"SeaSurveyor": An Innovative Floating Solution for Establishing Marine Protection Areas in Shallow International Waters

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Abstract

The recently signed UN High Seas Treaty aims to designate up to 30% of international waters as Marine Protection Areas (MPAs). Hotspots of marine biodiversity are sea mountains that form shallow waters in the middle of the sea. Since the successful protection of MPAs depends mainly on a physical presence on-site, we propose to position over the sea mountains floating bases that survey the MPAs and are therefore called "SeaSurveyors".
Low costs of the SeaSurveyors are crucial: the cheaper they are, the more MPAs can be created. Therefore, a new space frame system for the swimming platform has been developed, which is covered by a perforated aluminum mesh skin mainly for data protection reasons. The equipment with autonomous air vehicles and autonomous underwater vehicles with a range of up to 2000km allows a corresponding distance between SeaSurveyors positioned on different sea mountains.
Initial estimations validate the hypothesis that the integration of pioneering engineering techniques and an emphasis on marine mountain biodiversity could enable a team of 15 SeaSurveyors to safeguard 25% of global oceans as Marine Protected Areas at a very modest expense.

1. The miracle of New York

After more than 15 years of preparation, the United Nations General Assembly in New York approved the "UN High Seas Treaty" in March 2023 with the unwieldy title "Draft agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction" (United Nations, 2023). For the first time in human history, a legal framework was adopted that makes it possible to define marine protection areas (MPAs) in international waters located beyond 200 nautical miles from national shores and without any jurisdiction making up more than 40% of the surface of the earth.

For a long time, ecosystems have become increasingly fragile in international waters. The faster the demand for marine resources and free space is currently growing, the more companies and nations are starting to scramble for claims on the high sea. Thereby, the return on large investments into offshore fishing and sea-mining must be as predictable and beneficial as possible which was one reason for an internationally accepted long-term framework like U.N. High Seas Treaty.

But for the time being, the treaty on the protection of international waters is just a promise. It will not come into force until at least 60 countries have ratified it. Negotiations will have to be held in the next months on how the protection status will be defined, where the protected areas will be located and what exceptions will be possible, for example for deep-sea mining.
When implementing this UN treaty, it will certainly also help that, in contrast to previous UN resolutions, this time decisions do not need an absolute but a three-quarters majority. More than 75 years after its founding, the United Nations finally has the opportunity to protect international waters.

But how could the U.N. High Seas Treaty be effectively implemented?
And what strategies can be employed to achieve the UN's objective of establishing 30% MPAs in international waters?

2. Shallow international waters

The question of which MPAs should be prioritized in international waters has been debated hotly among scientists for a long time. Suggested approaches include:
- Design evaluations measuring species, biodiversity, and connectivity,
- Input evaluations reflecting shortfalls in terms of budget, capacity, and social equity,
- Threat reduction evaluations considering changes in human pressure and the environmental state, and
- Outcome evaluations examining extinction risk, species abundance, and socio-economic outcomes.

However, these approaches are limited by incomplete, inaccurate, or biased data, which often overlook significant elements of the marine environment leading to sub-optimal identification of the best biodiversity patterns (Maxwell et al., 2020).

Reliable data exist for the underwater topography in international waters. Underwater mountains, so-called seamounts often rise just below the sea surface, creating shallow waters in the middle of international waters. These seamounts are crucial hotspots for marine biodiversity and play a vital role in supporting species in neighboring suboptimal, non-seamount sinks (McClain et al., 2009).

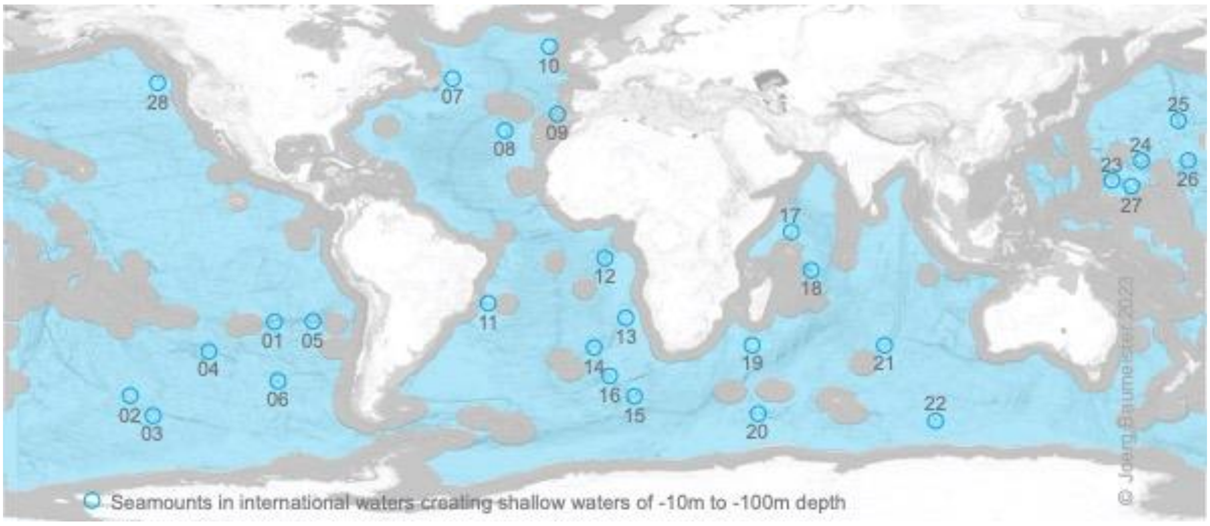


Figure 1: Result of a GIS survey indicated around 28 areas with shallow waters in international waters

The overlay of the GIS layer "international waters" with "shallow offshore areas providing less than 100m depth" generates a basic map of around 28 areas with shallow waters, 5 of which are only 10m and another 10 only 25m below sea level.

Given the clear data available, we propose to start the introduction of seamount MPAs as quickly as possible via the UN High Seas Treaty in order to prevent uncontrolled exploration and to support their supra-regional function as bio-diversity hotspots. These areas could also be connected, in part, with one another or with nationally protected coastal ecosystems.

3. Surveillance of MPA's

In the upcoming "UN High Seas Treaty" negotiations, the precise definition of the borders will be important. But two other points are even more crucial for the success of protected areas: Physical presence as well as monitoring are the main important indicators of effective and equitable protection and therefore the critical success factor for these very remote MRA areas (Gill et al., 2017).

Monitoring of boats can be supported by the "Automatic Identification System" (AIS), which is located on all vessels and sends and receives identifying information. However, the associated transceivers on the boats can be switched off. Satellites can also be utilized to monitor the water surface and a few meters below, although this method requires significant effort and is reliant on clear weather conditions. Remote monitoring from a distance is therefore not very reliable (Emery and Camps, 2017).

Since a physical presence is required anyway, one cannot avoid thinking about direct on-site monitoring of the future marine protected areas. This presence can happen directly manned or unmanned by sea or air vehicles (Kokkalis and Lekas, 2017). AAVs (autonomous air vehicles) and AUVs (autonomous underwater vehicles) navigate intelligently and use automatically auxiliary sensors and survey equipment (Tang et al., 2011).

One example of a new AUV generation is the Solus-LR from the Canadian company Cellula Robotics LTD. The equipment of the 8m long AUV includes Cameras, Laser, OFG Self Compensating Magnetometer, CTD, pH, CO2 and other chemical sensors and a variable buoyancy system. The use of hydrogen as a propellant not only provides environmental benefits, but also enables a range of over 2000km (Solus-LR).

Automation of launch and landing/disembarkation processes of AUVs and AAVs will continue to increase in the future so that fewer crews will be required for on-site presence. But there will be still a need for a physical base to accommodate AAVs / AUVs (including their energy supply and workshop) and a permanent crew who will work more and more remotely in the future. Data security will become an increasingly demanding challenge; the required base surveying the sea and called, therefore, SeaSurveyor must be protected against external intervention as much as possible.

The greatest possible cost reduction of the physically present SeaSurveyor is a decisive success factor for the implementation of the "UN High Seas Treaty". The lower the investment, the larger the area of MPAs that can be protected (Watson et al., 2014). The following chapter will therefore deal with the creation of the most affordable SeaSurveyor construction.

4. The SeaSurveyor

Establishing a local presence that is as environmentally friendly as possible requires either a ship or a floating platform. A ship is significantly more expensive due to its hydrodynamic shape and the propulsion unit used for locomotion (2a). In contrast, floating platforms are much cheaper (Wang and Wang, 2014), but they have to be manufactured in a complex manner and towed over several hundred to thousands nautical miles to the MPAs (diagram 2b).

Figure 2: Different types of floating bases

Therefore we propose a modular platform (diagram 2c) that can be assembled on-site as lightweight construction coming from building construction. It is modelled on the Mero Space Frame System developed by Max Mengeringhausen in the 1940s, which became famous at the latest with the introduction of the tetrahedron shape by Konrad Wachsmann in the 1950s (Watts, 2016). Members are connected with node connectors to statically efficient triangles and integrated buoyancy bodies to floating bodies. Danish company n55 has already successfully combined small scale 50cm members with 36cm x 36cm buoys to create an inexpensive space frame platform (n55.dk).

The herewith proposed SeaSurveyor structure uses a 7m x 7m grid due to the spatial requirements for AAVs and AUVs, workshops and individual rooms. Together with the buoyancy bodies, the members can be efficiently transported in 40-foot containers and set up on-site using the connecting knots. The space frame is not only used for the platform construction but continues above to accommodate the necessary functions. The presented example shows a 70m x 35m platform on which two 7m wide buildings are located, but the dimension and shape of the structure may change if required.

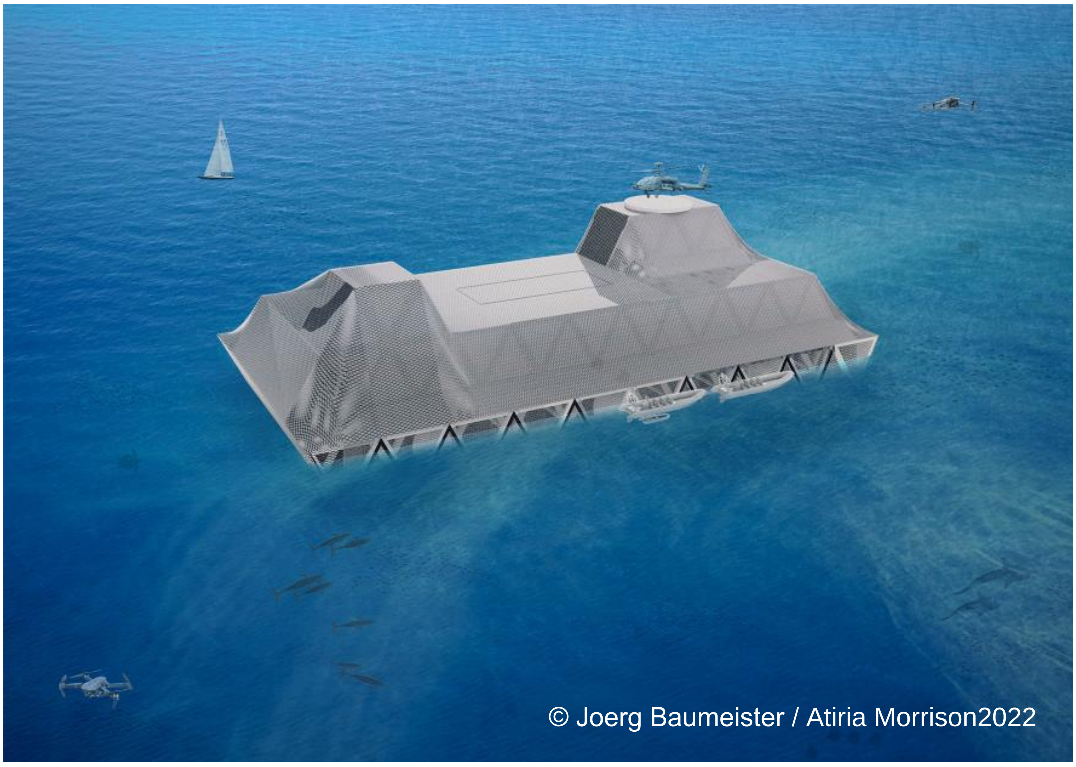
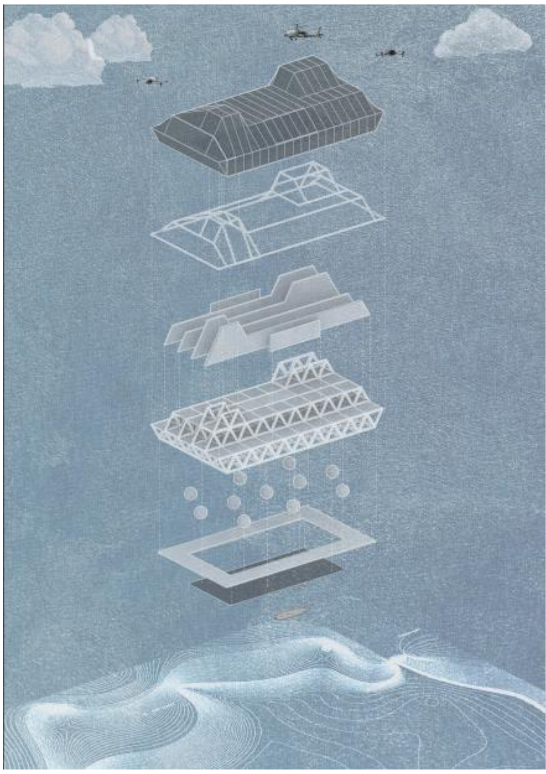


Figure 3: SeaSurveyor from top

A shell of semi-transparent aluminum boards wraps around the entire structure, which fulfils several functions: The most important is the creation of a Faraday cage as a protective enclosure that prevents electromagnetic radiation from entering and exiting and therefore unauthorized data access and manipulation of recorded surveillance data. The aluminum cover stops also AAVs from landing without authorization and its reflection and materiality make the SeaSurveyor an unattractive landing site for seabirds, which avoids pollution.



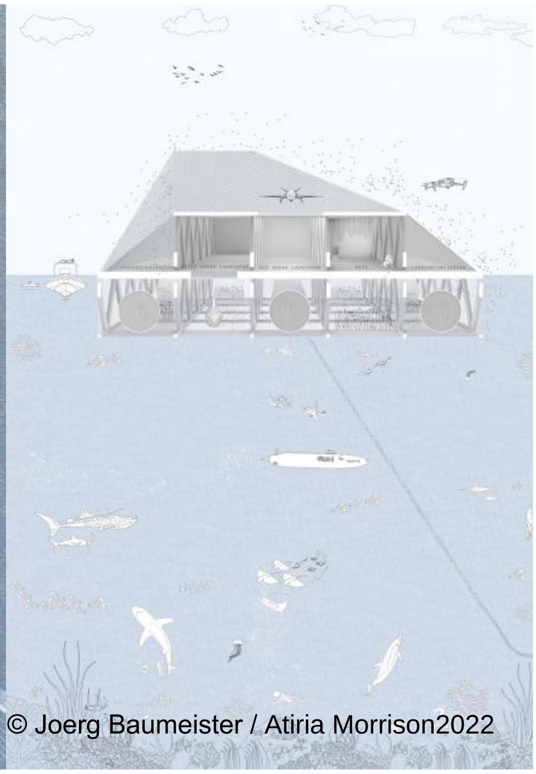


Figure 4 (left): From top to bottom: Perforated aluminium mesh skin, outline, walls, space frame structure, buoyancy bodies, heave plates, seamount
Figure 5 (right): Section of the SeaSurveyor

Figure 6: The SeaSurveyor operating with AUV and AAV

Depending on the wind, waves and currents, the position changes and reduces the influence of the waves on the structure to a minimum. The very good seakeeping behavior under various wave conditions has been confirmed by a feasibility study calculating wave-induced motions of the platform in 6 degrees of freedom (DOF) Response Amplitude Operators (RAOs). The identification of potential critical wave frequency and height resulted in the introduction of heave plates optimizing the seakeeping behavior (Kosleck and Schacht, 2021).

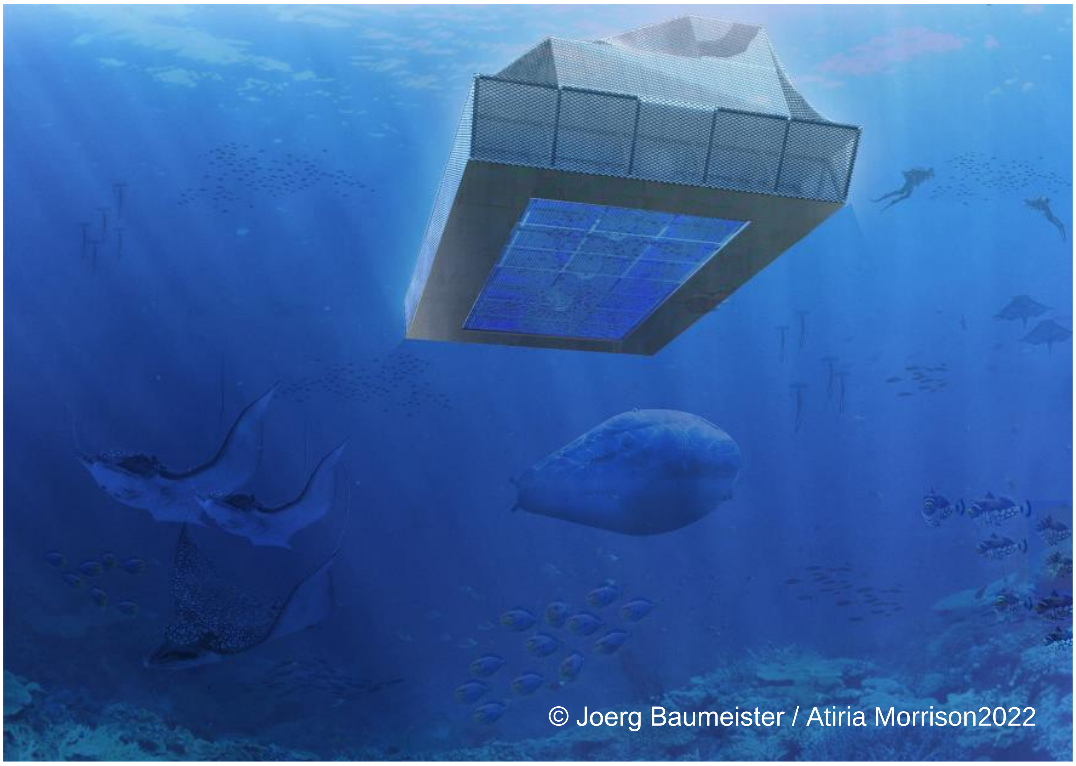


Figure 7: SeaSurveyor from seabed

5. Cost-efficiency

Once the technological aspects and their associated design implications have been determined, the next step is to consider the desired level of cost-effectiveness. In the current development phase, a cost estimate would not be very reliable, which is why we compared maximum cost reduction with an adapted "Life-cycle Cost System (LCS)" (Castro et al., 2016).

In contrast to the use of ships or common floating platforms, the manufacturing costs of the SeaSurveyor are the lowest due to the lack of propulsion and the modular space frame construction, which can also be used to create superstructures. Mooring and anchoring costs will be in all cases the same due to the proposed single-point mooring. The costs to produce the infrastructure such as energy will be comparable everywhere.

	Vessel	Floating Platform	Space Frame
Manufacturing Cost			
Construction	-	+	+
Superstructure	-	0	+
Mooring, Anchoring	0	0	0
Infrastructure	0	0	0
Installation Cost			
Transport	0	0	+
Infrastructure	0	0	0
Operation, Maintenance, and Dismantling			
Operation	-	+	+
Maintenance	-	0	+
Dismantling	-	0	+
Total	4 x 0 / 5 x -	2 x + / 7 x 0	6 x + / 3 x 0

Figure 8: Comparison of cost-efficiency between vessels, conventional floating platforms and the SeaSurveyor's floating space frame structure

The SeaSurveyor can be either towed or installed on site, giving the most cost-effective option for transport. The costs for operation, maintenance and dismantling are highest for ships due to their more complex shape. The SeaSurveyor's operation costs are comparable with usual swimming platforms and the SeaSurveyor's maintenance and dismantling will be cheaper due to the modularity. The costs associated with technical equipment and AAVs/AUVs operations were excluded from consideration, as they are identical across all three cases.

In summary, it can be stated that the SeaSurveyor will be significantly cheaper than competing vessel and platform types. Further savings in personnel costs are expected due to adjustments to the current status of remote controlling technology. The requirement to develop a base on top of seamounts that protects MPAs as inexpensively as possible is therefore achieved.

Further development steps of the SeaSurveyor will allow an exact determination of costs. The following calculations are very vague estimations (Ghigo et al., 2017) of $20 Mio for the structure explained, $20 Mio for its technical equipment, and $ 15 Mio for additional costs incurred annually. A lifespan of at least 10 years would result in a CapEx of a total of $20 Mio / year ($40 Mio / 10 years equals ca. $5 Mio + $15 Mio / year) including the purchase and maintenance of one SeaSurveyor.

6. Result

The objective of this research was to explore the most effective method of implementing the U.N. High Seas Treaty for the protection of MPAs. In a first step, seamounts were proposed as centers of MPAs due to the high biodiversity rate and the short distance to the water surface.

In the second step, on-site presence and monitoring were identified as the most important success factors for the protection of MPAs. Following these requirements, the SeaSurveyor was developed in a third and fourth step. It is a cost-effective structure positioned above seamounts and is equipped with AAVs and AUVs, the latter with a monitoring range of more than 2000 km.

In a last step and based on the previously determined factors, the following example demonstrates how the SeaSurveyor can help to implement MPAs in international waters as effectively as possible.

For maximum extension of the protected area at minimum cost, neighboring SeaMounts at a slightly smaller distance than the monitoring range are interlinked together with one exception protecting Antarctic marine biodiversity. At the same time, the proposed MPAs already integrate major biodiversity hotspots such as Salas y Gomez and Nazca Ridges, Gulf of Guinea, Walvis Ridge, Arabian Sea, Mascarene Plateau, and the Emperor Seamount Chain (World Economic Forum).

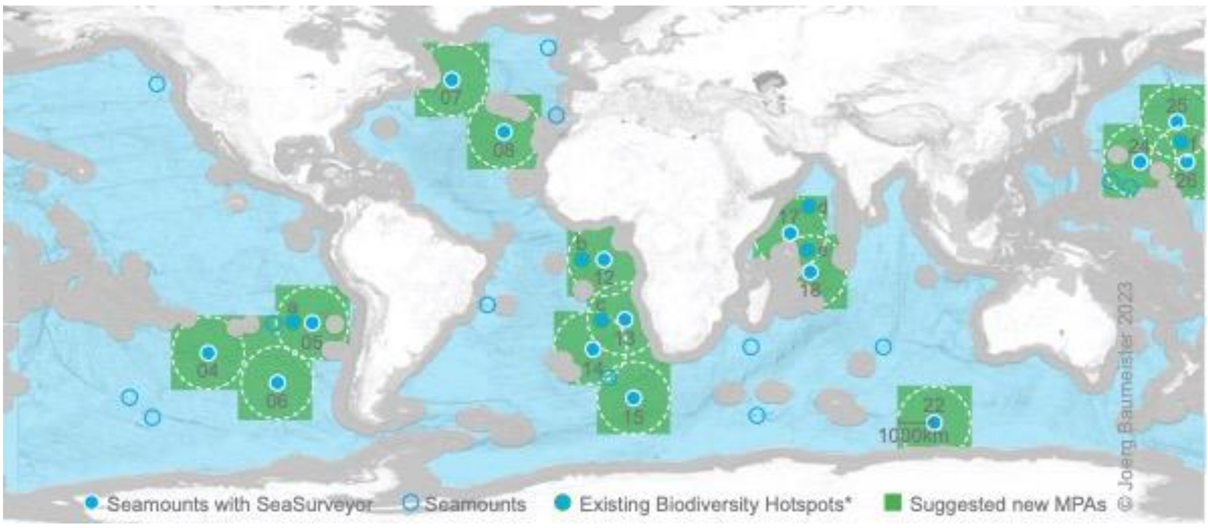


Figure 9: Suggested MPAs in international waters and existing top biodiversity hotspots

The arrangement of 15 SeaSurveyors proposed here is flexible and can be adapted to biological and environmental conditions. The SeaSurveyor platform aligns with several sustainable development goals outlined by the UN (UN SDGs), including quality education and gender equality (goals 4 and 5) due to integrated research facilities and a responsible consumption and production (goal 12) due to its cradle-to-cradle approach. Its use of hydrogen as clean energy and potential in situ production of renewables like wind, solar, and wind aligns with goals 7 and 9. The SeaSurveyor is geared to protect MPAs and its underwater design supports the colonization of marine environments (goal 14). Finally, we want to attract partnerships for achieving these goals (goal 17) which is one of the reasons for our participation at this Floating Solutions 2023 conference.

This raises the final question: What strategies can be employed to achieve the UN's objective of establishing 30% MPAs in international waters? The example mentioned before has already achieved 25% of the 30% target and could be implemented within a few years. The estimated total cost of 15 SeaSurveyors, at $20 million per year, would amount to $300 million per year. This cost is significantly lower than the UN's $6.7 billion annual budget for peacekeeping missions (UN Peacekeeping Missions, 2022), while the benefits to the world are substantial.

Given these considerations, it is reasonable to assume that utilizing SeaSurveyors on top of seamounts could serve as a significant aid for the UN in fulfilling their wonderful objective of establishing a substantial number of MPAs in international waters.

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