Proposal for a Methodology Review of the Determination of Fish Ages Using Fourier-transform Near-infrared Spectroscopy (FT-NIRS) Analysis of Otoliths and Vertebrae

Proposal Title:
Review of the determination of fish ages using Fourier-transform Near-infrared Spectroscopy (FT-NIRS) analysis of otoliths and vertebrae, and methods for incorporating age data developed using this approach in groundfish stock assessments.

Proposers:
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Background:
The development of representative age data from fisheries and surveys is a vital component of most benchmark/update assessments conducted for West Coast groundfish species. These data inform estimates of catch composition, species longevity, growth, and maturity at age. Most ages are determined through microscopic counting of rings/layers visible on otoliths that have been broken-and-burned or thin-sectioned. The process of age-reading is time-consuming, especially for samples from long-lived species. Even experienced age readers can produce an average of no more than 40-60 age reads a day, for many of our species. Additionally, experienced agers often produce differing age reads for the same sample, particularly for fish over 30 years of age, as considerable judgment is required to differentiate true annuli from other marks within the otolith. Age-reading of other structures, such as vertebrae, is standard practice for some species, and these require even more preparation time before microscopic evaluation can begin.

The NWFSC funds the Cooperative Ageing Project in Newport, through a grant with Pacific States Marine Fish Commission. The funding the NWFSC has received from NMFS Headquarters that has supported the ageing lab for more than a decade has been reduced by about 18% over the past 4 years. Meanwhile, the costs for ager salaries and supplies continue to increase at a modest rate. From a high of 7 staff from 2012 to 2014 (with 50% of one's time devoted to supervision), CAP is expected to be down to 5 staff by October. Even that number will become unsustainable before 2024, without increased funding. With more than 30 species having had benchmark assessments, the demand for groundfish age data is now greater than ever. Every assessment cycle presents hard choices of how many samples from each source to age for each selected species. As of last winter, the NWFSC's bottom trawl survey, through 2016, had collected 160,000 age structures more than we have been able to age. Oregon has commonly relied on CAP to age most of the structures collected from its fisheries. As of last winter, their backlog adds another 70,000 structures to the unaged inventory for 2007-16.

Proposal:
The technical and financial realities of traditional age reading imply that recent levels of age reading cannot be sustained without either ongoing additional funding or a technological breakthrough that allows ages to be determined more rapidly. Recently, new applications of the

established FT-NIRS technology have focused on ageing fish otoliths (Wedding et al. 2014; Robins et al., 2015) and shark vertebra (Rigby et al. 2016). Over the past year and a half, the ageing program at the AFSC has tested the feasibility of using FT-NIRS, along with calibration from traditional age reading, to age walleye Pollock from the North Pacific. The successful results of that exploration, in which calibrated machine ages were obtained in less than 1 minute per otolith, will be reported in an upcoming edition of the Canadian Journal of Fisheries and Aquatic Sciences (Helser, et al. In Press). Testing earlier this year on red snapper from the Gulf of Mexico also found good correspondence between traditional and machine-derived ages for a longer-lived species (Helser, Pers. Comm.).

As a follow-up to these successes, the NWFSC will be collaborating with staff from AFSC to evaluate FT-NIRS performance with a range of west coast groundfish species. These will include longnose skate and Pacific hake. AFSC agers are experienced in reading longnose vertebrae, and will age the samples needed to calibrate the machine readings and to test the machine's performance on an independent set of structures. This testing and evaluation phase will be completed between October and December 2018, and the results ready for review by January. Results from new testing with other species (in addition to pollock) may also be available in this timeframe. Due to CAP capacity, machine-determined ages represent the only opportunity to incorporate any ages in the longnose assessment, beyond an amount needed for growth estimation. If these evaluation results are acceptable and use is supported by the SSC, remaining longnose vertebrae would be aged solely using the machine and calibration function. In addition to species-specific testing, the AFSC is supporting a student who is also expected to develop a simulation evaluation of sample sizes for calibrating and testing machine results.

In addition to having the SSC review the appropriateness of this method for determining fish ages, we also anticipate a discussion focused on best practices for including these ages in assessments, particularly with regard to the treatment of ageing error.

Literature Cited:

Helser, Thomas E., Benson, I., Erickson, J., Healy, J., Kastelle, C., Short, J. In Press. A transformative approach to ageing fish otoliths using Fourier transform-near infrared spectroscopy (NIRS): a case study of eastern Bering Sea walleye pollock (*Gadus chalcogrammus*). Canadian Journal of Fisheries and Aquatic Sciences, forthcoming.

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Robins J.B., Wedding, B.B., Wright C., Grauf S., Sellin M., Fowler A., Saunders T. and Newman S. (2015). Department of Agriculture, Fisheries and Forestry, Revolutionising Fish Ageing: Using Near Infrared Spectroscopy to Age Fish. Brisbane, April, 2015. CC BY 3.0. http://frdc.com.au/research/Final_reports/2012-011-DLD.pdf

Wedding BB, Forrest, A.J., Wright, C., Grauf, S., Exley P. 2014. A novel method for the age estimation of Saddletail snapper (*Lutjanus malabaricus*) using Fourier Transform-near infrared (FT-NIR) spectroscopy. Marine and Freshwater Research 65, 894-900.