

## 1. EXECUTIVE SUMMARY

This project was a PLANED LEADER and Pembrokeshire Coast National Park Authority SDF joint funded feasibility study into the extraction of haemocyanin from the invasive slipper limpet.

The problem with slipper limpets in the UK and the EU is that they have no natural predators and no commercial value as a human consumption product. As an invasive species it is illegal for them to be moved in the water or returned to the water once removed. As a result, there is a disposal cost for getting rid of them when they are caught, however most fishermen do one of three things.

They either:

Stop fishing where there is an infestation of slipper limpets.

Illegally dump them back into the water.

Land them and illegally dump them on the shore above the high-water mark or on land such as farm land.

Like most Invasive Non-Native Species (INNS), the management and clean-up costs are seen as prohibitive to their removal, despite the potential long-term economic and environmental gains. This project has been able to show that there are can also be commercial opportunities available from exploiting invasive species, in this case targeting the slipper limpet.

The research into the viability of extraction of hemocyanin from the slipper limpet is important to those groups and companies that deal with slipper limpets as a barrier to their present works or as a by-catch or waste product from their core commercial activities. Having a route for disposal is a significant part of any invasive species management and the information from this project will be an important part of any slipper limpet management process.

## 2. INTRODUCTION

The feasibility study into the extraction of hemocyanin from the slipper limpet was a large-scale project that required input from a wide range of groups, as well as undertaking detailed scientific analysis. The work was carried out in two locations, Mikota's lab and research facility in Pembroke Dock and at Cardiff University's School of Biosciences.

The project involved harvesting slipper limpets, monitoring yields and results based on storage and location, storage trials, extraction and purification of the hemolymph, and hemocyanin and then detailed analysis and characterisation of the hemocyanin.

The harvesting, storage trials, and extraction of the hemolymph took place at Mikota's site with regular visits from the Cardiff University Professional Training Year (PTY) student.

Hemocyanin refinement and purification research was shared between the Mikota site and Cardiff University.

The detailed analysis work took place at Cardiff University. The analysis data forms the majority of the feasibility project data as it is the most important aspect as to the long-term commercial viability of the extraction of hemocyanin from the slipper limpet.

As part of the feasibility study there were various outputs generated. These were:

This feasibility report.

A progress and data report.

The PTY student's technical data report.

The overall project included additional outputs. These were:

"Additional benefits to Mikota" document.

"Project promotion" document.

Publicity and media coverage around the project.

Meeting and liaising with stakeholders in the region.

### **3. FEASIBILITY ANALYSIS**

In conducting the feasibility study we reviewed several aspects that were critical to the feasibility analysis of the project.

#### **Technical Feasibility**

This was a review of the technical hurdles and the extraction and purification processes identified during literature analysis for the extraction of hemocyanin from the slipper limpet.

This resulted in the creation of the core "Progress & Data Report" and the "PTY Report", which was a more detailed hemocyanin analysis.

These reports showed that slipper limpet hemocyanin, in its crude form, can be extracted and purified from the slipper limpet.

These reports also showed that while the product that was produced with present processes and technology was not a commercial grade product, the feasibility of producing a viable hemocyanin product from the invasive slipper limpet was indeed possible with further investment and research.

**Commercial/market analysis**

The commercial feasibility section looked at two different aspects. Firstly, is it commercially viable for fishermen or clean-up operations to mitigate the costs of disposing of slipper limpets and secondly, is the product one that is commercially feasible with and for a viable market.

For the fishermen aspect, the product would be seen as a waste product. As part of the project we liaised with Pembrokeshire Scallops (Stakeholder 1) who were investigating the commercial potential of diving on the Milford Haven Waterway oyster beds. They undertook a detailed analysis of 5-6 known oyster beds and discovered that the slipper limpet problem over the past decade had become so detrimental to the oyster beds that they are no longer functional.

In four days of two divers surveying the oyster beds, they found only 100 poor quality oysters in total on all the oyster beds they dove on. With this information Mikota met with Welsh Government's Marine and Fisheries Division (Stakeholder 2) and Milford Haven Port Authority (MHPA) (Stakeholder 3) about submitting an EMFF application to undertake a slipper limpet removal and oyster reseedling trial in the Milford Haven Waterway. While there was initial interest the submitted project was not funded by the Welsh Government.

For the clean-up activities Mikota also looked to undertake a monitoring and project in collaboration with Pembrokeshire Coastal Forum (Stakeholder 4) which was looking to use Coastal Lottery Fund and Heritage Lottery Fund funding to undertake a project to remove slipper limpets from Wales' only Maerl bed, which is in the Milford Haven Waterway.

To undertake the clean-up project we needed approval from NRW (Stakeholder 5) who were contacted with our proposed plan for the project, which included monitoring and sampling. We asked NRW if there was any support they could offer, either in kind staff or funding to which we were told there was no support and no funding was available for that kind of work. To our dismay NRW then proceeded to undertake their own monitoring activity on the Maerl Bed and even though it was put out to a selective tender process they did not contact us to be part of the process despite being aware of our project and plans. This killed our application for the project, which if successful would have brought an estimated £500k of funding for Mikota and the Pembrokeshire Coastal Forum, who would have headed and managed the project. For this monitoring work NRW spent just under £50k with Francis Bunker, the husband of Anne Bunker the Pembrokeshire Senior Marine Conservation Officer. This obvious conflict of interest has led to a range of formal complaints being lodged with NRW on this and other projects that were submitted for their review re environmental impact that they have just taken and done with Francis Bunker. This information regarding projects lost to the region

was also submitted to BBC for future media coverage and Pembrokeshire Coast National Park Authority (Stakeholder 6) were advised of the negative impact on environmental and commercial activities in the region as well as the loss of jobs from NRW's actions.

Regarding hemocyanin's commercial and market feasibility, early stage meetings were had with BBI Group (Stakeholder 7) as well as global product distributors like Fisher Scientific. Meetings were also held with companies over two consecutive Medica trade-shows, which Mikota attended in 2017 and 2018. While the product still requires significant time and financial investment to get it to a commercial ready state, there was significant interest for a product that is seen by the companies we met and spoke with as a viable replacement for the very expensive and limited availability gold standard of the Keyhole Limpet Hemocyanin (KLH).

### **Legal Feasibility**

Overall the legal feasibility of this type of project is pretty clear. It is illegal for slipper limpets to be returned to the water, so fishermen and clean-up activities either need to dump them illegally (they are considered a biological waste by landfill and are therefore not accepted by normal waste management groups), or pay to dispose of them. This project showed that there is a viable third option where the product is disposed of at zero cost and used as feedstock by a company to produce other products.

Clean-up operations have other aspects that need to be considered, especially where they need support from the relevant local authority, trustee or environmental group. NRW for Wales and Natural England for England, have significant influence and control of projects that can be undertaken. Our experience over several years of phone calls and meetings was that Natural England is active in supporting and activities regarding INNS. NRW was the polar opposite, seeming to either blatantly take projects, which in our case were allocated to the partner of the Conservation Officer in charge of the region, or to not be willing or able to commit any resources to undertake INNS actions and activities. Support from the local trustee for the harbour or protected environment is also required for clean-up activities to be undertaken. All of these approvals fall under some level of legal governance or licensed approval. In our experience we found that getting all the required approvals and consent in Wales would most likely pose a significant barrier to future projects. The reasoning behind this statement is covered within the following Operational Feasibility section.

**Operational Feasibility**

The biggest barriers to ongoing operations for commercial scale-up and clean-up operations in Wales are:

NRW's misappropriation of projects submitted to them for their review,  
the lack of funding within the Welsh Government for any environmental clean-up operations,  
the lack of support for clean-up activities by the MHPA (effectively the ports trustees),  
and the lack of aquaculture support for divestment opportunities within the region.

These all impact the operational feasibility of any project that would be undertaken in not just the Milford Haven Waterway, but Wales in general.

Another operational feasibility aspect is the limited viability of a projects within the Milford Haven Waterway. In a meeting with MHPA, Swansea University (Stakeholder 8), and NRW, MHPA staff made a direct statement that "MHPA would not support future commercial scale-up activities for Mikota that involved increased harvesting of slipper limpets above the small volumes for the feasibility study". This means that any clean-up activities would be negatively impacted operations wise and even increased commercial expansion by Mikota would not just be hampered, but would be limited to the present scale (which is not commercially viable).

The position taken by MHPA has been reviewed and discussed with other groups with it being suggested that slipper limpets are seen as an expensive problem to clean up and that if there was a solution, use or viable way to remove them, that it would be expected that the trustee for a Special Area of Conservation would be legally obligated to clean up areas such as marine reefs and the only Maerl Bed in Wales. If this is the case, then it stands to reason that groups like the MHPA would not want to have to bear the burden of these clean-up activities and may therefore be reluctant to support projects encouraging clean-up activities.

Regardless, slipper limpet management and removal is a significant cost undertaking, with limited financial reward in the short term for the companies involved without commercial opportunities being available. At present this commercial operations opportunity does not seem to be viable in Wales, especially within the Milford Haven Waterway.

**Environmental Analysis/Feasibility**

One of the most important aspects is the environmental feasibility of projects based on the slipper limpet. Given their invasive species mantle and the well observed and recorded negative impact that they have on the local environment, water quality and species diversity, there is no perceived negative aspect to their removal.

To confirm this, Mikota wanted to ensure that the short to medium term impact of slipper limpet removal was analysed and any risks identified, which would have added to the value of this feasibility report. Mikota took a project to Swansea University and the SEACAMS2 (Stakeholder 9) group which was to evaluate the return of other species into a region after differing %'s of slipper limpets were removed. This project was presented to NRW during a meeting with MHPA, Swansea University and SEACAMS2, under commercial confidence. However, this once again did not stop NRW taking the project and passing it off to Francis Bunker while using NRW divers to undertake the research for a company. Divers that NRW had expressly advised Mikota, would never be able to dive or support any of our projects as we are a company. This is again part of the larger complaint to NRW on their practices and negatively impacted the environmental analysis data compiled during this study.

While not directly related to the environmental feasibility of this project, it highlights the bigger issue that projects presented to NRW are effectively being stolen away. This will only reduce the potential of any companies in the future wanting to commit time and resources to focus on developing an environmental project if NRW, the Welsh Government's environmental regulatory and review body, breach the Welsh Government's ethics and confidentiality requirements and the UK's "data and information privacy act" by sharing and giving projects to competing companies.

**4. CONSTRAINTS**

There are various constraints to commercialising slipper limpet hemocyanin that have been identified and outlined in the above sections.

While some of these can be overcome, it became obvious during the promotion and dissemination of the results to other parts of the UK that other locations within the UK, such as Portsmouth and Cornwall, were more proactive and supportive of these environmental focused activities. For example in Cornwall the local IFCA (Inshore Fisheries & Conservation Authority) was looking at ways to help fishermen dispose of their slipper limpet bycatch and wanted a project to commercialise slipper limpets in their region. Natural England, who were also consulted on the wider UK and legislative issues surrounding INNS' were active in proposing Mikota apply for England EMFF funding to try and progress the projects that had

been misappropriated/stolen by NRW. The lack of support from NRW and other bodies within Wales would most likely be the most significant constraint to this project proceeding to the next level within Wales. It should be noted that while there have been multiple parliamentary investigations into NRW's conduct that their behaviour does not change. The Welsh Government's External Assurance Panel reviewed our complaints re NRW and recommended we lodge a formal complaint, almost 12 months on we are still waiting for NRW's internal investigation to be completed. These issues have led to investor uncertainty regarding Mikota's operations in Wales, which has significantly impacted and constrained Mikota's ability to grow, expand and facilitate commercial exploitation of the slipper limpet.

## **5. CONCLUSION**

In conclusion this project showed that it is feasible for hemocyanin to be extracted from slipper limpets, but it also identified some significant constraints imposed by third parties and government organisations in the guise of regulatory oversight, for this type of project in Wales.

Slipper limpet hemocyanin was identified as having significant commercial and market opportunities, and that the harvesting of slipper limpets to produce the hemocyanin was of environmental benefit to any region that the activity was undertaken.

That being said, this study also found that the endemic behaviour of groups like NRW would be detrimental to any company planning to undertake long term and beneficial activities targeting slipper limpets in Wales. Also, the lack of financials support and targeted actions has significantly accelerated the negative effects of the slipper limpet population in the Milford Haven Waterway, with nearly all native oyster beds being completely decimated. This ongoing lack of targeted support would also make companies reluctant to invest time and money if there was no backing and support for commercial or clean-up activities.

The commercial opportunity for slipper limpet hemocyanin requires significant research and investment to realise, and this feasibility study and the data generated lays the early foundations for this work. Mikota has already continued this research with the successful award of an Innovate UK grant for the development of new methods of purification and refinement of slipper limpet hemocyanin.