Macroalgae Reefs, Cyprus Case Study

Introduction to the site

Driving factors, motivations, and goals for initiating restoration actions

Despite its importance and protection status it faces many threats, mainly from anthropogenic activities and climate-change related impacts. As water temperatures continue to rise, the area becomes a hotspot for marine non-indigenous species that are slowly "tropicalizing" the biodiversity of the protected area, removing local species. One of the biggest marine invasions observed at the moment is the long-spined sea urchin *Diadema setosum*. The long-spined sea urchin is notoriously known for its grazing capacity, leaving barren rocks of once algae dominated reefs, such as *Cystoseira sensu lato*. The effects of its spread around the protected area are already visible to divers and users of the site, where the once biodiverse-rich reefs are now only covered with long-spined urchins. Akamas finds itself at a "tipping" point, where active efforts of protection and restoration are needed to prevent ecosystem shifts and ensure its natural beauty.

Description of the restoration project location

The project REstoration of CYpriot REEFS (ReCyReef) is located on the island nation of Cyprus, in the Akamas Peninsula and Natura 2000 site. Akamas is one of Cyprus' most biodiverse and pristine Natura 2000 sites which covers an area of 179 km2 of which 79 km2 is marine. The Natura area protects over 170 species and 29 different habitat types. Its marine environment hosts a plethora of important marine habitats such as *Posidonia oceanica*, coralligenous reefs and macroalgae dominated reefs. The area hosts nesting and foraging sites for many protected species such as monk seals, loggerhead and green turtles as well as several commercially important fish species. The natural beauty of the peninsula has made it a popular tourist destination with many recreational activities such as scuba diving and boat tours. Akamas also hosts an important number of small-scale fishers that rely on its resources year-around.

Assessment Phase

General description of the background and the Initial site assessment

Grazing from indigenous species, such as sea urchins, has always taken place but the appearance of barren reefs used to be a rare phenomenon. During initial assessments of the site in the first few years since the appearance of non-indigenous grazers, the impacts of their grazing pressure on the rocky reefs has become quite prevalent. Reefs that used to be covered with *Cystoseira* and associated fauna have been completely lost in some areas, while signs of increased grazing pressure in more remote areas has also been observed.

Planning and Design Phase

Permits applied for and from where

To conduct sea urchin removals, while not illegal since it is a non-indigenous species, the Department of Fisheries and Marine Research that is responsible for the management of marine resources has been informed. For restoration actions, however, it was essential to take a permit from the Department to ensure that these actions are aligned with national legislation as well as with national goals and aims regarding the management of marine resources and habitats.

Restoration objectives of the project

1. Determine the grazing pressure of non-indigenous species (specifically for *D. setosum*) on macroalgae habitats. This allows us to establish the thresholds that might lead to habitat shifts as well as whether interventions are necessary.
2. Determine the most suitable restoration methodology. In order to conduct large-scale restoration, it is essential to understand all the available methodologies and their success rate in order to establish the most viable option for large-scale restoration.
3. Determine how restoration success might be affected by the presence of non-indigenous species. It is important for us to understand the level of intervention (e.g. removal of non-indigenous species) that is needed to allow for restoration efforts to be successful on a large scale.
4. Determine the role of stakeholders and their involvement in restoration objectives. Large-scale restoration requires the participation and awareness of relevant stakeholders. Without their support and inclusion, such efforts might not yield the benefits on a socio-ecological scale, which would directly undermine the success of restoration and long-term viability.

The objectives of the site, as a replication site aiming, aimed to establish some thresholds for future restoration projects.

Protocol for the restoration project

The restoration project was a small-scale experimental study conducted on the north coast of the Akamas Peninsula, covering four sites totalling 720 m^2. The team selected restoration techniques based on ecological pressures, including macroalgae transplantation and sea urchin removal. Donor thalli were collected and transplanted using epoxy, with some placed inside protective cages to test grazing impacts. Each site represented a different treatment:

1. Transplants with urchin removal
2. Urchin removal only

3. Transplants with caging
4. Transplants alone

These served as comparative control/reference conditions to evaluate the influence of each variable. Monthly monitoring includes sea urchin removals and assessments of transplant survival and growth. Gonadic Somatic Index (GSI) measurements from collected urchins help gauge reproductive pressure. Success indicators include macroalgae establishment, reduced grazing, and signs of natural reef recovery.

Implementation Phase

Description of the Implementation of the protocol

The initial setup for the protocol took a total of 2 full days using scuba diving. On day 1, the wider area was visited to conduct biodiversity, algae and urchin assessment to identify areas in need of restoration as well as suitable donor sites. On day two, the team prepared the restoration area via drilling to create small crevices to place cages and transplants. This was then followed by the placement of transplants and cages using epoxy. Following the placement of the transplants, the sites were visited on a monthly basis for monitoring purposes.

Data collection, analysis, and assessments of ecological Indicators

After the baseline phase, all monitoring surveys are repeated on a monthly basis using the following variables:

1. Fish: visual census along 25 m × 5 m transects
2. Macroalgae: species composition assessed along the same 25 m tapes using quadrat cover
3. Sea urchins: detailed counts in a 25 m × 20 m area (zig-zag search extending 10 m to either side of each transect)
4. Transplanted *Cystoseira*: record survival, growth, and grazing damage.

These data were then used to compare how monthly removals and restoration efforts have been affecting the wider area.

Additionally, some of the harvested sea urchins were used to conduct GSI. The sea urchin wet weight was measured followed by the dissection and removal of their gonads which were then also weighted. Their ratio was then calculated to establish how their GSI changes over a year.

Ongoing Management, Monitoring, and Evaluation Phase

Major Issues and problems encountered

Restoration using cutting and thalli has been quite labour-intensive. This methodology might not be suitable for large-scale restoration as it requires a significant amount of time and effort, as well as resources while potentially causing significant damage to donor site if a larger amount of donor thalli were to be used. This experimental design was setup to investigate how transplants are affected by NIS species and their grazing pressure. For these reasons, this methodology was conducted on a relatively small scale using a small number of transplants. Removals, over a large scale can similarly be quite labour intensive. To overcome this, a number of volunteers and stakeholders are essential for the success of such effort.

Sharing and Communication

The project has been communicated through social media channels, mainly Instagram where we have a wider audience across science and public. Stakeholders that were mostly communicated directly have been diving shops of the area that regularly visit the site. However, the wider public has found an interest in these activities, while national authorities responsible for these resources have been following the development of these efforts.