What has computer imaging ever done for otolith science? The need for a digital otolith data format

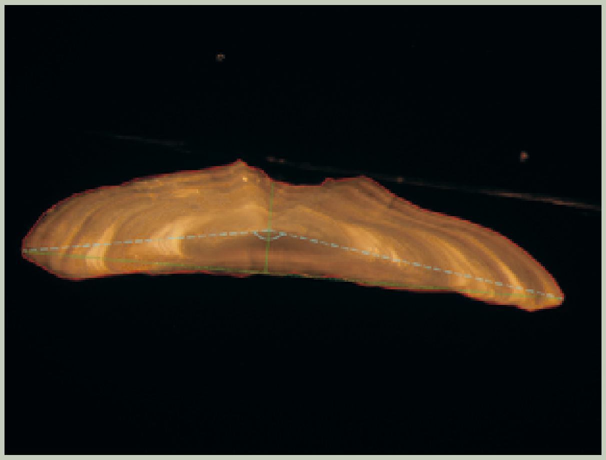
J. Scutt Phillips, J. Walton, G. Pilling, S. Songer, and W. Dawson
Centre for Environment, Fisheries & Food, Lowestoft UK
www.cefas.co.uk

Introduction

Storing otolith images presents a non-trivial problem. Varying image quality, file formats and the system used to arrange collections with associated and meta-data is of major importance. Whilst high quality and comprehensive imaging solutions are currently available, any new methods should be neat, polymorphic and, above all, accessible across institutions. As shown here, many areas of otolith science could benefit greatly from a standard otolith data format, including computer assisted ageing and classification, morphological analysis, ageing and inter-calibration, and microchemistry. Following a broad literature review and a survey of otolith scientists, and with an emphasis on storage and viewing otoliths, this poster examines some of the specifications currently required of images across study areas and considers how these might be combined to provide an all-purpose, accessible digital otolith data format.

Morphological analysis

Morphological analysis is increasingly employed in the capture of life history and other information from otolith images. In developing a standard data format, a broad specification should be considered for the requirements of morphological study. The most important aspect of analysing morphometrics effectively is to ensure that the entire otolith has been imaged, enabling the capture of shape descriptors, multiple axes and features from across the whole surface or section. Where anthropogenic-marked features such as the nucleus or growth axes have been identified, it is essential to retain this vector and coordinate information. Morphometric data capture requires specialised software, such as Visilog/TNPC, ImagePro Plus or MatLab scripts, and so data formats should be compatible with these and emerging applications.

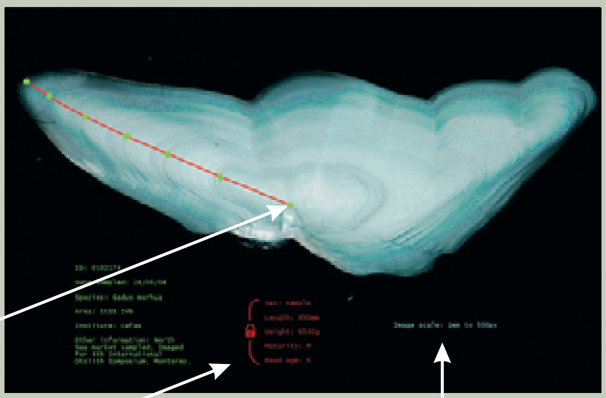


Growth and increment study

For growth analysis, images may be a high resolution area of an incomplete otolith image, with increments and growth axes marked for measurement. This is contrary to the requirements of many other otolith imaging uses. Some imaging software allows a composite of an entire otolith surface to be produced from a mosaic of high magnification images. Whilst the resulting files may be very large, a theoretical digital otolith format should still allow such images to be stored complete with marked rings and axes stored as vector coordinates within the file.

A theoretical digital otolith

Quality and Resolution
The otolith should be imaged at the maximum size possible within a frame of suitable resolution to provide a strong contrast and intensity histogram. If the otolith image is captured in this way, a resolution of around 2 MegaPixels is sufficient for most macrostructure studies, but a variety of resolutions are supported including images taken in mosaic fashion (see above). Compression is important in reducing file size, but with advances in hardware and communication speed, it is anticipated that preserving quality in larger files using lossless (no loss of detail) compression is more important for a digital otolith solution, future-proofing its use with human and computer assisted analysis.



Layered Information
The coordinates of vector information are stored within the otolith file and, depending on software implementation, may be viewed on the image visually or exported for other uses. This can include growth axes, nuclei, increments and sampling tracks for microchemistry.

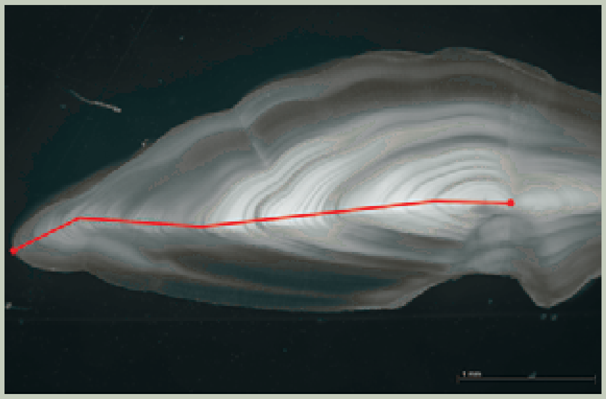
Associated Data
These data are stored within the image file, with anticipated fields indicated here. Fields can also be password protected or easily removed, e.g. for reducing bias during inter-calibration exercises.

Scale Information
Image scale is stored within the file header and so there is no need for a calibration bar to be 'burned' into the image. With correct software implementation, images can automatically be adjusted in size when side-by-side comparison is required.

Age determination and inter-calibration

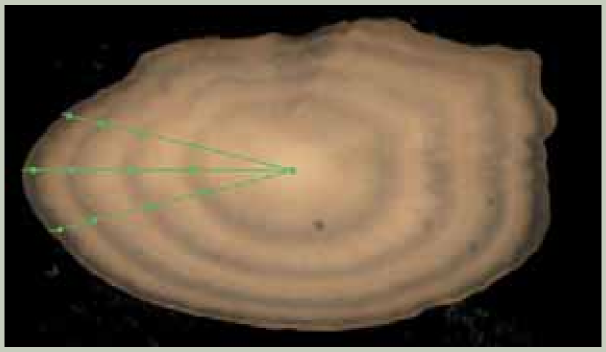
Traditionally, otoliths have been read from the original sample using microscopy. However, images are increasingly being used due to their ease of transfer and review. Efficient inter-calibration is possible through emailed digital images, but returning to the original sample may often provide the highest precision due to the increased definition that focal planes and stereoscopic viewing allow. Some of these issues could be resolved by imaging several focal planes and storing each as a separate layer within an image file. This provides access to a 'virtual' focus, but results in large file sizes that are, at present, not practical. Imaging across several focal depths and merging these images to create a single image that is in focus at all depth planes is possible with some imaging software, and offers a functional solution to improving clarity compared to storing individual image layers.

Fisheries and other data are stored in association with digital otoliths for age readers, as this information can be used to enable improved accuracy in ageing. Data may include sex, date sampled, area or stock and fish length or maturity. Associated databases of this information are not currently standardised and may not easily be exchanged with other parties, whilst data stored in a file name is limited and easily lost or changed. Moreover, it is sometimes important to withhold certain information during inter-calibration to reduce bias, which results in yet further editing or sub-setting of data. Information can be 'burned' into the image itself, which is commonly done in the case of a calibration scale, but can be time consuming and introduces new artefacts to the image, potentially affecting automatic systems (see below). Another approach is to store data within the image header file, presenting a neat solution while these data are accessible with inexpensive software.



Automated systems

The development of a variety of automatic systems, including age determination and species identification, clearly demonstrates the need for the standardisation of otolith imaging and digital storage. Clarity and orientation are typical prerequisites of automated systems, and access to various associated data such as fish length or weight may also be required. Where pre-marked features or axes are used in calculations, this vector information overlaying the image needs to be marked and stored.



Microchemistry

When identifying the track for microchemical sampling with micromills or lasers, otolith images are often used to mark growth axes or paths. The position of annuli on this track are used to establish when, in the lifetime of the fish, measured trace chemicals were deposited. These vectors and annuli are usually permanently marked on a copy of the image, considerably increasing data storage requirements.

Implementation

The proliferation of a digital otolith file format will depend on its suitability, ease of use and accessibility. From a survey of otolith scientists, the three most sought after characteristics of a digital otolith format were high and improved quality, the storage of other data, and small file sizes.

The issue of quality is, in most respects, dependant on the procedure observed at image capture. However, present open-source solutions such as the TIFF file format provide both high quality and lossless file compression, as well as the ability to develop custom file header information to store associated data. Using this format also allows accessibility of the image data, and possibly some associated data, with non-specific image software. Creating a custom file format would provide greater control over a specific, otolith-orientated, specification, but would also require more complex software applications to be written to visualise and make the information stored within the file fully accessible. This software could be a stand-alone application or plug-in, but should be open-source or inexpensive to facilitate ease of use and availability amongst fisheries and otolith scientists. With rapidly improving hardware and communications it is anticipated that file size will play a decreasingly important role in determining the usability of particular formats and compression, and storing high resolution images should be not be compromised.

Conclusion

There exist already, digital solutions for storing otolith images, but here we consider a simple, comprehensive format for use across all areas of otolith study. As more advanced software packages are developed to improve complex image analysis, the standard digital otolith outlined here should

- Have a standard imaging procedure developed and observed to provide maximum image quality
- Include associated information and vector data within the file
- Be open-source to facilitate the exchange, inter-calibration, and storage of otoliths digitally by institutions worldwide, such as in a centralised global archive.