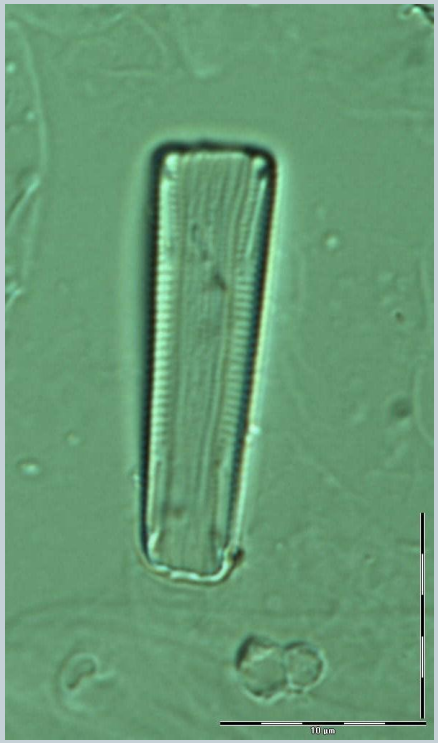
Diatoms: ecological proxies of the past & present - North Stradbroke Island case study



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Premise

Wetlands are biodiversity 'hotspots' that posses a great deal of natural capital and provide many services that are today under threat.

As such it is essential to gain an insight into the current ecology of wetland ecosystems, particularly in the context of natural variability.

Biological indicators

- Birds, fish, amphibians, macroinvertabretes, vegetation and algae
- Often more accurate in their inference of ecological condition than simple ‘snapshot measurements’ of water chemistry alone.
- Integrate disturbance over large spatial and temporal scales

Legislation

- EU - Water Framework Directive (WFD)
- USA – National Wetland Condition Assessment (NWCA)
  - Legislate the need to measure and record ecological status of wetland ecosystems using biological monitoring
- Australia – Water Act & Water Resource Plans (2007)
  - Identify environmental 'assets' and water required to sustain them
- Ramsar – monitoring of listed wetlands is an obligation of signatory nations

Diatoms

- Major group of Algae and common type of phytoplankton
- Single celled organisms and an integral component of almost all aquatic ecosystems
- Identification based of variations of the frustule (shell)
- M short
- I

Palaeolimnology

- Examination of sediment cores
- Diatoms just one proxy of past ecological condition
- Transfer function –Chemical specific inference model based on modern assemblages coupled with environmental variables
  - Regression - Weighted averaging (WA)
- Enable the reconstruction of variables that have a *significant* influence upon diatoms and the overall ecology of wetlands
  - i.e. - pH, electrical conductivity, turbidity, temperature
  - Ordination – Canonical Correspondence Analysis (CCA)

pH reconstruction

- One of the first anthropogenic impacts identified by palaeolimnology was the acidification of Round Lock of Glenhead, Scotland (Flower & Batterbee 1983).
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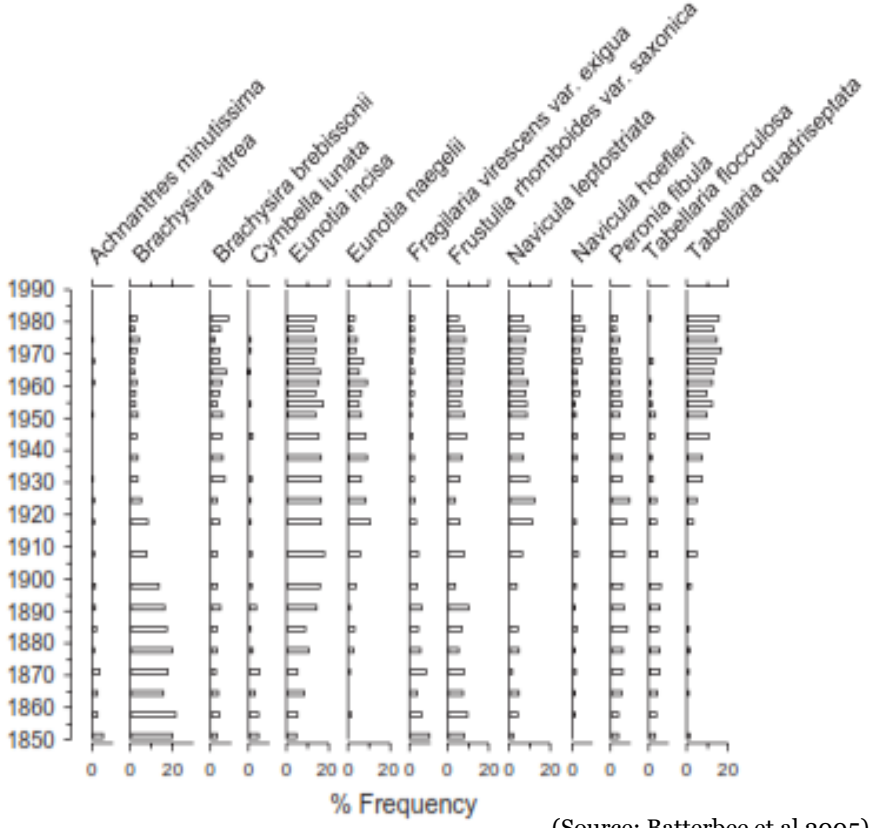


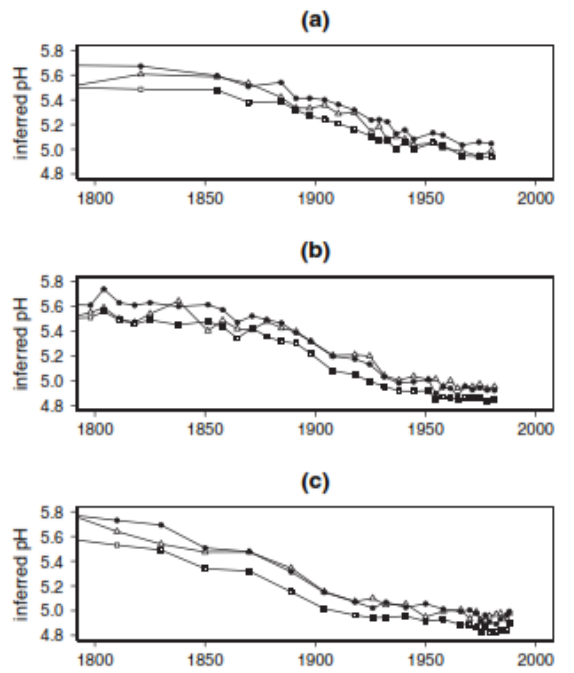


Fig. 6. pH reconstructions according to the three models: SWAP (open squares); EDDI (triangles); UK (filled circles), for the three ^{210}Pb dated sediment cores: (a) RL81; (b) RL3; (c) K05 from the Round Loch of Glenhead. The minimum measured annual mean pH for the site (pH 4.7 for 1979) is indicated by the thickened line in each plot.

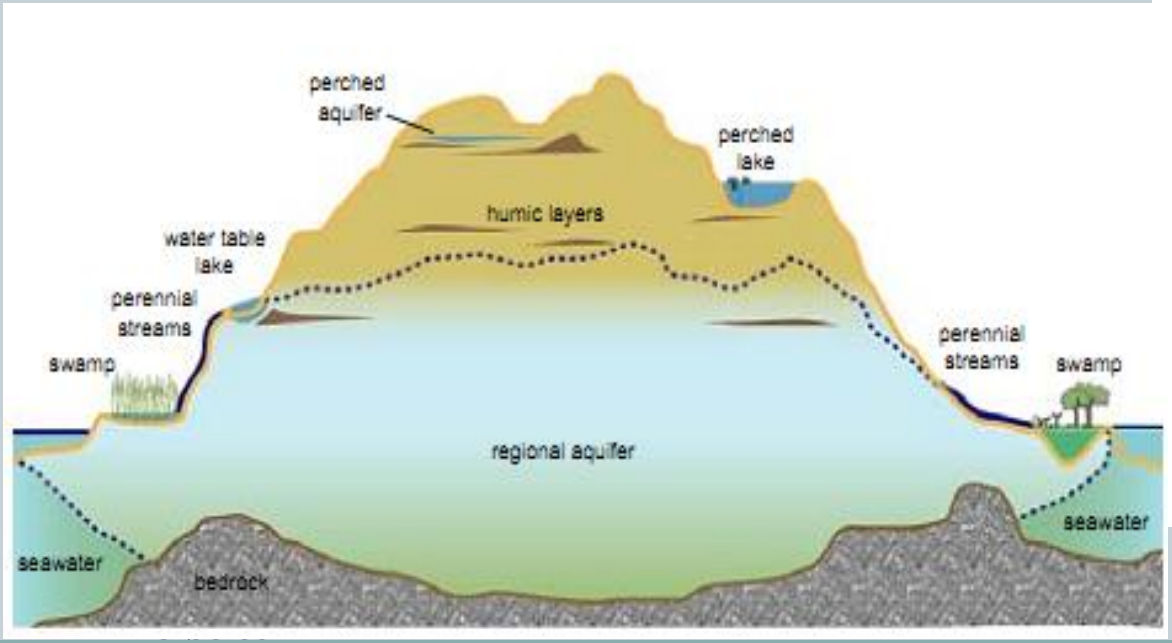
(Source: Batterbee et al 2005)

Summary

- Wetlands are vital component of the Earths biosphere
- Biological monitoring is a key management tool and a requirement under EU & US legislation.
- Diatoms are ideal organisms for biomonitoring.
- Preservation in sedimentary record allows for historic inference of ecological condition
  - Natural variability Vs anthropogenic impacts
  - Reference point for remediation of impacted sites

North Stradbroke Island

- 40 km east of Brisbane
- One of Worlds largest sand Islands
- Predominantly acidic/semi acidic wetlands
  - pH between 4 – 6.5
  - Diverse type and hydrology



Aims and Objectives

- Biologically monitor diatoms of two wetlands over 12 months
- Develop pH transfer function and reconstruct pH of Blue Lake, a “window” aquifer fed wetland
- Integrate these two distinct types of diatom limnology

Methods – Data collection

- Two subsets of samples
  - Monthly samples for Biomonitoring (August 2010 – July 2011)
    - Brown Lake – deep permanent wetland
    - Duck lagoon – shallow fluctuating wetland
  - Quarterly samples for transfer function (Aug. 2010, Nov. 2010, April 2011)
    - 11 wetlands
    - 32 samples
    - Detailed water chemistry (n=52)

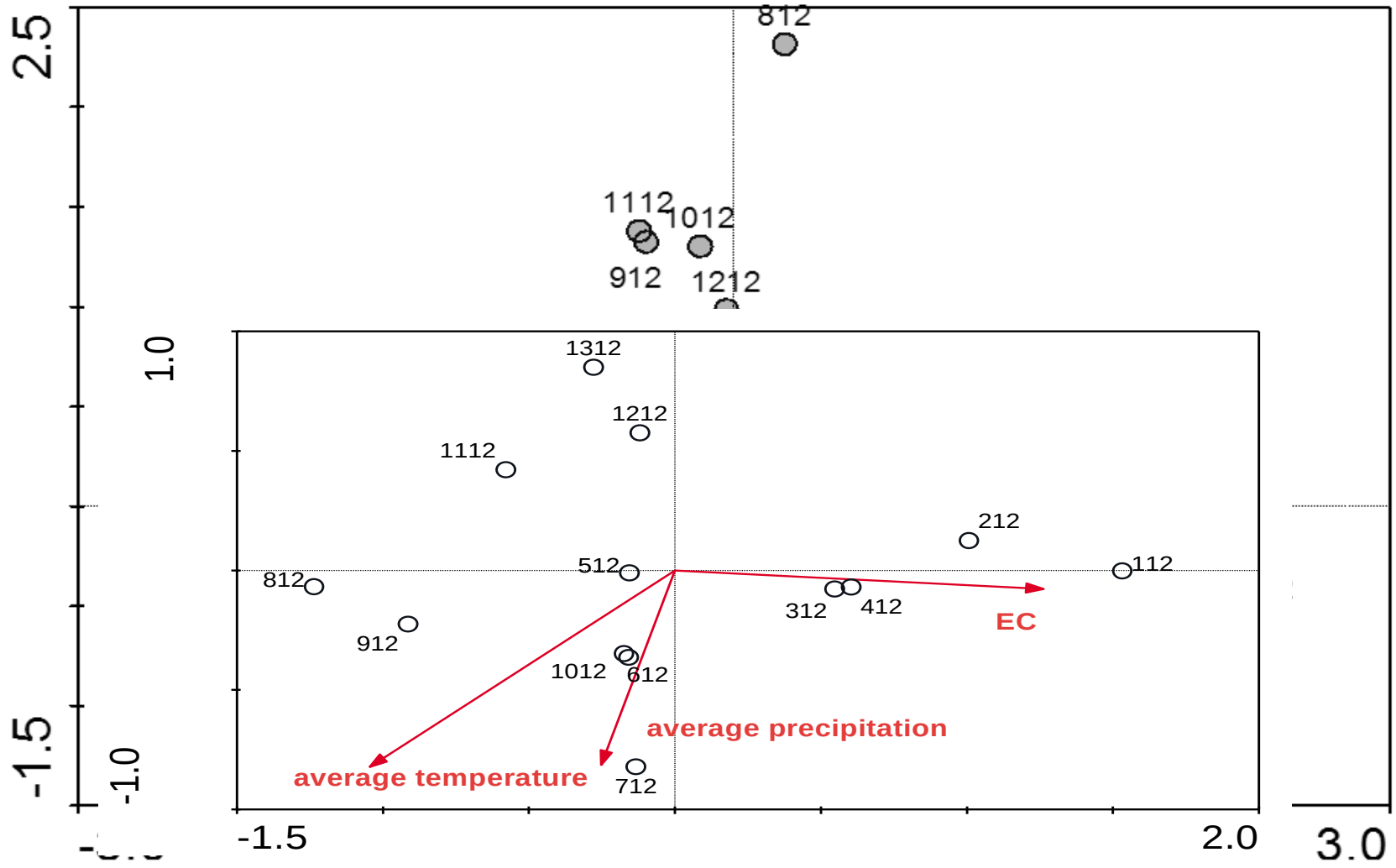
- Diatom collection, preparation and identification
  - Literature search for rare/newly identified species
  - Problem with *Eunotia* in girdle view

Methods - data analysis

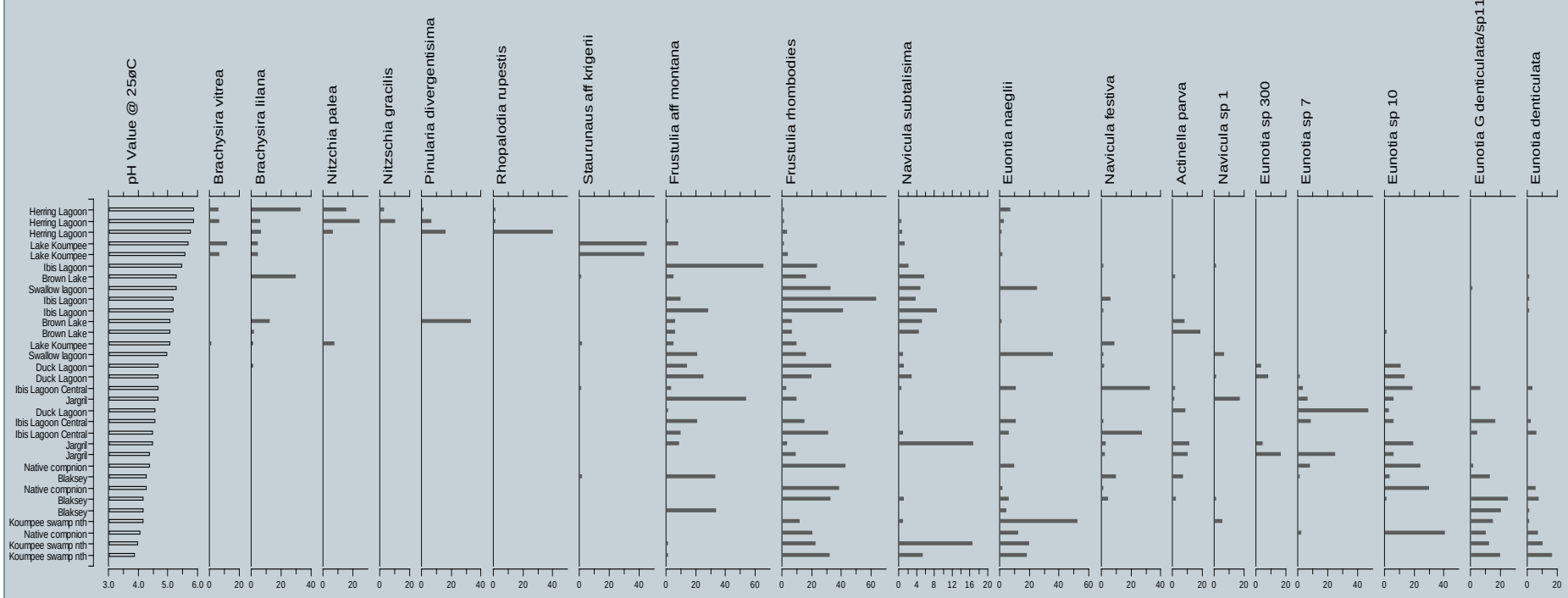
- Ordination Techniques
  - Multivariate techniques that locate samples in two dimensional space based on their species composition
    - CANOCO (ter Braak & Smilauer 2002)
      - Correspondence Analysis (CA)
      - Canonical Correspondent Analysis (CCA)

- Regression
  - Average the relative abundance and identify optima of species to a particular variable along the observed gradient
    - C2 (Juggins 2010)
      - weighted averaging (WA)
      - weighted average partial least squares (WA-PLS)

Results - biomonitoring



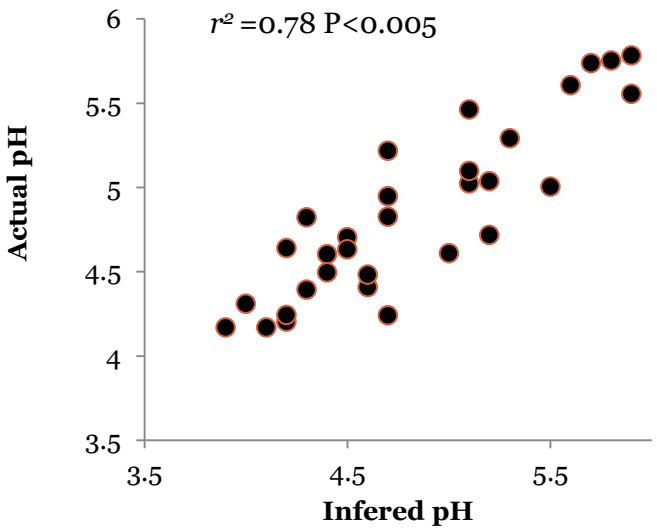
Results – Transfer Function



Results – Transfer Function

Successful development of pH transfer function

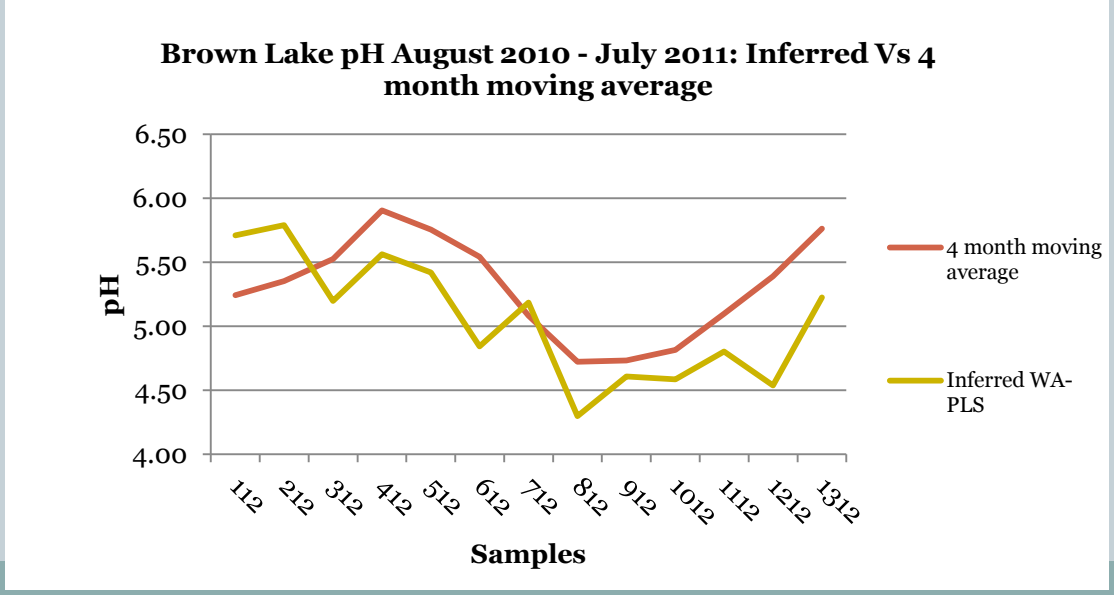
- pH identified as a highly significant variable along with hydroxide alkalinity through CCA ($p<0.005$)
- r^2_{jack} 0.78 ($p<0.005$) WA-PLS
- root mean square error of prediction (RMSEP) 0.27 pH units
- Strongest known training set developed in Australia



Results – Transfer function

Independent validation of training test

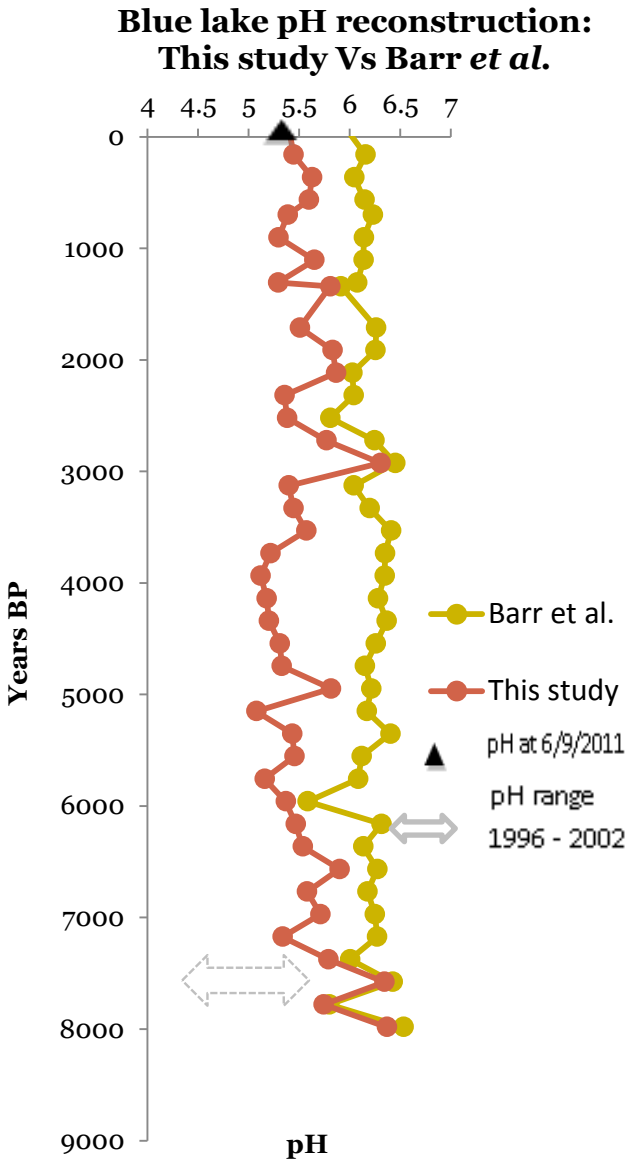
- Rarely undertaken, more precise test of training set than RMSEP (Birks 1998)
- Brown Lake monthly samples/pH 4 month moving average
- Significant relationship (r^2 0.39 $p<0.05$)



Results: Transfer Function

Reconstruction of Blue Lake fossil record

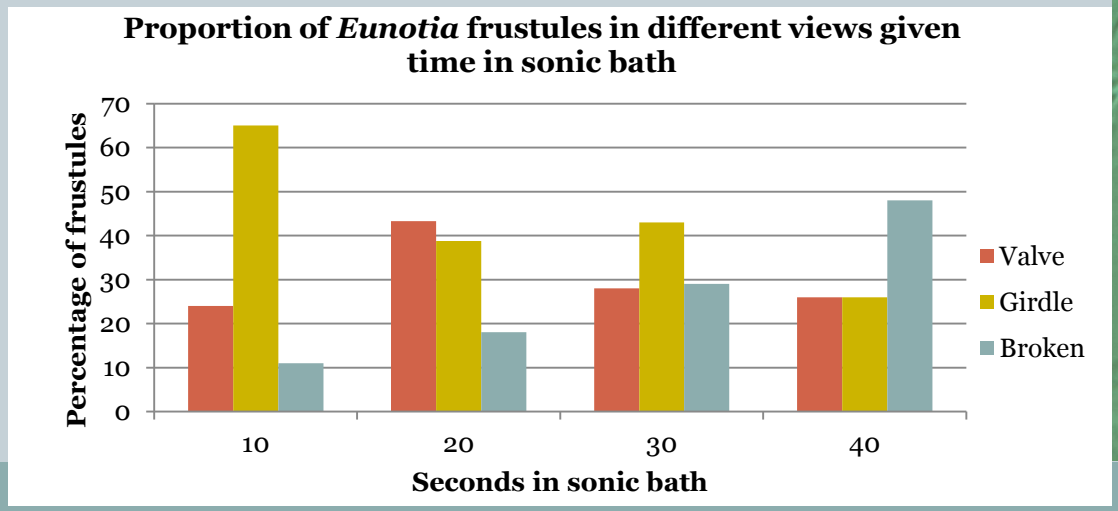
- "Window" lake fed by the aquifer
- Reconstructed pH compares well with recent measurements
- pH range of 5.3 and 6.5 with a mean of 5.78 suggests long term stability
- Small spike approximately 3000 years BP
- Better inference of pH than EDDI training set



Developments

- Identification of *Actinella parva* K. Sabbe & D. Hodgson
  - Confirmed by Professor Koen Sabbe via e-mail correspondence
  - First time outside of Tasmania

- Optimal time of sonication 20 seconds
  - Reduced girdle view from 65% to 39%
  - Increased broken values from 10% to 17%



Key findings & recommendations

- Development of robust pH transfer function most accurate in Australia
  - Use transfer function to reconstruct pH of other wetlands on NSI
  - Recommend expansion of training set to include nearby Fraser Island and Moreton Island
- Seasonal patterning identified in Brown lake but not Duck lagoon
  - Likely bio-geographic influences such as hydrology and wetland type
  - Requires further research to clarify influence and classify wetlands
- Blue lake has remained quite stable over the past 7,000 years
  - Likely a refuge for aquatic biota
  - Small spike approx 3000 Yrs/bp requires further analysis of climate/pH relationship on the Island
- Identification of 20 second optimal sonication
  - Replication of experiment needed to confirm findings

Questions

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