Marine & Coastal Programme

<u>Proposal for:</u>

The implementation of a functional, whole-sea systems approach to understand and conserve Plettenberg Bay's marine and coastal systems

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Summary

Plettenberg Bay is a small coastal area situated in the Western Cape, South Africa. It is known for its scenic beauty and high biological diversity. Despite being "fenced" by two marine protected areas (MPAs), the Bay currently does not enjoy any form of formal protection, nor does it have an updated marine management plan or anyone driving the conservation of the Bay outside of the MPAs. However, before the Bay can be monitored and managed/conserved in an optimal manner, the makeup of the Bay, the wildlife that inhabits its niches, the quality of its waters and pollutants of these waters need, amongst others, to be understood as well as the human interactions in and around the Bay (e.g. how, where and when different stakeholders interact with the Bay).

To address these shortcomings, a group of marine, coastal, spatial and social scientists will have to guide a well-planned and executed research process. More importantly, though, an entity willing to drive the entire process from beginning to end and to secure the buy-in and support of a broader spectrum of stakeholders is crucial if success is to be assured. We belief that the Nature's Valley Trust (NVT) is ideally suited to fulfil this role since it can oversee monitoring, research and management efforts in the Bay over the long term.

The proposed Marine and Coastal Programme will be implemented in four phases that will be executed over a five-year period. In brief, the four phases and timelines encompass:

- Appointing a **marine scientist at the NVT**, sourcing experts and establishing a **steering committee** as well as facilitating an **inaugural stakeholder meeting** with a broader spectrum of stakeholders as indicated in annexure 1 (phase 1 – 2023/24);
- Conducting **seven research projects**, with the assistance and support of external (expert) service providers (phase 2 – 2024/25);
- Developing a local-scale **marine spatial and management plan** for the Bay (phase 3 – 2025/26); and
- Continuing with the **long-term monitoring of the Bay and facilitating the implementation of the Bay management plan** (phase 4 – 2026/27 to the end of 2028).

Several partners (see annexure 1) have been identified and the plan is to include all local, regional, provincial and national stakeholders. If the proposal is successful, Plettenberg Bay – already recognised for its biodiversity significance since it encompasses two MPAs, a Hope Spot and a Whale Heritage Site – will be the first small coastal area to implement a marine spatial management plan and continuous monitoring of marine and coastal systems over an extended period.

Introduction

Plettenberg Bay, with its rocky platforms, sandy beaches and subtidal rocky reefs, is renowned for its scenic beauty and biological diversity. The huge array of ecological niches and habitats in and around the area offer a multitude of social and economic benefits in the form of recreational and subsistence fishing and tourism activities. Significantly, though, another environmental benefit derived from this rich biodiversity is its ability to regulate and control pollutants. Combined, all these benefits have a hefty impact on the quality and attraction of the location and its surroundings since they have a direct bearing on the health and well-being of the Bay's ecosystem. Unfortunately, due to the ever-growing pressures exerted by human activity, this ecosystem is becoming more and more vulnerable. Pollutants, rising sea temperatures, acidification of the ocean, overfishing, inappropriate disposal of waste and a proliferation of microplastics that end up in the ocean or wash ashore all contribute to the health of marine ecosystems plummeting worldwide. To counter the potential threats posed to its unique ecosystems and to maintain all benefits derived from its exceptional biodiversity, it is of utmost importance to, first and foremost, gain a scientifically sound understanding of the Bay's make-up that extends well beyond merely establishing which species inhabit its niches but also the levels of pollutants and other anthropogenic pressures that threaten the sustainability and well-being of biodiversity in this volatile area.

Comprehensive research on the living organisms present at all trophic levels will result in a better understanding of Plettenberg Bay's marine and coastal environments. The indicators thus derived can then be used to calculate and monitor the effects of the pressures imposed on the area. In this way, the health of the environment can be monitored in a suitable, consistent manner that will elucidate any action needed to protect the pristine condition of Plettenberg Bay against any anticipated threat.

Approach and site

A functional, whole-sea system approach will be followed which will be applied in a structural, site-specific manner in the Plettenberg Bay area (between the Robberg and Tsitsikamma MPAs). The marine boundary of the Bay is delineated between the south-western seaward corner of the Robberg MPA (31 07.633'S; 23 22.300'E) and the south-eastern seaward corner of the Tsitsikamma MPA (34 07.633'S; 24 11.665'E). The approximate size of the area is 92 km².

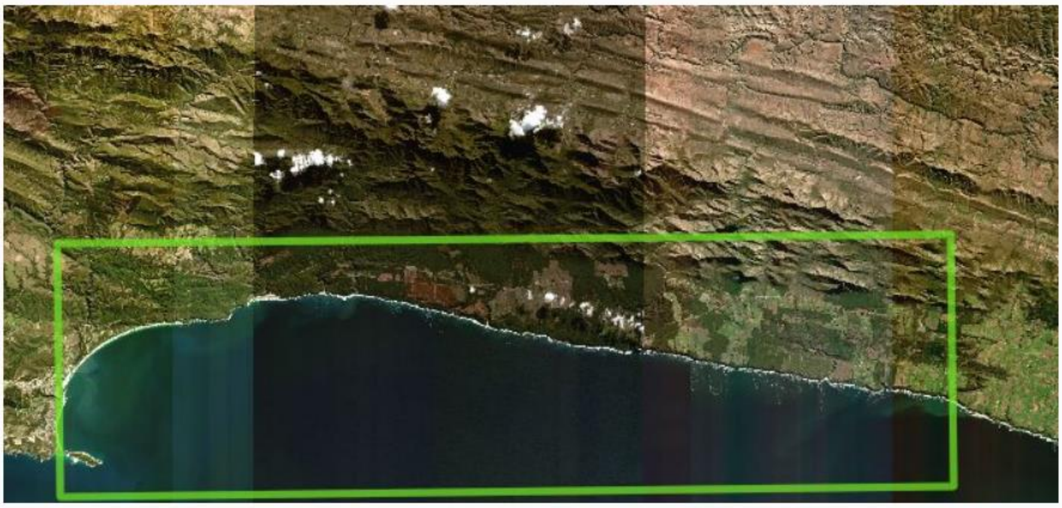

Figure 1: Site

Programme phases

The proposed process will be implemented in four phases:

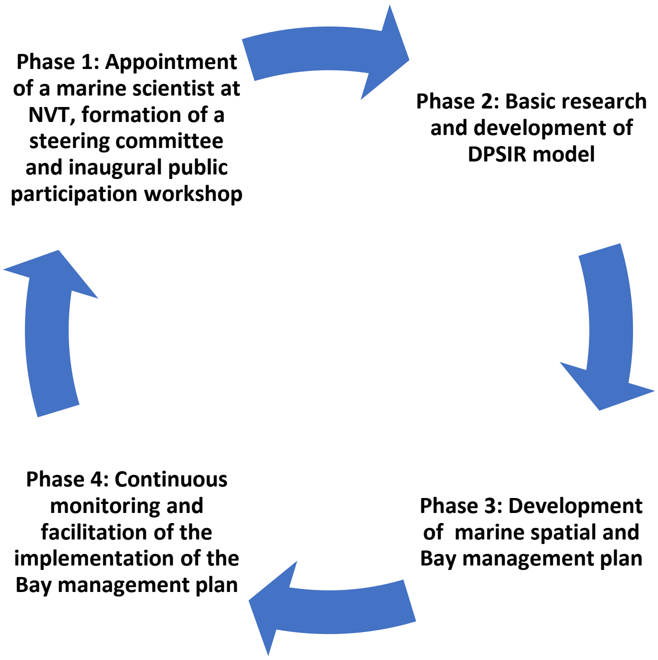

Figure 2: Proposed process

Phase 1: Appointment of a marine scientist at NVT, formation of a steering committee and inaugural public participation workshop

The first step in phase one involves the appointment of a marine scientist who can develop and refine the proposed process and manage NVT's marine and coastal programme. This person will be responsible for the coordination and implementation of the proposed projects.

The second step will be to source and appoint several marine and coastal experts (institutions). Their role will be to provide expert advice and guidance on the programme in general, but particularly on the proposed research projects. Some of the members (or representatives of certain institutions) will also act as service providers for the seven proposed projects. Amongst the key institutions that will be approached for this purpose are:

- CapeNature
- Department of Forestry, Fisheries and Environment (DEFF)
- Garden Route Biosphere Reserve
- Plettenberg Bay Whale Heritage Site
- Nelson Mandela University's (NMU) Sustainability Research Unit and Institute for Coastal and Marine Research
- South African National Biodiversity Institute (SANBI)
- South African National Parks (SANParks) – in particular the Garden Route National Park's Scientific Services
- South African Network for Coastal and Oceanic Research (SANCOR)

The third and final step in phase 1 will be to host and inaugural public participation meeting to which the stakeholders indicated in annexure 1 will be invited.

Phase 2: Basic research and development of DPSIR model

In the past, a whole array of methods has been employed to monitor and manage marine and coastal ecosystems. As of late, though, one approach of a more contemporary nature proved to be exceptionally effective. This approach is commonly referred to as the **DPSIR** model and involves establishing the link between an area's **driving forces** (i.e. the composition of its human populations and their activities) and the **pressures** (exerted by both human actions and the climate on ecosystems) and the **state** (i.e. biodiversity, pollutant levels and overall health) of the area. Once this link has been established, the **impact** of the driving forces and pressures can be derived which, in turn, facilitates the formulation of appropriate **responses** to counter negative consequences.

Successful implementation of this model is, however, dependent on an intensive study of each habitat's biodiversity which involves a meticulous analysis of each indicative species/species population at multiple trophic levels so that scientifically sound indicators of system health can be derived. By way of illustration, in the case of a rocky-shore habitat, multiple surveying techniques must be deployed to calculate the number of species present and to gain a greater understanding of the role each fulfils in this habitat and how well they are faring in contributing towards the overall health of the ecosystem. One indicator species in a rocky-shore habitat is mussels: Since mussels are filter feeders that act as ecosystem engineers by filtering pollutants from the water they inhabit, their relative abundance has a direct correlation with water quality and clarity. Given, too, that mussels are also a very important food source for rare and protected species such as the black oystercatcher, the sustenance they provide spirals upwards throughout the entire trophic system and impacts the abundance of harvestable fish and the likes of sharks and whales, all of which have high monetary and tourist value. Furthermore, due to their filter-feeding capabilities, the flesh from mussels holds pollutants passing through the area and can thus be used to monitor the fluctuating levels this threat poses to the Bay.

The above serves as an indication as to why biodiversity must be understood at an ecosystem level if the health and value of the Bay is to be protected. Monitoring mussels is, however, but one of the options.

Various other aspects such as water quality and clarity, the various habitats occurring in the Bay (benthic aspects) and the depth of the ocean floor (bathymetric aspects) can also be studied via remote sensing, while space-based lidar can be used to track changes to the ocean floor or shoreline. The afore-going is necessary to derive meaningful water-quality parameters, keep track of changes in benthic habitat classes and to conduct shoreline assessments on a seasonal basis.

It has been observed that large commercial fishing boats are forced to travel further afield to meet their fishing quotas due to overfishing of areas near harbours such as Port Elizabeth and Mossel Bay. Through future partnerships, NVT will be able to use satellite imagery to analyse trends with a view to refining tasked times and even to detect illegal vessels – especially those attempting to enter the marine protected (no-take) areas.

The development of a DPSIR model also involves conducting a social baseline study. The importance of such a study should not be negated since many of the threats to marine and coastal systems are anthropogenic. As a minimum, this study should aim to gain an understanding of human interactions with the Bay by focusing on threats, drivers and needs. The results thus derived will feed directly into the development of a marine spatial and management plan for the Bay so that the key institutions listed above will be in a better position to develop suitable interventions to counter identified threats.

Phase 2 will encompass seven projects:

Project 1: Ocean floor classification and underwater depth (bathymetry)

Based on a whole array of features, the aim of this project is to classify the seafloor and to determine underwater depth (bathymetry). In addition to gaining an understanding of the ocean floor and coastline, the data thus gathered can also be used to determine where fish and other marine life feed, live and breed. Certain inferences can then be made about which local species should be thriving in different areas of the Bay and, after further sampling, hypotheses as to the reasons why they are thriving or are as not as abundant as expected can be formulated. In the long term, bathymetry data can also be used to study the ocean's climate and to model the effects global warming has on the seabed. Furthermore, it is anticipated that project 1 will also help to determine which survey techniques will be most suitable for the remainder of the projects in this phase and are most likely to prevent damage to research equipment.

Methods: A multi-beam survey technique is proposed. Multiple WorldView 2 or 3 satellite images will be used to compile a 2 m satellite-derived ocean floor classification (figure 3) and to derive bathymetric systems (figure 4). The different areas thus identified will then be verified by way of diving excursions.

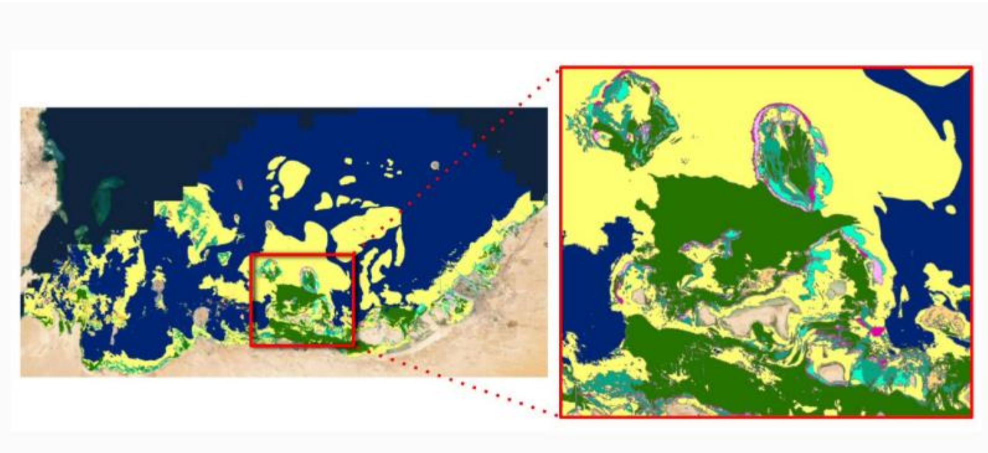

Figure 3: Example of ocean floor classification

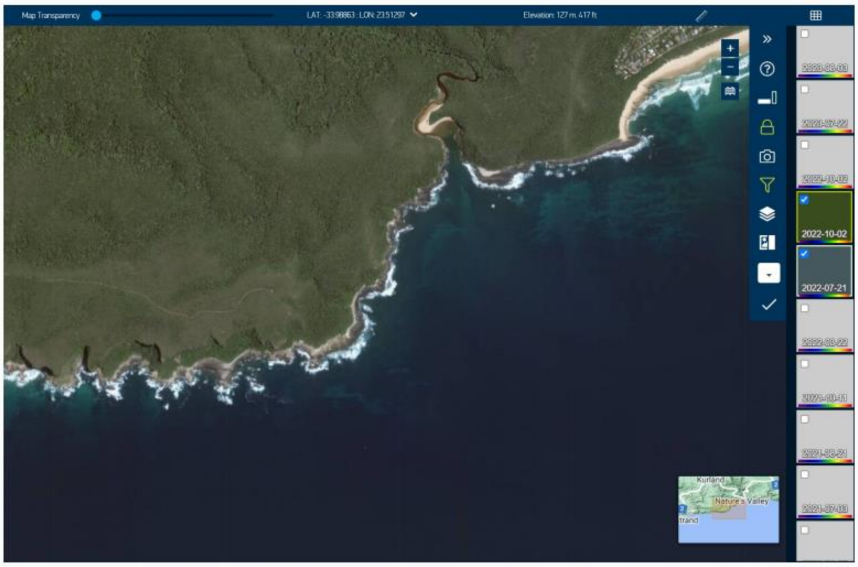

Figure 4: Example of bathymetric systems

Project 2: Aerial water-quality assessment and monitoring of pollutants

The aim of this project is to conduct an aerial water-quality assessment, which will be used to identify areas of interest for ongoing monitoring.

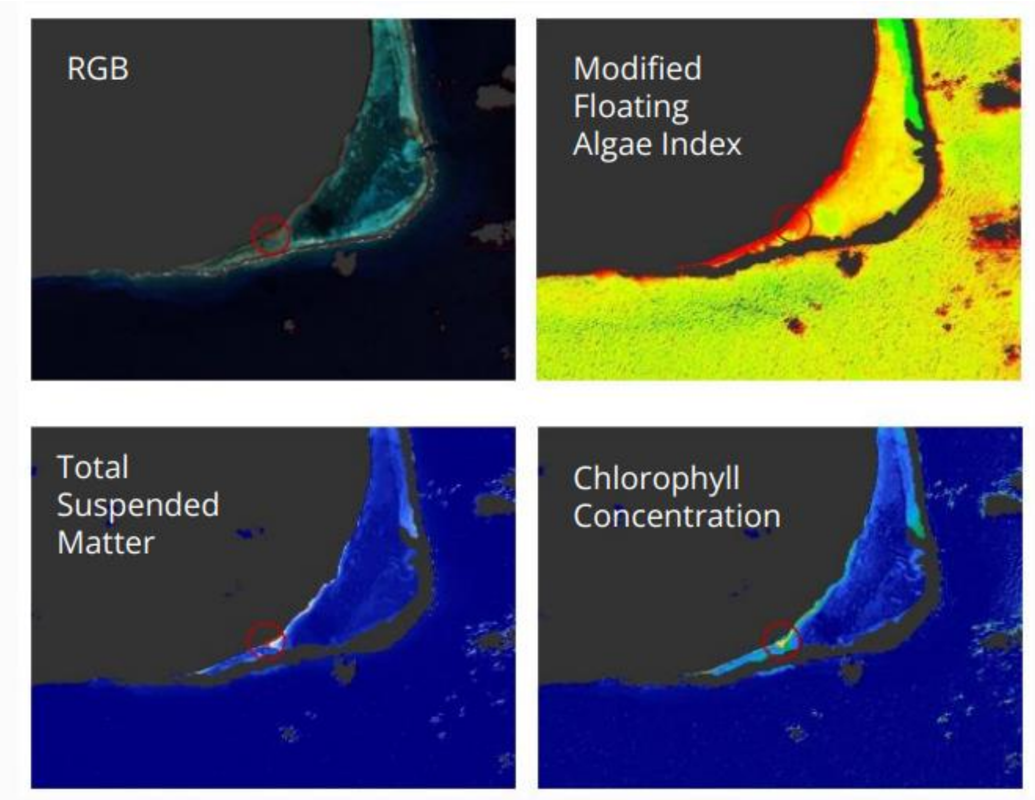

Figure 5 (a-d): Example of aerial water-quality assessment

Short- to medium-term aerial monitoring will include daily imaging and monitoring with weekly and monthly trend analyses. Currently the level of pollutants in the Plettenberg Bay area cannot be monitored remotely since the spatial resolution required for this purpose is not yet available. Until such time as the necessary technology becomes available, the intention is to either detect and discriminate pollutants on a pixel-by-pixel level or by percentage of influence within a pixel. If spatial and spectral accuracy thus derived proves to be reliable over time, the way oceans are monitored will change rather dramatically.

In the interim, additional on-the-ground monitoring[1] will have to be conducted at periodic (i.e. annual or quarterly intervals) mainly because:

- For rocky-shore systems especially, salinity levels can affect water evaporation times and disrupt the forming of rock pools. Salinity also affects the level of oxygen required for life, as well as marine plants' nutrient uptake such as macroalgae.[2]
- Calcifying organisms are key to ecosystem health since they form most of the ocean floor and rocky-shore fauna and, in areas with acidic pH, sea shells and skeletons formed are bound to dissolve.
- Marine species survive within certain oxygen ranges and fluctuating dissolved oxygen conditions will determine the ability of said organisms to thrive in their chosen niche.

[1] This involves, amongst others, monitoring salinity, water pH, dissolved oxygen levels, nitrogen levels, phosphate levels, microplastics and other waste levels.

[2] Macroalgae are key to ecosystem health both as a food source and as an absorber of pollutants.

- Both nitrogen and phosphate levels affect the growth of algal blooms. Eutrophication is a common cause of harmful algal blooms and once these algal blooms become overgrown, no light can reach the ocean floor which means other plant species cannot survive, resulting in the demise of organisms all the way up the food chain. This can lead to dead zones, toxin production and lower species diversity, all of which will have knock-on effects on food web interactions and result in an area becoming less attractive for wildlife and, ultimately, tourists.
- Microplastics is a known scourge that pose a serious threat to marine ecosystems and have caused the demise of several species, notably tourist-centric species such as turtles that mistake microplastics as a source of food.

Methods: Aerial water-quality assessments will include the calculation of monthly average percentages for clarity and turbidity. Data will be sourced via Sentinel 2. For monitoring purposes, a multi-parameter assessment based on the delivery of daily geospatial data in the form of PlanetScope imaging of two 10 x 10 km locations will be used to identify trends based on weekly and monthly averages.

On-the-ground equipment used to assess water quality and monitor phosphate levels could include the use of hydrometers, ion-sensitive field effect transistors, pH dyes, dissolved oxygen meters and censors as well as nitrogen chemiluminescence detectors. In the rule, a seawater sample is allowed to react with a composite reagent containing ammonium molybdate, ascorbic acid and potassium antimonyl-tartrate. The resulting complex is reduced in situ to render a blue-coloured solution, the absorbance of which can be measured spectrophotometrically.

The level of microplastic infestation and the bioaccumulation of trace metals in mussel flesh will be determined per quadrat along the coast.

Project 3: Habitat mapping (benthic survey)

Once the ocean floor has been mapped, sites along the seabed with different niches that can be explored for sampling purposes to, for example, compare benthic organisms found in a sandy seabed to those found in a rocky seabed can be identified.

Benthic organisms often hold the key to understanding the dynamics of and biodiversity present within underwater ecosystems. Benthic infauna (those organisms responsible for the degradation of larger fauna that die and consequently drop to the ocean floor) fulfil a vital role in the ocean's nutrient cycles. In essence, they enable the release of vital nutrients needed to sustain the health of plants, sponges and corals which, in turn, serve to sustain the rest of the trophic system.

The intention with this survey is to gauge the presence of benthic infauna by means of "day grabs" [3] given that their absence in a sample likely means that toxic chemicals are present. Since chemical contamination of the sediment and the resultant contamination of the infauna that serve to sustain larger, economically viable fish and marine species, the benthic fauna found is key to understanding ecosystem biodiversity.

Therefore, undertaking benthic surveys will not only serve to establish indicators that can be used to monitor and protect the Bay against harmful toxins, but they can also be used to identify vulnerable

[3] Smith-McIntyre grabs (also known as day grabs) will be used to take samples of the seabed in quadrats measuring 0.1 m^2 up to a depth of 15-20 cm.

marine ecosystems (VMEs) and indicator species typical of those systems, depending on where which species are found.

Methods: The 2 m satellite-derived ocean floor classification (project 1) will be used to derive bathymetric systems and to compare and quantify benthic habitat changes based on historical and more recent findings. In addition, on-the-ground samples will be taken to verify benthic infauna in specific habitats that cannot be confirmed via remote sensing.

Project 4: Fish population and biodiversity survey

The Bay's ecosystem food web is dependent on fish species, in particular benthic fauna fish that act as a food sources for species higher up the food chain. An abundance of the latter not only serves to attract tourists to the Bay but also offers other economic opportunities in the form of fishing on a larger scale. To gain an understanding of the economically and ecologically important fish species present in the Bay, a survey needs to be conducted. More importantly, though, indications of the population size and abundance of these species will serve as important indicators of issues such as overfishing which, unless addressed, could pose a serious threat to the health of the Bay's ecosystem.

Methods: The latest, least invasive method used to estimate fish populations is sonar fishing. However, less invasive methods also include timed swims, towed divers, remote sensors and distance sampling (underwater cameras) and passive acoustic monitoring. The methods that will be used will be informed by projects 1 and 2. For the purposes of this survey, though, it is envisaged that some more invasive methods (e.g. otter trawls and other forms of netting) will have to be employed to take actual samples of fish species for identification purposes.

Project 5: Rocky-shore survey

In the Bay, rocky-shore habitats hold a wide variety of life, all of which are indicative of the health of the ecosystem. Generally separated into four unique zones (i.e. splash zone, high-tide zone, mid-tide zone and low-tide zone), it is relatively easy to establish biodiversity in these habitats and to map the abundance of indicator species such as mussels, green algae and calcifying organisms on foot, depending on the tide. Likewise, where appropriate, samples of these species can be collected at regular intervals to test for stressors such as bioaccumulation and acidification.

Methods: As of late, as part of its long-term monitoring of the rocky shores in Nature's Valley, the NVT has been relying on tools such as the species image library and photo station for the purposes of rocky-shore zonation, rocky-shore profiling, quadrat sampling, habitat mapping and establishing habitat quality. Given the reasonable success achieved thus far, it is envisaged that the same methods will be used in this case.

Project 6: Sandy-shore survey

Sandy-shore surveys should not only include surveys of wildlife but also the structure and longevity of the shore. In this regard, remote sensing can be used to gauge how the shore is affected by processes such as longshore drift and to detect whether dunes are in any danger of being damaged in future.

With reference to wildlife, bird surveys are of reasonable importance given that the presence of species such as the oystercatcher is indicative of ecosystem health, both physically and in terms of available food sources for the bird species present.

Infauna found beneath the sand are also important to determine the quality of the ecosystem and its sediments and to gain an idea of food sources for species of higher economic and ecological value.

Methods: An integrated system with a high operational resolution will be used for shore monitoring, augmented by digital elevation models and bird and infauna transect surveys.

Project 7: Social baseline study

The overall aim of the social baseline study will be to develop a thorough understanding of all anthropogenic threats and drivers across the entire marine and coastal system in Plettenberg Bay. This will be done by identifying and quantifying all the human-induced threats and drivers, identifying and quantifying human interactions with the Bay and based on the results, developing awareness and education materials and other suitable interventions that can be used to mitigate the identified threats and drivers and maximise/optimise the conservation of the Bay. The results will also be used to inform the DPSIR model.

Methods: Participatory (mapping) workshops, inclusive of qualitative and quantitative data, will be used.

Phase 3: The development of a marine spatial and Bay management plan

Once all the baseline work has been completed, the next important step will be to develop a marine spatial and management plan for the Bay. NMU is the most obvious partner for this phase since they have been involved in similar projects. The data produced via partnership will also add a lot of value. What is critical in the data-collection phase is to create map layers covering the whole planning area and all the biodiversity features that need to be represented, inclusive of all the socio-economic activities that need to be accommodated and/or avoided. In the long run, the objective is to feed all data into a matrix which (more or less) serves to indicate the "pros" and "cons" of why each planning unit (pixel making up the study area) should be selected for conservation, or not. A lot of the work that NVT and its partners will undertake will be new and innovative. One of the biggest challenges will be to convert biophysical data into spatial data. Even though this might prove difficult, it is not impossible.

- From a spatial perspective, ocean floor mapping (project 1) will not only provide baseline data, it will also feed into things such as fine-scale adjustments to the map of ecosystem types and used to identify any special features on the ocean floor in the Bay that are important (or that we know little about). We will then need to code features or areas where processes are taking place into the planning units.
- Water quality and monitoring of pollutant levels (project 2) would need to be translated into a map depicting pollution, including aspects such as the sources thereof. Pollution can be mitigated through restoration efforts. For that reason, it is not always something we would want to avoid strongly. However, if the source of the pollution is a sewage outfall or similar, we need to know about those so that they can be avoided. Here it ought to be kept in mind that even though pollution is a strong measure of ecological condition, it can also be affected by many other things.
- Ideally, project 3 (the benthic survey) should result in species distribution maps for the entire Bay. Otherwise, the sites where the sampling took place will be selected because the requisite data will be readily available. The same holds true for data on fish populations, biodiversity, rocky-shores and sandy-shores. Nevertheless, the intention is to produce maps of the African black

oystercatcher’s (and other bird species’) nesting sites, distribution maps of sandy-beach invertebrates, maps of sediment sources, et cetera.

- In terms of the social baseline study (project 7), the intention is to map where people are doing what, to establish how important the respective areas are to users, and to identify/quantify uses that have no or little bearing on biodiversity. Here we will not only explore activities such as line fishing, squid fishing and small-scale fishing, but also beach walking, swimming, surfing, boating and sailing. Given the increasing emphasis on areas of cultural significance, we also intend to establish whether there are any sites that are of cultural significance (even sacred) to the community and to map these. Even though national maps can be used to depict commercial activities, the benefit of working on a more manageable, local scale is that one can engage on the ground with stakeholders to derive qualitative data to either support or refute quantitative findings.

Phase 4: Continuous monitoring and facilitation of the implementation of the Bay management plan

The fourth and final phase of the overall programme will be to continue with the monitoring of the aspects explored during the second phase of the project. At this stage, all the necessary systems and processes will be in place. The plan is to do so for at least two years after the marine spatial and Bay management plan has been finalised. Additional resources may be required at this stage, but it is difficult to predict what the exact needs will be. Nevertheless, cooperation and strong partnerships will still be crucial.

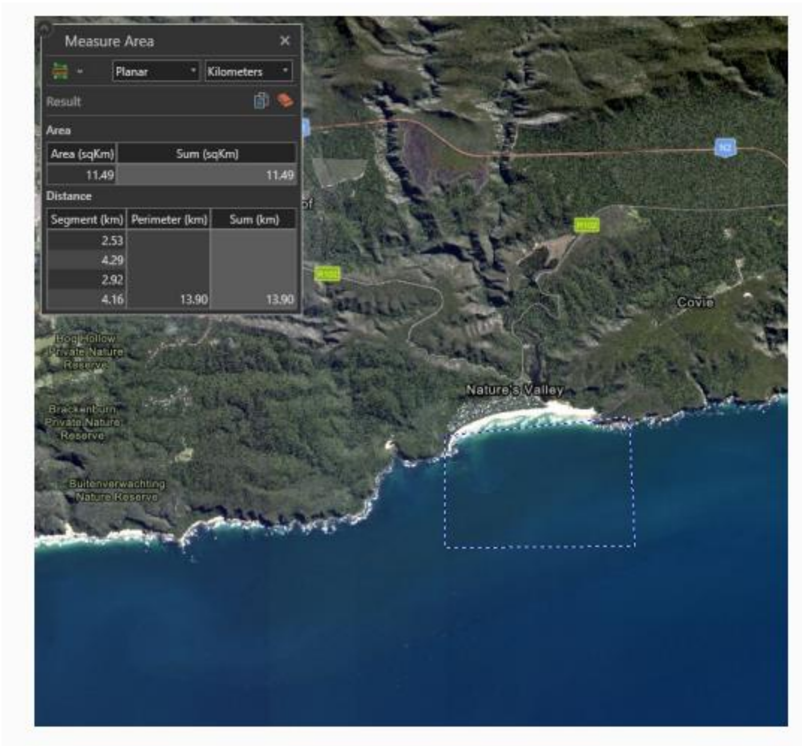

Figure 6: Example of data viewing and monitoring dashboard

Methods: For the purposes of continuous monitoring of the Bay, use will be made of the following: web-based maps, charts and a data viewing dashboard that will require portal development, real-time data integration, cartographic product development, tabular summaries and 2D and 3D visualisation options; ongoing water-quality management; an SAR-based shoreline monitoring programme (four collects/yr, ~5 linear km of shoreline) involving tide-correlated image tasking, vector shoreline extraction and change detection; SAR and lanet-based vessel detection; Pixel/hyperspectral satellite imagery and spectral unmixing to detect different types of pollutants and environmental stressors; high-resolution sea-surface thermal imaging (4.4 km x 3.5 km).

Time frame

The proposed process will be implemented in four-phases and will require approximately five years to complete.

- The first phase will involve appointing a marine scientist at NVT, the establishment of a steering committee and the facilitation of an inaugural stakeholder meeting. The plan is to start with the first phase towards the end of 2023 and to continue into 2024. The inaugural meeting may also coincide with other planned activities by the Plum Foundation.
- Seven projects will be conducted during the second phase of the overall project. These projects will be outsourced and conducted by external service providers (see list of key institutions listed above). When service providers are invited to express their interest, they will be asked to develop and submit proposals, timelines and cost estimates for their projects. The implementation of these projects will commence around mid-2024 and will spill over into 2025 to account for interannual variability. Regular feedback will be given to stakeholders during follow-up sessions/workshops.
- The development of a spatial and management plan will from part of the third phase of the overall project. The inaugural and follow-up meetings with the various stakeholders will feed into this. This phase is likely to commence in the second half of 2025.
- The fourth and final phase will consist of the continuous monitoring of the Bay. The plan is to continue with the monitoring of the Bay for at least an additional two-year period. In other words, up and until the middle or end of 2028.

Annexure 1: List of Plettenberg Bay stakeholders and their perceived utilisation of Plett's marine and coastal system

	Organisation/company	Utilisation of the system
1	Bitou Municipality	Tourist drawcard
		Economic driver
2	Businesses, local (over and above tourism linked)	Consultancy
		Construction
		Environmental
3	CapeNature	Conservation
		Research
		Law enforcement
4	Commercial fisheries, large-scale (octopus, trawlers, and long-line)	Income
5	Commercial fisheries, small-scale (private vessels)	Income Food
6	DEFF	
7	Estuary Management Forums	Keurbooms, Piesang, Matjies, Groot & Salt
8	Fishermen, competitive	Sport
		Food
9	Fishermen, recreational	Recreation
		Food
		Economic driver
10	Fishermen, subsistence	Food
		Income
11	Fishing charters (boat-based)	Income
		Food
12	Fishing charters (land-based)	Income
		Food
13	Garden Route Biosphere Reserve	Environmental impact
14	General public (local)	Exercise
		Recreation
		Mental well-being
		Property value
15	General public (tourists)	Exercise
		Recreation
		Mental well-being
16	Nature's Valley Trust	Research
		Education (adopt a beach)
		Income

17	NMU	Research
		Students
18	NSRI	Training
		Rescues
19	Ocean Blue (BBWW)	Income
		Research
		Education
20	Ocean Safaris (BBWW)	Income
		Research
		Education
21	Offshore adventures (SWS, Jet skis, pelagic trips)	Income
		Research
		Education
22	ORCA Foundation	Research
		Income
		Education
23	ORI, Marine Research Institute (and other marine academic institutes)	Marine research
24	Plett Seal Adventures	Income
		Education
25	Plett Tourism	Town attraction
		Economic driver
26	Plettenberg Bay Environmental Forum	Environmental impact
27	ProDive	Income
		Education
		Formal training
28	SANParks	Conservation
		Research
		Law enforcement
29	Surf school	Income
		Education
30	Plett Shark Spotters	Research
31	Whale Heritage Site	Research
		Fundraising