



KELP FOREST FOUNDATION

2022

ANNUAL REPORT



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MESSAGE FROM THE BOARD

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CELEBRATING A YEAR OF IMPACT AND PROGRESS

Once again, we are delighted to present the annual report on the Kelp Forest Foundation. It brings us immense pleasure to be able to take a moment to reflect on the remarkable work and achievements we've accomplished together over the past year.

Our mission to establish the ecosystem services of cultivated giant kelp and our vision to plug the gaps in the science continued to guide our actions and decisions throughout the year. By staying true to our core principles, we've been able to move quickly and achieve significant progress in addressing some of the pressing challenges faced by our society, namely climate change and biodiversity loss.

Over the past year, we successfully executed a wide range of projects and initiatives within our mission, including:

- Completing 12 months of the first-ever eDNA biodiversity baseline study in Luderitz, Namibia
- Funding 7 students to undertake MSc and Postdoc studies and theses
- Working with 22 of the world's leading research institutions on 16 research projects
- Participating in a dozen global awareness events
- Supporting over 20 ocean related after-school activities in Luderitz

COLLABORATION AND PARTNERSHIPS

Collaboration has always been at the heart of our approach, and we are proud to have fostered strong partnerships with various organisations, including NGOs and government bodies. These collaborations have allowed us to leverage collective knowledge, expertise, and resources. Key new research collaborations that have been established include:

- SAERI
- Montpellier University
- MIT Solve
- Wageningen University
- ETH Zurich
- Bremen University

FINANCIAL TRANSPARENCY

Upholding the importance of financial transparency and accountability, we are pleased to report that our foundation's financial performance has remained strong, thanks to the support of our donors and efficient resource management. Detailed financial statements can be found on page 30.

TEAM MEMBERS

Our foundation's success would not have been possible without the dedication and commitment of our exceptional team. We would like to express our sincere appreciation for their hard work and passion. We also extend our gratitude to our board members, donors, and all stakeholders who have been instrumental in our achievements.

RECOGNITION AND IMPACT MEASUREMENT

We are proud to have received recognition and acknowledgment for our work from various quarters. These accolades not only validate our efforts but also inspire us to continue striving for excellence. We are particularly proud of the fact that we were recognised by MIT Solve as a Solver in their Climate: Ecosystem + Housing category.

FUTURE OUTLOOK

As we move forward, we are filled with optimism and excitement for the year ahead. We will continue to innovate, collaborate, and adapt to ensure we are always striving to fulfil our mission. The foundation remains committed to making a meaningful and lasting impact in our focus areas.

In conclusion, we want to extend our deepest appreciation to each member of the Kelp Forest Foundation for their unwavering dedication and passion. Together, we have achieved remarkable milestones and positively impacted countless lives. We look forward to another successful year ahead, where we continue to create sustainable change and make a lasting difference.

Thank you once again for your outstanding contributions.

Warm regards,



SAMANTHA DEANE
Managing Director



CAROLINE SLOOTWEG
Board Chair



ABOUT KELP FOREST FOUNDATION

**OUR MISSION IS TO INDEPENDENTLY
AND TRANSPARENTLY ESTABLISH
THE ECOSYSTEM VALUE OF
CULTIVATED KELP FORESTS AS A
POWERFUL NATURE-BASED SOLUTION**

The Kelp Forest Foundation (KFF) is a Netherlands-registered charity with a vision of harnessing the power of giant kelp to help restore the health of the planet. Our research and results are intended to be open access and publicly available. Funding for the foundation comes from donations, grants, subsidies, prizes, and periodic contributions.

WHO WE ARE

TEAM

Samantha Deane
Managing Director



Xu Ben Zhang
Project Manager



BOARD OF DIRECTORS

Caroline Slootweg
Board Chair



Prof. Tim Flannery
Chief Scientist, Board Member



Daniel Hooft
Board Member



Dr. Kat Bruce
Board Member



Sarah Mathies
Board Member



OUR STRATEGY & FOCUS AREAS

Kelp is drastically understudied given the benefits it can deliver. The Kelp Forest Foundation was set up in 2021 to address the gaps in science and knowledge around the ecosystem services of kelp forests and ensure that this knowledge is publicly available to companies, governments, regulators, non-profits, academics, and other stakeholders. We want to unlock the potential of giant kelp by accelerating global awareness, preserving kelp biodiversity through spore banks, and building the next generation of ocean custodians through ocean education, scholarships, capacity-building and skills development. We work with top research institutions around the globe, driving research on the many and varied services of giant kelp.

ACADEMIC RESEARCH

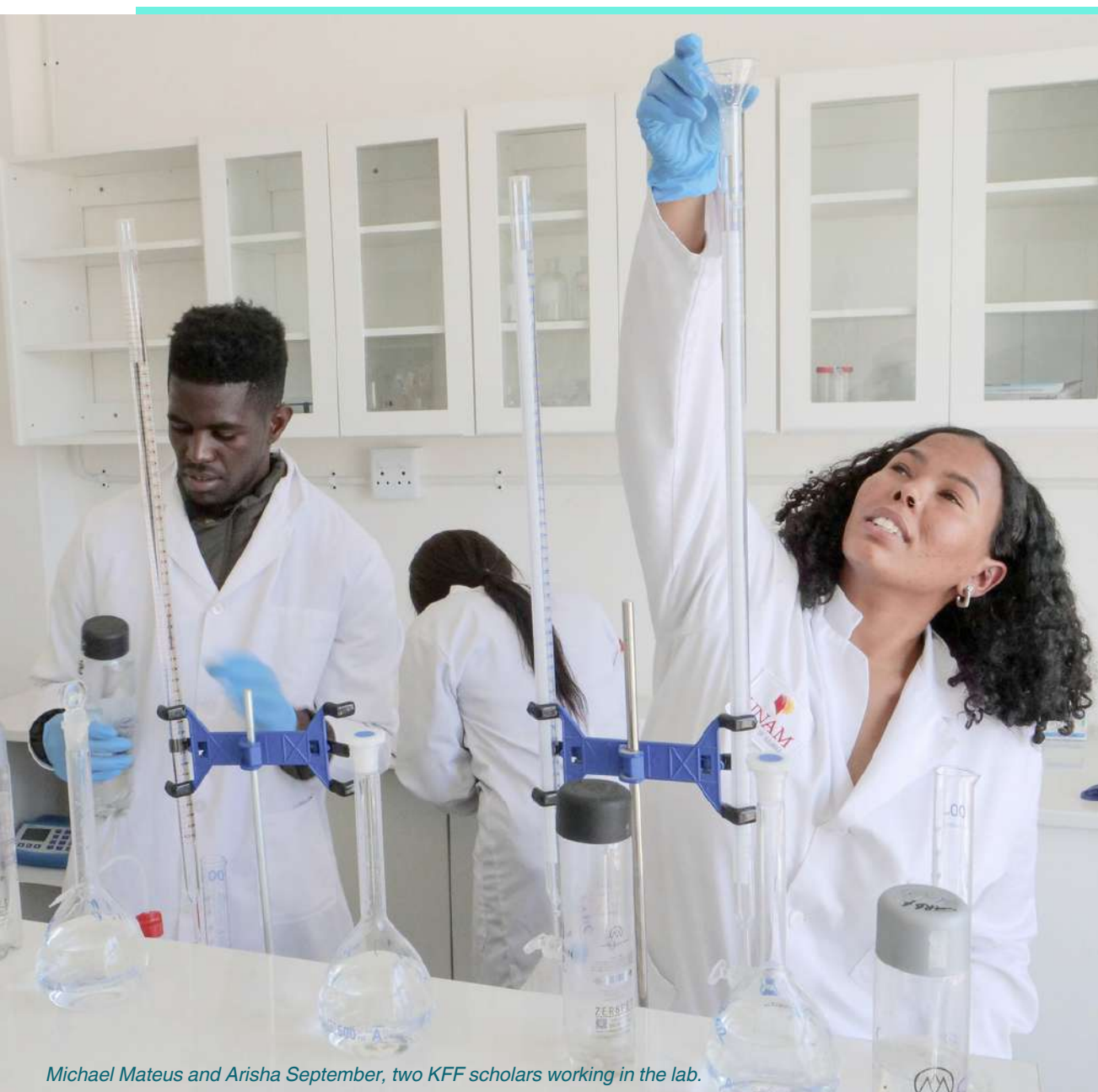
Our main focus is to fill the gaps in science around the various ecosystem services of giant kelp forests (wild and cultivated). We connect silos of academia and collaborate with the best international universities and research institutions to achieve this.

OCEAN EDUCATION & AWARENESS

We build the capacities and skills necessary for the next generation of ocean custodians, from swimming lessons to robotics classes.

SPORE BANKS

We aim to create a global network of giant kelp seed banks to preserve genetic diversity for future generations.



Michael Mateus and Arisha September, two KFF scholars working in the lab.



Protasius Mutjida, a KFF scholar, showing children how an ROV works





MEET GIANT KELP

Giant Kelp (*Macrocystis pyrifera*) is a remarkable species of brown seaweed that can grow very fast. It is capable of growing 50cm (2ft) per day and can reach a height of 45 metres (147ft) during one growing season (in ideal environmental conditions). As the giant kelp grows, it develops gas bladders at the base of its blades ('leaves'), which enables it to grow float vertically in the water column, reaching up towards the surface where sunlight is abundant. When it reaches maturity, the kelp floats on the ocean surface, forming a beautiful canopy. The kelp forest acts as an important marine habitat where species can find food and shelter as well as provide spawning and nursery grounds for a myriad of marine species.

Giant kelp is a perennial species and can live over 7 years. As a result, kelp forests continue to sequester carbon continuously for years. The ability of giant kelp to sequester carbon has significant implications for our planet, and it is essential that we drive research to understand how giant kelp forest ecosystems contribute to blue carbon sinks. Giant kelp forests also provide many other important ecosystem services that make our planet liveable. Cultivation of giant kelp can be a vital nature-based solution in our fight against climate change and the challenges we are currently facing as a result of human activities and pollution.

THE ECOSYSTEM SERVICES OF CULTIVATED GIANT KELP

LIVELIHOODS

Kelp cultivation creates employment, improves livelihoods, ecosystems and fisheries, and can support food security.

INDUSTRIES

Kelp products are a sustainable alternative for plastics, synthetic fertiliser, medicine, nutraceuticals, cosmetics, and potentially textiles and building materials.

Excess CO₂ emissions caused by humans lead to climate change and global warming.

AGRICULTURE

Applying kelp bio-stimulant can improve soil health, plant performance, and can reduce the amount of synthetic fertiliser required.

BIOREMEDIATION

Kelp cultivation helps absorb excess nutrients in the water, reducing the risk of eutrophication which is known to create dead-zones.

Global warming and increased CO₂ levels in the ocean are a threat to ocean life: it causes acidification and disturbance to marine life.

Kelp products can be used to return nutrients to land

Runoff from agriculture pollutes water systems and causes eutrophication due to excess nutrients.

CARBON SEQUESTRATION

Farming kelp aids CO₂ sequestration by exporting carbon to the deep ocean, playing a crucial role in combating climate change.

OCEAN ACIDIFICATION

Kelp reduces acidification in surrounding waters as it captures excess CO₂ and oxygenates the water at the same time.

COASTAL PROTECTION

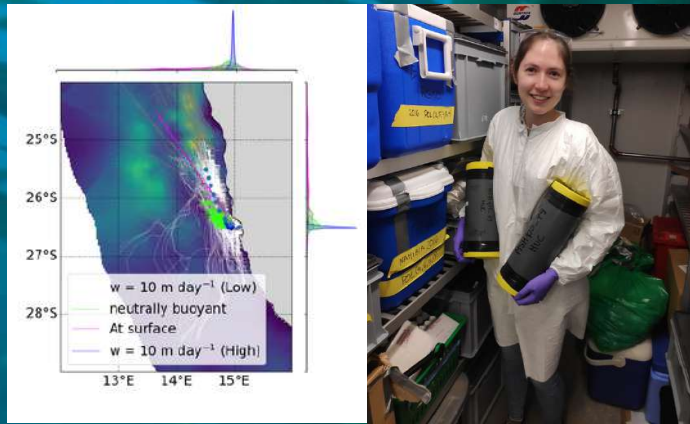
Giant kelp ecosystems can protect the shores from waves and can act as noise barriers for marine life.

BIODIVERSITY

Kelp is an ecosystem engineer: it creates marine habitats, boosts biodiversity (>800 species), increases fish stocks (+10-15%), and acts as nursery or spawning grounds.

Kelp Farm

2022 HIGHLIGHTS



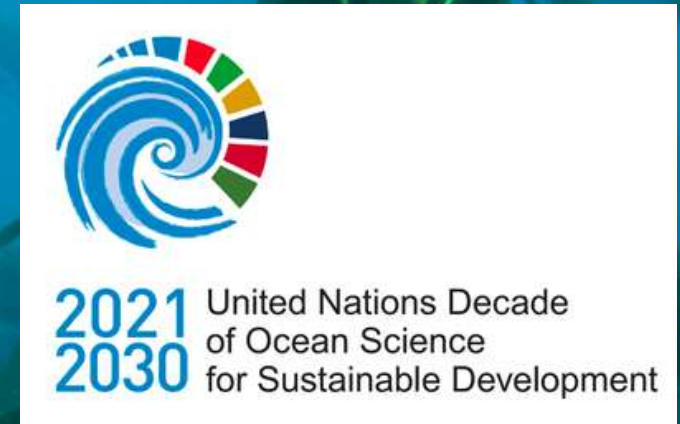
RESEARCH PROJECTS

- Great progress was made in our kelp carbon sequestration research: the 1st stage of the kelp carbon model was completed, which helped identify the key locations for the baseline sediment sampling off the Namibian coast.
- We completed a full year of biodiversity monitoring and eDNA sampling around the Kelp Blue site.



MIT SOLVE 2022 WINNER

We were selected as a "Solver" in the MIT Solve 2022 **Climate: Ecosystems + Housing Global Challenge**. Our project with **reNature** and **Kelp Blue** aims to regenerate soil using cultivated kelp in a model organic cotton farm in Kenya. We will assess the ability of kelp biostimulant to improve crop and soil health whilst driving sustainability in agriculture.



UN OCEAN DECADE

Our research project, "**Offshore kelp cultivation as a carbon sink**", has officially been endorsed by the UN Ocean Decade as one of the 35 new Decade Actions. This research is carried out by several research institutions led by KFF and aims to understand kelp sequestration pathways.

OUR IMPACT BY THE NUMBERS

ACADEMIC RESEARCH

16 Research projects ongoing in 2022

22 Research partners worldwide

WE FUNDED

3 Master's students

2 Masters thesis'

2 Postdoc researchers

OUR ENVIRONMENTAL MONITORING PROGRAMME

64 Number of eDNA samples taken

131 Species identified with eDNA at the Namibian pilot site

PUBLIC AWARENESS

12 Interviews, conferences, webinars and podcasts

With our funding, the Luderitz Blue School organised

20 Ocean's Day as part of afterschool activities

18 Robotics Clubs

ACHIEVEMENTS 2022

ACADEMIC RESEARCH



RESEARCH TOPICS

The Kelp Forest Foundation is dedicated to advancing academic research on the ecosystem services of both cultivated and wild giant kelp, as well as the various benefits of giant kelp products. Through collaborations with renowned universities and research institutions, we address key research questions within this field. We provide funding opportunities for Postdoc, PhD and Master's students. Furthermore, we actively promote awareness and facilitate knowledge sharing by making our research and results accessible to the public.

The research programme is focused on four main areas:



Impact on biodiversity

What is the impact of cultivated kelp forests on existing fauna, algae, zoo- and phytoplankton?



Impact on geochemistry

How does cultivated kelp affect surrounding waters?



Carbon capture

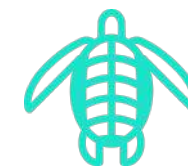
How much and at what rate is kelp carbon sequestered in the deep ocean forever?



Avoided emissions

How much do kelp-based products avoid/reduce emissions?





THE BIODIVERSITY OF CULTIVATED GIANT KELP FORESTS

GIANT KELP: AN ECOSYSTEM ENGINEER

Giant kelp is considered a foundation species in the marine environment, as the kelp's structure and canopy provides a vital habitat for fish and other marine species. Fish like to seek shelter in the giant kelp forest, often resulting in high fish abundance and diversity. Moreover, kelp forests harbour many small invertebrates, such as crustaceans and gastropods, that serve as prey for higher-level organisms in the food chain. Understanding the biodiversity function of giant kelp ecosystems is crucial to better protect and preserve wild giant kelp forests, and to understand the value of cultivated giant kelp forests in creating healthy and thriving marine ecosystems.

MEASURING BIODIVERSITY IN LUDERITZ, NAMIBIA

The Kelp Forest Foundation (KFF) research programme is dedicated to understanding the impact of cultivated kelp forests on biodiversity. Our case study, the cultivated giant kelp forest of Kelp Blue in offshore Luderitz, Namibia, is one of the first offshore giant kelp farm ever established. To assess the extent to which this farm promotes biodiversity and creates a thriving ecosystem that could potentially restore depleted fish stocks in the area, KFF sponsors a biodiversity research program aimed to measure algal, fauna and benthic biodiversity in and around the farm. In 2022, the research team, consisting of Namibian MSc students, collected eDNA samples at eight locations to measure biodiversity. These locations represent the Kelp Blue farm, upstream and downstream locations and a control site; offshore and their respective adjacent coastal sites.

Environmental DNA (eDNA) is an innovative technique to detect species present in the environment. Samples of sea water samples are passed through a filter which captures DNA material that can then be analysed. This allows for detection of species that are usually not easily seen through visual observations, as species present in that body water up to 48 hours can be detected.

To support the eDNA findings, the team also monitors water quality, pH levels to assess alkalinity/acidity, phyto- and zooplankton abundance and diversity, and jellyfish distribution by means of visual observations, lab analyses, and acoustics. By monitoring these metrics, the team can provide indicators of ecosystem health.

MEET OUR MSC STUDENTS



ANGELIQUE DODDS

Angelique is conducting a baseline study of algal diversity and creating an eDNA library of the existing algae in and around the Kelp Blue farm. She is supervised by Dr. Samuel Mafwila and Ms Cathleen Deelie of UNAM and Dr. Ian Hendy of University of Portsmouth.



ELIZABETH PETRUS

Elizabeth is conducting a baseline study of fauna diversity using eDNA methods combined with visual observations. She is looking at existing fauna biodiversity in and around the Kelp Blue farm. She is supervised by Dr Clinton Hay and Mr Lineekela Kandjengo of UNAM and Mika Peck of University of Sussex.





Impact on biodiversity

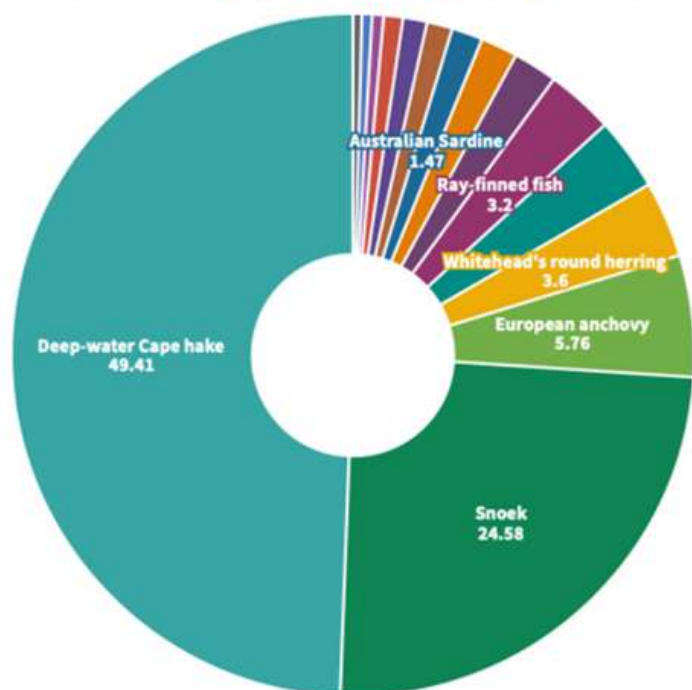


Ukarapo Mungunda helping KFF scholar use a multi parameter sonde.

© Kelp Blue

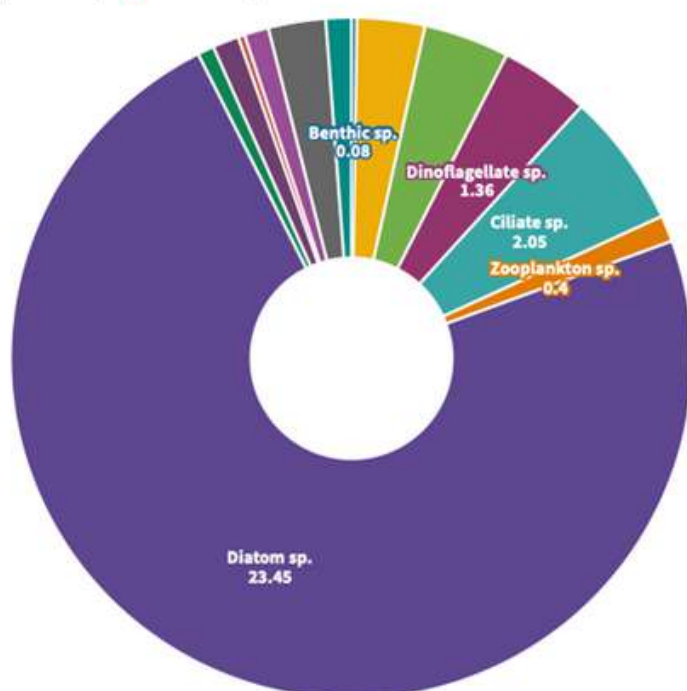
Common names of Vertebrate Species

- Australian Sardine
- Whitehead's round herring
- European anchovy
- Ray-finned fish
- Deep-water Cape hake
- South African mullet
- Pacific pomfret
- Snoek
- Gobi
- Sea robins
- Seahorses/pipefishes/Seadragons
- Cape Cormorant
- Cape elephant fish
- Dolphin
- Rodent sp.



Common names of Eukaryote Species

- Benthic sp.
- Copepod
- Nanoflagellate sp.
- Dinoflagellate sp.
- Ciliate sp.
- Zooplankton sp.
- Diatom sp.
- Coccolithophorids
- Green fungus
- Picoplankton
- Algae sp.
- Phytoplankton sp.
- Unknown sp.



BASELINE RESULTS

Eight locations in and around the Kelp Blue pilot site were monitored monthly, starting from February 2022, using eDNA samples, visual observations, plankton nets and acoustics. These measurements were done to establish a baseline of biodiversity in the area, before the kelp farm was established, in order to monitor for impact of the cultivated kelp forest would have on the existing ecosystem.

A total of 64 eDNA samples were deployed to gain an understanding of the species present at the locations. The eDNA kits that were used, were provided and analysed by NatureMetrics. By the end of 2022, 131 species were detected using this monitoring method. The results included a list of species that had been present at those locations in the last 6-48 hours before the samples were taken. The data also helped us flag important species, such as keystone species, IUCN red list species, rare or commercially important species.

The graphs on the left indicate eukaryotes (organisms whose cells have a nucleus) and vertebrates (animals with a backbone) that have been detected using eDNA samples in August 2022.

CARBON SEQUESTRATION POTENTIAL OF CULTIVATED GIANT KELP FORESTS

COLLABORATING ACROSS UNIVERSITIES

The carbon sequestration potential of seaweed ecosystems is gaining recognition, and our research program aims to quantify this potential for cultivated giant kelp forests. In order to do so, we need to understand the complex interactions within the marine environment and the behaviour of kelp matter/biomass in the water. Unlike terrestrial ecosystems, where carbon is stored in the soil as well as in the biomass, there is a need to track the fate of kelp detritus and carbon matter that is exuded by the kelp into the water which would end up far away from the kelp forest ecosystem.

By studying these interactions and tracking the fate of kelp detritus, we can better understand the potential for carbon sequestration of cultivated kelp forest. Some of this matter is eventually stored in the deep ocean, where it can remain locked away for over 100 years. This process, when accurately quantified, will show the significance of how kelp forest ecosystems can act as a carbon sink, consequently provisioning as a nature-based solution in our fight against climate change.

KFF is collaborating with a number of renowned universities to answer the following research questions pertaining to the carbon sequestration potential of giant kelp:

- Where does giant kelp detritus flow to?
- How much of it becomes stored in ocean sediments?
- What is the Net Primary Production (NPP) of cultivated giant kelp?
- What is the source of the carbon that is found in sediment samples, and how old is this carbon content?
- Can lipids be a biomarker to identify kelp carbon in sediments?

Other research projects that we are looking to fund will answer the following questions:

- How much of the kelp carbon gets exchanged back to the atmosphere once it breaks off?
- How much of the dissolved organic carbon (DOC) from kelp does not degraded by bacteria (and is therefore 'recalcitrant')?
- What is the unique biomarker of giant kelp in sediments, using qPCR and ddPCR technology?

OUR CARBON SEQUESTRATION RESEARCH TEAM



Prof. John Taylor

Analysing the kelp sequestration pathways using a three-part model focusing on ocean physics, kelp growth and particle movement. The model will create a dispersal pathway of the kelp detritus of the giant kelp farm in Luderitz.



Dr. Ke Li



Prof. Carlos Duarte

Using the dispersal pathway to collect and analyse sediment samples taken from the ocean floor to analyse their carbon content, the accumulation of carbon, and the contribution of kelp to carbon in sediments.



Dr. Chuancheng Fu



Dr Sarah Paradis

Analysing the carbon content of existing Namibian sediment cores which have been identified as originating from previously identified "depocentres".



Assessing the water biogeochemistry to understand physical indicators related to carbon sequestration and water quality in and around the Kelp Blue giant kelp farm.



Protasius Mutjida



Emilia Heiskanen



Researching whether there are any unique lipid biomarkers of giant kelp to help identify kelp within the organic carbon in sediment samples.

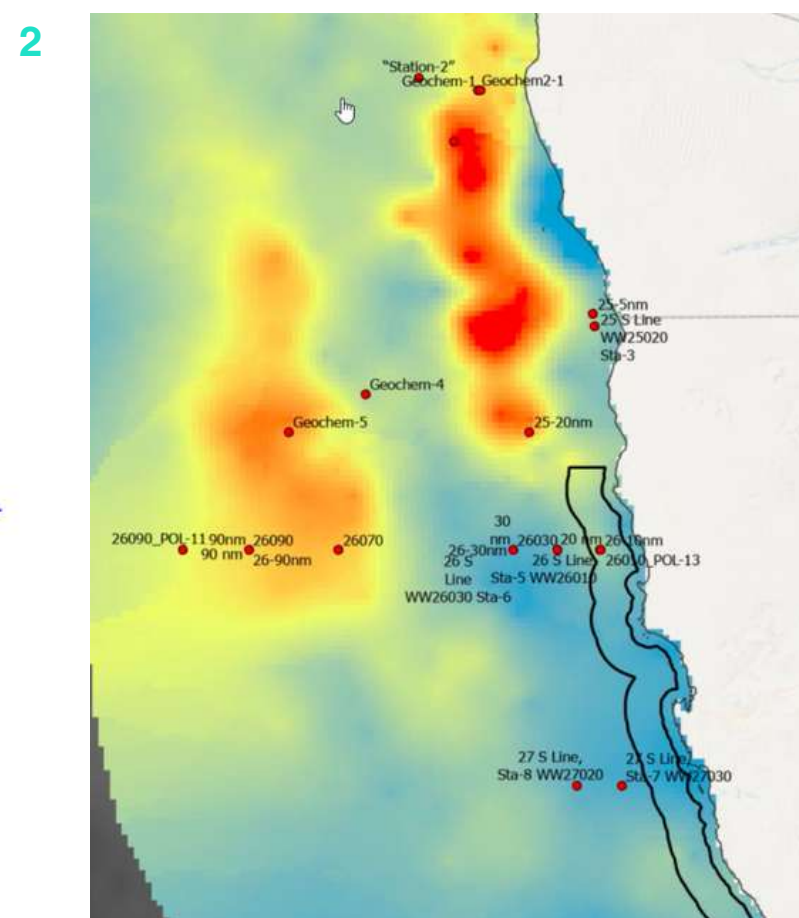
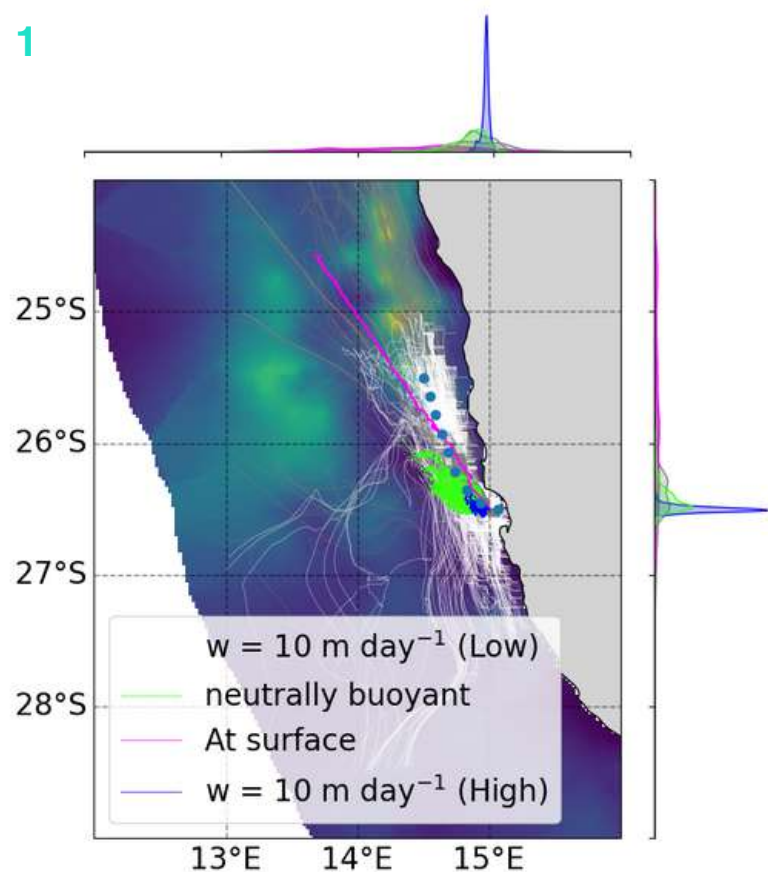
RESEARCH PROGRESS IN 2022

The research projects focused on quantifying the carbon sequestration potential of giant kelp forests have made great progress in 2022. Some of the activities included:

- Prof. John Taylor and Dr. Ke Li have successfully concluded the initial phase of their carbon transport model. This has contributed to the identification of dispersal pathways of kelp detritus originating from the Kelp Blue farm. By mapping these pathways, the study has highlighted specific depocenters where organic carbon is expected to accumulate. The depocenter locations were identified by previous research done by ETH Zürich and University of Bremen.
- ETH Zürich possesses a collection of sediment cores, which were initially gathered by along the Luderitz coast by University of Bremen. These cores will be analysed for to determine their carbon content which will help establish a baseline carbon content within the sediments of the Luderitz Coast.

- Combining the research, we have designed a sediment collection plan, identifying the exact locations where the research team will be collecting new core samples to complete the baseline
- In preparations for a sediment collection trip, we have identified the most suitable vessel to deploy a soon-to-be purchased multi-corer, to take fresh sediment samples
- We will then mobilise the researchers from KAUST to Namibia to take the sediment samples. These samples will be taken back to KAUST for analysis

Once the baseline study has been established, we will conduct a follow-on study (yet to be funded) in a few years time to assess the extent of kelp carbon accumulation in the researched areas.



1. This image by University of Cambridge shows the likely dispersal paths of kelp detritus from the kelp farm (bright green and pink). The blue dots indicate the ideal sediment collection points.
2. The large red areas indicate the organic carbon depocenters, as identified by researchers of ETH Zurich and Bremen University. The red dots indicate existing sediment cores kept at the ETH Zurich archives.
3. The research team discussing results of the kelp trajectory model.
4. Dr. Sarah Paradis at ETH Zürich holding the archived sediment cores taken previously by University of Bremen.



Clockwise: Protasius Mutjida (UNAM), Dr John Taylor and Dr Ke Li (University of Cambridge), Dr Sarah Paradis (ETH Zurich), Samantha Deane (KFF) and Dr Chuancheng Fu (KAUST).





UNDERSTANDING THE VALUABLE COMPOUNDS IN GIANT KELP

Giant kelp holds immense potential with its many valuable compounds but it is yet to be fully researched. The phytohormones and other molecules present in the kelp can, when extracted properly, boost crop/plant health and yield, increase nutrient use efficiency and improve the soil microbiome. This biostimulant can also increase resilience against abiotic stresses such as drought, heat and salinity. The alginates present in giant kelp can provide a sustainability alternative to the packaging industry by replacing oil-based plastics, while the kelp pigment can be used as a renewable ingredient for eco-friendly dyes and coatings. Furthermore, the sugar fucoidan, present in kelp, has many anti-bacterial and anti-inflammatory properties, benefiting both humans or animals.

Beyond kelp's versatility, another advantage lies in the low environmental impact during production: kelp requires no freshwater, does not compete for land, and requires no external inputs to thrive. Our research explores the potential of kelp as a sustainable ingredient in many industries, and assesses the potential emission reductions achieved through the use of kelp products across various applications.

ALZHEIMER'S RESEARCH

Dr. Monique Mulder at Erasmus University (Rotterdam, Netherlands) assessed the composition of giant kelp samples to look for those compounds interesting for treating Alzheimer's disease. In this research, Dr. Mulder assessed different types of seaweeds to look for levels of saringosterol, a rare plant sterol, known to prevent cognitive declines in Alzheimer mouse models. These phytosterols are found across several types of seaweed, and this comparative study showed that these compounds were also found in giant kelp.



KELP BIOSTIMULANT

In 2022, KFF established a collaboration with Wageningen University, one of the top agricultural universities worldwide. During our visit to their lab and facilities, we were shown their work on understanding how biostimulants (products that stimulant plant nutrition processes and improve resilience to abiotic stress) act on crops and plants. One of Kelp Blue's main products is biostimulant extracted from kelp, as the valuable active compounds in kelp have the potential to improve crop yield, nutrient efficiency and as well as plant and soil health.



REDUCING CATTLE METHANE EMISSIONS

A study¹ in 2021 has shown that red seaweed can reduce methane emissions from cattle by up to 80%. KFF collaborated with Queen's University Belfast to understand the potential of giant kelp to reduce methane emissions as well as improve animal health since giant kelp also contains active compounds such as phlorotannins that can improve immunity and are anti-bacterial. Dr Sharon Huws and her team are looking for alternatives to *Asparagopsis taxiformis* since the red seaweed also contains high levels of bromoform (a compound known to be ozone layer depleting) and is difficult to cultivate.

¹ Roque, Breanna M., et al. "Red seaweed (*Asparagopsis taxiformis*) supplementation reduces enteric methane by over 80 percent in beef steers." *Plos one* 16.3 (2021): e0247820.





Avoided emissions

THE CHEMICAL COMPOSITION OF 3 TYPES OF SEAWEEDS THAT GROW IN LUDERITZ

To uncover the valuable compounds present in giant kelp, Erastus Tobias, an MSc student from NUST (Namibia University of Technology and Science) studied its chemical composition for his master's thesis. In this study, he performed tests to determine the occurrence and concentrations of metal elements (manganese, iron, copper, zinc, arsenic, magnesium and lead) and the ash content of giant kelp (*Macrocystis pyrifera*) and two other seaweed species that are found along the coast of Lüderitz, Namibia: *Ecklonia maxima* and *Laminaria pallida*. The level of these elements are important to analyse, as the trace metals form a great part of the essential macronutrients, but also potential toxins. The ash content carries more information on the nutritional content of the seaweeds, as well as their potentials.



Erastus Tobias receiving fresh kelp samples.

1. Metal elements analysis

2. Ash content determination

MATERIALS & METHODS

1. Raw samples

2. Oven drying



3. Acid-based digestion

4. Extracts



5. ICP analysis

6. Furnace (ash content)

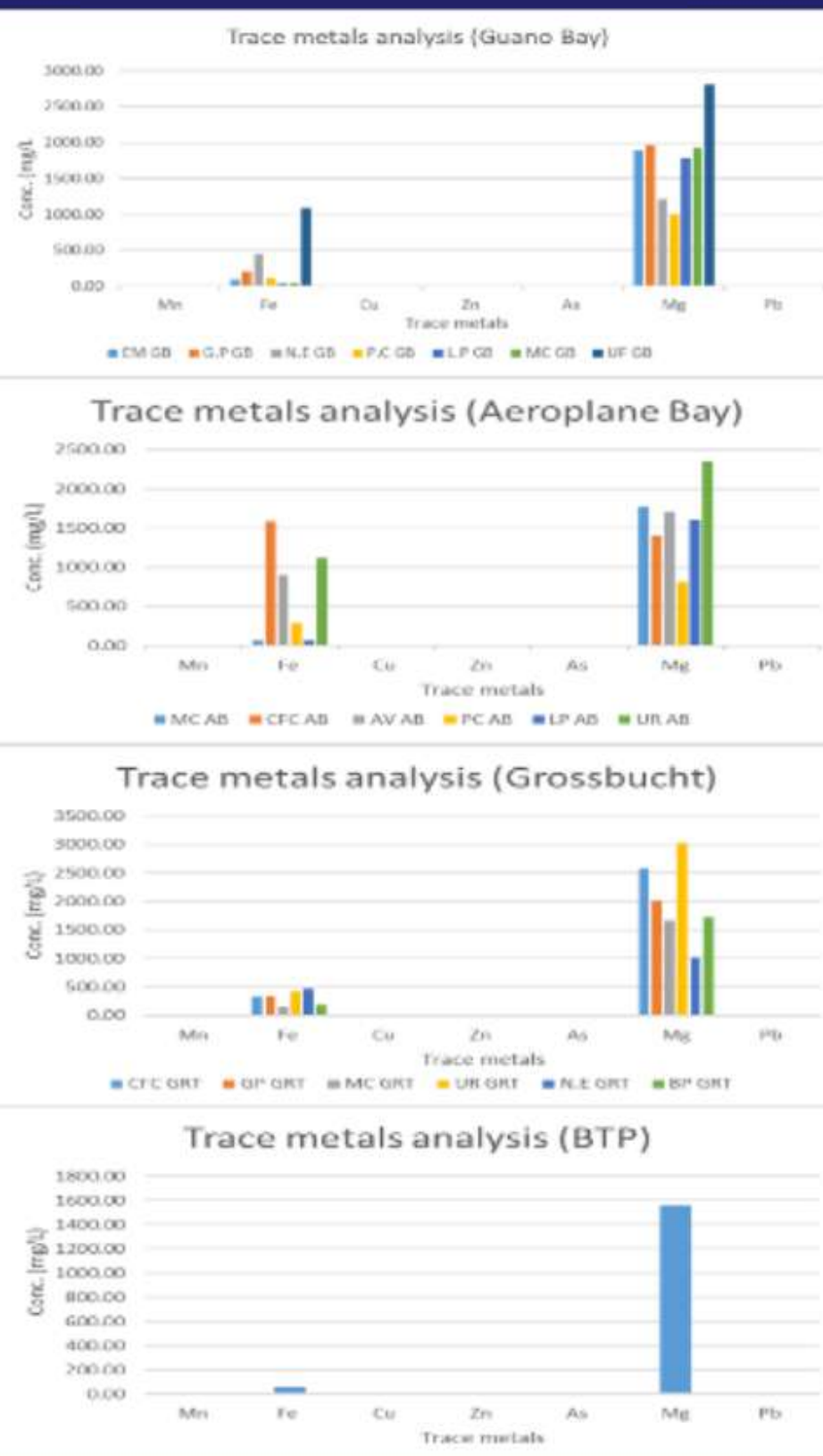


Fig3. Trace Metals Analysis

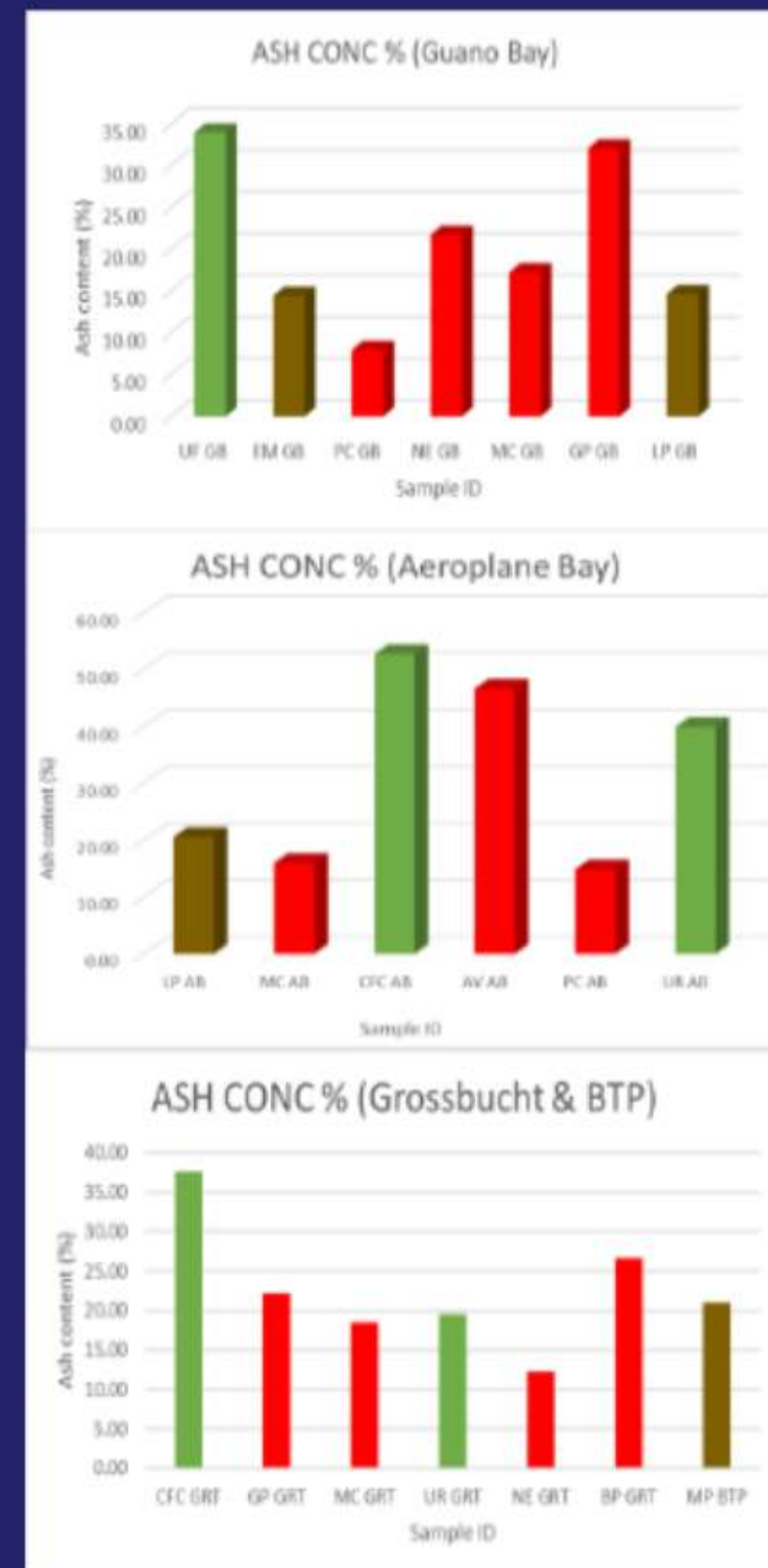


Fig4. Ash content

ACHIEVEMENTS

OCEAN LITERACY



THE LUDERITZ BLUE SCHOOL

As part of our Ocean Literacy and Skills Development program, we collaborate with The Luderitz Blue School to run extra-curricular activities open to all children in Lüderitz with a special focus on ocean education and robotics.

THE LUDERITZ STRANDCUBS

The Strandcubs is our club for children that participate in the Oceans Day programme every Friday afternoon. These activities are open to the whole community and include kids of age 8-13, where they enjoy an incredibly diverse programme of activities all related to the unique (coastal) environment of Lüderitz. These activities include:

- Studying the beach biome on Grosse Bucht
- Ropes and knot-tying masterclass in Kelp Blue
- Lab work with Protasius in Kelp Blue
- Raft building and testing with the Engineering team at Kelp Blue
- Treasure hunt challenge – map reading and route planning
- Beach clean up at Agate Beach
- Ocean artwork and nature sculptures
- Skip painting for town council clean-up day
- Spaghetti Bridges – engineering challenge with students TU Delft
- Visit to the Lüderitz wind turbines
- Tour of the Lüderitz Maritime Museum
- Lüderitz Speed Challenge with Bjorn Dunkerbeck
- Sperrgebiet Diamond mine trip



1, 2 & 3: The Luderitz Speed Challenge with Bjorn Dunkerbeck



3 & 4 Raising awareness on beach waste



Visiting a wind farm





Raft building & testing



Lab work and food testing



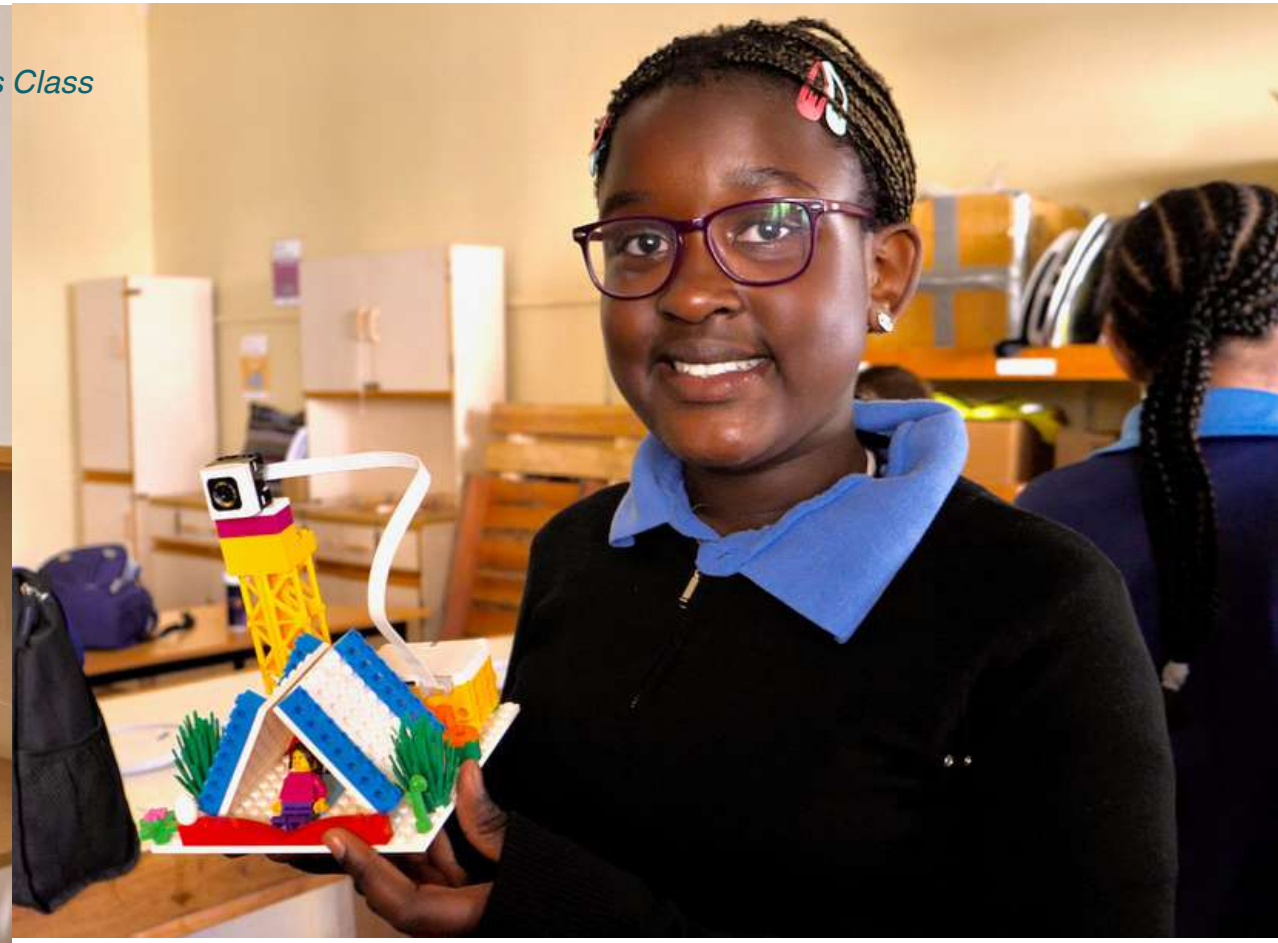
Ropes & knot tying class

THE BENGUELA ROBOTICS LAB

Robotics are transforming the understanding of life in the oceans. The future of science is supported with the use of AI and robotics, allowing us to monitor the marine environment in a precise and cost-efficient way. The Benguela Robotics Lab opened in September 2022 and provides a place where children from age 8-12 learn basic coding and programming using microbits, the basics of sensors and remote control. The programme includes building a remote-operated boat and making robots using LEGO Spike. The programme is organised by the Luderitz Blue School and is sponsored by KFF.



Benguela Robotics Class





THE LUDERITZ TIDAL POOL

Lüderitz is a harbour town at the Atlantic Coast in Namibia. The combination of high temperatures, high swells, and only very few people that know how to swim, has resulted in a strong need for a safe place to acquire swimming skills. A collaboration between the Kelp Forest Foundation, Kelp Blue, TU Delft and NUST is enabling the building of a tidal swimming pool at Aeroplane Bay which will provide exactly that: a safe and self-sustainable swimming area for the community.

The tidal swimming pool will be a man-made version of the well-known existing rock pools: small pockets of water that occur along rocky areas where ocean meets the land. The tidal pool concept uses the tide as the main mechanism for water replenishment during every high water (both neap and spring tide).

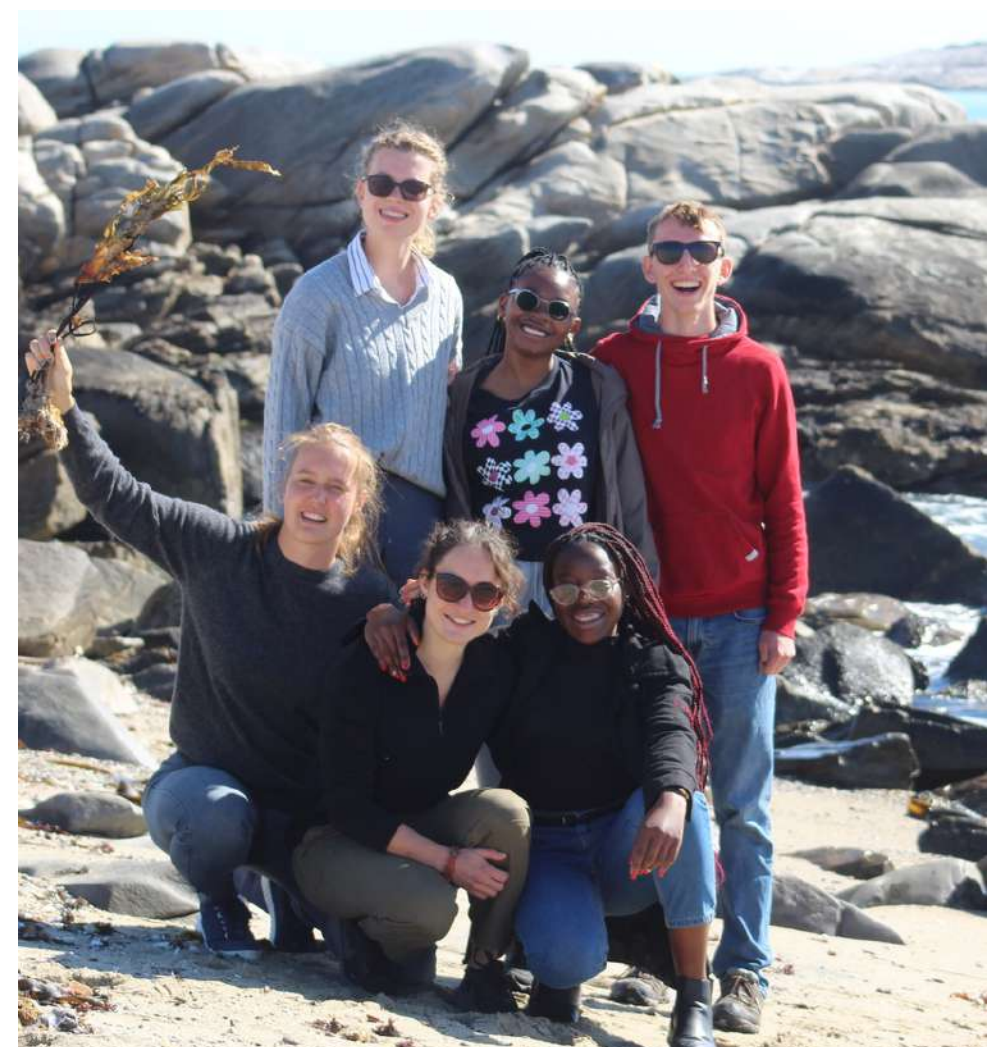
In 2022, six students from two universities (TU Delft, Netherlands and NUST, Namibia) visited Lüderitz and the Kelp Blue team to design the tidal pool and the adjacent community house. KFF sponsored the students' trip and accommodation and will continue focusing efforts on fundraising for the construction of the tidal pool.

The tidal pool design includes a recreational facility building. The community-led facilities will be mainly built from recycled materials, and the shape adapted to the local landscape. The facility building will provide a space to store materials needed for the swimming and life-saving lessons, as well act as a community house and cafe to host ocean-related events.

Top left: a photo of a tidal pool in South Africa (as example)

Top right: render of the tidal pool and community house design

Bottom right: the NUST and TU Delft students who designed the tidal pool



CAPACITY-BUILDING

As part of our mission to foster ocean awareness and cultivating the future generation of ocean lovers and custodians, our skills development program strives to develop local talent, bridge capacity gaps, and promote the sustainable wellbeing of the community in which we operate. Throughout 2022, the KFF scholars participated in various programs and trainings designed to enhance their skills related to lab safety, lifeguarding, swimming proficiency, and the operation of advanced sensor technology. Moreover, the scholars were presented with opportunities to showcase their research at conferences, thus not only testing their public speaking skills but also sharing their knowledge and amplifying the impact of their findings in the scientific community.

7TH ANNUAL RESEARCH CONFERENCE, UNAM

Two of our MSc students, Angelique Dodds and Ukarapo Mungunda, presented at the 7th Annual Research Conference held at the Sam Nujoma Campus of University of Namibia on the subject of measuring biodiversity in cultivated kelp forests.

Angelique presented the eDNA (environmental DNA) biodiversity research on kelp beds. The non-invasive collection of data is done by drawing water up in a large syringe and passing it through a plastic disk that contains a filter membrane. The membrane traps the eDNA which is then sent to the NatureMetrics lab for analysis.

Ukarapo explained how she uses bioacoustics - the use of sound production and transmission in the water - to understand what animals are attracted to the kelp forests. For example, after 40 consecutive days of underwater sound recording (passive acoustics), she learnt that the pod of visiting Heaviside dolphins are most chirpy, chatty and active between 9 and 10am but that they hang around the entire morning. By applying deep learning algorithms, trained to distinguish species from each other, Ukarapo can identify which animals are emitting sound.

COSDEC BENGUELA

Kelp Forest Foundation sponsored ten students to attend Cosdec Benguela training courses in Lüderitz. Cosdec Benguela provides skills training that incorporate business skills, entrepreneurship and life skills and relates the training programs to opportunities in the local economy in terms of demand for goods and services. The main aim is to assist young people to find employment in the local economy either in the formal or informal sector. The training provided at the centre is competency-based and the courses focus on the basic skills that an employer expects of an entry level worker. COSDEC Benguela was established in 2009 and aims to target and market courses to the unemployed youth and women.



REGIONAL RESEARCH GRADUATE NETWORK IN OCEANOGRAPHY (RGNO)

Two of our MSc students, Protasius Mutjida and Angelique Dodds, attended the Regional Research Graduate Network in Oceanography (RGNO) programme organised by University of Namibia's Sam Nujoma Campus, Namibia's National Marine Information, Research Center (NatMIRC) and Dr. Kurt Hanselmann of ETH Zürich.

The programme covered a mix of research themes presented as workshops and talks by experts, lectures with tutorials and the students' own efforts.

This workshop focused on oceanographic topics and it was aimed at inspiring participants to advance scientific research in ocean ecosystems in an exploratory way. Hands-on work on the MIRABILIS research vessel at sea (such as sediment coring as seen on the bottom-left photo), instruction in the classroom and work in the laboratory made RGNO Research Discovery Camps a unique experience for Protasius and Angelique. By working across disciplinary fields and initiating partnerships with scientists from internationally leading research institutions, the RGNO offered opportunities to collaborate in interdisciplinary research projects with guidance and supervision by active scientists.



GEOCHEMISTRY BASELINE STUDY



Protasius Mutjida

Protasius Mutjida, our scholar, presented his abstract regarding his bio-geochemical baseline study at the 1st Multidisciplinary Research Conference held by University of Namibia at the OHP Campus, in the northern part of Namibia. The conference invited researchers, students, and academics to submit abstracts, to share research findings and create collaborative links between academics, professional practitioners and their workplaces, aiming at long-term sharing of knowledge.

EIA TRAINING

Our MSc scientists travelled to Swakopmund (Namibia) to attend a 2.5 day Environmental Impact Assessment (EIA) course run by Patrick Werner and Pierre Smit of NAMISUN. The training covered why and when an EIA is needed, and which processes and steps need to be followed to complete a full EIA. It also provided knowledge on project life-cycles, mitigation measures, site visits report writing and reviewing. In addition, our students Ukarapo Mungunda, Iriya Jona, Angelique Dodds and Caatje Hooft learned the initial screening and scoping methods, analysed a case study where they could apply the theory and watched some inspirational videos of EIA teams at work.



Our scholars Protasius Mutjida and Angelique Dodds with their teachers



The team being given life saving lessons.

Given that our team of MSc researchers and scholars frequently conducts their work in and near the ocean, it is crucial for them to possess essential swimming skills to ensure their safety in this environment.

To address this requirement, our ocean skills programme includes swimming and life-saving lessons. These training sessions were organised by Monarch Lifeguard and Rescue and focused on equipping our team with valuable skills such as providing first aid assistance, along with swimming classes held at the pool of the Prospector's Inn Hotel located in Lüderitz.

BIOACOUSTICS

Ukarapo Mungunda, our marine-bio-acoustic specialist, attended the 3rd African Bioacoustics Community (ABC) Conference held in South-Africa, where she and other experts shared their knowledge and experience in topics such as sound measurement and use of recording equipment.



Ukarapo Mungunda

Ukarapo presented her masters thesis titled "Hydro-acoustic discrimination and biomass estimation of jellyfish" as well as the bio-acoustic work she is doing of investigating biodiversity changes in the kelp farms by using passive and active acoustic methods. Her MSc thesis entailed adapting an algorithm to detect and discriminate jellyfish from all other organisms in the water column, isolating them and calculating their biomass. This concept she is now using in Lüderitz, Namibia, not only to track marine animal behaviour but to calculate changes in kelp biomass.



Ukarapo also visited the Seatech team to learn more about maintaining the sensors that she will be deploying at the Kelp Blue site. These sensors will give us valuable data on the water quality and geochemistry, as well as support in biodiversity measurements using acoustics.



Swimming lessons at the Prospector's Inn pool

THE BLUE HOUSE PROGRAMME

The Blue House Programme is a partnership between Stuchtey Daughters & Sons, Kelp Blue and the Kelp Forest Foundation which will provide rolling scholarships to Namibian students (with a bias towards women) to develop scientific talent in natural ecosystems. The aim is to build climate and social impact. Our vision is for the graduates of this programme to enrich the national and Southern African talent pool in the skillsets required for a future in which humanity and nature are in better harmony. We hope to see the graduates of this programme further their careers in government, business, entrepreneurship, and academia. The Blue House, owned by the Stuchtey family, will be rented to Kelp Blue. The rent will be used as a contribution towards scholarships of the Namibian students.

The Blue House will also be used as living accommodation for these students as well as a working office, reference library and a place to store equipment. The office will be used by the students, apprentices, international interns and their supervisors.

The Blue House Programme will initially sponsor two MSc students from Namibian universities, and provide them with scuba diving training to undertake their research; sponsor a series of rolling interns from an international university and pair them with a Namibian sponsored apprentices; purchase the necessary equipment to undertake the research; cover accommodation, stipends, tuition and other costs.



The Blue House in Lüderitz, owned by the Stuchtey family.



ACHIEVEMENTS
**PUBLIC
AWARENESS**

CONFERENCES & PRESENTATIONS

Public awareness of the value of (cultivated) giant kelp is important as it can help support the growth of the industry and future farmers, as well as harness the potential for giant kelp ecosystem to mitigate climate change climate change mitigation. At the Kelp Forest Foundation, we are committed to sharing knowledge and fostering awareness on these topics through various platforms, including conferences, online or in-person presentations, as well as through podcasts or films. In 2022, the KFF team actively participated in global conferences and events, aligning with our overarching ambition to enhance awareness and understanding of the potential of cultivated giant kelp.

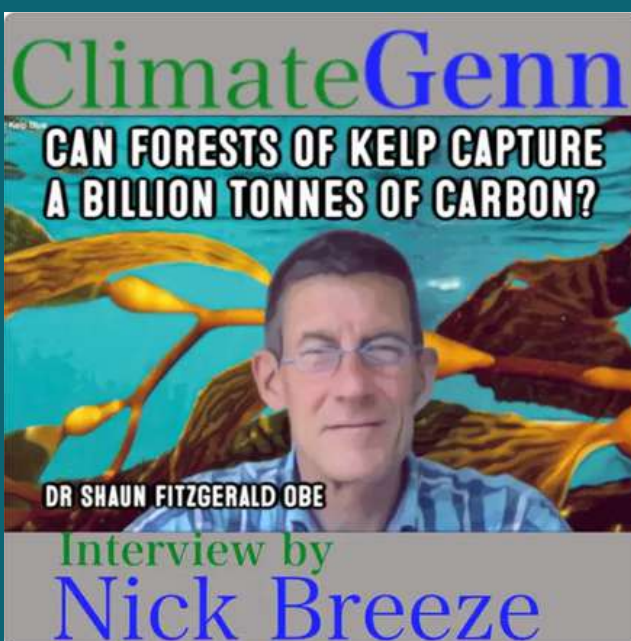
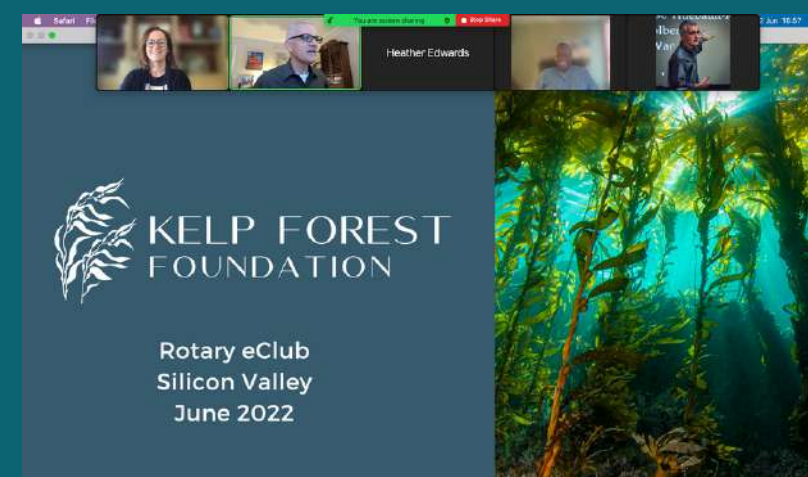


UN OCEAN DECADE CONFERENCE

Samantha attended the UN Ocean Conference hosted in Lisbon, Portugal. The theme was “Scaling up ocean action based on science and innovation for the implementation of Goal 14”. The aim was to unlock ocean-based solutions to address some of the most defining issues of our time, from climate change to income equality.

ROTARY ECLUB PRESENTATION

Samantha spoke to Rushton Hurley of Rotary eClub of Silicon Valley about the power of cultivated kelp forests to combat climate change and diversity loss. Samantha also spoke about the innovation that is occurring in the whole value chain, from hatchery and offshore cultivation to employing biorefinery processing methods to create exciting new products whilst minimising waste.



CLIMATEGENN PODCAST

In an episode of the ClimateGenn podcast, Dr. Shaun Fitzgerald OBE of Cambridge University, in conversation with Nick Breeze, highlights the important modelling work to assess the carbon sequestration potential of cultivated kelp forests at a global scale. In this episode, he also discusses new research to build resilient and scaleable kelp growing platforms, asking the key question: can kelp forests capture and store a billion tonnes of carbon?



MAYMA AZUL ONLINE SEMINAR

Samantha was invited to speak alongside Mr Adolfo Alvia, head of the Club Innovation Acuicola of Chile, about their views of the seaweed market, both in general and the potential for Latin America. The Mayma Azul program focuses on the global blue revolution through the creation of the first blue regenerative ecosystem in Latam by bringing together business models and people in the blue economy.

Left: Following Samantha's presentation with Mayma Azul, the newspaper Comercio Argentina presented the conversation and the information she had during the conversation.

OCEAN BORN FOUNDATION PRESENTATION

The Ocean Born Foundation offered a generous grant to support KFF's purchase of a Seabird nutrient sensor. The Ocean Born Foundation is a grant-giving foundation with the goal to create new, sustainable streams of income to combat climate change by focusing on ocean health. Samantha presented to the Ocean Born team to speak about the mission and work the Kelp Forest Foundation does, including explaining how the Seabird sensor is a key piece of equipment to understand the impact cultivated kelp forests have in the surrounding water geochemistry.



SEAGRICULTURE LECTURE, WAGENINGEN UNIVERSITY

Kelp Blue and KFF were invited to present a lunch lecture at Wageningen University as part of the Seagrass course, a BSc minor that focuses on this topic as one of the pillars of a biobased economy. The goal of this minor is to provide students with knowledge and insights on sustainable seaweed production and value creation of seaweed biomass.

A CRY FOR KELP PODCAST

A Cry For Kelp is a podcast series that delves deep into the seaweed industry through interviews with its movers and shakers. Hosted by Nic Woodhams, Samantha spoke during a two-part podcast about quantifying the positive biodiversity impact of growing kelp, the potential for kelp to be a genuine ocean based solution to climate change, and the role the Kelp Forest Foundation plays to achieve these goals.



FEMIN PLURIEL PRESENTATION

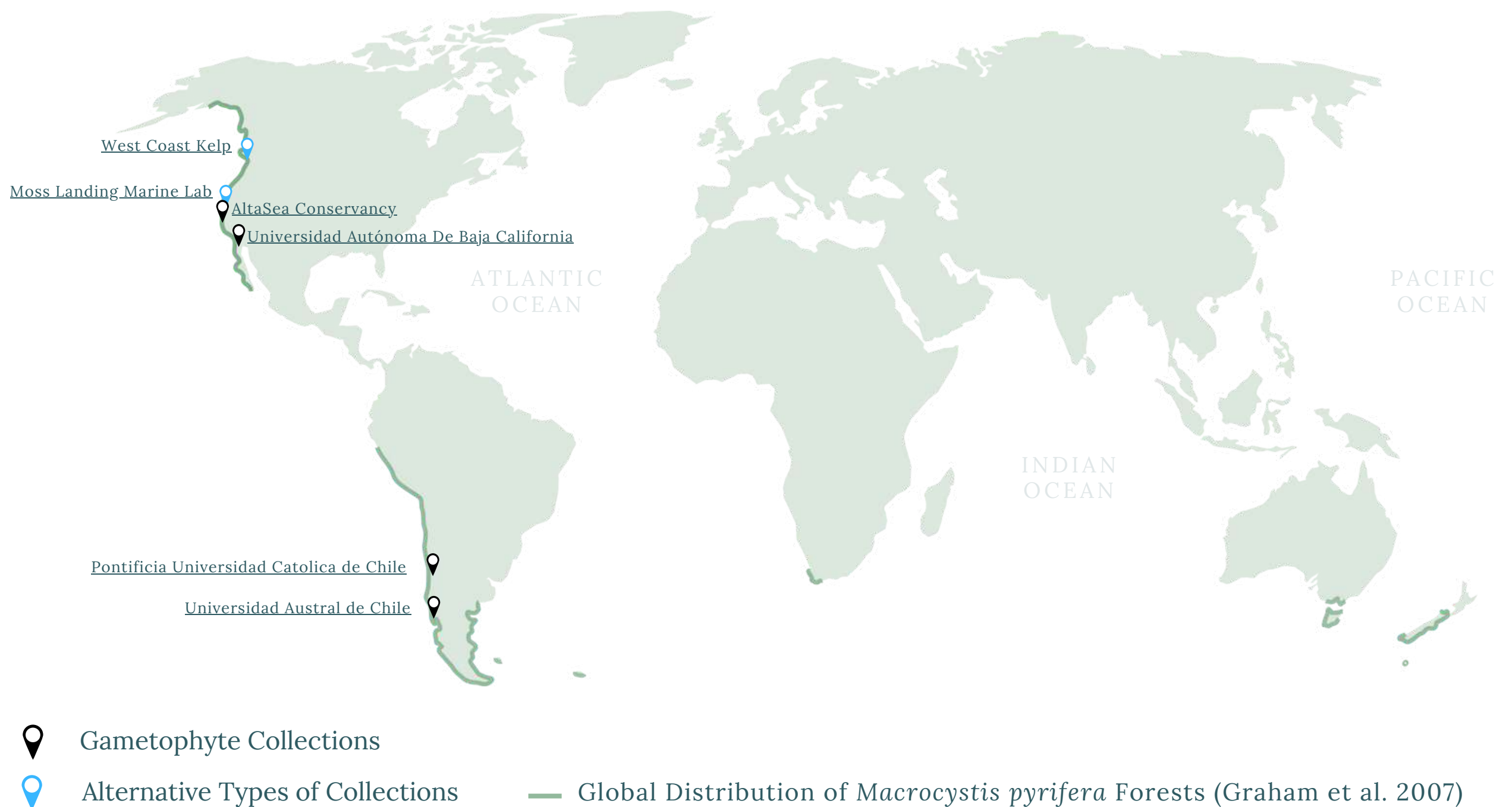
Feminin Pluriel is an international network aimed at connecting women in high profile positions to help them grow their business, provide a resource platform for members, and to create events, meetings and conferences to support personal growth. Samantha was invited to present herself and her journey with the Kelp Forest Foundation. She spoke about her past experiences and career, and how she started devoting her time and energy to kelp and its potential to be a solution to climate change.





ACHIEVEMENTS 2022

**MACROCYSTIS
SPORE BANKS**



PRESERVING GENETIC DIVERSITY OF GIANT KELP

Many kelp forests, such as those found off the coast of Australia and California, are disappearing mainly due to warming waters. Giant kelp species prefer cool temperatures, and researchers are worried that the losses could accelerate in the coming years as climate change continues. Kelp spore banks are an important tool to help us during restoration efforts. By keeping a genetically diverse set of wild giant kelp spores, we can: identify warm-tolerant kelp stocks; restore beds that are wiped out due to more localised disasters, such as oil spills by replanting the beds with previously collected propagules from the original local stocks; preserve genetic diversity for future generations and provide the much-needed starting material for future kelp farmers.

Diana DiMarco, biostatistician and marine ecologist, completed an internship with KFF during which she created an overview of the giant kelp depositories and spore banks around the world, with the goal to map the status of the global seaweed seed banks, identify opportunities for collaborations and sharing, and understand which gaps need to be filled. This supports our aim of looking to align our own approach with other institutions to enhance fair sharing. The digital inventory provides knowledge of the associated knowledge centres, universities, research institutions, and companies that are safekeeping spores and researching giant kelp.

The map above shows the global distribution of giant kelp (*Macrocyctis pyrifera*) as well as the existing genetic collections. It highlights the **lack** of regional and global seed banks. Global collections can help safe-keep genetic material for kelp restoration in the case of a kelp forest ecosystem being lost or harmed.

A "spore bank" is generally agreed upon to refer to a collection that includes a large amount of individuals and the genetic/physical diversity necessary to completely restore a damaged natural location. In this case, "spores" usually refer to gametophytes (developed from spores produced by the sporophyte), as gametophytes are the most common way to keep giant kelp in a dormant state. Considering these details, the word "collection" is used because most collections do not contain the diversity or size necessary to be considered a true "spore bank". The map indicates both spore banks and collections with a black location pin (📍).

The blue location pins (📍) are used to indicate other types of collections. These include an emerging type of collection, a sorral bank, which is a group that does not *keep* a collection but instead *regularly collects* fresh sori from natural populations.

Please note that this is not a complete overview of kelp collections globally.



Beata Tooleni, KFF MSc scholar, assisting with marine birds and megafauna monitoring.

LOOKING AHEAD

Kelp Forest Foundation will continue to push forward the scientific knowledge on the ecosystem services of cultivated giant kelp. In the coming years, we will focus on a range of research topics related to the carbon sequestration potential, impact on biogeochemistry and biodiversity, and the reduction in emissions and beneficial effects of kelp products. These research projects will span several years and the knowledge will be shared publicly to help accelerate the entire sector.

PROJECTS, TIMELINE & FUNDING

RESEARCH (CO2)

	2021	2022	2023	2024	2025	FUNDING NEED
• CO2 sequestration pathway model, Cambridge		●	●	●		funded
• Sediments study			●	●	●	USD 420,000
• Net Primary Production of giant kelp			●	●	●	USD 35,000
• Geochemistry impact	●	●	●	●	●	USD 35,000 P/A
• Kelp composition		●	●			funded
• Ocean acidification			●	●	●	USD 100,000
• qPCR and ddPCR of giant kelp			●	●	●	USD 480,000
• Stable Isotopes / NMR spectroscopy			●	●	●	t.b.d.
• Recalcitrant Dissolved Organic Carbon			●	●	●	USD 310,000
• Kelp degradation pathways			●	●	●	USD 250,000

RESEARCH (BIODIVERSITY)

• Impact on algal ecosystems	●	●	●	●	●	USD 35,000 P/A
• Impact on fauna	●	●	●	●	●	USD 35,000 P/A
• Impact on benthic biodiversity			●	●	●	USD 35,000 P/A
• Global eDNA study of wild kelp forests				●	●	USD 620,000
• Pilot eDNA study, Falkland Islands			●	●		funded

RESEARCH: KELP PRODUCTS

• Kelp biostimulants effects on plants/soil/carbon			●	●	●	funded
• Kelp in animal feed				●	●	t.b.d.

OCEAN EDUCATION

• Benguela Robotics Lab	●	●	●	●	●	USD 25,000 P/A
• Ocean education and after-school activities	●	●	●	●	●	USD 45,000 P/A
• Blue House Programme/Capacity building			●	●	●	USD 105,000 P/A
• Tidal pool				●	●	USD 750,000
• AR/VR kelp awareness project				●	●	USD 150,000

MACROCYSTIS SEED BANKS

• Setting up seed banks globally				●	●	USD 1,000,000
• Kelp spores awareness & scientific sourcing expedition				●	●	t.b.d.

PUBLIC AWARENESS

• Documentary				●	●	USD 550,000
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Michael Mateus, KFF MSc scholar, measuring morphological characteristics of beach cast kelp (*Laminaria pallida*).

FINANCIAL REPORT

BALANCE SHEET

(after allocation balance of income and expenses)

ASSETS

Cash at bank	€	406.225
Current assets	€	6.340

Total assets	€	412.565
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LIABILITIES

Current liabilities	€	19.130
Other reserves	€	393.435

Total liabilities	€	412.565
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PROFIT AND LOSS STATEMENT

INCOME

Income from companies	€	38.332
Income from non-profits	€	453.747

Total income	€	492.079
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Income minus expenses	€	157.338
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EXPENSES

Spend on objectives	€	322.807
Cost of management/admin	€	9.042
	€	
Financial expenses	€	2.892

Total expenses	€	334.741
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A BIG THANK YOU TO OUR SUPPORTERS

The Kelp Forest Foundation is incredibly grateful to the following foundations and institutions for their funding support:



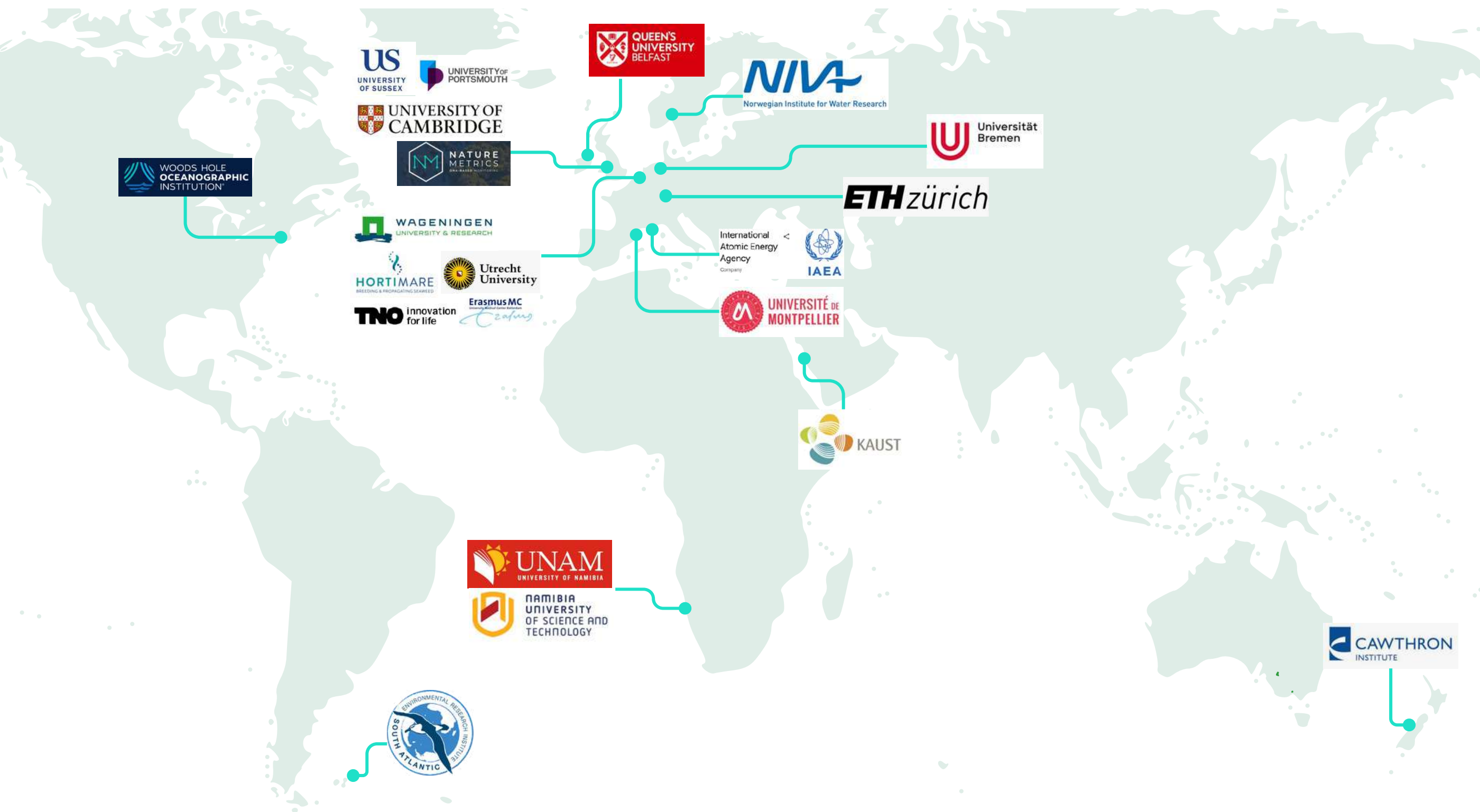
J, C & R KREDIET
CHARITABLE FOUNDATION

Great Island Foundation



GLOBAL RESEARCH PARTNERS

The Kelp Forest Foundation is working together with top universities and research institutions worldwide. The map below shows our global research partners who support our mission by executing research projects, providing supervision for our scholars, or sharing knowledge and support towards answering our research questions.





KELP FOREST
FOUNDATION

STICHTING KELP FOREST FOUNDATION

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ANBI RSIN: 862389677