OCEAN SCIENCE IN ACTION

10.1 BIG RESULTS WITHOUT BIG SHIPS: PEMBA CHANNEL FIELDWORK

VIDEO DURATION– 05:29

In this lecture we will take you to the shores of the Pemba Channel, where our teams have conducted fieldwork using marine gliders and a more traditional biogeochemical survey onboard a small research vessel, the RV Angra Pequena.

The Pemba Channel is a dynamic coastal channel separating the island of Pemba from the Tanzanian mainland. The Channel is approximately 40 km wide and 70 km long, running from north to south and almost 900 m deep at its deepest point. A branch of the powerful East African Coastal Current flows through this narrow passageway, reaching speeds of up to 7 km per hour. Its steep, rugged bathymetry and the fast current can create dangerous conditions for fishing boats, and make this a challenging environment to study. However, the unique dynamics of the Pemba Channel sustain healthy fisheries, which suggests this energetic environment provides a mechanism for high levels of nutrients that are trapped in deep water to be upwelled to the ocean surface, where there is sufficient light for phytoplankton to grow. This presents the question of whether the relatively deep nature of the Pemba Channel may support an ecosystem more resilient to climate change, than shallow nearby channels and coastal systems such as the Zanzibar and Mafia channels?

Not much is known about the physical oceanography, biogeochemistry or ecosystem dynamics of the Pemba Channel. To date, only a handful of in-situ observational studies have taken place. The challenge our teams face is to test if it is possible to overcome the difficulties of working in such complex dynamic environments, together with the shortage of local infrastructure, such as highly equipped research vessels. This novel approach brings state-of-the-art marine robotics together with the more traditional oceanographic survey capability of a small research vessel.

Here is Dr Matthew Palmer from the National Oceanography Centre in the UK. He is leading an international team deploying state-of-the-art equipment to study the physical controls on nutrient supply to surface waters in the Pemba Channel.

Using a small, locally supplied commercial vessel, the team will undertake daily missions in the Pemba Channel to release a series of underwater robotic gliders capable of surveying the region.

These gliders are equipped with sensors capable of measuring the temperature, salinity and the oxygen concentration of the ocean, as well as chlorophyll-a fluorescence, which provides an indicator for phytoplankton abundance.

One specialist glider is equipped with the latest lab-on-chip technology that has been developed at the NOC. This lab-on-chip sensor automatically measures the concentration of nutrients in the ocean interior, providing the capability of a chemical laboratory housed in a small ocean robot. It is important to know the nutrient concentration throughout the water column from the sea bed to the sea surface, as the nutrient supply from depth is one of the key factors sustaining primary production in the Pemba Channel.

A second glider is equipped with an echosounder capable of detecting small fish, using the reflection of emitted low-energy sound pulses.

While the robot gliders are autonomously sampling the channel, the team uses additional instruments on their small boat to measure the local weather, strong currents and turbulent mixing within the channel. Combining these datasets will enable the team to establish a link between the physical dynamics of the Pemba Channel and the small pelagic fisheries that are important to local communities.

The strong flow in the channel provides many challenges to the glider team and crew. Recovering the gliders each day required a combination of experience and luck, as the fast-moving surface flows continually swept the gliders along the channel towards neighbouring Kenyan waters and made navigation of the support vessel difficult.

Here is the Angra Pequena, with an international team of scientists on board led by Dr Stuart Painter from the NOC in the UK.

The team of 8 scientists have 10 days to complete a detailed survey of the Pemba Channel, which will provide new and much needed information about the oceanographic conditions within the channel during the Southeast Monsoon period.

Angra Pequena is a small vessel and every available working area is used. A bigger ship would have provided more room for a larger science team and more equipment, but the Angra Pequena is well suited to these waters and more than capable for the task at hand.

During the survey, sampling techniques are used that involve the deployment of vertical profiling systems to measure temperature and salinity down to 500 m depth, to collect water samples from different depths beneath the surface and nets to capture the plankton.

A particular focus for the cruise is on the upper ocean distribution of plankton and nutrients, which are poorly known, yet are important for the productivity of these waters.

Some data are immediately examined onboard.

Some water samples can also be analysed onboard, but most samples will be stored for analysis back onshore in the laboratory.

Boat based sampling and the collection and preservation of samples for later analysis remains central to many aspects of marine science. Currently, many more parameters can be measured this way than can be measured by autonomous platforms such as gliders, but the gap continues to close and in future, perhaps similar surveys will be entirely glider based.

Marine science can be expensive but even a short survey like this provides a lot of new and important information.

For the Pemba Channel system, the team found an environment with low surface nutrient concentrations, which has implications for the productivity of the water. Chlorophyll, which is a useful indicator of phytoplankton, was broadly distributed throughout the upper 80 m, often forming a peak at depth – the deep chlorophyll maximum – and the smallest phytoplankton species contributed the most to the measurable chlorophyll pool.

Despite obtaining a detailed snapshot of the Pemba Channel system, it remains unclear what the Channel environment would look like during the northeast monsoon period. Would the same results be found? Would something unexpected be found instead? More research is needed to complete the picture of this important coastal region.

Working on the eastern side of the Channel, close to Pemba Island, the glider team were immediately confronted by extremely turbulent waters in the lee of the island. Dr Palmer decided to focus the mission on this region to identify the mechanisms that contributed to the energetic boils that were clearly visible from the boat. Preliminary analysis of data shows that strongly opposing currents hundreds of metres beneath the surface, are sending out pulses of energy, that may be a contributing factor in the links between the high energy flows and the local ecosystem.

The Pemba Channel mission has demonstrated the effectiveness of ocean robotics in highly dynamic coastal environments in the Western Indian Ocean. Global coverage of satellite communications and the ever-increasing reach of broadband internet access, has provided the connectivity for state-of-the-art technologies to be used in developing coastal regions.

This ocean robotics mission provides confidence in local applications, with state-of-the-art autonomous technologies to expand the regional capability for ocean monitoring and exploration.

Tanzanian partners have actively participated in the deployment and recovery of these robots, and are now well placed to develop future missions with marine autonomy to meet their growing requirements for ocean research.