Development of a novel NIRS method for estimating the age of tropical fish from otoliths

Brett Wedding, Carole Wright, Steve Grauf, Paul Exley, Andrew Forrest and Sue Poole
Department of **Employment, Economic Development and Innovation**
Queensland, Australia

Introduction

Reliable fish ageing methods are needed for age-based stock assessment and sustainable fisheries management. Fish ear bones known as otoliths are calcareous structures that have annual growth rings similar to tree-trunks. Otoliths are formed through an accretionary process, which results in alternated translucent fast summer growth and opaque slow winter growth rings. Different fish species have otoliths of different shapes and sizes.

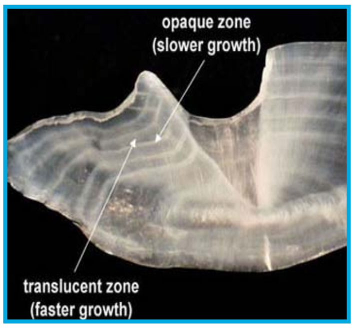

Figure 1. Growth rings of a prepared otolith sample.

Conventional methods of fish age estimation are based on the examination and interpretation of these translucent or opaque growth rings in otoliths. Estimation of fish age by otolith increment analysis can be a time consuming, labour intensive and an expensive process.

The technique is also highly subjective in the visual interpretation of growth rings, particularly for many tropical fish species where banding patterns are highly variable. Process and interpretation error can result in age estimates that differ by as much as a factor of three among investigators.

Figure 2. Whole otolith sample.

Presently, no rapid, objective and widely applicable method exists to determine the age of fish. In this preliminary study the potential of Fourier Transform (FT) - near infrared spectroscopy (NIRS) was investigated as a tool to predict the age of *Lutjanus malabaricus* (Saddletail snapper) from whole otoliths.

Materials and Method

Otoliths from 100 *Lutjanus malabaricus* were obtained in 2009 from the Gulf of Carpentaria, Australia. Diffuse reflectance spectra of individual whole, dry otoliths were collected using the integrating sphere and sample wheel system on a Bruker MPA, FT-NIR spectrophotometer (Bruker Optics, Ettlingen, Germany; operating software: OPUS™ version 6.5) in the 800–2780 nm range.

Otolith samples were placed with no specific orientation in the sample vials in preparation for spectra capture. In obtaining each sample spectrum, 32 scans at a resolution of 8 cm^{-1} were collected and averaged. Otolith age estimation was carried out by conventional sectioning techniques and visual examination of growth bands.

Calibration Techniques

Data analysis was carried out using 'The Unscrambler' Version X.1 (Camo, Oslo, Norway). Partial least square (PLS) regression models were developed between the reference otolith age estimation of growth bands and the FT-NIR spectra. Full cross validation was performed and a number of different pre-treatments were investigated. A mathematical pre-treatment of 25 point Sovitsky-Golay (SG) spectral smoothing, 2nd order polynomial and a first derivative transformation (25 point SG smoothing, 2nd order polynomial) was found to give optimum results and are presented below.

Results

Preliminary calibration statistics are presented in Table 1 and Figure 3. The results were very encouraging considering the preliminary nature of the trials and the error associated with the conventional visual interpretation of the otolith banding patterns for estimating age.

Table 1. Preliminary PLS calibration statistics for whole dry *Lutianus malabaricus* otoliths.

Spectra (n)	Age range (years)	SD	Terms	R^2	RMSECV	Bias	SDR
100	1-21	5.89	3	0.94	1.41	-0.015	4.2

Note: SD = standard deviation; SDR = standard deviation ratio.

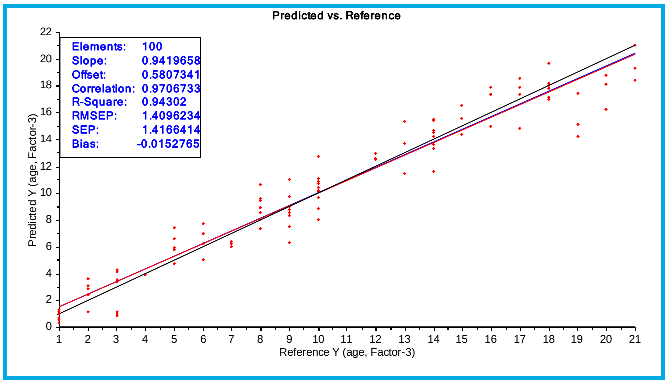

Figure 3. Preliminary PLS calibration statistics for whole dry *Lutianus malabaricus* otoliths.

Conclusion

The preliminary study demonstrated the potential of FT-NIRS to rapidly and non-invasively predict the age of whole *Lutjanus malabaricus* otoliths indicating further work in this area is warranted. Further work is required to optimise this technology in relation to sample presentation, calibration model development, and speed of throughput for industry adoption. The development of robust calibration models will require training sets that cover variables such as summer and winter otolith growth, yearly differences, fish size, diversified age structure and location variables, and measurement conditions (sample handling and presentation).

More information

Department of **Employment, Economic Development and Innovation**

Name: Brett Wedding
Email: brett.wedding@deedi.qld.gov.au

www.dpi.qld.gov.au

Queensland Government