An Odyssey in Vanquishing Ocean Abyssal Depths, and the Mysteries of the Last Unknown Earth Frontier:

Why Prioritise Accelerating the Blue Economy via Investing in Underwater Exploration? –

Contents

INTRODUCTION 1
RECENT DEVELOPMENTS 3
(i) Seabed Exploration for Mining 4
(ii) Exploration for Non-Mineral Assets and Climate Change Impacts 5
(iii) Investigations by China 7
(iv) Investigations by Japan. 8
(v) The United Kingdom. 8
(vi) France. 8
(vii) Germany. 9
(viii) Multi-National initiatives 9
(ix) Tourism Related Initiatives 12
(x) Future Opportunities. 14
CONCLUSION 16

Jack Dyer, PhD.

INTRODUCTION

To truly know our planet, the consequences of our actions and prospects for our own survival, we must know the oceans. Although an increasing proportion of the world has expressed commitment to the blue economy, it has only recently pledged to formally fathom the farthest reaches, but with far fewer formal resources than have been pledged to warfare and space exploration. For all that the mysteries of the seas have mesmerised many of us for aeons, around 95% remained uncharted until as little as three years ago.

The World Bank estimates a projected increase in potential from US $1.5 trillion in blue/ocean economic activity and 31,000,000 direct jobs, to over $3 trillion and 45,000,000 jobs between 2010-2030. The oceans will be radically transformed by initiatives such: as the pledge to commit 30% by 2030 of marine protected areas; the Commonwealth Marine Economies Programme and Blue Charter; World Bank Pro-Blue; private investors and entrepreneurs such as the World Ocean Council; Blue Prosperity Coalition and UNEPI; activists such as Children for the Oceans, Sustainable Ocean Alliance and others, as encountered in my previous research[1].

However, if the world is to claim true long-term sustainability, economically, socially, environmentally and equitably, we need to understand just what features, resources and valuable organisms exist, living and non-living. We need to appreciate their purposes and ocean processes; so as to avoid irrevocable damage, forecast anticipated risks, costs, consequences and opportunities in our own custodianship of the oceans.. We need to reverse our millennia of damage and destructive practises and commit to extensive, planetary ocean ecological restoration. However, whatever plans we might have for fisheries and aquaculture; ports, shipping and logistics; ecotourism, marine renewable energy, blue carbon, biotechnology and even seabed mining, these could be completely pulverised by unknown repercussions for the marine environment. Nor can we truly act decisively against marine plastic; other pollutions such as the great Garbage Gyres of the world; illegal fishing; climate change; disappearing islands; changes in maritime boundaries and resources; design policies; enforce ocean governance and security; or even raise artificial islands and floating/underwater habitats, research stations and resorts, without committing to investing in comprehending our oceans.

We can therefore only achieve the blue economy if we prioritise across the oceans, the high seas and individual nations, our own odyssey to vanquish submerged ocean abyssal depths. This article and proposal urges us to prioritise the blue economy, by supporting and investing directly in underwater exploration, whilst urging and mobilising others to do so. Only a full concerted, coordinated effort can emphasis the true status of ocean resources and whether they should be exploited, the implications of doing so, the opportunity costs, risks and alternatives. This applies both to ensure the effectiveness or motivation for marine conservation as for any ocean/blue economy activity. It includes truly understanding ocean, climate and marine environmental processes so that we start to embrace a new future as self-appointed stewards and users of the planet. We all need to become planetologists. We all need to be fascinated in the oceans - to realise how the prosperity is not only generated but threatened- even those landward who depend on the oceans in myriad ways they may not be aware of. The way to truly inspire humanity is to understand the mysteries of the last unknown Earth Frontier.

The highest function of ecology is the understanding of consequences. Not only will people gain greater awareness and ocean ecological literacy, but our species can become more united by the hope, fascination and aura of wonder that many, who feel some spiritual or material connection to the seas, possess. As with space, the perils of climate change and pollution; deep ocean exploration can serve as a rallying point to connect far more of us as humanity, to decide our future on this planet before it is too late; but to truly appreciate what is out there, by known what is out and down there. These expeditions, surveys and research could not only guide our blue economy practically but re-orientate us as people, to become far more empathy-driven towards the ocean and its life forms; profoundly changing our awareness and perhaps our attitude and behaviour, even our contributions towards desecrating and befouling it. We inherited the oceans from our forebears but given the risks to coral reefs, ice caps, low flung atolls, collapsing fisheries and mass extinctions, Great Garbage Gyres and others; not to mention ocean and blue economy industries, how much of it will last - and for how long and in what condition - if we fail to take it seriously?

Most see only the surface, several perhaps deeper into coral reefs and marine life if they dive below. Very few are more privileged to venture down deeper, and most cannot afford to. Even if they did, very few private, research, NGO or non-military options exist to venture into the subterranean sanctuaries and

[1] To be found at www.blueeconomyfuture.org.za

chasms below a few hundred metres. Favouring a new Global Age of Marine Exploration would enable us to really appreciate and understand not just mangroves, coral reefs, seagrass and other blue carbon sources and their demersal, pelagic and benthos species, and not be confined to observing whirlpools, currents, waves, tides, eddies, storms, tsunamis and other phenomena such as the Green Flash. Below the surface behold fabulous and intriguing entities to marvel at and decipher: from seamounts to underwater volcanos, abyssal plains and the escarpment, hydrothermal vents, underwater forests, fossil forests, ridges, plateaus, canyons, shelf valleys, caverns and trenches, including Challenger Deep and the Mariana Trench. Non-living marine mineral marvels that only seabed mining experts and geologists are mostly sampling and valuing at present include cobalt rich crusts, manganese and marine placer deposits, polymetallic sulphates and even fuel possibilities from methane hydrates. Ocean Thermal Energy Conversion, salinity gradients and algal biomass may empower us as sources of marine renewable energy of the present and future, not just wind, wave, solar, current and tidal.

Then there are extremophile and other lifeforms that should inspire us with their tenacity and resilience, how life can persevere under many extreme conditions. Other species are not only fundamentally worth protecting as part of a complex carbon and biological lifecycle but also in their own right. Each needs to be understood and added to the Census of Marine Life, and the species' existence including genetics, preserved, as all life forms serve a purpose. It is only those with too superficial understanding who may not recognise what that might be. If that were not enough to marvel over, there are millennia of treasure troves - not just from corsairs and buccaneers, but the legacy of whatever cultural heritage that has survived through shipwrecks and buildings on the seabed and surroundings. This may galvanise us to commit even more to researching and protecting our marine legacy, such as globally envisioned with the 30% by 2030 vision. It is also essential to understand the various risks, ocean, climate and other processes, as our interference in climate change, pollution, overfishing and other existing/intended uses; may without further commitment to marine exploration, literacy, awareness and the blue economy; may threaten our existence, just as much as our interference on land

This update therefore proposes to investigate the present and future status of ocean exploration, and assess how much progress we are making in conquering the hallowed and sacrosanct mysteries of the the deep oceans. Other sources focus on history - this resource concerns itself with the present in preparation for the future. In exploring the unknown depths; we can consider the latest advances; news, trends, developments; risks; opportunities, purposes and applications. It is only by understanding this frontier as a new, eco- and ocean conscious populace that we can fabricate a true blue economy future, based on sound custodianship principles and priorities. Only then can we claim true sustainability from a position of knowledge and certainty, rather than ignorance, on areas as potentially controversial as seabed mining, marine renewable energy, fisheries, offshore oil and gas, desalination and others. We may be turning to the oceans for answers, but the launch of visions such as a new UN Decade of Ocean Science, Seabed 2030, the Abyssal Initiative and others can be said for the next decade from 2021 to 2030 to be the true Age of Marine Exploration, another truly inspiring process to be conscious of, alive and hopefully mobilised to become more involved in, interested and concerned/caring about the ocean and its future.

RECENT DEVELOPMENTS

Recent developments have proven just how much interest is rapidly growing in exploiting the blue economy, with interest gradually rising in actually exploring the oceans, and understanding the true implications of our collective species relationship and behaviour towards the denizens and processes encountered. Since the tales of the Iliad and the Odyssey, Jason and the Argonauts and others, not to mention the legends of Atlantis, the Bermuda Triangle, Lemuria and voyages of Captain Nemo and the Nautilus in Jules Verne's 20,000 Leagues under the Sea, we have been inspired to dream of the sea. But it was the voyages of HMS Challenger from 1972 to 1976, delivering over 4,700 marine species that made it first possible.Only this year, by July 2020, 13 people had reached the deepest depths of the Marianna Trench, including the original effort under Jacques Piccard and US Navy Lieutenant Donald Walsh in the Trieste in 1960. In 2018 Victor Vescovo, in his DSV Limiting Factor, reached 8,375metres or 27,477ft below the ocean surface, to the bottom of the Puerto Rico Trench. Recently, Kathryn Sullivan and Vanessa O'Brien completed their missions, becoming the first women to reach the bottom of Challenger Deep at 10,925 m (35,843 ft.) There are therefore no physical limits to our endurance or capacity to reach the beckoning mysteries, provided we have the audacity, imagination, will, daring spirit and endurance to do so. Since the discoveries of Pierre Simon de Laplace and the stalked crinoid at 10,200 feet or 3,109 metres below, we have known that life may be possible but not to what extent it might exist or entail a response.

(i) Seabed Exploration for Mining

Global efforts towards ocean exploration are mostly uncoordinated efforts by the private sector offshore oil and gas sector, and research/academic institutions or national governments conducting occasional surveys and expeditions. More recently this has included seabed mining, marine conservation parks and renewable energy feasibility/prospecting projects. One exception is Seabed 2030. This aims radically to attain 100% exploration of the oceans by 2030. Since its inception in 2017, and sponsorship with the Nippon Foundation and cooperative partnership with GEBCO - General Bathymetry Chart of the Oceans, UNESCO-IOC, the International Hydrographic Organisation and members, it increased coverage of the oceans from 6.7% in 2012 to 19.6 % in 2020. In December 2019, the Schmidt Ocean Institute surveyed 1,000,000 Km^2 of seafloor alone. By 21 June 2020 an additional 14,500,000 km^2 of ocean was mapped. It currently includes an online database of charts and information not only obtained via formal expeditions, surveys, satellites and sensors, but also from a Crowd Sourced Bathymetry Working Group of volunteers. It has centres based in Southampton (Headquarters) and four regional centres in the Arctic and North Pacific Ocean, the Atlantic and the Indian Ocean, and the South and West Pacific Oceans, along with the Southern/Antarctic Ocean.

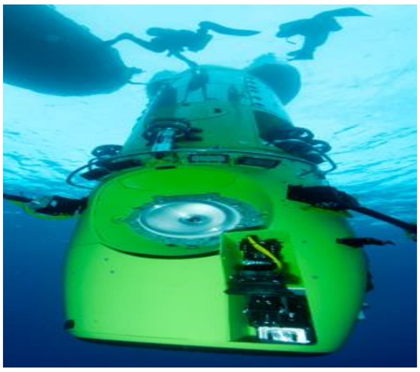
Although controversial, seabed mining has yielded prospects of significant data, which may help us to truly understand the implications of this blue economy activity and what finds sanctuary in the deeper seas. The International Seabed Authority (ISA) also indicated greater prioritisation to underwater exploration, requiring scientific data from its seabed mining contractors, even for exploration, although incurring the significant concern of remaining confidential, and not being linked directly to Seabed 2030 or individual nations. This was highlighted in the Strategic Plan for 2019-2023 ISA and the Department of Economic and Social Affairs of the United Nations Secretariat (UNDESA). These registered a possible extension of the SPC-EU initiative towards developing Pacific seabed mining but, along with this, an implied need to prioritise greater surveys. They registered at the 2017 UN Ocean Conference; a joint Voluntary Commitment entitled "The Abyssal Initiative for Blue Growth." This aims to start by identifying stakeholder needs for Cook Islands, Kiribati, Nauru and Tonga before other Pacific Island territories. The ISA have also indicated possible support in developing Deep Sea Long Term observatories, and

Taxonomic Atlases and mapping Africa's Deep Sea Resources. ISA recently drafted the Marine Scientific Research Plan. On 22 September 2020 the ISA hosted a deep data and sea marine ecosystem workshop.

(ii) Exploration for Non-Mineral Assets and Climate Change Impacts

There is a need for registers of deep sea lifeforms, non-living marine minerals, Cultural Heritage, cables, research facilities and other ocean assets, whether above or below the surface. The Census of Marine Life, from 2000 to 2010, aimed to identify all marine life forms, investing over US $650,000,000 and with 2,700 researchers. It focused on 14 divergent projects over 540 expeditions. However new discoveries - and new extinctions - along with the various ecosystem and individual species themselves, remain continuously changing. Thus, there is always the need for more surveys, research and investment. No submersible can reach the projected ocean depths - the very bottom. Early drone developments included Argo and Jason - exploring the Titanic shipwreck in 1985, then refined further by the time of the 2012 National Geographic Deep Sea Challenger Expedition to include high resolution equipment for pictures and samples under film director James Cameron. The Deep Sea Challenger is illustrated in Figure I. Recent developments in new technology are helping to make this more possible, especially hope for autonomous capabilities, given biophysical human limits. On 2nd April 2020 the United States National Oceanographic and Atmospheric Administration or NOAA committed to expanding these autonomous drone vessels via an Unmanned System Operations Program. On 15 August a 12 metre autonomous USV Maxlimer mapped the Atlantic seafloor continuously on a 22 day voyage and returned successfully. In October the UK indicated the creation of a 50 foot trimaran replica of the Mayflower will be autonomously directed with renewable wind/solar energy power and AI. On 9 October 2020, media reported that engineers at the University of California, San Diego, have built a self-powered squid-like robot that can swim untethered, propelling itself by generating jets of water. This minimises risk to coral and fragile organisms including 3D printing. It managed half a mile per hour in speed.

Figure I: Deep Sea Challenger



Source: NOAA 2012.

Exploring the ocean depths can be extremely expensive, technologically challenging, lack major public support and other initiatives as barrier costs to entry. Perhaps more prizes and incentives would also inspire further innovators to participate for profit or fame, not just curiosity or innovation. For example, the Shell Ocean Discovery XPRIZE was a $7,000,000 prize for achieving autonomous deep sea exploration technology set in 2018. It was won in 2020 by the GEBCO-Nippon Foundation Alumni Team, developing the SEAKIT vessel as an AUV. The $1,000,000 NOAA Bonus Prize aimed to improve chemical or ocean biological signals. There is also a need to undertake more research expeditions to less understood regions. In 2020, results were concluded for the 5 Deeps Expedition by Victor Vescovo to explore five great ocean depths. As conditions change, these may need either more permanent infrastructure and institutional capacity, and/or improvements in the frequency, duration and effectiveness of potential missions. In 31 July 2020 NOAA created a deep water exploration guide as further inspiration and advice to prepare those becoming more interested in this new sector.

Comparatively few institutions have truly specialised in deep ocean exploration facilities and infrastructure. Although a more detailed review is beyond the scope of this article, knowing the existing finite gaps and capacity argues more persuasively for the rest of these gaps and weaknesses to be overcome, to attain Seabed 2030 and a true Age of Marine Exploration. For example, in the US current submersibles can take up to 3 people at the venerable Woods Hole Oceanographic Institute in Massachusetts. The illustrious Alvin, though aging, can go down to 4,000 metres or 13,123 feet, and has been active since 1964, exceeding over 3,000 dives. Aside from this is the National Oceanographic and Atmospheric Administration, (NOAA's) infrastructure and the National Science Foundation. These include the US National Science Foundation's Oceans Observatories Initiative.

Indirectly this connects to separate programmes to understand various marine ecosystem, ocean and climate processes. Projects incorporate the Arctic Ocean: ArcOD (Arctic Ocean Diversity); CAML (Census of Antarctic Marine Life); MAR-ECO (Mid-Atlantic Ridge Ecosystem Project); ChEss (Biogeography of Deep-Water Chemosynthetic Ecosystems for vents and seeps). It extents to abyssal plains via CeDAMar (Census of Diversity of Abyssal Marine Life); seamounts: CenSeam (Global Census of Marine Life on Seamounts); COMARGE; (Continental Margin Ecosystems) and POST (Pacific Ocean Shelf Tracking Project) for continental shelves. The nearshore environment includes NaGISA (Natural Geography in Shore Areas); Creefs; (Census of Coral Reefs) and regional ecosystems under the GoMA; (Gulf of Maine Program). Several ecosystem-specific sub-initiatives include ICoMM (International Census of Marine Microbes); MarZ (Census of Marine Zooplankton) and TOPP (Tagging of Pacific Predators) for top predator species. Recent news at Woods Hole includes a recent Arctic Ocean polar voyage by German icebreaker Polarstern. Current institute research also indicated over $500,000,000,0000 in potential benefits that could be obtained to global ecosystems and economies, just from deciphering deeper ocean biological/cultural systems.

Global arrays of ocean sensors including those for greater depths are depicted in Figure II. These include the Global Southern Ocean Array, Global Argentine Basin Array, Coastal Pioneer Array, Global Station Papa Array, Coastal Endurance Array, Regional Cabled Array and Global Irminger Sea Array. Significant gaps exist around the mid-Atlantic Ridge, the Clarion-Clipperton and South Pacific and Central/other Indian Oceans or Middle East. Incidentally, these areas are those favoured for seabed mining and prospecting, so forming sensors and underwater observatories there, along with the other notable gap around Africa - including the Agulhas/Benguela Currents and archipelagos – which may be urgent priorities as necessities for deep sea ocean observation gaps to rectify.

Figure II: Global Arrays of Ocean Observation Sensors

Source WHOI 2020.

In Canada, Ocean Network Canada used a remote operated crawler to obtain data, and partnered with the University of Victoria, to create the underwater Neptune and Venus Ocean Observatory since 2007. NEPTUNE (North East Pacific Time-series Undersea Networked Experiments) is anticipated to conclude relatively soon, by 2022. It includes sourcing data from as deep as 2,660 metres, although not at all points. This will provide data from fibre optic cables and Internet connectivity to an online database. Memorial University in St John's, Newfoundland, launched a recent underwater exploration laboratory on 15 October 2020. It invested $440,000 in ROV's, simulators and laboratory equipment/facilities. Key features of the Underwater Exploration Laboratory include integrated pilot stations, launch and recovery simulators, dual simulator capability and enhanced manipulator control functionality. Disturbingly, on 1 October 2020, these sensors identified that the local oceans, seamounts and ecosystems are losing major marine biodiversity from risks such as increased ocean acidification, higher sea surface temperatures, from climate change and other risks.

(iii) Investigations by China.

China are undertaking their own Great Underwater Wall or monitoring system of hydro-acoustic and other sensors/arrays, UUV's and USV's primarily for communications, military and geopolitical purposes down to 3,000 metre depths in the 'South China Seas', but with scientific research application potential. It aims to have manned underwater habitats by 2030. It has resulted in controversy in influencing the Spratly Archipelago, investing over two billion yuan or US $313,000,000. China also has reportedly deep ocean sensors in Yap Micronesia and Challenger Deep. Its present capacity incorporates two manned deep-sea submersibles - *Jiaolong*, (Sea Dragon) since 2010, and *Shenhai Yongshi*, (Deep-Sea Warrior) since 2017; with descent potential down to 4,500 metres. China has also recorded continued USV monitoring of seafloor crustal movements and features including earthquakes and tectonic plates. It has located deep sea microbes and genomes. It also, in March 2020, conducted tests to assess how biodegradable microplastic and other waste was not on the deep seafloor via benthic landers. On 16th October 2020, the Chinese launched a new three-person capacity, deep-sea manned submersible Fendouzhe (Figure III) to reach depths up to 10,000 metres, or the depths of the Mariana and Challenger Deep Trenches. Designed by the China Shipbuilding Corporation, it can host 10 hour scientific research missions.

Figure III: Fendouzhe

Chinese Government 2020.

(iv) Investigations by Japan.

Japan's JAMSTEC agency (Japan Agency for Marine-Earth Science and Technology), the URI Graduate School of Oceanography, the National Institute of Advanced Industrial Science and Technology, the Kochi University and Marine Works currently collaborate on investigating deep ocean information. Recently it indicated dormant microbes, 100,000,000 years old, may revive in life. In January 2019 Russia committed to constructing six more deep sea submersibles for offshore oil and gas/exploration, by Malachite Design Bureau. These three-person capacity vessels will also be linked to the Russian Navy in deployment, with abilities to reach to 2,500 metres deep and 24 hour timeframes. In May 2020 Russia's Vityaz submarine attained the depths of the Mariana Trench up to 10,028 metres. It also included a deep sea bottom research station, autonomous vessel and control complex. This links to Russian Navy and Shirshov Institute of Oceanology of the Russian Academy of Sciences research via its sonar and bathymetry surveys, video cameras, sensors, echo sounders, sonar and other equipment.

(v) The United Kingdom.

Aside from the autonomous Mayflower expedition, the UK's National Oceanography Centre in Southampton announced, on 15 September 2020, the need to consider a divergent future for ocean exploration: one that is more ecologically sustainable and climate-sensitive or zero-carbon emitting. Its initial one year research plan targets these core focal areas. These include developing autonomous technology options and reducing the need for physical field research or stakeholder consultation such as Skype, Zoom, Google Hangout etc. This incidentally has co-benefits during a COVID19 and post-COVID environment. Specific sections of focus include: Future Science Needs, policy and regulation, future ship technology, marine autonomous systems, future sensor systems and networks and data ecosystems.

(vi) France.

The French have concentrated their deep ocean research efforts under institutions aligned to IFREMER (Institut Francais de Recherché pour l'Exploitation de la Mer) under the REBENT Network with universities, aquariums, observatories and other institutions. Other facilities include the mid-Atlantic Ocean deployed EMSO Azores Observatory, oceanographic vessel Pourquoi Pas? (Why Not?) since 2010. A 2020 deep ocean survey in the Atlantic Ocean identified 320 seagrass species, but new sampling from cruises and INDEEP network is expected to intensify understanding of deeper ocean ecology and processes, especially moving from a current focus on deep sea viruses and microbes to extremophiles and other life forms. IFREMER is undertaking the Pourquoi Pas Les Abysses? Project. This emphasises marine genetics, biodiversity, microbes and larger fauna of the ocean abyss with the remote controlled submarine Victor 6000, the Pourquoi vessel (Figure IV), 3D video surveys and more satellite transmitted sensors and data processes.

Figure IV: The Oceanographic Vessel Pourquoi Pas?

Ifremer 2020

(vii) Germany.

The German Research Institute GEOMAR coordinates German contributions to ocean exploration, including the only manned research submersible in Germany JAGO, the remotely operated underwater vehicles ROV KIEL 6000 and PHOCA, as well as the autonomous underwater vehicle ABYSS. Other ocean monitoring observation networks include the Kiel Off-Shore Mesocosms for Ocean Simulations (KOSMOS), oceanographic moorings, one of the largest glider fleets in Europe, deep-sea observatories (landers) and the mapping and observatory instruments of the Marine Geodynamics and platforms. However, none of these have focused on the deep ocean below 2,500 metres. Spain has focused on prioritising underwater cultural heritage exploration and, in April 2020, published findings of a continental shelf survey. Aside from millennia of human shipwrecks, these also include geological samples, Neolithic remnants and fossils such as those of Pleistocene fauna. However, it has experienced bureaucracy issues with permission needed from at least 10 different agencies, reducing coordinated approaches.

(viii) Multi-National initiatives

Governments, regional organisations such as the European Union and the private sector are not only embracing scientific oceanographic research, but also looking to seabed mining, prospecting and related surveys to provide enriching answers of marine geology, benthic flora and fauna. Many facilities still incur major funding and other technical constraints. Therefore by motivating the private sector, perhaps existing expeditions will finally resolve the qualms and quandaries as to whether seabed mining can reflect a viable future, and the implications of permitting such prospecting activities. In the Cook Islands they have recently committed to deep ocean exploration through favouring seabed mining as a means of possible economic diversification following COVID. These includes not only exploration license concession rights, the appointment of a Seabed Minerals Advisory Committee, a Seabed Minerals Amendment Act and stakeholder engagement along with growing calls for more scientific information to investigate the impact of mining and related ocean sector prospecting activities, creating another possible commercial alternative for supporting underwater exploration.

They remain particularly interested given possible benefits of rare earth minerals to decarbonisation, other technology and electronics and marine renewable energy/batteries. However, others have viewed the impact of seabed mining as too uncertain, given unknown impacts on marine ecologies and blue economy activities. To truly understand if a commercially and technically viable industry or ecologically responsible industry can exist, the EU invested in the Blue Nodules and MIDAS projects from 2015 to 2020, as well as supporting SPC-EU guidance and capacity building for Pacific island nations from 2014 to 2017. The Blue Nodules project created the subsea harvesting vehicle Apollo II, used for collection of the nodules in water depths up to 6 km with a seabed crawler and cable. The European Union are now investing in the Blue Harvesting Project from 2020, to further enhance environmental sustainability. This will receive an overall budget of €7,991,137,50, funded under H2020-EU.3.5.3 and coordinated by IHC Mining. It also has access to COPERNICUS, various sensor arrays and satellites. Other efforts include those by the ISA and its contractors (Table I).

Whilst nations such as Fiji, Namibia and Vanuatu are pursuing moratoriums on mining, aiming to focus on the marine, the industry is increasingly looking for clarity with greater enthusiasm to investing in seabed exploration, including Lockheed subsidiary UK Seabed Resources Limited. They wish greater legal and investment certainty from the UN and other institutions. The ISA and national governments have already conceded over 1,500,000 km^2 to explore. UK Seabed Resources indicate that they have surveyed more than 66,000 square kilometres of the Pacific and mapped 235 square km in high resolution. It hopes to field a prototype vehicle to collect nodules in 2023.

Table I: ISA Seabed Mining License Concession Holders, Locations and Sponsoring States

Company/Contractor	Sponsor	Location	Start Date
Yuzhmorgeologiya	Russian Federation	Clarion-Clipperton Fracture Zone	29 March 2001
Interoceanmetal Joint Organisation	Bulgaria, Cuba, Czech Republic, Poland, Russia and Slovakia	Clarion-Clipperton Fracture Zone	29 March 2001
Korea Government	Korea	Clarion-Clipperton Fracture Zone	27 April 2001.
China Ocean Mineral Resource Research and Development Association	China	Clarion-Clipperton Zone	27 April 2001
Institut Francais de Recherche pour 'Exploitation de Mer	France	Clarion-Clipperton Fracture Zone	20 June 2001
Deep Ocean Resources Development Co	Japan	Clarion-Clipperton Fracture Zone	20 June 2001

India Government	India	Indian Ocean	25 March 2002
Federal Institute for Geosciences and Natural Resources	Germany	Clarion-Clipperton Fracture Zone	19 July 2006
Nauru Ocean Resources Inc	Nauru	Clarion-Clipperton Fracture Zone	22 July 2011
Tonga Offshore Mining Ltd	Tonga	Clarion-Clipperton Fracture Zone	11 Jan 2012
Global Sea Mineral Resources NV	Belgium	Clarion-Clipperton Fracture Zone	14 Jan 2013
UK Seabed Resources Limited	UK	Clarion-Clipperton Fracture Zone	8 Feb 2013
Marawa Research and Exploration Limited	Kiribati	Clarion-Clipperton Fracture Zone	19 Jan 2015
Ocean Mineral Singapore Limited	Singapore	Clarion-Clipperton Fracture Zone	22 Jan 2015
UK Seabed Resources Limited UK	UK	Clarion-Clipperton Fracture Zone	29 March 2016
Cook Island Investment Corporation	Cook Islands	Clarion-Clipperton Fracture Zone	15 July 2016
China Minmetals Corporation	China	Clarion-Clipperton Fracture Zone	12 May 2017
Polymetallic Sulphides			
China Ocean Mineral Resources Research and Development Association	China	Southwest Indian Ridge	18 Nov 2011
Russian Government	Russia	MidAtlantic Ridge	29 Oct 2012
Korean Government	Korea	Central Indian Ridge	24 June 2014.
Institut Francais de Recherche pour l'Exploitation de la Mer	France	Mid-Atlantic Ridge	18 Nov 2014
Federal Institute for the Geosciences and Natural Resources	Germany	Central Indian Ocean	6 May 2015
Indian Government	India	Central Indian Ocean	6 May 2015
Polish Government	Poland	Mid-Atlantic Ridge	12 Feb 2018
Polymetallic Crusts			
Japan Oil, Gas and Metals National Corporation (JOGMEC)	Japan	West Pacific Ocean	27 Jan 2014
China Ocean Mineral Resources Research and Development Association	China	West Pacific Ocean	29 April 2014
Russian Ministry of Natural Resources and the Environment	Russia	Magellan Mountain Pacific Ocean	10 Mar 2015
Companha De Pesquisa de Recursos Minerais	Brazil	Rio Grande Rise South Atlantic Ocean	9 Nov 2015
Korea Government	Korea	West Pacific Ocean	27 Mar 2018
Beijing Pioneer Hi Tech Development Corporation	China	West Pacific Ocean	Oct 18 2019

Source: ISA 2020.

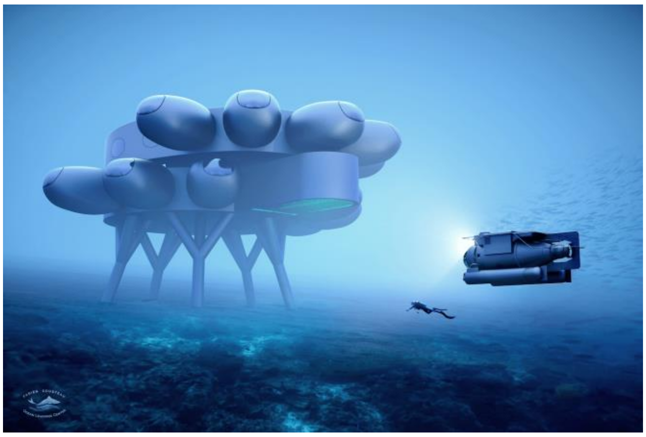
Aside from the UN, the EU, ISA, Seabed 2030, GEBCO and Nippon Foundation, National Geographic Society, Royal Society or individual governments, another core stakeholder for ocean exploration is the International Council for the Exploration of the Seas. This currently includes 20 member countries and a support base of nearly 6,000 scientists from over 700 marine institutes. It also has a working group on deep water ecology. On 30th September 2020 the Council partnered with the European Union's Horizon 2020 to invest 11,500,000 euros in Mission Atlantic. This focuses on deeper Atlantic Ocean exploration including emphasis on assessing ecosystems, creating high resolution ocean models and evaluating various risks as they manifest to curtail disruption with as much early warning as possible. It also aims to form integrated ecosystem assessments for the Atlantic Ocean. This valiant initiative will not only use surface vessels, robots, artificial neural networks, sensors, satellites, people and acoustic sensors, it will focus on far less known and previously less accessible regions. It also claims to communicate results and findings to policymakers and other various stakeholders along with local education, training, research and capacity building. It therefore devised the Mission Atlantic High-Level Stakeholder Forum and is aiming to form an extensive database of findings and joint international access to infrastructure.

(ix) Tourism Related Initiatives.

One of the deeper concerns for the future of ocean exploration is how few governments truly invest in it as a priority. For example, the US marine research fleet decreased from 27 to 18 from 2007 to 2020 and will reach 16 by 2025. Private sector philanthropy and research initiatives remain comparatively few. Few philanthropic underwater research vessels exist. Yet one of the more promising developments is Ocean X linked to Vulcan Inc, the Ocean Exploration Trust and Schmidt Research Institute. On 24 September 2020 Ocean X created the R/V Ocean Xplorer combining scientific research with tourism and media production, as it aimed to use tourists to partially offset marine scientist costs, tapping into the growing trend for new experiences. However, tourism recovery remains conditional upon COVID-19 pandemic and travel restrictions. The 183 metre, state of the art vessel boasts of three submarines, a helicopter, 40 ton crane and sophisticated on-board marine sampling laboratories, and wishes to livestream voyages digitally including conventional and social media, to gain greater interest and support for deeper ocean investigations. It aims to be the largest private deep sea global research vessel costing $350,000,000 and is owned by Norwegian billionaire Kjell Røkke, It will be leased by REV Ocean for three years, receiving $150,000,000 in funding. It offers capacity for 60 researchers, several tourists for four months per year, a submersible down to 2,000 metres and two helicopters. The vessel claims eco-efficiency with reduced emissions and collecting boom grabbers for a daily five tons of plastic pollution scooper. Other private research vessels include the Nautilus (1967), Petrel (2003) and Alucia (2010).

In 2014, Cousteau and his crew spent 31 days living under the ocean in an underwater habitat known as 'Aquarius' -- and has revealed that an even bigger version, dubbed Project Proteus, is already in the works. Fabian Cousteau, in September 2020, indicated the creation of Proteus (below), the largest underwater floating laboratory - 60 foot below the sea and off Curaçao. Only through underwater floating habitats to compliment art galleries, museums, hotels, submarines may perhaps the mysteries be truly unearthed but the relationships between us and other species will irrevocably change forever. Livestream data visualisation and observation sensor feeds. Aquarius Reef Base provides one of the very few sustained remaining examples. This not only includes the addition of on-site labs, but a layout that maximizes the quality of life while living underwater. The research base is structured on two levels that are connected by a curving ramp. The central social space is surrounded by pods that house living quarters, labs, medical facilities, and bathrooms. Portholes and skylights help bring in as much natural light as possible, while full-spectrum lights will ensure that scientists receive the minimum amount of UV exposure needed each day. They are currently fundraising the projected cost. Ocean Infinity have commissioned up to 13 autonomous exploration vessels via Norwegian aluminium workboat specialist Grovfjord Mek. Verksted down 6000 metre depths, estimated delivery for 2021.

Figure V: Project Proteus -Largest Global Underwater Floating Laboratory



Source: Cousteau 2020.

It could transform the very future of tourism via the ultimate undersea adventures. Ocean Gate, under CEO Stockton Rush, aimed to be among the pioneers, launching voyages to the Titanic via submarine Titan and other famous shipwrecks. It focused on carbon fibre composite materials rather than the metal fabrication of other deep ocean exploration submersible counterparts as a more cost-effective substitute. Tourist prices cost at least $125,000. Yet the Titan submarine experienced electric lightning storm damage in April 2018 and experienced a subsequent need for a revised installed acoustic monitoring system. Around 10,000 feet on a final test dive it lost contact after experiencing psychotic effects and eventually landed. He attracted 54 affluent clients for the first of six scheduled voyages on 27 June 2020 but then this was waylaid by the COVID pandemic. Each dive will involve about 90 minutes of descent, three hours exploring the wreck, and a 90-minute ascent to the surface. Recorded missions such as these could generate even more support if it were to explore the possibility for TV, social media, online observation platforms and live data feeds scientific research, video games and immersive exhibitions.

Most exploration encounters high costs, with navies and institutes, severely resource-constrained financially, concentrating on very shallow water exploration. There are few hydrographic surveyors present in global navies, with most work restricted to coastlines, harbours and waterways/river channels Few species are understood beyond the more commonly known ones featuring in aquariums. Very few private submarines exist. The sector experiences challenges jeopardising the future of ocean exploration from a disconcerting loss of private sector funding, innovation and interest. Higher risks exist than for many other blue economy or space activities for market entrants facing investment and often regulatory uncertainty. Deep water and submersible tourism is unregulated in many nations or limited to marginal dive depths. Comparatively few people are conscious not just of marine species, but of the depth of oceanographic features, non-living mineral resources or cultural heritage affluence. Space attracts far more funding than ocean exploration in many nations. There may be risks of losing it all - forfeiting our oceans and their capacity to provide sanctuary to other life forms if we do not act, and if not managed under UNESCO, UNDOALOS, the ISA or any responsible local governments/industry etc. This may extend to looting shipwrecks, noise/light and other impacts, or irrevocable damage to the seabed from our ocean activities if we do not make the effort to understand. There is a need to understand other unknown ramifications of various ocean activities and users, to reduce significant risks of unknown impact costs.

From July 2020 onwards, the explorer Victor Vescovo under Caladan Oceanic Expedition, partnered with Triton Submarines and EYOS expeditions for the most ambitious recorded private sector ocean expedition to two oceans and two seas. The 5 Deeps Voyager Finder (Figure VI) focuses on 5 phases. These include Phase I: “La Minerve” (West Mediterranean), Phase II: The Calypso Deep (East Mediterranean as first historical one). Phase III: The Red Sea, Phase IV: Indian Ocean/Nekton Expedition and Phase V: The “Ring of Fire” Expedition. Potential partners committed to the project include the Greek government and Explorations de Monaco, the King Abdullah University of Science and Technology and the Nekton Expedition. In the Ring of Fire the expedition aim for history’s possible deepest human powered vessel dive to the USS Johnston off Samar Island in the Philippines. The expedition was meant to occur from February to July 2020 but was subsequently delayed due to the COVID19 pandemic.

Figure VI: 5 Deeps Voyager Finder

Caladan Oceanic Expeditions 2020

(x) Future Opportunities.

Significant blue economy opportunities therefore exist from favouring an Age of Marine Exploration not just from tourism, but from research and natural understanding, technology innovation and other spinoff developments. One August 2020 commercial market report estimated the unmanned underwater vehicles (UUV) global market to reach US $5,200,000,000 by 2022, including $2,400,000,000 for the robotics market. Unquantifiable other wealth options arise for fisheries and aquaculture, communications. Other options may include seabed mining, offshore oil and gas, marine renewable energy, desalination, surveying ports, vessel repair, maintenance and upgrades, enhancing, safety, security and proactive climate/ocean risk management. This can try to mitigate against emergent risks.

More and more species are being discovered, that may be worth preserving in some ecologically significant role, that of biotechnology and other uses. In July 2020 expeditions experienced the triumph of Australia's Coral Sea Marine Park depths. On 26 March 2020 another survey highlighted the first reputed migration of deep sea fish species off Angola. A Western Australia survey to Cape Range and Cloates Canyons off Ningaloo has discovered 30 new species and undertaken 20 dives at depths of up to 4,500 meters over 181 hours of exploration. In August 2020, the Galapagos alone encountered 30 new species. Other discoveries include the ET- and glass sponges, the siphonophore and the deep sea lizardfish. From 2015 to 2017, scientists plotted more than 230,000 square miles of seafloor around western and central Pacific islands. Their cameras and equipment identified more than 347,000 deep-sea creatures. 4000 Argo floats have been deployed recently to monitor ocean temperature changes down to 2000 metres low; not deeper. On the 14 September 2020, various Institutes reported collaboration in the first comprehensive global survey of coral reefs. There is a significant potential benefit in locating new species and learning more about existing ones such as the value of underwater microbes in re-catalysts for life. Other fascinating new species include the quaintly named bloody belly comb jellies and giant larvaceans. It is also essential to fathom oceanographic processes and lifeforms. Ocean Blue Holes around Gulf of Mexico also received deeper probing by intrepid divers and benthic lander.

However, Seabed 2030 remains relatively small and not the all-encompassing network I propose across multiple blue economy users and that could be reconfigured to consider the various sectors and stakeholder priorities, so they could contribute in real time and understand. Data loggers and tracing apps could aid also in ocean governance, safety and security against piracy, poaching, climate change, violators of MPA, seabed mining and pollution agreements or other incidents. Observations have proven the risks of pollution and others reach the farthest reaches and chasms of the oceans. Other recent risks identified including loss of oxygen from climate change, possible seabed mining, offshore oil and gas and others such as sound waves. Pre-emptive exploration and intervention minimises direct catastrophes! This would be the most proactive source of continuous risk management. Direct access could link to a centralised Internet of Things. There remains a need to charter the entire oceans so that all can understand and access the blue economy, on ecosystems and communities. Given scarce resources, this needs to engage and convince other stakeholders to cooperate and be coordinated, to avoid unnecessary dupplication of effort and that all may benefit from whatever findings surface. Developing countries and even others more advanced, but with limited surveying capacity, may need to either be supported or encouraged to reprioritise. This would add to institutional capacity, training, vessels, equipment, technology transfer and or other resources/partnerships and awareness to foster both marine eco literacy and exploration. Many underestimate or value the role of oceanographic features or the implications for the blue economy. Seabed 2030's efforts and those of others believing in this hopeful Age of Marine Exploration may be inspired by the upcoming UN Decade of Ocean Science Initiative from 2021, following 1971 to 1980 International Decade of Ocean Exploration.

Seabed 2030 will be complemented by the efforts of various ISA/industry contractors, governments including their navies and several research institutions, although most of these remain confined to shallower water capabilities. China, Russia, France, the UK and the USA are the main nations with this capability, although others such as Japan, Spain and Korea are also expressing greater interest in supporting deeper capabilities for underwater exploration. The private sector across marine mining, offshore oil and gas and others could cooperate in data sharing; they just need to release the climate/ocean/ecological/non-commercially sensitive information. The greater the awareness and marketing so that people feel personal interest and stakes in how more knowledge can benefit them of self-interest, the swifter we can more accurately know the oceans instead of planning the new Blue Economy Epoch blindly. There remain unquestionable benefits, aside from ensuring ecological survival and blue economy prosperity. There is a need to understand the oceans -or blue ocean activities, for risks, forecasting weather, geology, repairs and maintenance, mystery, cultural, economic, Marine Spatial Planning, Marine Protected Areas and international law or domestic law for sea level rise and other risks conflict, migration and geopolitics. It is also essential for resolving transboundary risks and cumulative impacts.

CONCLUSION

In conclusion, there has never been a more opportune moment to become involved in the blue economy nor for the future of underwater exploration to be technologically, geopolitically, commercially, strategically and psychologically of interest. Given growing global interest in the blue economy and what ocean solutions may emerge to save our all-consuming species; it is curious and disturbing that too few of us truly know what is actually out and down there. Creating anything from the simplest fishing excursion or aquaculture farm to tourism charter operation to elevated seabed mining or offshore marine renewable energy complexes, underwater habitats and policies conceding the sovereignty and future of millions of kilometres of our oceans, before we truly have surveyed and processed comprehension of it, appears only brilliant for those incredibly short term minded. We need to not only accelerate exploration initiatives such as Seabed 2030 aiming to survey all the oceans by 2030, and protection measures such as 30% by 2030, but all who profit and value from the ocean should support, understand, mobilise others and if necessary, decisively act, interceding where necessary. Our oceans are too significant for our policymakers to decide alone, or for us to rely and not abdicate responsibility to them. It remains up to us to determine if we are content with the way the oceans, our blue economy and world are progressing or if we are not willing to surrender and abdicate our fates to those of others.

There is therefore a need to accelerate ocean exploration initiatives both publicly and privately utilising the integrated data, Internet of Things, sensors and quantum cloud computing processing capabilities of the 4th Industrial Revolution, but also physical archive backups. We need full marine and ecological impact surveys and assessments. It includes accelerating marine conservation and research measures but also marine ecological literacy and awareness into every school curriculum, not just climate change, pollution and the circular/green/blue economy. This information needs to be out there, available and accessible, so that not just policymakers but all of us are illuminated. Ignorance can no longer serve as a convincing excuse. We can therefore not just become passive observers but active participants in the blue economy. Many of us could be continuously providing real time live data of our observations to swiftly facilitate and accelerate the process. Observation could instil perhaps not just fascination but the immediacy and urgency in drive rather than apathy that is needed to jolt too many into taking it seriously.

Failing to act or invest in marine exploration and literacy may only aggravate the conflicts, tensions and competing priorities over resources, the issues over ocean security and governance, anticipated to only hasten in the forthcoming years. As Kiribati, Tuvalu and the Maldives are threatened with extinction, and many sea users face pressures over dwindling resources, few have considered how to ultimately avert that future. Perhaps what may be needed is the ocean equivalent of the Artemis Accords governing lunar exploration just launched in October 2020, or the South Antarctic Treaty or peaceful use of space. Pursuing the oceans, exploration and the blue economy, along with the quest against climate change and Great Purge of Pollutions, may remain among the greatest rallying cries the human race needs not just for our species but all those that may be affected by whatever pathways we decide for the oceans and planet. We can turn to solving many of the core risks, problems and concerns that face us and our oceans from population growth to food, water and energy security, to health and longevity, to psychological despondency, to proactively pursuing blue carbon and sustainable financing source alternatives, to fight against climate change, marine pollution and other issues.