Scales as growth history records for Pacific herring

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INTRODUCTION

Fish grow in response to the extrinsic influences of their environment constrained by the intrinsic influences of genetic predisposition for growth and of size already attained (Weathedey and Gill 1987, Weisberg 1993). Understanding how these intrinsic and extrinsic sources of variability influence growth is important for several reasons. The effects of stock size and environmental conditions on growth have been studied by a number of investigators (Anthony and Fogarty 1985, Hagen and Quinn 1991, Kreuz et al. 1982, Martinson et al. 2009, Peterman and Bradford 1987, Rijnsdorp and van Leeuwen. 1992, Stocker et al. 1985), primarily because of the consequences that growth variation can have on reproductive potential through its influences on fecundity and spawn timing (Ware and Tanasichuk 1989), natural mortality, recruitment, and age at maturity (Haist and Stocker 1985, Schmitt and Skud 1978). Haist and Stocker 1985 stated that factors affecting growth rates can be of fundamental importance to the understanding of the dynamics of exploited populations and the responses of natural populations to abundance and environmental influences have remained a central issue in population biology (Tanasichuk 1997). Variation in growth has a strong affect on the selection of appropriate harvest policies that are based on demographic models that reflect the natural processes (Methot 1997, Tanasichuk 1997).

The underlying mechanisms for cyclic changes in annular growth for herring in the northern Gulf of Alaska are currently unknown. A period of the lowest observed average body sizes for PWS herring coincided with a period of historic high abundance followed by a catastrophic population decline associated with outbreaks of viral hemorrhagic septicemia virus (VHSV) and *Ichthyophonus hoferi* (Marty et al. 1998). Although the links between herring energetic condition (growth) and disease susceptibility are not yet well understood, it is postulated that the observed population decline was a result of density dependent growth effects leading to decreased body condition and resistance to disease. Analysis of growth increments between annular patterns on scales can provide a means to reconstruct past growth changes that can assist in determining the possible environmental and density-dependent causes of growth variation. The current picture of growth is based on cross sectional size at age data. In contrast, growth increment information incorporates a longitudinal history of growth that increases the effective degrees of freedom and can be used in modeling changes in growth in relationship to environmental and population indices (Chambers and Miller 1995, Kreuz et al. 1982, Tanaischuk 1997, Weisberg 1993). Determining the underlying distribution of individual growth patterns can provide improved inputs into population dynamics models that are used to establish harvest guidelines.

This project will require use of the scales available in the Cordova ADF&G archives, and research in developing the methodology for measuring growth information from herring scales. Technique development will include the use of image processing methods to semi-automate the data collection. During the first year of this project, it will be necessary to examine criteria for assigned ages, natural variability in scale measurements between and within individual fish from a single population. The second year of this project will consist primarily of completing the measurements of scale growth increments of representative samples from the archived collections.

PROJECT DESIGN

A. Objectives

1. FY2012:
   a. Standardize scale interpretive criteria, evaluate alternative measurement techniques, and develop semi-automated procedures for measuring scale increments of PWS herring.
   b. Measure scale growth increments on scales subsampled from archived collections.
2. FY2013:
   a. Finish measurements of scale growth increments on subsampled scales.

Methods

Extensive scale collections are maintained in the Cordova ADF&G office. Many fish have associated records including location, age, size, weight, and maturation state. Some early collections of scales may not have been collected from the preferred area on the body and their condition and usefulness remains unknown. One task will be to identify the number of scales by year and age class available. To age herring scales consistently and accurately requires experience and training. To help develop consistent criteria for identifying and measuring annuli, sample personnel will meet with experienced age readers in the ADF&G Mark-Tag-Age Lab in Juneau. Side by side comparison and discussion of problems in reading scales and potential biases in measurements will be addressed. Image processing techniques will be used to collect the growth information from scales. Off-the-shelf imaging software will be used where possible, but additional customization of routines maybe necessary, particularly to streamline the data acquisition.

Scale collections were standardized in many locations in the mid 1980s by the identification of a preferred area on body of herring. However for earlier samples there is likely to be considerable variation on scale size and shape. Several approaches will be taken to determine methods for adjusting the growth increment data such that it accurate reflects body growth. The biological intercept model used for backcalculation studies represents one possibility (Campana 1990). Other approaches may involve collecting multiple scales from several individuals and determine which transformations based on body size or scale size achieve the greatest reduction of within individual variation of the growth increments using variance component analysis (Sokal and Rohlf 1981). Concurrent studies on herring energetic may also provide samples by which scale growth can be measured in relationship to known somatic growth. If such specimens are available they will be examined. In addition, with the biological intercept approach for back calculation it is necessary to establish the body size at initial scale formation (Campana 1990). Collections of young of the year herring will be examined to determine those values. Once the methodology is established, production measurements will first be collected from the Prince William Sound archive collections.

Sample Collections: The PWS scale collections extend back to 1979, with some older scales from the early 1970's. The archives contain approximately 200,000 scales classified into different groups (harvest or collection types), and the most complete is the commercial harvest collection. The number of scales drawn from these collections will be determined by a power analysis. A preliminary sample size goal is 50 scales from 6 or 7 age classes per year for as many as 35 years (n=10k to 12k). The goal will be to measure a sufficient number of scales such that biologically significant differences in growth increments between cohorts can be detected. Since the scales themselves may not have examined since they were originally stored considerable effort may have to be expended in pulling out the selected scales to see if they are suitable for digitizing.

Scale Measurements:

Each scale selected for the study will be examined to confirm the original age estimate. Scales will be examined through a microfiche equipped with a scanner. The scanner feeds the image into a framegrabber board in a computer. Using software calibrated to the magnification of the image, a line or series of lines will be overlaid on the scale image from the focus to the scale edge by the reader and they will mark the annuli on the image. The number of annuli and the spacing between annuli will be collected in a database and collated with the existing information about the herring. The image and the overlaid measurements maybe saved for future reference. It is anticipated that this step can occur relatively quickly during the production phases.