Detecting, interpreting, and measuring both true and false annuli in Pacific halibut ages one to four: Project Update

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Abstract

Since otoliths do not regenerate or become resorbed, they act as excellent long term recorders of physical events experienced by a fish throughout time. Once deposited, annuli and checks will forever hold both their position and chemical signature within the otolith matrix. It is this characteristic that we wish to exploit in an attempt to determine if certain depositional events in the otolith can be used to determine the general geographic nursery origins in otoliths of adult halibut. A microstructural measuring program has been initiated to illustrate and quantify the occurrence of both the annual winter hyaline zone (true annulus) and of non-annual hyalinization ('checks' or false annuli) in otoliths of young Pacific halibut (*Hippoglossus stenolepis*) from the Bering Sea, central Gulf of Alaska, southeast Alaska, and the waters of northern British Columbia. Of 1,907 samples collected to date during the summers of 2002-2005, 2007, and 2008, 735 otoliths have undergone microstructural measurement along both the antero-posterior axis (primordium to rostrum) and dorso-ventral axis (primordium to ventral edge).

Project description

The study of fish otolith structure is a rapidly expanding field showing considerable promise for examining a variety of questions facing fisheries biologists and ecologists. Throughout the life of the fish, otoliths accrete calcium carbonate in layers in much the same way rings are formed during the growth of trees. The accretion or deposition rate of material on the otolith changes according to seasonal or metabolic factors, producing growth zone patterns on the otolith. Since otoliths do not regenerate or become resorbed by the fish's body, their layers act as excellent long term recorders of oceanographic and metabolic events experienced by a fish throughout time. Once deposited, growth zones will forever hold both their position and chemical signature within the otolith matrix. It is this characteristic that we wish to exploit in the present study, in an attempt to determine if certain depositional events in the otolith can be used to determine the general geographic nursery origins of adult halibut. A microstructural measuring program has been initiated to illustrate and quantify the occurrence of both the annual winter hyaline zone (true annulus) and of non-annual hyalinization ('checks' or false annuli) in otoliths of young Pacific halibut (*Hippoglossus stenolepis*) from the Bering Sea, central Gulf of Alaska, southeast Alaska, and the waters of northern British Columbia.

Comparison of first-year growth increment in otoliths from juvenile halibut among geographic areas

In the first phase of this study, we will specifically focus on the measurement of the first true annulus (winter zone) in relation to the distance from its outer margin to the otolith's primordium (core). It has been observed that the amount of otolith growth within the first year varies in increment width as a function of latitude. Qualitative evidence suggests that the measure of first year growth decreases as a function of increasing latitude. For example, one-year-old halibut caught on the nursery grounds of northern British Columbia have a distinctly larger first-year increment then those halibut caught within the same year from nursery grounds in the Bering Sea. The influence of varying ocean temperatures (OT), as conveyed along the Alaskan Coastal Current and the Alaskan Stream, is an obvious candidate for this variation in otolith growth. Best (1968) and Skud (1977) presented evidence that the countercurrent migration of juvenile halibut begins approximately when the fish are between the ages of two to six years. Because our primary objective is to examine annulus formation in halibut prior to their departure from their natal grounds, two-year-old halibut collected from nursery grounds in the Bering Sea, central Gulf of Alaska, southeast Alaska, and the northern waters of British Columbia were selected to represent each target study area. Hagen and Quinn (1991) found that inter-annular distance varied as a function of collection year among halibut aged zero to two years, which they attributed to a strong linear correlation between OT and otolith growth. Taken together, these observations suggest that the potential may exist to utilize the magnitude of the first-year increment as a natural marker to identify nursery grounds within year classes from a latitudinal perspective. Quantifying the decreasing gradient of first-year increment widths from British Columbia to the Bering Sea could potentially allow researchers to determine the general latitude of nursery origin for adult halibut, based on relative width of otolith first-year increments.

False annulus as a potential natural marker in otoliths from Bering Sea halibut

The project's second objective stems from observations made when examining juvenile halibut under high magnification using the surface ageing technique. During ageing, it was noted that some Bering Sea halibut otoltiths demonstrate a repetitive growth pattern that is not consistent with what is considered typical winter deposition for the geographic region (S. Wischniowski, 2320 West Commodore Way Suite 300, Seattle, WA 98199, unpublished data). Almost exclusively, this pattern manifests as a false annulus or check between the first and second true annuli (winter zones). The relative proximity of the check to the assigned first annulus results in a degree of uncertainty regarding the fish's true age, depending upon how these hyaline depositions are interpreted. The positioning suggests that the hyaline zone close to the first annulus should be classified as a check (Fig. 1); however, the strength and completeness of the deposition is consistent with the definition of a true seasonal annulus by the International Pacific Halibut Commission's (IPHC) ageing convention (Forsberg 2001). Qualitative evidence by way of visual inspection suggests that these false annuli are not random in position, but occur in a consistent pattern with respect to distance from the primordium. Furthermore, otoliths from halibut collected from the same trawl tow reveal hyaline zone patterns of similar distance from the primordium which differ from the patterns observed in halibut collected from trawl tows in different geographic locations. That is, the hyaline zone patterns appear to be more similar within tows than between tows from different geographic areas.

With respect to quantifying annular structure, we wish to first characterize the position of suspected false annuli, as well as the true first annulus, to determine if they consistently occur at the same location within the otolith. These measurement data will be referenced to the location of capture, allowing us to statistically test whether any relationships may occur between false annulus patterns and geography, using pattern analysis techniques similar to those used to compare banding patterns in electrophoretic gels (Ridder et al. 1984). These specific patterns of false annulus formation have not, as yet, been identified outside of the Bering Sea, and not all Bering

Sea halibut demonstrate these microstructural events. It is possible that the occurrence of these suspected false annuli may be environmentally influenced at relatively small spatial scales. If so, the identification of these false annuli in adult otoliths may be exploited as a natural marker not only to identify halibut born in the Bering Sea, but potentially also to trace the origin of individuals back to specific nursery ground(s) within the Bering Sea.

Future work

Of the 1,907 otoliths that have thus far been collected, 735 have undergone microstructural measurement. In 2011 we will begin quantitative analysis of these measurement data before continuing on with measuring the remaining structures.

References

Best, E.A. 1968. Studies of young halibut: census of juveniles. West. Fish. 75(5): 38-41, 59-60.

Forsberg, J. 2001. Aging manual for Pacific halibut: procedures and methods used at the International Pacific Halibut Commission (IPHC). Int. Pac. Halibut Comm. Tech. Rep. 46.

Hagen, P.T. and Quinn, T.J.,II, 1991. Long-term growth dynamics of young Pacific halibut: evidence of temperature-induced variation. Fish. Res. 11:283-306.

Ridder, G., VonBargen, E., Burgard, D., Pickrum, H., and Williams, E. 1984. Quantitative analysis and pattern recognition of two-dimensional electrophoresis gels. Clin. Chem. 30: 1919-1924.

Skud, B.E.1977. Drift, migration and intermingling of Pacific halibut stocks. Int. Pac. Halibut Comm. Sci. Rep. No.63.

Wischniowski, S. and Loher, T. 2009. Detecting, interpreting, and measuring false annuli in Pacific halibut ages one to four: Project Update. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2008: 383-385.

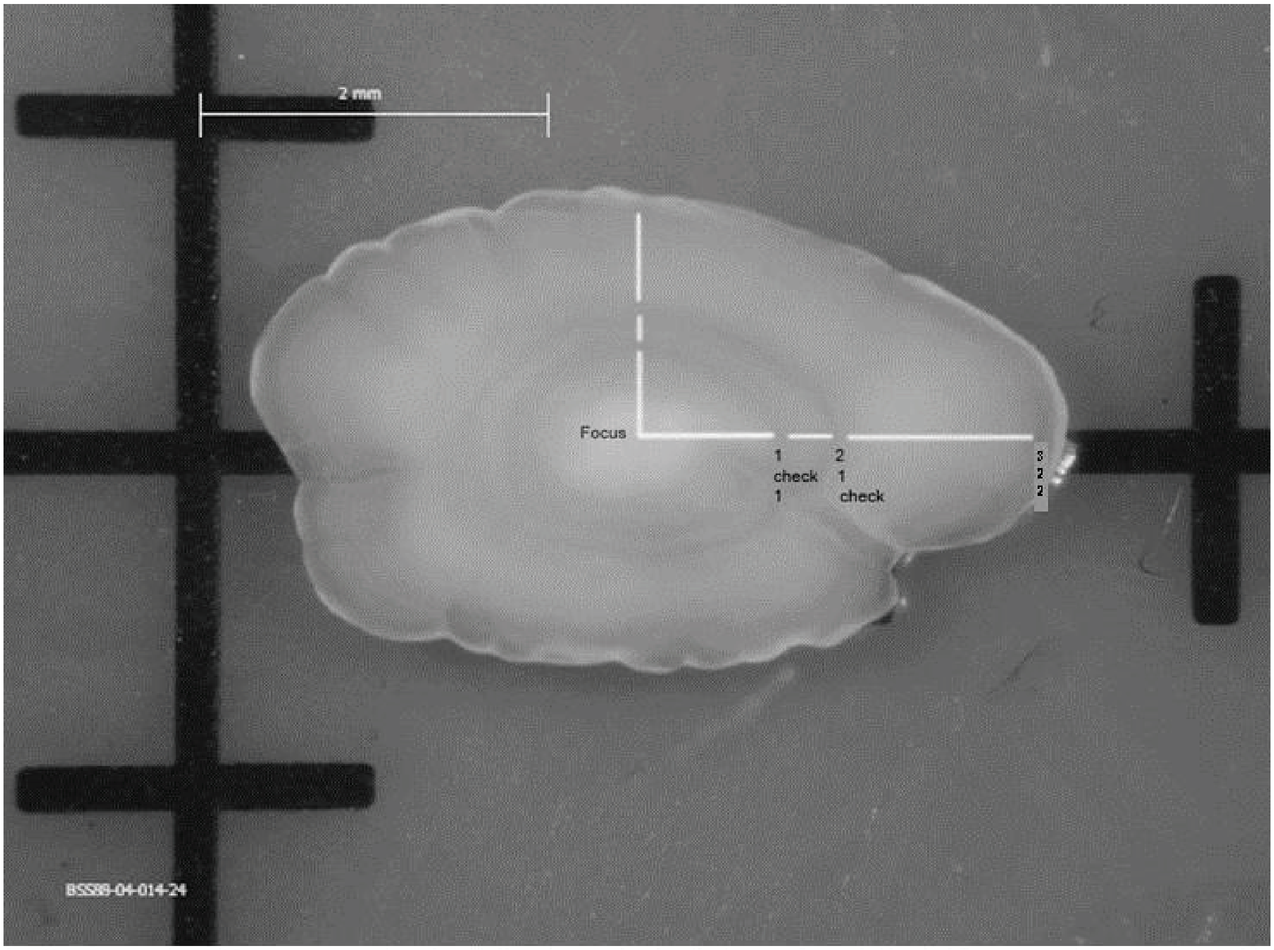

Figure 1. This image illustrates both the antero-posterior axis (primordium to rostrum) and the dorso-ventral axis (primordium to ventral edge) of a juvenile halibut otolith, along which annulus width measurements may be taken. Three possible ageing scenarios are presented.