

Namibian deep-sea benthos collection project: history and progress

4th May 2022

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Despite the wealth of expert fisheries scientists in Namibia, the lack of deep-sea benthic (seafloor) ecologists and taxonomists poses a problem in meeting requirements for monitoring current and proposed impacts in the deep-water environment of Namibia's Exclusive Economic Zone (EEZ). In light of this issue, a collaboration between benthic ecologists Bronwen Currie (Namibian Ministry for Fisheries and Marine Resources, Namibia), Maria Baker (University of Southampton, UK and co-lead for [INDEEP](#) and [DOSI](#) – global networks for deep-sea science and policy) and Lisa Levin (Scripps Institution of Oceanography, USA and co-lead for DOSI) resulted in the organisation and convening of a 10-day workshop in April 2016 in Swakopmund, Namibia at the National Marine Information and Research Centre of the Ministry of Fisheries and Marine Resources headquarters. This event attempted to inspire scientists to engage in benthic biodiversity assessment efforts. The workshop considered not only the fundamental principles of benthic ecology but also addressed the main concerns of a variety of deep-sea anthropogenic activities. The event was funded by INDEEP, the International Seabed Authority Endowment Fund and MFMR. Funding enabled participation of 28 individuals, mostly from Namibia but also representatives from Kenya, Madagascar, Mauritania and Angola. Their experience spanned sectors and disciplines, although most were related to fisheries in some way, and included an Executive Director of the Centre of Studies and Development of Fisheries, Senior Fisheries Biologists, Head of Data Management, PhD Students, Fisheries Research Technicians and Research Scientists.

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A diverse range of subjects was taught using a variety of methods. Participants were introduced to benthic environments and the associated fauna, the history of deep-sea exploration, animal-sediment interactions, human impacts, sampling and sampling design, metrics used in characterisation of the benthos, ecosystem function and services, life-histories, larval dispersal and connectivity, consideration of mining impacts, management strategies and governance. The teaching comprised a combination of lectures, hands-on investigations of benthic fauna (from meio- (microscopic animals) to macrofauna (e.g. sea stars)) including boat work, sample processing, laboratory observations, data analysis exercises, discussion groups and feedback presentations by participants. All participants were given access to the course presentations, associated key literature and webinar recordings. They were also given course participation certificates. Post-course evaluations were extremely positive, with the majority of participants eager to use their new knowledge in their current roles to varying degrees and to pass on this knowledge to their colleagues.



11-21 April 2016 Workshop Activities, Swakopmund.

The workshop was deemed a great success and stimulated increased effort in terms of benthic monitoring being incorporated into standard practices in Namibian waters alongside fisheries assessments. Some of the workshop participants are now leading these new dedicated efforts for sampling, analysis and establishment of museum collections of Namibia's deep-sea fauna. The main demersal fisheries of Namibia are hake (fished predominantly at 200-700m), monk, deep-sea red crab and to a lesser extent orange roughy (which is currently under moratorium). Prior to these dedicated benthic collections, invertebrates trawled during fishery research cruises (once per TAC species per year) on board *RV Mirabilis* using dedicated research trawl nets have been coarsely identified where possible, abundance coarsely quantified (e.g. how many buckets filled), and this has been recorded on spreadsheets and then most of the catch discarded at sea, with only a few samples returned to shore for storage/identification. A few photographs of samples collected (taken on board and subsequently discarded) are also in existence. There is capacity for storage of initial collections in the Swakopmund labs/storage rooms. In addition to these benthic fisheries research collections, a few sediment cores and grabs with samples of meio and macrofauna from the Walvis Ridge region have also been collected and stored. There are also a few historical samples/data around the Ministry of Fisheries and Marine Resource building in Swakopmund as well as some in the museum in Cape Town, South Africa. External research initiatives (e.g. German – *RV Sonne* and others) have collected benthic samples from the Walvis Ridge but Namibian researchers have no idea where these samples are and if they can have access to them for training/curation purposes as no Namibian scientists were invited to be involved in these expeditions.

Making connections

On 15th July 2020 DOSI continued working with NMFMR to begin the process of establishing a deep-sea benthos collection and this was accompanied by a 1-day online training workshop with the fisheries researchers who will undertake this work and the Namibian National Museum who will host the collections. Links were made between DOSI

and One Ocean Hub colleagues in South Africa and the UK. Lara Atkinson (South African Environmental Observation Network – SAEON) gave an introduction to detailed hake survey protocols for invertebrates used successfully in South Africa, Kerry Howell (University of Plymouth, UK) gave an introduction to Vulnerable Marine Ecosystems, Bronwen Currie (Namibia) presented on Namibian benthos and its role in ecosystem functioning and Tammy Horton (National Oceanography Centre, Southampton, UK) presented on preservation techniques, options and requirements for different taxon groups. There was active discussion and enlightening knowledge transfer among all participants.

One of the main drivers for this new programme is to satisfy the Marine Stewardship Council standards for certification, one of which concerns generating information on baseline data of the benthic invertebrate fauna associated with the deep Namibian fisheries, including Vulnerable Marine Ecosystem habitats. This is now an urgent priority. A further key driver is that a Namibian deep-sea benthic curated collection, based in Namibia and looked after by Namibian Fisheries scientists, would be a great asset – for use in any future activities that may affect Namibian deep waters, and also for increasing knowledge and inspiring wonder in this little-studied realm. Namibian deep-sea benthic diversity data collection is underway on a regular basis in conjunction with fisheries assessment cruises. Through the transfer of knowledge and opportunity, endeavours such as these decentralise and democratise deep-sea expertise and provide the foundation for local communities to sustainably manage their own deep-sea environment and to implement global regulations at a local level – a critically important outcome. The deep-sea work undertaken by Namibia has great potential for establishing a long-lasting Namibian skilled benthic workforce and will be an excellent case study for others to aspire to.

“The sampling methodology has not changed since 1990”

Historical data at least since 1990 for the hake survey are available, other surveys like monk surveys and crab surveys would also have some data available. Even though samples were coarsely identified they still very valuable. Some species such as peanut worms, bryozoans, ascidians and hemichordates may have not been recorded. Readily identifiable species like starfish, molluscs and others would exist as such in the database. Also within the *Nansis* database most of the benthic organisms that have now been identified were not named in the database (no codes) and as such new codes needed to be generated for these (important to know the family names). To date the most well-structured survey would be the 2022 hake survey and 2021 monk survey. During these two surveys about 99% of the organisms were identified to the species level and quantified. Photographs from each station where invertebrates were collected are also available. Of course challenges exist such as having various teams conducting the identification work at sea resulting in the possibility of mis-identification of species. With expert help, photographs would help to rectify this. Samples are stored in jars with formalin and later transferred to ethanol and these will also help with verification.

The sampling methodology has not changed since 1990. Prior to Namibia’s Independence in 1990, there are few records of benthic collections. Fisheries were handled by South Africa. Some bottom areas along the Namibian coast were mapped by trawl fishermen, providing coarse but valuable information on benthic features such as sponge beds. Much earlier, around the 1920s research cruise records before the onset of commercial fishing likewise contain some valuable but undetailed indications of benthic fauna.

Today surveys target a specific species, e.g. hake, and the sampling strategy for hake would be followed. The sampling procedure of a trawl catch can vary with the size and the composition of the catch, but the final data entered into the form should always be the total catch by species in kilograms and numbers. The following are standard practice when a trawl comes on deck:

- If the catch is small, the **whole catch** must be taken and sorted by species.
- If the catch is large, the fish must be well mixed with shovels. A portion of the catch should randomly be chosen and all fish in the decided proportion must be taken as a sample.
- If the catch is large but there is medium catch for hake, all hake may be taken/collected for sampling and then the rest of the catch is sub-sampled. Note that all the bigger fish species, for example snappers, can be removed from the total catch and measured separately.
- *All* species taken for sampling are sorted by species, counted and weighed. The weight and number of the species are then **raised** according to the ratio:

$$\text{Total weight of the catch} / \text{Sample weight of the catch.}$$

In the case of benthos for past surveys, in most cases numbers were not recorded only weights. Recently benthic species are counted where possible although challenges exist for some organisms e.g. some species of starfish and sea urchins tend to break apart.

Environmental data exists (oxygen, temperature and salinity) from CTD measurements. The CTD however is only deployed at every third station. Temperature is recorded for every trawl station from the ScanMar sensors.

The species that were collected on the 2022 hake survey will be rechecked by Bronwen and Sarah (currently busy with this). It was very difficult to take proper photographs on the vessel as the camera struggled to focus. We will then cross-check the species with what we have in the database to make sure we have correctly identified these species (changes can always be made in the database). In some instances, we were unable to identify species and as they were not in the Atkinson ID Guide or they were too similar to each other.

So far, benthic epifauna (macro- and mega-fauna) are the main focus. However a 0.1m² van Veen grab may be used during the upcoming 2022 surveys.

Funding was made available to Namibia through collaboration with the One Ocean Hub and sampling equipment and consumables have been acquired to support benthic invertebrate collections going forward, including: laptop, hard drive, formalin, ethanol, buckets, jars and other consumables. Ideally when we are done these specimens can be given to the National Museum. In addition, the commercial log sheets have been redesigned in order for the fisherman/observers to record the type of benthic invertebrates caught in their nets (this however will be a crude identification as they would require some training in benthos identification, but for now they will be allowed to coarsely identify the species).