**Monitoring in Protected Areas : The Importance of Monitoring in Marine Protected Areas**

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**Abstract**

The purpose of this study was to investigate the importance of monitoring Marine protected areas and to identify tools and techniques that are appropriate for monitoring in marine protected areas. The importance of monitoring marine protected areas is an increasing concern for stakeholders of Marine protected areas. Using a cross-sectional analysis, this study analyzed research articles from 2000 to 2018 and measured these results against a similar study conducted in 2022. Remote sensing technology was found to play the greatest role in facilitating the monitoring of marine protected areas within developed and developing nations. Additionally, this study has discovered that Omic technology is one of the newest bio technologies for monitoring the biodiversity of marine protected areas. The study suggests that the monitoring of marine protected areas is a continuous process and it permits management of Marine protected areas to identify and evaluate the status of threats and address issues ,such as the reputation of conservation targets and the execution of conservation actions. Furthermore, the monitoring of marine protected areas allows stakeholders to appraise the effectiveness of management interventions. The study definitively answers the question regarding what are the importance of monitoring protected areas and the tools and techniques used for monitoring marine protected areas. However, further studies are necessary to identify the challenges of monitoring marine protected areas and develop remedies for ameliorating those confrontations.

***Keywords* : *c***onservation status, threats, , monitoring ,importance techniques ,remote sensing

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**INTRODUCTION**

Marine protected areas are defined as geographical ocean spaces that are recognized and managed through legal or other effective means ,with the intent to conserve nature over the long term, taking into account the maintenance of ecosystem services and cultural values.(Dehens & Fanning, 2018).The aim of this research is to identify the importance of monitoring Marine Protected Areas/seascapes and outline tools and techniques that are relevant for monitoring Marine Protected areas /Seascapes. . This research contributes to the body of knowledge on the importance of monitoring marine protected areas and contemporary tools and techniques for monitoring indicators of Marine Protected Areas. This research will fill the gap of the limited existing research regarding the importance of monitoring marine protected areas and those tools and techniques for monitoring Marine protected areas(seascapes). Scientific research in the area of Marine species diversity has clearly established that monitoring in Marine Protected Areas is a significant remedy for biodiversity conservation in marine protected Areas and for Marine spatial planning. According to the IUCN, Protected Areas can be defined as a clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature. (*Monitoring of Biodiversity in Protected Areas*, n.d.).

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This research paper aims to investigate the importance of monitoring in protected(marine) Areas and identify various tools and techniques used for monitoring in Protected(marine) Areas. The rationale for elaborating on this topic is to cover the knowledge gap on the importance of monitoring in Marine protected areas(seascapes). This paper is divided into two sections: The importance of monitoring in Marine Protected Areas, and the tools and Techniques used in monitoring Marine Protected Areas. Monitoring in Protected Areas can accord the opportunity for the management of Marine Protected Areas to detect and understand various risks of invasions by different species, ascertain the potential paradigm of invasions, and design strategies to minimize risks in Marine protected areas.(Otero & Cebrian, 2013).Monitoring in Protected Areas is significant to identify processes that have adverse impacts on the conservation and sustainable use of biodiversity. Monitoring in Marine protected areas allows management to assess the status of threats and address issues such as the status of conservation targets, the implementation of conservation interventions, changes in the levels of threats, and evaluation of the effectiveness of management interventions. (Rao et al., n.d.).

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Some researchers have proposed that Monitoring in Marine Protected Areas should be done continuously, for example to detect the possible occurrence of poaching by comparing species, ecosystem recovery, and measuring compliance with regulations in Protected Areas.(Bergseth et al., 2015). It’s cogent to monitor Marine protected areas for detecting human pressure, ecological performance, reference, and ambient conditions that are impeding protected seascapes..( Dunham et al., 2020). Marine protected areas should be monitored in order to measure their ecological effectiveness, by comparing the values of biological diversity such as the sizes of plants and animal species, fish assemblages, and species richness, to their previous status (prior to their establishment as Marine Protected Areas) (Giakoumi et al., 2018).A vessel Monitoring system can be used as a tool for quantifying fishing activities for the inshore fishery in Marine Protected Areas. It can be used as a monitoring technique/tool for identifying the impact of fishing on species and habitats of Marine Protected Areas. This technology is used as a significant tool for the acquisition of data, for stakeholders and management in the fishery sector of marine Protected Areas, to improve conservation strategies.(Birchenough et al., 2021; MacKeracher et al., 2019) .

Contenporary researchers have used satellite imagery of remotely sensed data, to monitor sea turtles, that were located at the Western fringe of the Algerian Basin.( Abalo-Morla et al., 2022).Radar satellite images have been used by the management of Marine protected areas in oil spill accidents in Jiaozhou Bay, China, to monitor oil spill accidents in Marine Protected Areas(Ma et al., 2023).Remote sensing plays a succinct role in the monitoring of marine habitats, species diversity, and fragmentation (degradation and habitat loss). Landsat images contained a significant data source for the monitoring of marine protected Areas.(Nagendra et al., 2013).

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**Literature Review**

This chapter analyses similar research topics about the tools , techniques, and importance of monitoring marine protected areas, in different regions. The findings in this research were compared to similar research conducted by a group of researchers from different universities and institutions. According to a research article by Finn Danielsen, the monitoring of protected areas can be sustained if we consider the participation of local personnel in the management of protected areas, and use aerial surveillance, and satellite imagery for the collection of data.(Danielsen et al., 2000). Furthermore, this article analyses a research article by Philip A. Townsend and others from the University of Wisconsin. In the article, Philip A. Townsend explains that Landsat data are the most reasonable choice of tool for monitoring protected areas(Townsend et al., 2009) and this research paper definitely buttress the argument of Philip A Townsend .In the article entitled “A Global Analysis of the Effectiveness of Marine Protected Areas”, Marine protected areas are monitored, to prevent overfishing and human land use practices, that affect the biodiversity of Marine Protected Areas.(Selig & Bruno, 2010).

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Fanny Douvereand Charles and N. Ehler of the Intergovernmental Oceanographic Commission (IOC)of UNESCO, present in their article “The importance of monitoring and evaluation in adaptive maritime spatial planning”, that monitoring the status of biodiversity in marine protected areas is essential for determining the overall health of the ecosystem within marine protected areas.(Douvere & Ehler, 2011).This has also been explored in prior studies by Fiona Leverington and others ,that detailed monitoring and reporting on the condition and trend of the activities of marine protected areas (for example cultural values, socioeconomic impacts on the fish population, etc.) are paramount for the conservation of biodiversity in marine protected areas(Leverington et al., 2010) .A review article published by John p. Croxall and others in 2012 accentuates that monitoring in marine protected Areas is sacrosanct for addressing the current threats that are inflicted on the sustainability and health of marine protected areas and ascertaining the type of baseline that exists, against which future change can be measured. (Croxall et al., 2012).

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Previous studies showed that the use of tools such as miniature implanted acoustic transmitters and a fixed acoustic receiver array has been used to determine the movement patterns of fish populations and to evaluate the function and design of the Caribbean Marine Protected Areas.(Pittman et al.,2014).A series of recent studies have shown that baseline monitoring and the monitoring of appropriate indicators, and collecting in situ data (for example the rate of fish harvesting and fish biomass(Ahmadia et al., 2015) are appropriate for investigating the status of a marine protected area.A recent project by Pew Bertarelli Ocean Legacy, a Pew Charitable Trust in South Georgia and the South Sandwich Islands in September 2021 demonstrates that satellite remote sensing technologies can be used as a tool for tracking changes in global oceanography such as sea surface temperature and productivity, quantifying fishing and other anthropocentric activities within marine protected areas of Southern Georgia and the South Sandwich Islands. However, this research article supports the concept of the Pew Bertarelli Ocean Legacy project because remote sensing techniques or tools can capture nature changes that can also influence the biodiversity of species such as global warming, seasonal variation, floods, and droughts in Marine protected areas.The concept that was employed in the aforementioned project for monitoring marine protected areas was compared to a research article by J. L. Andersen of the University of Copenhagen. J. L. Andersen of the University of Copenhagen demonstrates that a spatial bio econometric model can be used to monitor the adverse impact of fishermen on key species. However , this research paper has argued with the concept of Andersen, on the basis that spatial bio econometric model is most often based on prediction.(Hoff et al., 2013).

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Additionally, the article entitled “Establishing a functional framework for monitoring protected landscapes”, by Emily Horswill and others from the University of Plymouth, confirms that monitoring of protected areas is important for tracking consistent landscape quality and environmental interventions(Horswill et al., 2020).While J. Aguzzi and others from the Polytechnic University of Marche, Ancona, Italy, in their article entitled “Ecological video monitoring of Marine Protected Areas by underwater cabled surveillance cameras” ,have suggested that the monitoring of marine protected areas is significant for detecting changes in the seascape/landscape of marine protected areas, defining suitable environmental protection measures and for protecting the sustainable use of vital resources.(Aguzzi et al., 2020).

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**Discussion**

This section of the research is concentrated on the tools and techniques for monitoring marine protected areas.This chapter suggests several tools and technologies for monitoring marine protected areas such as hydro acoustic technologies , which are magnificent tools and techniques used for monitoring the threats reposed on fish habitat and their population. Findings have accentuated that the hydroacoustic technique is one of the amicable tools for assessing human-induced pressure on marine protected areas.(Egerton et al., 2018)This research also elucidates that the use of drones and Unmanned Aerial Systems are effective tools and techniques for assessing the biodiversity status of marine protected areas because they can capture high resolution images and can detect changes in marine protected areas at high spatial-temporal resolution.(López & Mulero-Pázmány, 2019).

In addition to the above-mentioned tools and techniques that are used by the management of marine protected areas for monitoring threats, this research has identified that the application of satellite remote surveillance in monitoring offshore fisheries was used by the British for monitoring commercial fisheries. Satellite-derived intelligence was used to set risk thresholds and trigger detailed investigations.(Rowlands et al., 2019) According to the “Council for Scientific and Industrial Research”, an outstanding research institution in South Africa, an anti-pollution project called “Prevention of Ocean pollution” for the conservation of the Ocean. The project team members consisted of local stakeholders and representatives from the plastic industries. Meanwhile, the research has ascertained that a researcher from the Bedford Institute of Oceanography, suggests the use of Omic technology is an emerging biotechnology tool that focused on DNA meta bar-coding for biodiversity monitoring in Marine protected areas in Canada.(Jeffery et al., 2022). This study has unveiled that a cohesive monitoring framework is a fulcrum for the effective monitoring of marine protected areas. Because a framework provides the relevant hallmark for the conservation of marine protected areas. (Katsanevakis et al., 2011).

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This research has also recognized that setting up a National Marine Ecosystem Monitoring program for coastal wetlands and evaluating the perception of residents of marine protected areas are inevitable techniques for monitoring marine protected areas.(North-East Asian Marine Protected Areas Network Management Plans, Monitoring, and Assessment of Marine Protected Areas, 2021).

**Types of Indicators to monitor in Protected Areas**

An indicator of protected area biodiversity can be defined as a parameter that modifies the protected area`s biodiversity condition. Protected Areas indicators can serve three cardinal purposes: (1) they can be used to compute complex events. (2 ) foster communication about multiplex connection and (3) Reduce the number of measurements needed to make a precise handing over of a circumstance. This research identifies four magnificent indicators to be measured when monitoring the biodiversity of protected Areas: (1) Changes in the number of similar species and local reserves used. (2) changes in the relative extent of vegetation types and land use preference areas. (3) Changes in the occurrence of discernment of particular symptoms of the presence of similar fauna species and local resources utilized along confirmed transects and (4) changes in observed volume per assay and in the number of stakeholders involved in specific anthropocentric activities within a defined period.(Danielsen et al., 2000) .

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In addition to the aforementioned indicators, this research has localized its findings into Marine Protected Areas as indicated below. Findings in this research suggest five indicators to be monitored in marine protected areas. Namely: pressure, physical parameters, biological structure, functional structure, and ecological models.(Smit et al., 2021).

**Pressures**

The category of pressure that this research exemplifies includes organic land pollution, merchandised shipping, the impact of invasive species, and seabed mining. In South Africa, cumulative pressure and impact assessments were employed to capture all potential human-induced and extrapolate their impacts on a broad range of marine ecosystem components.(Coll et al., 2010)

**Physical parameters**

The perspective of physical parameters that are elucidated by this research paper includes abiotic attributes such as temperature, salinity, the chemical composition of the water, and physical properties of the sediment size as well as disturbances.(Bald et al., 2005)

**Biological structure**

The findings in this section suggest that biological indicators can be used to measure all trophic levels, such as phytoplankton, Zooplankton, benthic invertebrates, macroalgae, fish, and megafauna as well as marine predators in marine protected Areas. Biological indicators can be used to monitor the concentration of eutrophication /nutrients and pollutants in Marine Protected areas.(Ojaveer & Eero, 2011)

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**Functional structure**

The functional structure indicator refers to the activities of organisms within marine Protected Areas. This caption epitomizes the morphological, behavioral, and life history traits. The presence or absence of a particular trait can be used to assess the structural and functional components of ecosystem conditions within marine protected areas (Baird & Baird, n.d.)**.**

**Ecological model**

This section illustrates a broad range of models and indicators that are used to monitor the state and trend of marine protected areas. For example, food web indicators can be used to measure ecosystem conditions in marine protected areas (Borja et al., 2009).

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**Conclusion**

This chapter will conclude the study by summarizing the key research findings in relation to the research aims and research question, as well as the value and contribution thereof. Furthermore, it has reviewed the limitations of the study and proposed opportunities for future research. This study aimed to investigate the importance of monitoring marine protected areas and identify tools and techniques for monitoring Marine protected areas. Remote sensing is a tool for identifying invasive agents and surrogates within marine protected areas and for focusing on habitat dynamics (Kuenzer et al., 2014).

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The result indicates that Remote sensing technologies are contemporary tools for monitoring marine protected areas (Dolph et al., 2018). The study shows that the monitoring of marine protected areas, such as changes in vegetation dynamics is paramount for the management of Marine protected areas to detect the response of the marine ecosystem to climatic variability and the impact of human activities on coastal ecosystems (Osunmadewa et al., 2018). However, future researchers can use this research to address the challenges involved in the monitoring of protected areas and the paradigm in which biodiversity indicators are used to ensure sustainable management and protection of marine resources, as well as things that hinder us from monitoring the precise indicator. Meanwhile, findings in this research were confined to marine protected areas within developed and developing nations. This study was based on a similar study by marine ecologists who recommended five pragmatic indicators that management of marine protected areas may consider while assessing the biodiversity status of marine species.

Those indicators include pressure, physical properties, biological structure, functional structure, and ecologic model. Further findings show that monitoring of protected areas is important for tracking consistent landscape quality and environmental interventions and for ascertaining the overall health status of species within marine protected areas. This study will contribute to the body of knowledge in the field of marine ecosystems because it reaffirms existing theories.

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