/
419 https://phys.org/news/2016-01-solution-ships-marine-biofouling.html
420 https://www.coatingsworld.com/issues/2016-10-01/view_features/advances-in-antifouling-coatings-technology/

Table 31: Blue Economy Technologies and their Applications to Shipping. (cont.)

No.	Industry	Technology	Readiness	Description
85	Shipping	Blockchain	Medium	Blockchain is being effectively used within the shipping industry to provide a digital paper trail so that regulators and clients alike can verify that shipping companies are keeping their carbon-cutting promises.[421]
86	Shipping	Drones	Low	Hull cleaners are autonomous or semi-autonomous underwater robots used to scrub ship hulls clean while still in the water, both to avoid biofouling as well as to increase efficiency of movement and fuel savings while in the water.[422]
87	Shipping	GIS & Spatial Mapping	Medium	*See AI
88	Shipping	Nanotechnology	Low	Corrosion and biofouling are two major byproducts impacting vessel materials, durability and performance. New nanotechnology solutions are being explored in the form of nanostructured coatings using nanoparticulate substances. These coatings are capable of providing superior protection because they involve substances which form and interact on previously unreachable scales, in which the corrosion and biofouling processes begin.[423]
89	Shipping	Robotics	Low	*See Drones
90	Shipping	Sensors	Low	*See Drones

Tourism

Table 32: Blue Economy Technologies and their Applications to Tourism.

No.	Industry	Technology	Readiness	Description
91	Tourism	AI	High	Chatbots are ideal for customer centric-businesses and destinations. They can serve as 24/7 front-end customer care specialists and are capable of providing services at destinations after hours. Additionally, chatbots may be personalized to know key services elements such as guests' name, when their flight has arrived, preferred activities and brands, dietary needs, and additional factors as required for the level of personalization desired.[424]

421 https://grist.org/article/shipping-industry-takes-a-page-from-bitcoin-to-clean-up-its-act/
422 https://wp.wpi.edu/washingtondc/projects/projects-by-year/2015-2/analyzing-the-current-market-of-hull-cleaning-robots/
423 https://www.maritime-executive.com/corporate/nanotechnology-offers-solution-to-corrosion-and-biofouling
424 https://www.trilyo.com/blog/top-6-chatbots-that-are-transforming-the-hospitality-industry/

Table 32: Blue Economy Technologies and their Applications to Tourism. (cont.)

No.	Industry	Technology	Readiness	Description
92	Tourism	AR/VR	Medium	Countries such as Haiti are utilizing AR programs to create virtual tours of their nation's most popular destinations to try to maximize tourism potential. Programs provides users with educational information on culture, architecture and history through 3D tours in several languages, and are focused on attracting more visitors by bringing Haiti to the forefront of the region's tourism industry.[425]
93	Tourism	Biotechnology		Rapid detection of pathogens or viruses using biosensors. Novel nature-based surface coatings and disinfectants
94	Tourism	Blockchain	--	N/A
95	Tourism	Drones	Medium	*See AR/VR
96	Tourism	GIS & Spatial Mapping	High	A GIS-based approach for information management in ecotourism is based on a multilevel analysis including economic data collection, annual visitor trends, spatial analysis, and layered financial and ecological values. GIS is able to combine these diverse images and data points into one figure, which can then be utilized for improved planning and management purposes.[426]
97	Tourism	Nanotechnology		Metal nanoparticles, carbon nanotubes, metal oxide nanoparticles, and graphene-based materials have all demonstrated enhanced antimicrobial and antiviral activity. Antimicrobial, Antiviral, and Antifungal nanocoatings are available in various material compositions for healthcare and household surfaces, to protect against corrosion and mildew, and for water and air purification. Nanocoatings also reduce surface contamination, are self-cleaning, water-repellent and odor-inhibiting, reducing cleaning and maintenance costs.[427]
98	Tourism	Robotics	Low	In recent years, a number of hotel chains have adopted Automated Guided Vehicles (AGVs) to carry out delivery services, from drinks to towels, in hotel rooms. Usually, the guest completes the request (a comb or a snack, for example) using the phone or mobile app. Relying on GPS, a robot collects the object requested, then enters an elevator and tells the guest it has arrived via phone.[428]
99	Tourism	Sensors	--	N/A

425 https://ascape.com/blog/2019/1/25/experience-the-caribbean-through-augmented-reality-amp-virtual-reality

426 Advanced in Control Engineering and Information Science: A GIS-based approach for information management in ecotourism region

427 PR Newswire Association. "Global Market for Antimicrobial, Antiviral and Antifungal Nanocoatings 2020: Focus on Future Preventative Measures After COVID-19 Pandemic." *CISION PR Newswire*, 21 May 2020, www.prnewswire.com/news-releases/global-market-for-antimicrobial-antiviral-and-antifungal-nanocoatings-2020-focus-on-future-preventative-measures-after-covid-19-pandemic-301063755.html.

428 Tanner, Daniel A. "Robots in Tourism Are More Popular | .TR." *Tourism Review News*, 17 Sept. 2018, www.tourism-review.com/robots-in-tourism-are-growing-in-numbers-news10740.

Appendix C:
SIDS Blue Economy Rapid Assessment Tool Guide

Introducing New SIDS Blue Economy Foresight Tool

Originally pioneered by Small Island Developing States (SIDS), the concept of a blue economy — where environmental and social benefits are married to economic gains from the responsible use of ocean resources and space — offers enormous opportunities for nations whose territorial waters far exceed that of their land masses. Yet, determining the best path for developing the blue economy is not obvious, nor easy. The ever-growing list of possible blue economy activities, constantly shifting technological landscape, and inherent challenges of development for small islands, creates a unique set of obstacles that SIDS must navigate in order to identify promising, best-fit solutions.

The SIDS Blue Economy Rapid Assessment Tool facilitates effective evaluation of blue economy opportunities specifically for SIDS. The goal of the tool is to help accelerate strategic growth of blue economy initiatives in SIDS by offering a means for critically evaluating initiatives. The tool consists of a robust rubric to assess individual projects across five Impact Criteria and five Feasibility Criteria (**Table C1**) in order to compare different kinds of projects according to their potential for change (impact) and their risk (feasibility).

The tool serves two primary functions:

1. For practitioners (governments, NGOs, companies) that are launching initiatives, the tool can be used to:
   a. Assess an initiative's design and scope and determine if there are elements that need to be added or addressed in order to boost a project's potential impact or feasibility.
   b. Evaluate potential initiatives against each other in order to determine which ones are best to pursue that meet desired impacts while accounting for risks and feasibility.
   c. Monitor the initiative over time, to determine how well a project is achieving impact or reducing risks.

2. For funders, government agencies, or other entities that may be looking to support or implement multiple projects in the blue economy, the tool can be used to:
   a. Determine the overall risk profile of a portfolio of projects, as well as the potential impact.
   b. Evaluate potential initiatives against each other in order to determine which ones are best to advance, based on desired impacts while accounting for feasibility risks

Both functions can help to advance more strategic blue economy project development and design in SIDS.

Table C1: Impact and Feasibility Criteria for Foresight Toolkit and Associated Rubric for Scoring.

Category	Criteria	Weight
IMPACT	Job Creation and Skills Upgrading	30%
	Vulnerable population Livelihoods and Resiliency	20%
	Institutional Strengthening and Sectoral Linkages	20%
	Local Economic Resiliency	15%
	Environmental Sustainability	15%
FEASIBILITY	Demand: Access to Viable Markets	25%
	Competitiveness of Production Factors	25%
	Adequacy of Institutional Factors	20%
	Geographic Vulnerabilities	10%
	Leadership Commitment for Implementation	20%

Components of the Tool

The tool is built as an open-source resource in Google Sheets and/or Microsoft Excel. The first Instructions tab provides 7 steps for how a project team can use the tool to evaluate one or more potential initiatives.

In addition to the Instructions tab, the tool contains three core elements:

- Scoring Guide;
- Evaluator Templates; and
- Master Scorecard

Each core element has its own specific tab in the tool and is described below, along with a rationale behind its structure.

Scoring Guide

The Scoring Guide (Table C2), provides a definition of each criteria (five Impact and five Feasibility), and a guide for determining the scores (1-5). Evaluators—individuals that are conducting an evaluation of one or more initiatives using the tool—can refer to the Scoring Guide as they fill in their templates.

Each criteria is ranked according to a score from 1 (low) to 5 (high) based on the POTENTIAL OF THE INITIATIVE to achieve a rank based on the project design, resources in place, and strategy for execution. Focus on potential, not realized outcomes, allows for examination of nascent initiatives and concepts, which is key to informing project strategy and design.

The Scoring Guide has been purposefully designed to drive an evaluation process appropriate to SIDS. The ten criteria reflect known and anticipated barriers to blue economy growth that are particularly relevant for SIDS. Consideration for these challenges, and how an initiative specifically addresses them (the ranking) is critical to effective design and strategy creation.

The rankings also reflect specific enabling conditions that need to be met in order for longer-term, larger-scale blue economy development to occur. For example, within "Job creation and skills upgrading," there are explicit ranking distinctions between projects that provide temporary vs. permanent job prospects vs. those that also provide long-term professional growth opportunities. These rankings reflect the all-too-common systemic barrier of "brain drain," where local talent leaves the region to secure more satisfying, often better-paying jobs that have greater room for growth and development.

By considering how projects are potentially meeting (or failing to meet) the specific milestones provided in each rank, users can more explicitly identify where more resources or better design may be needed in order to maximize potential impact of the proposed project.

Likewise, different projects will have variable strengths and weaknesses across the ten categories. When evaluating multiple projects, a project team may be able to determine how they are building resiliency and enabling conditions for success overall by looking at the individual ranks of criteria across their different projects, to see how the portfolio as a whole may address these critical elements.

Finally, the criteria provided in the scorecard reflect two urgent challenges of the day that are having significant, and somewhat unique, impacts on SIDS: the COVID-19 pandemic and climate change.

The weightings provided for each criterion (Table 1) were carefully chosen to give more importance to those criteria that are foundational and necessary to alleviate acute pain points as well as to realize short and medium-term growth opportunities for SIDS. The unprecedented loss of employment due to the collapse of the tourism sector demands that blue economy growth prioritize the ability to create new, skilled jobs (with long-term professional prospects) and focuses on resiliency in vulnerable populations. Thus, together, these two criteria account for 50% of the impact score.

Similarly, economic resiliency (impact) and market demand criteria (feasibility) both include an emphasis on local growth opportunities. This emphasis is in response to the vulnerabilities laid bare by COVID-19 of supply chains overly-dependent on foreign trade. From small-scale fisheries

to tourism to energy security, recent events have made clear that more local and regional supply and production are critical and offer new opportunities for development. Thus, the rankings for these criteria reflect a focus on circular economies and consideration for diversified markets that include local (not just foreign export) options.

In terms of climate change, several criteria, including Economic Resiliency, Environmental Sustainability (Impact) and Geographic Vulnerability (Feasibility), force consideration of how proposed blue economy initiatives build resiliency and apply mitigation strategies.

Detailed examination of the score guidelines reveals nuanced but important distinctions between each ranking. However, this is the first prototype of the tool, and improvements can be made. Input from practitioners, governments, and funders that use this tool into practice can help improve the took and inform more strategic blue economy development in SIDS.

Table C2: Guide for How to Allocate Ranks for Each of the Five Impact Criteria and the Five Feasibility Criteria.

Factor	Rank	Ranking Guide (1-Low 5-High)
IMPACT CRITERIA		
Job creation & skills upgrading	1	Opportunity adds no additional jobs, no new skills.. High risk of brain drain
	2	Opportunity adds a few new unskilled jobs, but has limited growth potential (may be only temporary).
	3	Opportunity adds new jobs. Limited growth potential, risk of brain drain remains
	4	Opportunity is rapidly creating jobs with skill upgrading pathways
	5	Opportunity is rapidly creating jobs oriented toward (blue) knowledge economy
Vulnerable Population Livelihoods & Resiliency	1	Negative impact on vulnerable populations
	2	No impact on vulnerable populations
	3	Minor indirect livelihood impact on vulnerable populations. No direct pathway for developing access for marginalized populations and youth.
	4	Positive impact on vulnerable populations at limited scale. Clear pathway for developing access for marginalized populations and/or youth.
	5	Major direct livelihood impacts vulnerable population households (and potential for scaled impact)

Table C2: Guide for How to Allocate Ranks for Each of the Five Impact Criteria and the Five Feasibility Criteria. (cont.)

Factor	Rank	Ranking Guide (1-Low 5-High)
Institutional Strengthening and Sectoral Linkages	1	Opportunity has negative impact on local institutional ecosystem
	2	No impact on institutional ecosystem. Minimal linkages among one or two sectors. No shared infrastructure but some shared skills.
	3	Minor positive impact on institutional ecosystem. Helps to promote minimal linkages among one or two sectors, minor positive pressure on institutional capacity building.
	4	Strong positive influence. Infrastructure, skillsets, and knowledge has application to 3 or more sectors, and depends on connectivity among SMEs for success.
	5	Opportunity creates strong local institutional ecosystem for competitive and resilient blue economy
Builds Local Economic Resiliency	1	Opportunity adds to local economic leakages (i.e., increased use of non-local inputs, exports of profits)
	2	Supports growth of existing local SMEs & sectors, but still local economic leakages
	3	Supports growth of new sectors, but majority of value escapes country. Opportunity remains subject to global shocks
	4	Supports growth of new sectors, local economic leakages are minimized
	5	Opportunity supports growth of local, circular economy, diversifies local economy through introduction of whole new sectors and retains value within the country. Opportunity is based on clean technologies, renewable energy, and circular material flows to secure economic stability over time. Opportunity reduces vulnerability to external shocks at global scale such as COVID or market disruptions
Environmental Sustainability	1	Opportunity harms (direct and indirect) coastal and marine ecosystem
	2	Direct and indirect harm to coastal and marine environment are limited, and mitigation measures in place
	3	Opportunity can show no direct harm and limited indirect impacts to coastal and marine environment; processes in place to mitigate any unforeseen impacts
	4	Opportunity shows benefits to local coastal and marine environment and has mitigation for any unforeseen impacts
	5	Restores, protects, and maintains the diversity, productivity, resilience, core functions, and intrinsic value of marine & coastal ecosystems

Table C2: Guide for How to Allocate Ranks for Each of the Five Impact Criteria and the Five Feasibility Criteria. (cont.)

Factor	Rank	Ranking Guide (1-Low 5-High)
FEASIBILITY CRITERIA		
Demand: Access to Viable Markets	1	No viable market
	2	Challenging access to highly competitive markets, demand conditions highly uncertain
	3	Opportunities for limited access to niche markets
	4	Opportunities for access to local and international markets exist.
	5	Significant and diverse local and international market demand exists, with strong potential for continued growth. Market demand has been consistent for at least X years, and opportunity can fill a distinct gap in existing supply. Multiple entry points into new markets exist.
Competitiveness of Production Factors	1	No competitiveness due to labor availability and/or skills, material inputs, access to technology and capital, entrepreneurial/mgmt capabilities, etc..
	2	Very low competitiveness due to labor availability and/ or skills, material inputs, access to technology and capital, entrepreneurial/mgmt capabilities, etc.
	3	Adequate competitiveness but new entrant in sector
	4	Adequate competitiveness with experience in sector
	5	Highly competitive capabilities
Adequacy of Institutional Factors	1	Weak regulatory and legal environment, lack of institutional linkages, poor governance
	2	Poor but improving, regulatory/legal environment, few quality institutions
	3	Fair regulatory/legal environment, few quality institutions
	4	Good regulatory/legal environment, growing number of functioning institutions, linkages
	5	Strong innovation ecosystem: well-functioning government, business, educational & scientific institutions and ecosystem

Table C2: Guide for How to Allocate Ranks for Each of the Five Impact Criteria and the Five Feasibility Criteria. (cont.)

Factor	Rank	Ranking Guide (1-Low 5-High)
Geographic Vulnerabilities	1	Opportunity may be impacted by natural events, and there are no mitigation measures or technologies in place to address 1) small island concerns (access to local energy sources, access to clean water), 2) natural disasters (hurricanes, tsunamis), and/or 3) effects of climate change (e.g. sea level rise, change in ocean temperature, increased intensity of atmospheric events)
	2	Some mitigation techniques are in place
	3	Significant/sufficient mitigation techniques are in place for at least 1 of 3
	4	Significant/sufficient mitigation techniques are in place for at least 2 of 3
	5	Significant/sufficient mitigation techniques are in place for all 3
Leadership Commitment for Implementation	1	None, no leaders identified
	2	Weak commitment by leaders
	3	Strong commitment, limited leadership capabilities and track record
	4	Strong commitment, good leadership capabilities and adequate track record
	5	Very high level of commitment and demonstrated track record, all partners on board

Evaluator Templates

The current tool contains templates for 5 Evaluators. This means that five different team members can simultaneously rank initiatives. Each template will provide a weighted average Impact and Feasibility score. More evaluator tabs can be added easily by duplicating one of the existing templates. Note: adjustments to the Master Scorecard will need to be made if more evaluators are added. See next section for details.

Currently, the Evaluator Template contains room for 10 distinct initiatives and weighted average scores (Impact and Feasibility) will be automatically populated and plotted on a scatter plot within the template.

Master Scorecard

The Master Scorecard is automatically populated, using data inputted into the Evaluator Templates. Within an initiative, the average rank of each criteria across multiple evaluators will be entered into the grid; then the weighted average of these scores will be provided. In this manner, the Master Scorecard provides a weighted average Impact Score and Feasibility score that reflects the assessment of multiple experts, who may bring different perspectives and thus, help increase the robustness of the scoring.

Note: If fewer than 5 evaluators are present, the Master Scorecard formulas should be adjusted to reflect inclusion of only the active templates; alternatively, zeros can be entered into the unused templates and they will automatically be discounted from the weighted average.

The total number of evaluators that contributed a rank for each initiative scoring is provided in row 10 (Impact) and 19 (Feasibility). Similar to the evaluator templates, the Master Scorecard will automatically generate a summary table and scatter plot of the Impact vs. Feasibility weighted average scores for each initiative.

Instructions: How It Works

Step 1: Assign Evaluator tabs to each member of project team

If more than five team members are evaluating initiatives, duplicate Evaluator 5 tab as many times as needed. You can rename the Evaluator templates to team member names for tracking purposes. Each practitioner or user of the tool will have his or her own template. The scores from each expert will then be combined and averaged in the Master Score template to provide an overall score.

Step 2: Enter names of different potential initiatives

Each initiative has its own column. Names of initiatives or projects go into row 2 and 11. Currently, the template provides space for ten initiatives (Columns C-L). More initiatives can be added by adding columns after L and copying the formulas in rows 8-9 and 17-18.

Step 3: Review the weighted averages in Column B

Consider any adjustments that are needed based on specific context (i.e., if one criteria needs to be weighed more or less heavily for one or more reasons). This is a key step in ensuring that

the tool is customized for SIDS conditions. The weighted averages provided reflect the current understanding of which criteria are particularly important (higher weighting) to creating the enabling conditions necessary for success in developing the blue economy.

Step 4: Rank Initiatives by using the Scoring Guide (Tab 2)

Each evaluator gives a single score (1-5) to each of the 10 criteria for each initiative, replacing the placeholder data with their chosen rankings in their own Evaluator template. For any initiatives that an evaluator cannot rank (lack of knowledge, familiarity, etc) enter zeros for all ten criteria. Each criteria is ranked according to a score from 1 (low) to 5 (high) based on the POTENTIAL OF THE INITIATIVE to achieve a rank based on the project design, resources in place, and strategy for execution.

The scores from the five Impact Criteria are then averaged to provide an overall Impact Score (cell C8)—this score is a weighted average, with some criteria having more influence over the total average than others. The same process holds for calculating the Feasibility Score (C18).

Step 5: Analyze the results and bring insights back to the team

Use the summary table and scatterplot to analyze a portfolio of projects and bring insights back to the team. Depending on who is using the tool, the ranking process can be used to highlight weaknesses in an initiative's design or strategy: where low scores occur, consider what kinds of pivots, resources, or design elements could be added/changed in the initiative to increase the initial rank.

Step 6: Review Master Scorecard (Figure C3)

A designated team leader must review the Master Scorecard to ensure each evaluators' scoring has been included in the formula. This can be done by first examining the total number of evaluators provided in rows 10 and 19 for each initiative. Reminder: not every initiative may be scored by every evaluator. Then, cross-reference by clicking on any of the cells D3:M7 and reviewing which Evaluator Template tabs are listed within the formula bar. For teams larger than 5, new evaluator tabs (beyond Evaluator 5) will need to be added.

Table C3: Screenshot of Master Scorecard showing preliminary test scores for eight projects generated by the foresight analysis and currently under evaluation. Each project was scored by 1-4 reviewers independently, based on familiarity and knowledge of the project and country.

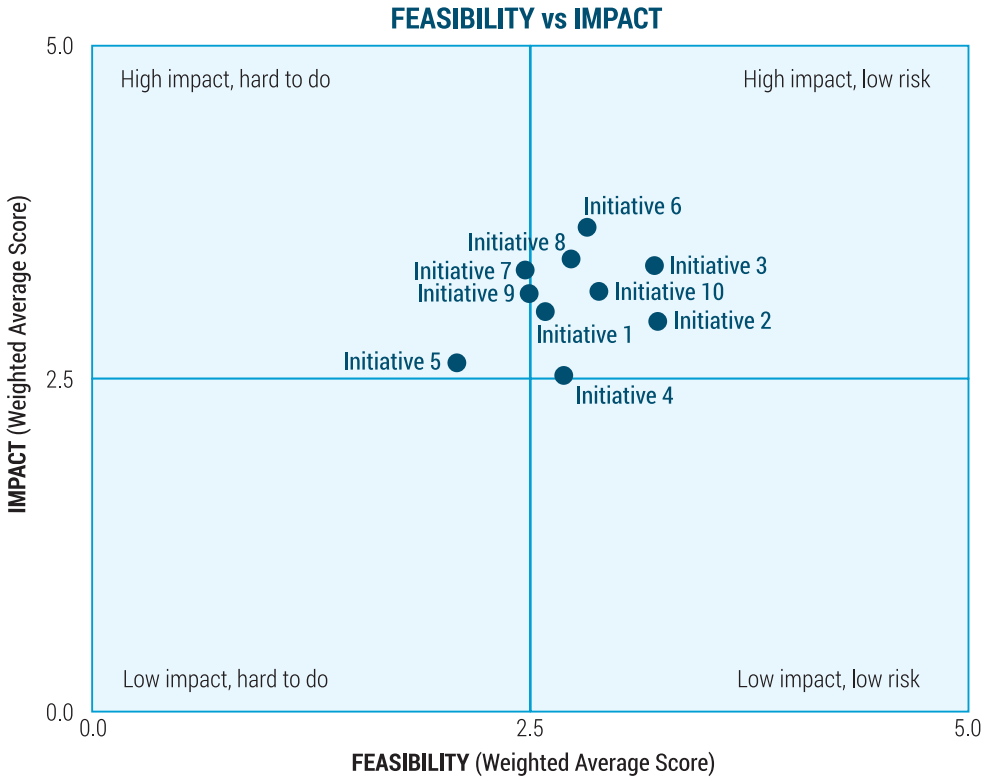
ASSESSMENT OF INITIAL CANDIDATE PROJECTS/INITIATIVES										
	Impact Factors	**Weight**	**Barbados C-Combinator**	**Guyana Drones for Mangroves**	**Suriname Mangrove Corridor**	**Barbados Tuna**	**Bahamas Virtual Tourism**	**Jamaica C-Combinator**	**Barbados Research Clearinghouse**	**Trinidad and Tobago Fisher Fuel Initiative**
IMPACT ASSESSMENT	Job creation and skills	30%	4.0	2.0	3.5	2.3	2.7	4.0	3.3	3.0
	Vulnerable population	20%	3.7	4.0	4.0	2.3	2.3	3.8	2.7	4.0
	Institutional strengthening and local linkages	20%	3.8	2.0	3.5	2.3	2.7	3.8	4.0	3.0
	Builds local economic resiliency	15%	2.3	4.0	3.5	2.3	3.0	2.3	3.0	3.5
	Environmental sustainability	15%	4.0	4.0	4.0	3.7	2.7	4.0	3.3	4.0
	Average Score	100%	3.6	3.2	3.7	2.6	2.7	3.6	3.3	3.5
	Weighted Average Score		3.7	3.0	3.7	2.5	2.7	3.6	3.3	3.4
	Number of Evaluators (n=?)		3	1	2	3	3	4	3	1

	Feasibility Factors	**Weight**	**Barbados C-Combinator**	**Guyana Drones for Mangroves**	**Suriname Mangrove Corridor**	**Barbados Tuna**	**Bahamas Virtual Tourism**	**Jamaica C-Combinator**	**Barbados Research Clearinghouse**	**Trinidad and Tobago Fisher Fuel Initiative**
FEASIBILITY ASSESSMENT	Demand	25%	4.2	3.0	3.0	3.0	2.7	4.1	3.0	2.5
	Competitiveness	25%	3.0	3.0	3.0	3.0	2.0	2.8	2.7	2.5
	Adequacy of institutional factors	20%	2.3	3.0	3.0	2.0	2.0	2.3	2.7	3.0
	Geographic vulnerabilities	10%	2.3	3.0	3.5	2.0	3..0	2.3	2.7	3.0
	Leadership	20%	1.7	4.0	3.5	3.0	1.0	2.3	1.3	3.0
	Average Score	100%	2.7	3.2	3.2	2.6	2.1	2.7	2.5	2.8
	Weighted Average Score		2.8	3.2	3.2	2.7	2.1	2.8	2.5	2.8
	Number of Evaluators (n=?)		3	1	2	3	3	4	3	1

Step 7: Analyze findings

Use the summary table and scatterplot (**Figure C1**) to analyze the portfolio of projects based on the group average rankings and discuss the findings.

Figure C1: Scatterplot Generated within Master Scorecard Reflecting Impact vs. Feasibility Scores for Different Initiatives.



The scatterplot can be used to quickly determine where to focus effort and resources and where there are "danger zones" in terms of investing in a project that has less chance of getting off the ground or having impact.

Generally, initiatives which fall in the upper right can be considered as low hanging fruit in that they are both relatively feasible and deliver impact. The upper left reflects initiatives that could be worthwhile to pursue, but because they are deemed more difficult to implement, attention to design and significant resource investment are likely to be important to success.

Initiatives that fall on the lower two quadrants are likely not smart investments at this time as the impact they deliver is considered minimal. That said, there can sometimes be an argument for supporting a project in the lower right: it may be low impact but easy to execute and could be a way to build trust or proof of concept. The bottom left, in particular, should be avoided, as initiatives here are anticipated to be both difficult to implement and deliver little impact.

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