Kimberley Marine Research Program

WAMSI Project 2.2.9

Historical reconstructions of water quality in the Kimberley using sediment records

Sediment records can be used to determine historical water quality and biological oceanographic changes. Now a team of researchers is working to obtain baseline and historical water quality information on the Kimberley so that future impacts and risks can be forecast, better managed and understood in the context of coastal development and global climate change.

Background

Water quality and the pelagic biological oceanographic environment is influenced by natural climate variability, greenhouse induced climate change and other anthropogenic influences e.g. nutrients from grazing, agriculture and other catchment uses including those in coastal towns and cities.

The remote Kimberley coast of northwestern Australia is one of the few marine environments largely unaffected by human use but the region is undergoing increasing economic importance as a destination for tourism and significant coastal developments associated with oil and gas exploration.

Because of the increasing human use and likely impacts in the region, there is a need to gain an understanding of the historical and baseline environmental conditions.

A team of researchers from CSIRO, Edith Cowan University, La Rochelle University and the Chinese Academy of Sciences is responding to some of this need by reconstructing historical water quality and biological oceanographic patterns from sediment records using a range of biogeochemical methods.

Researchers taking a sediment core at one of the sampling sites

Research Objectives

The research group, led by CSIRO, is bringing together skills in biogeochemistry and ecology (CSIRO), isotope chemistry (Edith Cowan University and La Rochelle University, France) and biological oceanography, biochemistry and paleo-reconstructions from sediment cores (the Chinese Academy of Sciences).

The key objective of this research is to reconstruct a timeline of water quality changes found in sediment cores for a selected set of sites in the Kimberley that have contrasting human uses and/or environmental influences.

The results will determine the level of variability and change in water quality over the last 100 years and provide a baseline against which future changes can be measured.

What we've found

This study is employing palaeoecological (fossil organisms and their remains) and biogeochemical (chemical, physical, geological and biological) methods to infer historical changes in water quality from sediment cores taken in coastal waters in the Kimberley. At each of the sites sampled, the research team has attempted to compare levels of human use or natural environmental variability in addition to looking for long-term environmental changes.

western australian marine science institution

AUSTRALIA ECU EDITH COWAN UNIVERSITY

CHINESE ACADEMY OF SCIENCES

UNIVERSITÉ La Rochelle

CSIRO

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WAMSI Project 2.2.9 Sediment record

Sediment core taken from King George River (KGR)

Sediment core sites:

- Cygnet Bay (comparison of pearl farm/ non pearl farm sites);
- King George River (comparison of embayments with high / low riverine input); and
- Roebuck Bay (comparison of sites near/far from Broome's anthropogenic inputs).

Sites have been selected in consideration with work being done on other WAMSI Kimberley Marine Research Program projects to maximise the relevance and usefulness of the data being generated.

Sediment cores (up to 1.5 m) have been collected for analysis and are providing a time series for about the last 100 years. The set of parameters measured along the core length (every 1-2 cm) include:

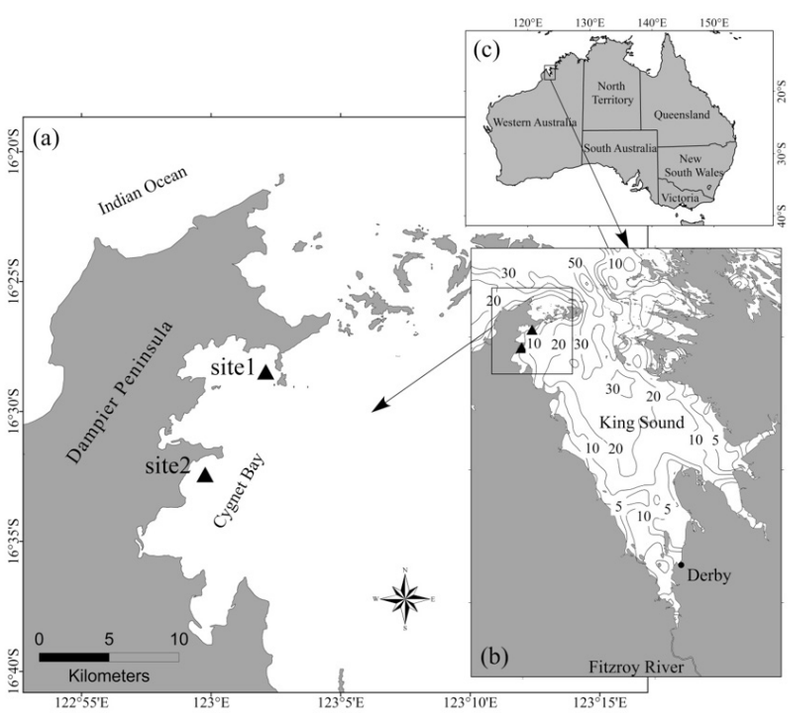
- ^{210}Pb – age of core, integrity of age structure in sediment;
- ^{15}N – proxy for nitrogen source – anthropogenic or natural;
- ^{13}C – proxy for carbon source – land or marine derived carbon;
- C/N –Carbon/Nitrogen ratio – can also be used to infer whether primary carbon source is marine or terrestrial;
- Sedimentation rate and grain size shows the variation of sedimentary environment (e.g. river input, sediment texture, other factors governing deposition and preservation);
- Total Organic Carbon (TOC) and Total Nitrogen (TN) indicate levels of productivity and deposition of organic matter;
- Biosilicate indicates siliceous phytoplankton deposits (e.g. diatoms, silicoflagellates), enhanced productivity; and
- Biomarkers – sterols can be used as proxies for dinoflagellates (dinosterol), diatoms (brassicasterol).

By obtaining an age profile in the sediment along with the time course of any change in sediment biogeochemical conditions, phytoplankton biomass and type, it possible to evaluate changes in water quality and local biological oceanographic features which can be matched to changes in climate and human use, including impacts such as pollution.

Case Study: Cygnet Bay – Oyster Farm vs Off Oyster Farm

Pearl oyster aquaculture, with a 50-year history in Australia, has been regarded as an anthropogenic activity with low environmental risk. The research team chose to investigate with cores taken from Cygnet Bay, which reflected an 80-year record of environmental processes.

With knowledge of the changes in farm practices over 50 years we were able to reconstruct a time series of change in biogeochemical parameters, which was then related to changes in water quality.



Location of Cygnet Bay core sampling

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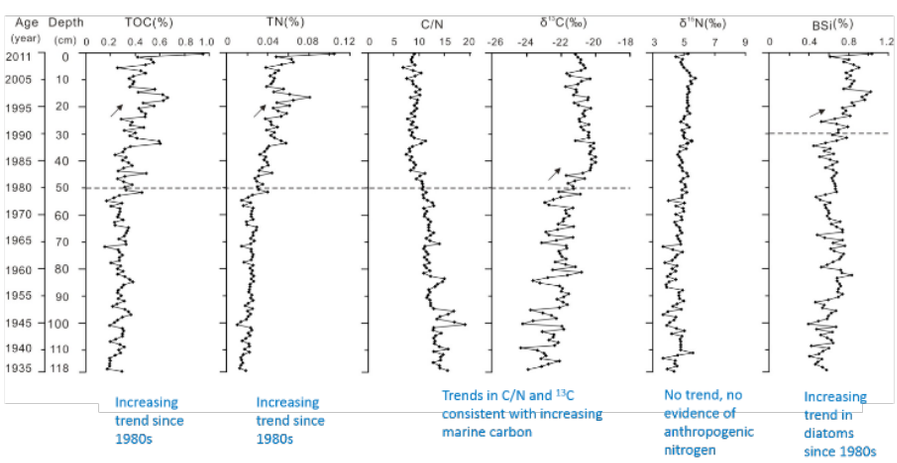


Figure 1. Core analyses from Cygnet Bay Pearl Farm showing trends in biogeochemical parameters in particular increases in organic content of sediment and diatom abundance in recent decades

Sediment cores taken inside and outside a pearl farm displayed contrasting characteristics after the start of farming in the 1960s. Total organic carbon, total nitrogen, biogenic silica, and fine-grained sediment inside the farm increased significantly over time.

The value ranges of C/N, $\delta^{13}C$ and $\delta^{15}N$ discriminated that the origin of increased organic matter were locally marine derived or transported from the land via run off or other modes of deposition. Our analysis detected significant changes responding to the development of pearl farming rather than variations in rainfall and temperature.

Modern long line pearl culture since the late 1980s was presumed to be a dominant driver of the changes observed, accelerating the increase of organic matter in the sediments by reducing water flow, altering sediment grain size and increasing nutrient flux. In contrast, only small variations in response to increased rainfall over time occurred outside the farm.

Geochemical ratios between the two sites showed pearl farming on decadal time scales, even at low density, can cause environmental change with a two to four-fold increase in organic matter, although consistent with environmental studies on surface sediments at the same sites, there is no suggestion that any environmental damage or ecological changes have occurred.

Who will use this information?

On completion of the project in late 2017, it's expected that the project will:

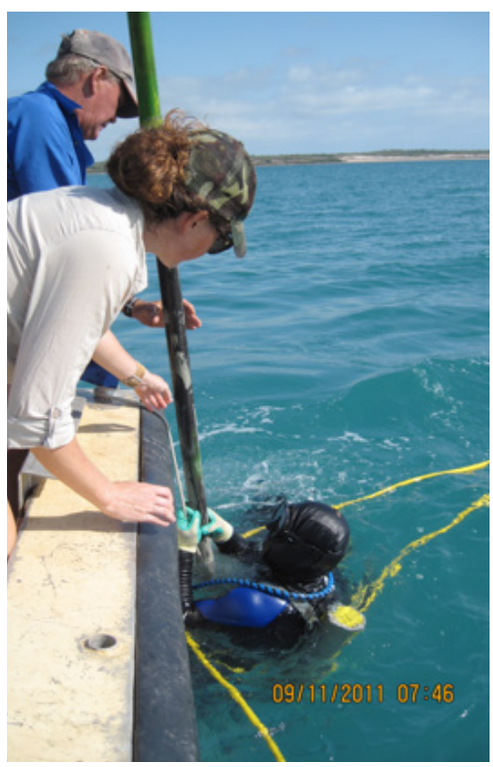
- improve capacity to identify and manage current human impacts and predict risks in the coastal waters of the Kimberley; and
- improve capacity to understand, adapt and mitigate climate change impacts in the coastal waters of the Kimberley.

The results of the project may also be extended by applying the technique to identify historical patterns of bush fires in the Kimberley, as black carbon or char from fires on land can be deposited in marine sediments via run off from river catchments.

Information collected as part of this research will be of particular relevance to the Kimberley Science and Conservation Strategy, the proposed Great Kimberley Marine Park network and Healthy Country Plans of Indigenous partners.

Type of data collected

A range of biogeochemical data has been collected on the sediments (e.g. grain size; TN, TOC; Biosilicate, various biomarkers; and isotopes, ^{210}Pb, ^{15}N, ^{15}C).



Cygnet Bay core sampling

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Cygnet Bay core sampling

Data available in:

The metadata associated with this project can be viewed via the AODN metadata catalogue. Data will be available via the CSIRO Data Access Portal and Pawsey after the embargo period for the project.

Project Team

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