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Workshop on Age Determination Methodology for Fish Stock Assessments held in St. Andrews, New Brunswick

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E.A. Trippel (editor)

Science Branch
Marine Fish Division
Gulf of Maine Section
Department of Fisheries and Oceans
St. Andrews Biological Station
St. Andrews, New Brunswick
E0G 2X0

Table of Contents

Introduction

Age determination is an important component of fish stock assessments conducted by staff of the St. Andrews Biological Station. A substantial amount of time is allotted each year to this aspect of the Gulf of Maine Section's program activities. In order to review current methodology and make recommendations for program activities, a one-day workshop was conducted at the St. Andrews Biological Station on December 7, 1995.

A variety of program components were identified as candidate subject areas several months in advance of the workshop. Selected contributors prepared and made presentations at the workshop and discussion focused, whenever possible, on developing standard protocols. To document these efforts, individuals were asked to submit a brief summary of their findings and recommendations and a working paper of their contribution. The recommendations (which will come under periodic review) are to serve as guidelines in relevant activities at the St. Andrews Biological Station.

Participants:

L. Brown, M.-I. Buzeta, D. Clark, J. Fife, S. Gavaris, J. Hunt, J. Neilson, C. Nelson, P. Perley, M. Power, M. Strong, E. Trippel, and L. Van Eeckhaute.

Contributions:

1. E. Trippel: Frequency of conducting intra and inter-reader tests, time requirements, half-year versus full year exploitation.

2. L. Van Eeckhaute: Utility for selecting material for age comparison tests.

3. M.-I. Buzeta: Bias variability and age determination comparisons for 5Zj,m cod (1991-94). (DFO Res. Doc. 95/117).

4. J. Hunt: An example of the impact of aging error on population estimates.

5. L. Van Eeckhaute and M. Strong: Steps involved to make corrections when a poor age comparison test occurs.

6. L. Brown and D. Clark: Proposed training outline for a new age reader.

7. P. Perley and J. Neilson: Establishment and use of archived age determination material.

Contribution #1 (E. Trippel)
Frequency of conducting intra and inter-reader tests, time requirements, half-year versus full year exploitation.

Two age readers have been assigned to each fish stock at SABS. This reduces the risk of introducing bias into one reader's interpretations over time and reduces the dependency on a single reader in obtaining age data for a stock. The primary reader is responsible for the majority of the necessary aging conducted each year, whereas the secondary age reader should conduct no less than 20% of production aging.

The appropriate types and numbers of tests needed to detect the possible presence of aging discrepancies within and between age readers were discussed. The following three tables outline the minimum amount of testing recommended. Three types of tests were identified: (1) Inter-Reader Agreement using contemporary material, (2) Intra-Reader Agreement using contemporary material, and (3) Intra-Reader Agreement using historical material. A fourth test, Canada-U.S. Agreement is similar to test #1 but is restricted to Georges Bank stocks. Contemporary material is defined as otoliths that have been recently sampled, whereas the historical material refers to otoliths covering a broader period of time spanning several years or more.

Table 1. Number of otoliths used in age comparison tests for each stock. Otoliths for the inter- and intra-reader tests are to be selected from the research survey(s) and the entire commercial fishery. Note: Canada/U.S. exchanges use research survey samples.

Stock	Inter-Reader Agreement (Contemporary)	Intra-Reader Agreement (Contemporary)	Intra-Reader Agreement (Historical)	Can./U.S. Agreement
4X Cod	100	100	100	
5Z Cod	100	100	100	100
5Z Haddock	100	100	100	100
Pollock	200	200	200	
Herring- 4WX	200	100	100	
5Z	200	100	100	

Table 2. Types and numbers of age comparison tests to be conducted for each stock. Note these are the total number of tests for both age readers; e.g., one intra-reader test per age reader. The second inter-reader test may be conducted by having both readers assess the ages of the same 100 archived otoliths from the historical collection.

Stock	Inter-Reader (Contemp.)	Intra-Reader (Contemp.)	Intra-Reader (Historical)	Can./U.S. Agreement	# of Tests
4X Cod	2	2	2		6
5Z Cod	2	2	2	2	8
5Z Haddock	2	2	2	2	8
Pollock	2	2	2		6
Her. - 4WX	2	2	2		6
5Z	2	2	2		6

Table 3. Optional approach to reduce number of otoliths to be read by one age reader from 300 to 250 (e.g., 4X Cod). Fifty of the 100 otoliths used by the Primary Reader in the intra-reader test are passed onto the Secondary Reader for an inter-reader test (and vice versa). Thus, each ager reads 150 otoliths + 100 historical collection otoliths = 250 otoliths.

	Primary Reader	Secondary Reader
Intra-Reader	100	100
Inter-Reader	50 + 50 (aged by Secondary Reader previously)	50 + 50 (aged by Primary Reader previously)

Timing of tests will depend in part on timing of the production aging in relation to requirements for subsequent analytical aspects of the stock assessment. It is recommended that test #3 (Intra-Reader- historical) be conducted just prior to the onset of the main production aging period. Therefore, if a problem is encountered, steps may be taken to resolve the issue before production aging is initiated. It is recommended that all tests be completed before the aging data are used to construct catch at age, sequential population analysis, etc.

Duration of time to conduct these tests was not reviewed by the group, but is expected to be at least 5 days per age reader. This includes time for the selections and tabulation of results, but excludes time required to resolve any potential discrepancies. It does not include the time required to produce annotated images, if desired, for the development of a historical collection.

Contribution #2 (L. Van Eeckhaute)
Utility for selecting material for age comparison tests

SQLPLUS queries and an APL program which select otoliths for age comparison tests were presented. Otoliths can be selected from the surveys and/or commercial samples databases using SQLPLUS queries. A random subsample based on the required number of otoliths per length grouping per quarter is then made on the selected otoliths using the APL workspace. This allows the selection to be made over the whole length range and from all quarters. The workspace also produces an agreement matrix.

It was recommended that an age-based selection with random, unequal sampling for each age be considered (e.g., 7-13 otoliths per age over ten ages equals 100 otoliths). In general, this would increase the number of older fish used in tests. It was agreed that no less than 100 otoliths covering all age groups would be the minimum acceptable number for comparison tests. Data selection for test #3 (Intra-Reader- historical), were considered to be of a different category, and the guidelines for these require further discussion and development.

Contribution #3 (M. Buzeta)
Bias variability and age determination comparisons for 5Zj,m cod (1991-94) (DFO Res. Doc. 95/117).

A summary of this paper opened the discussion of methods of reporting age comparison test results. Comparison matrices, percent agreement, coefficient of variation estimates and bias plots were all discussed. Bias plots were seen to be useful in detecting some trends, but concerns were raised that results would have to be plotted in two directions in order to detect all possible trends. That is, Primary Reader vs. the average of Secondary Reader, and Secondary Reader vs. the average of Primary Reader.

Age comparison matrices and percent agreement scores still appear to be the single best method of presenting the results of comparison tests. Sample size and specific differences at each age are easily detected. These are to be included in the stock status Research Document as appendices.

Contribution #4. (J. Hunt)
An example of the impact of aging error on population estimates

Simulations of the impact of aging bias and variance were presented. Bias was introduced to the last five years in the catch at age as positive and progressive. The "adjusted" catch at age was used in ADAPT and results compared with the original output. Similarly, variance was introduced as the proportion re-assigned to another age (i.e., number of age 3 fish re-aged as age 4) based on intra-reader aging comparisons.

The simulations produced a trend consistent with the expected direction and magnitude. However, diagnostics from ADAPT (residual trend, etc.) did not appear to indicate potential errors and on their own would not have pointed to an aging error. Further adjustment to account for changes in weight and size at age associated with aging error would probably result in even greater changes in apparent population abundance.

Additional Reading: Tyler, A. V., R. J. Beamish, and G. A, McFarlane. 1989. Implications of age determination errors to yield estimates, p. 27-35. *In* R.J. Beamish and G.A. McFarlane [ed] Effects of ocean variability on recruitment and an evaluation of the parameters used in stock assessment models. *Can. Spec. Publ. Fish. Aquat. Sci.* 108.

Contribution #5 (L. Van Eeckhaute and M. Strong)
Steps involved to make corrections when a poor age comparison test occurs.

Occasionally, two age readers may substantially disagree in their readings of the same otoliths, or possibly a bias is detected despite having high percent agreement scores. Under these sorts of conditions a step-by-step remedial process has been recommended to eliminate such aging discrepancies and permit production aging to resume. Utilization of the Image Analysis System by separately annotating annuli and storing these images, with subsequent discussions between the two age readers, was the main component of the recommended course of action. If no agreement in interpretation can be reached, then a third party would be asked for advice.

The specific threshold which determines whether remedial action be taken will likely vary from stock to stock. Northern, slow-growing stocks will likely have lower thresholds (i.e., lower percent agreement scores) than southern, fast-growing stocks. Results from intra-reader tests can serve to indicate the expected levels of inter-reader test scores that are achievable.

Contribution #6 (L. Brown and D. Clark)
Proposed training outline for a new age reader

Training of a new age reader begins by selecting examples of otoliths which have clearly defined annuli. Training progresses to otoliths that are more difficult to read. This process would begin by using a companion scope and advance to the Image Analysis System. The trainee would then read samples that the experienced reader has already interpreted. Each age reader would produce annotated overlays, using the Image Analysis System, of their interpretation. This would allow for comparison and discussion of independent readings of the same otolith. It is recommended that otoliths selected for training purposes include historical material as well as recent commercial and research survey material.

Training would be conducted frequently for the first few weeks, and then diminish as consistency is reached. The extent of training would depend on the time required to reach acceptable test scores in age comparison tests.

Contribution #7 (P. Perley and J. Neilson)
Establishment and use of archived age determination material

Hardware and software have been purchased that provide the capacity to save annotated images of otolith sections in a digital format. This capacity has significantly broadened our approach to archiving aging material. Archived age material provides a long-term record, it may be used to train new age readers, and if developed and used properly reduces the occurrence of biases or discrepancies in readings of a particular stock over time. All stocks have some form of historical reference material through the availability of otolith sections from previous SABS age readers. Three collections stored as digital images currently exist at SABS: 4VsW cod, 5Zj,m cod, and 4VWX5Zc pollock.

Archived material should consist of a wide variety of stored otolith images that span the growth conditions of a stock (i.e., easy and difficult to interpret samples). It is also recommended that it be continually updated, since fish growth and maturity patterns (location and clarity of annuli and spawning checks) can change within a stock over time.

It is recommended that future discussions focus on developmental protocols of otolith archives and accessing otolith images for various purposes. Several issues are germane here, including archived otolith images used for training material, "warm up" material, and to conduct tests.

An opportunity exists to simultaneously develop a historical collection while conducting some of the tests referred to in Contribution #1. The current situation is such that readers prefer to use the light microscope for production aging. However, it is possible that all test material can be saved as digital image files and the annotations saved as overlays. After several years of this process, SABS will have a significant archive of images. At that time, test #3 (Intra-Reader - historical) should be based on a sample from this archive. This will provide two readers with the ability to examine their respective interpretations when resolve differences in assessed age of an otolith. Also, this archive could be used for training or "warm up" if desired.

Appendix

Working papers of Contributions #1-7 are attached. Their contents have not been reviewed, and therefore should be treated accordingly.

SABS Workshop on Age Determination Methodology for Fish Stock Assessments

December 7, 1995

Frequency of conducting intra and inter-reader tests, time requirement, half year vs. full year exploitation.

Ed Trippel

Issue:

The frequency by which age readers conduct tests of precision (or repeatability) is an important issue in any age determination program. Without conducting tests of precision the danger exists that age reader determinations may change over time (perhaps in one direction, i.e. under or over ageing) or a general mis-assignment of ages to individual fish leading to lower precision in cohort size estimates.

Steps to Avoid Bias:

Individual age readers need to exhibit consistency in age determinations. This aim for consistency is an important goal in the course of a training schedule. Once trained, however, an established schedule to ensure the age reader does not stray from this original consistency needs to be put in place for each stock.

Intra-reader tests and Reference Collection tests:

An intra-reader test is one in which the reader is asked to age a sample of otoliths that the reader has aged before (ager is unaware of first readings). Test scores are derived (e.g. percent agreement and comparison matrix) and are reported with each assessment.

Alternatively, the age reader could go to a reference collection and randomly pick otoliths from this set and conduct a test. A shortcoming of the latter approach is that over time an age reader would be able to memorize the otoliths and correct ages from this set. Until now these reference collections have been small in size. If larger reference collections were developed the problem of "memorizing" the otoliths may be prevented.

The recommended target is to conduct one intra-reader test for each quarter in which the fishery is occurring (time about 1-2 days per quarter: 4-8 days per year; e.g., 4X cod and pollock, 50% of this for Georges cod and haddock).

Inter-reader tests:

An inter-reader test is one in which two age readers are asked to age the same sample of otoliths.

Test scores are derived (e.g., percent agreement and comparison matrix) and are reported with each assessment.

This has its advantages over the intra-reader test, because it will prevent a potential occurrence of repeated good intra-reader tests in which an age reader drifts slightly in the short term, but over a substantial period of time this practice may lead to substantial bias. This is especially so if no reference collection is used in the intra-reader test. It is less likely for two compared to one reader to miss age in the same direction over time. A reference collection is important aspect of any ageing program.

When two age readers are active on a stock, the recommended target is to conduct one inter-reader test for each quarter. It has been recommended that the secondary age reader conduct about 20% of production ageing. If this is done in one quarter (some discussion necessary on this) then the time requirement to conduct an inter-reader test would be about 1-2 days per year).

Total time for Age Comparison Tests:

Assuming high scores are attained in each test then the total number of days for a primary reader would be 4-8 days for intra-reader test and 1-2 days for an inter-reader test= 5-10 days. (4X cod and pollock; about 50% of this for Georges cod and haddock).

For a secondary reader this would amount to 1-2 days for an intra-reader test and 1-2 days for an inter-reader test = 2-4 days.

UTILITY FOR SELECTING MATERIAL FOR AGE COMPARISON TESTS

Prepared for: SABS Workshop on Age Determination Methodology for Fish Stock Assessments, Dec. 7, 1995.

Prepared by: Lou Van Eeckhaute

Selection is based on the required number of otoliths per length grouping per quarter. Greater or fewer otoliths can be selected by changing the number per length per quarter. An initial selection of all otoliths for which a comparison ageing test is required is made from the surveys database, the commercial samples database or both. Examples of SQLPLUS queries are included which may be modified to fit an individuals needs. An APL workspace is used with the resulting data files to select a subsample to be used in the comparison test. The workspace also produces an agreement matrix.

Step 1.

Use an SQLPLUS query to select records from the surveys or commercial samples database .
- query of survey database , eg. query in 'gsn216.sql', results in 'gsn216.lst' (m:\lou\age\util)
- query of commercial samples database, eg. query in 'cgs94mik.sql', results in 'cgs94mik.lst' (m:\lou\age\util)

Step 2.

Use OTO_SEL.W3 (an APL workspace) to randomly select the desired no. of otoliths from either of the above query results or from a combination of survey and commercial samples. The variable DESCRIBE has information on each function. Following is a description of the workspace.

'DO' is a cover function which allows the user to execute several functions in one step. The user can also execute each function on its own. The DO function illustrates the required syntax for each function.

'DO' - creates several variables named using the indicated convention
- the user supplies an identfier for 'fname' (ie, edit the DO function)
- does the following:
  - reads in results of queries into variable 'fname'
  - sorts file by length , creates variable 'fname_LEN'
  - selects rows from each length/quarter, overwrites 'fname_LEN'
  - sorts by sample no. and otolith no. into variable 'fname_BY_SAMP'
  - creates a variable which removes production ages, named 'fname_TO_AGE'
  - outputs number of rows (ie, no. of otoliths selected)

Step 3.

Use variable created by DO to record ages, ie. 'fname_TO_AGE'

Step 4.

Add a column to 'fname_BY_SAMP' with 2nd set of ages. Omissions should be given "0", ie. zero. Delete any empty rows.

Step 5.

Use the function 'AGREE' to create an ageing comparison matrix.

Filename = m:\lou\age\y95\OTO_SEL.DOC

GSN216.SQL

```
set heading off;
set echo off;
set feedback off;
set term off;
clear breaks;
clear columns;
set pages 900;
set pause off;
set lines 70;
Rem set pages 23;
Rem set pause on;
column QUARTER format A7;
COLUMN SAMPLE format A10;
spool gsn216

select (.5+2*floor(d.flen/2)) flen, DECODE((TO_CHAR(i.SDATE, 'MON')),
  'JAN','Q1','FEB','Q1','MAR','Q1','APR','Q2','MAY','Q2','JUN','Q2','JUL',
  'Q3','AUG','Q3','SEP','Q3','OCT','Q4','NOV','Q4','DEC','Q4','NO DATE')
  QUARTER, i.vesellli.cruno SAMPLE,
  d.fshno OTOLITH, d.age
from gsdet d, gsinf i
where i.vesel=d.vesel
  and i.cruno=d.cruno
  and i.setno=d.setno
  and i.vesel='N' and i.cruno=216 and d.spec=11
and fshno is not null
order by (.5+2*floor(flen/2))
/
set heading on;
set echo on;
set feedback on;
set term on;
clear breaks;
clear columns;
set lines 70;
set pages 23;
set pause on;
spool off;
```

GSN216.LST

```
      12.5 Q1       N216          184          1
      14.5 Q1       N216           15          1
      14.5 Q1       N216          335          1
      14.5 Q1       N216          355          1
      14.5 Q1       N216          352          1
      14.5 Q1       N216           99          1
      16.5 Q1       N216           14          1
      16.5 Q1       N216          137          1
      16.5 Q1       N216          302          1
      16.5 Q1       N216          319          1
      16.5 Q1       N216          337          1
      16.5 Q1       N216          341          1
```

CGS94MIK.SQL

```
set heading off;
set echo off;
set feedback off;
set term off;
clear breaks;
clear columns;
set pages 900;
set pause off;
set lines 70;
Rem set pages 23;
Rem set pause on;
column QUARTER FORMAT A7;
spool cgs94mik

select (.5+2*floor(a.fishlen/2)) flen, DECODE((TO_CHAR(S.DATELANDED, 'MON')),
  'JAN','Q1','FEB','Q1','MAR','Q1','APR','Q2','MAY','Q2','JUN','Q2','JUL',
  'Q3','AUG','Q3','SEP','Q3','OCT','Q4','NOV','Q4','DEC','Q4','NO DATE')
  QUARTER, s.sample, a.otolith, a.age, '  _______' BLANK
from samples.ages@cgs a,samples.samples@cgs s
where s.sample=a.sample
  and s.sample not in (940160,940164,940166,940174,940190,940209,940210,
  940211,940266,940269,940290,940326,940327,940376,940377,940386,940387,
  940435,940438)
  and s.sample > 940000 and s.sample < 950000
  and s.species in ('011','11')
  and s.area in (523,524)
order by (.5+2*floor(a.fishlen/2)),
  DECODE((TO_CHAR(S.DATELANDED,'MON')),'JAN','Q1','FEB','Q1','MAR',
  'Q1','APR','Q2','MAY','Q2','JUN','Q2','JUL','Q3','AUG','Q3','SEP','Q3',
  'OCT','Q4','NOV','Q4','DEC','Q4','NO DATE'), s.sample, a.otolith
/
spool off;
set heading on;
set echo on;
set feedback on;
set term on;
clear breaks;
clear columns;
set pause on;
set pages 23
set lines 70;
```

```
      38.5 Q3       940234         7094       2  _______
      38.5 Q3       940235         7133       2  _______
      38.5 Q4       940410         8680       2  _______
      40.5 Q3       940234         7093       2  _______
      40.5 Q3       940235         7117       2  _______
      40.5 Q3       940254       134325       2  _______
      40.5 Q3       940258         7186       2  _______
      40.5 Q3       940258         7190       2  _______
      40.5 Q3       940277         7478       2  _______
      40.5 Q3       940277         7480       2  _______
```

```
∇ DO NUM;ROW;TOT
[1]   fname ← READ∆FILE 'fname.lst'⍝ read in records selected by       SQLPLUS query
[2]   fname_LEN←LENGTH∆SORT fname ⍝ sort on length (needed for next     step)
[3]   fname_LEN← NUM SELECT_ROWS fname_LEN ⍝ select rows for each length-quart
      er=8/length max
[4]   fname_BY_SAMP←SORT∆ROWS fname_LEN ⍝ sort by sample no. and otolith no.
[5]   ROW←1↑⍴fname_BY_SAMP
[6]   ⍝ remove column with ages (print this and give to age reader)
[7]   fname_TO_AGE←((ROW,45)↑fname_BY_SAMP),(ROW,¯13)↑fname_BY_SAMP
[8]   TOT←1↑⍴fname_TO_AGE
[9]   'NUMBER OF ROWS SELECT = ' TOT
    ∇


⎕VR 'AGREE'
    ∇ R←AGREE MAT ;A;B;MAXA;MAXB;C;X;Y;COUNT;D;ROWTOT;COLTOT;MATCHES;OMITS;READER
      1;READER2;WIDTH;AGE_WIDTH
[1]   ⍝ creates an ageing comparison matrix
[2]   ⍝ "OMITS" should be given 0 (zero) and delete any empty rows from MAT
[3]   ⍝ assign vectors of ages to A and B
[4]   'Omissions should be given a value of 0 (ie. zero) and the matrix'
[5]   'should not contain any blank rows, ie ^END should place the cursor at'
[6]   'the end of the last row of data. Exit the function by responding'
[7]   'with "→" to the following question and ")reset" if this is the case.'
[8]   'Make the revisions and start AGREE again.'
[9]   ''
[10]  'Enter the number of columns which contain the age data (blanks can be'
[11]  'included.)'
[12]  ''
[13]  AGE_WIDTH←⍬
[14]  AGE_WIDTH←⍎FI AGE_WIDTH
[15]  WIDTH←¯1↑⍴MAT ⍝ no. of columns
[16]  D←((1↑⍴MAT),2) ⍴⍎FI,MAT[;((WIDTH-AGE_WIDTH)+⍳AGE_WIDTH)],' ' ⍝ extraxts
[17]     ⍝ columns with ages and converts to 2 columns of numeric data
[18]  A←,D[;1] ⍝ A is a vector of ages for 1st reader
[19]  B←,D[;2] ⍝ B is vector of ages for 2nd reader
[20]  ⍝ create an empty comparison matrix
[21]        MAXA←⌈/A ⍝ find the maximum age for A
[22]        MAXB←⌈/B ⍝ find the maximum age for B
[23]        R←((1,MAXA+1)⍴0,⍳MAXA)⍪((MAXB+1),(MAXA+1)⍴0 ⍝creates a matrix of
[24]           ⍝ 0's with column headings of ages for ager 1
[25]        C←((2+MAXB),1)⍴0,0,(⍳MAXB)⍝ a column of ages for reader 2
[26]        R←C,R ⍝ R is a matrix with ages at top and left; "0" means "OMIT"
[27]  ⍝ compute the number of matches for each comparison of A to B
[28]  X←¯1 ⍝ initial age value for reader 1
[29]  MATCHES←0
[30]  L10: X←X+1 ⍝ loops through all ages given by reader 1: augment X
[31]  →(X>MAXA)/L20 ⍝ exit when all age values have been compared
[32]  Y←0 ⍝ initial age value for reader 2
[33]  L30:→(Y>MAXB)/L10 ⍝ loop through all ages given by reader 2
[34]      COUNT←+/(A=X)∧(B=Y) ⍝ count matches
[35]      R[Y+2;X+2]←COUNT ⍝ insert no. of matchs into agreement matrix
[36]      MATCHES←MATCHES+(Y=X)×COUNT⍝ count no. of matches
[37]      Y←Y+1 ⍝ augment reader 2 age value
[38]  →L30 ⍝ loop back to L30:
[39]  L20:
[40]  ROWTOT←+/1 1↓R ⍝ compute row totals
[41]  OMITS←1↑ROWTOT
[42]  R←R,(0,ROWTOT) ⍝ add row total to matrix
[43]  COLTOT←+⌿1 1↓R ⍝ compute column totals
[44]  OMITS←OMITS+1↑COLTOT
[45]  OMITS←OMITS-(R[2;2])
[46]  PERCENT_AGREE←MATCHES÷(1↑⍴MAT)-OMITS
[47]  R←R⍪(0,COLTOT) ⍝ add column totals to matrix
[48]  'Name of first age reader?'
[49]  READER1←⎕
[50]  'Name of second age reader?'
[51]  READER2←⎕
[52]  '                    'READER1
[53]  'O0<->I3' ⎕FMT R
[54]  READER2
[55]  'Percent agreement (omissions excluded) = ' PERCENT_AGREE
    ∇
```

```
AGREE_1_1←AGREE m_1
Omissions should be given a value of 0 (ie. zero) and the matrix
should not contain any blank rows, ie ^END should place the cursor at
the end of the last row of data. Exit the function by responding
with "→" to the following question and ")reset" if this is the case.
Make the revisions and start AGREE again.

Enter the number of columns which contain the age data (blanks can be
included.)

14
Name of first age reader?
Lou
Name of second age reader?
Mike
                              Lou
  -  -  1  2  3  4  5  6  7  8  9 10 11 12 13  -
  -  1  -  -  -  -  -  -  -  -  -  -  -  -  -  1
  1  - 15  1  -  -  -  -  -  -  -  -  -  -  - 16
  2  -  - 10  -  -  -  -  -  -  -  -  -  -  - 10
  3  -  -  3  6  -  -  -  -  -  -  -  -  -  -  9
  4  -  -  -  4  6  -  -  -  -  -  -  -  -  - 10
  5  -  -  -  -  1  2  -  -  -  1  -  -  -  -  4
  6  -  -  -  -  -  2  1  -  -  -  -  -  -  -  3
  7  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  8  2  -  -  -  -  -  -  -  1  -  1  -  -  -  4
  9  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
 10  -  -  -  -  -  -  -  -  -  -  2  3  2  -  -  7
 11  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
 12  -  -  -  -  -  -  -  -  -  -  -  -  -  1  1
  -  3 15 14 10  7  4  1  -  1  3  4  2  -  1 65
Mike
 Percent agreement (omissions excluded) =    0.7258064516
```

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DFO Atlantic Fisheries
Research Document 95/117

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MPO Pêches de l'Atlantique
Document de recherche 95/117

BIAS AND VARIABILITY IN AGE DETERMINATION COMPARISONS FOR 5Z j,m COD (1991-94)

by

M-I. Buzeta
Department of Fisheries and Oceans
Maritimes Region
Biological Station
St. Andrews, New Brunswick

[1]This series documents the scientific basis for the evaluation of fisheries resources in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the secretariat.

[1]La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Les Documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

Abstract

Coefficient of variation estimates, bias plots for the analysis of trends or shifts between past age assignments (1991-1994), and a re-analysis in 1995 are reported for Georges Bank cod. Published Can/USA otolith exchanges and annual precision tests were also analyzed in this manner. Comparison matrices and percent agreement are also reported.

The percent agreement for the re-analysis of 1991-1994 age assignments ranged between 69% and 74%, corresponding to coefficients of variation of 4.64% and 5.20%. Bias plots suggest that the age by age bias is low and with no apparent pattern, and that the 95% confidence interval increases with age.

The present results suggest that within year precision is good, but that there is a small and consistent tendency for the second age determination to be lower than the original age. There is no apparent age specific bias, except possibly with older ages that usually account for only a few fish.

The Canada/USA exchanges show good agreement and coefficient of variation ranges, with similar values for both the author's results and the former experienced Canadian age reader. Both Canadian age readers seem to have a within year bias, but this bias is random when all years are reviewed together.

Résumé

On rend compte ici des estimations de coefficients de variation et des courbes de biais destinées à l'analyse des tendances ou des décalages dans les déterminations des âges de la morue du banc Georges réalisées dans le passé (de 1991 à 1994) ainsi que d'une ré-analyse pour 1995. On analyse également les résultats publiés des échanges d'otolithes canado-américains et de la vérification annuelle de précision. Enfin, on présente des matrices de comparaison et le pourcentage de concordance.

Le pourcentage de concordance dans la ré-analyse des déterminations d'âge réalisées de 1991 à 1994 s'échelonnait entre 69 % et 74 %, ce qui correspond à des coefficients de variation de 4,64 % et de 5,20 %. D'après les courbes de biais, il apparaît que le biais âge par âge est faible et ne présente pas de tendance apparente, et que l'intervalle de précision de 95 % augmente avec l'âge.

Il ressort des résultats actuels que la précision au sein d'une même année est bonne, mais que la deuxième détermination de l'âge reflète une légère tendance constante à la baisse par rapport à l'âge original. Il ne semble pas y avoir de biais spécifique à certains âges, à l'exception peut-être des âges plus élevés, qui ne comprennent habituellement que quelques poissons.

Il ressort des échanges canado-américains que la concordance et les gammes de coefficients de variation sont bonnes, les valeurs étant similaires tant dans les résultats de l'auteur que ceux de l'ancien spécialiste canadien expérimenté dans la détermination de l'âge. Un biais au sein d'une même année semble présent dans les résultats des deux spécialistes canadiens, mais ce biais est aléatoire quand on considère l'ensemble des années.

An Example of the Impact of Ageing Error on Population Estimates

A. Bias in ageing

1. Bias in age determination for Canadian estimates was introduced to the catch at age and survey index

2. Bias was set to be positive and progressive (ie a trend to age fish older)

3. Bias was introduced starting in 1990 and was set to increase at age each year
   eg. in year t, x% of age i were reassigned to age i+1 and 10>x<30%, details in attached function listing

4. ADAPT, as used in the 1995 assessment, was run with the revised catch and Canadian survey index; USA indices were unchanged.

5. Comparison of population estimates for 3+ numbers, biomass and F shown in figures

6. Impact of ageing error should have generated more older fish and lower exploitation. Results confirm this with apparent higher 3+ numbers, biomass and lower fishing mortality.

B. Variation in ageing

1. Variation in age determination estimated from replicate readings. ie. proportion aged as three in first reading relative to second

2. Alternate catch at age derived using template of long term variation eg. number at age i in year t set to x% same age plus y% re-aged as j. Same template for all years.

3. ADAPT re-run with new catch at age

4. Population estimates compared.

```
AGEMOD
A←13◊B←14◊C←15◊D←16◊E←17
 MCAT[1;A]←CAT[1;A]
 MCAT[2;A]←CAT[2;A]
 MCAT[3;A]←CAT[3;A]
 MCAT[4;A]←(CAT[4;A]×.9)
 MCAT[5;A]←((CAT[5;A]×.9)+(CAT[4;A]×.1))
 MCAT[6;A]←((CAT[6;A]×.9)+(CAT[5;A]×.1))
 MCAT[7;A]←((CAT[7;A]×.8)+(CAT[6;A]×.1))
 MCAT[8;A]←((CAT[8;A]×.8)+(CAT[7;A]×.2))
 MCAT[9;A]←((CAT[9;A]×.8)+(CAT[8;A]×.2))

MCAT[1;B]←CAT[1;B]
 MCAT[2;B]←CAT[2;B]
 MCAT[3;B]←CAT[3;B]×.95
 MCAT[4;B]←(CAT[4;B]×.9) +CAT[3;B]×.01
 MCAT[5;B]←((CAT[5;B]×.9)+(CAT[4;B]×.1))
 MCAT[6;B]←((CAT[6;B]×.9)+(CAT[5;B]×.1))
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 MCAT[9;B]←((CAT[9;B]×.7)+(CAT[8;B]×.2))

MCAT[1;C]←CAT[1;C]
 MCAT[2;C]←CAT[2;C]×.9
 MCAT[3;C]←(CAT[3;C]×.9) +CAT[2;C]×.1
 MCAT[4;C]←(CAT[4;C]×.8) +CAT[3;C]×.1
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 MCAT[8;C]←((CAT[8;C]×.8)+(CAT[7;C]×.2))
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MCAT[1;D]←CAT[1;D]
 MCAT[2;D]←CAT[2;D]×.9
 MCAT[3;D]←(CAT[3;D]×.85) +CAT[2;D]×.1
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 MCAT[8;D]←((CAT[8;D]×.8)+(CAT[7;D]×.2))
 MCAT[9;D]←((CAT[9;D]×.7)+(CAT[8;D]×.2))

MCAT[1;E]←CAT[1;E]
 MCAT[2;E]←CAT[2;E]×.8
 MCAT[3;E]←(CAT[3;E]×.8) +CAT[2;E]×.2
 MCAT[4;E]←(CAT[4;E]×.8) +CAT[3;E]×.2
 MCAT[5;E]←((CAT[5;E]×.75)+(CAT[4;E]×.2))
 MCAT[6;E]←((CAT[6;E]×.75)+(CAT[5;E]×.25))
 MCAT[7;E]←((CAT[7;E]×.75)+(CAT[6;E]×.25))
 MCAT[8;E]←((CAT[8;E]×.7)+(CAT[7;E]×.25))
 MCAT[9;E]←((CAT[9;E]×.7)+(CAT[8;E]×.3))
```
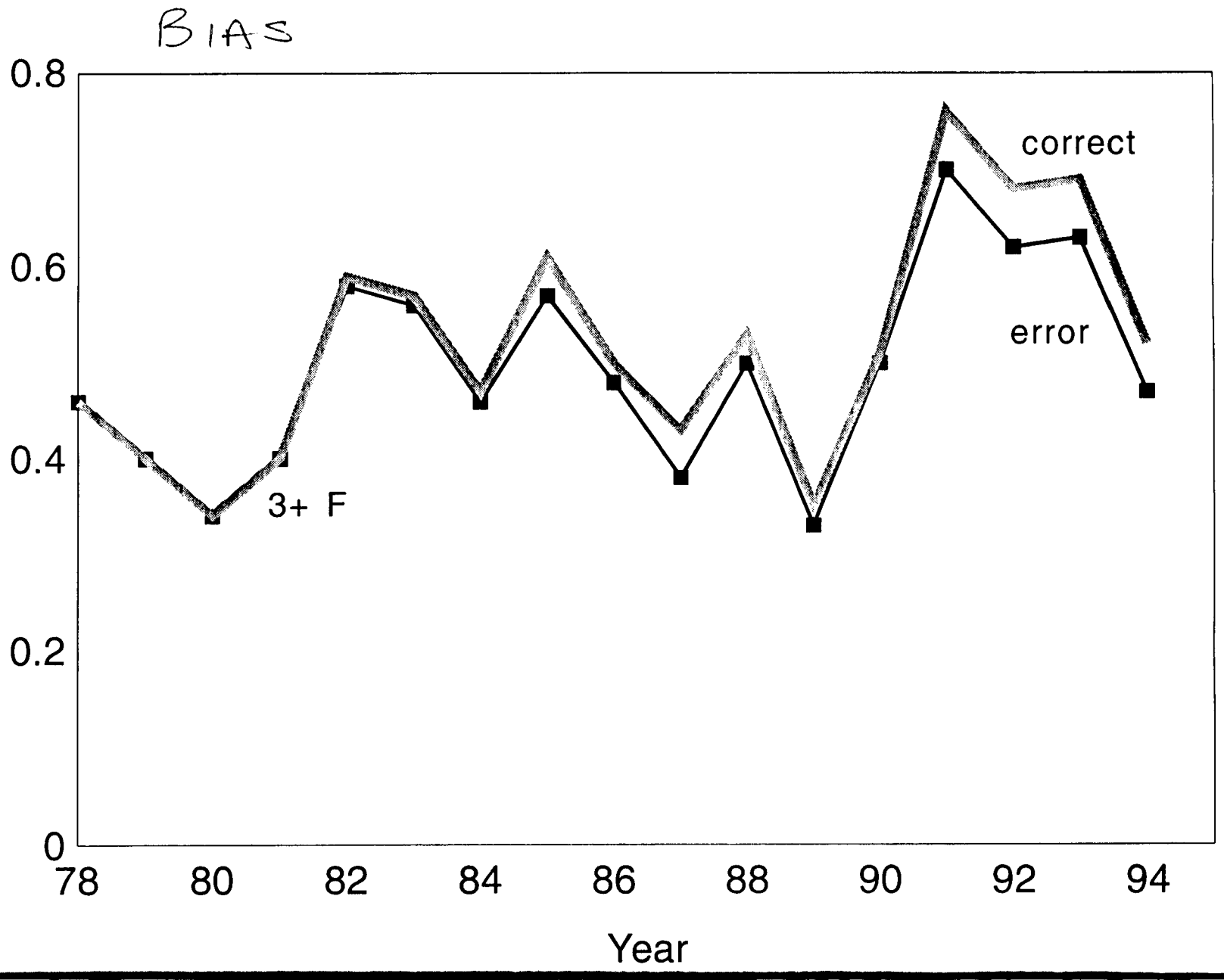
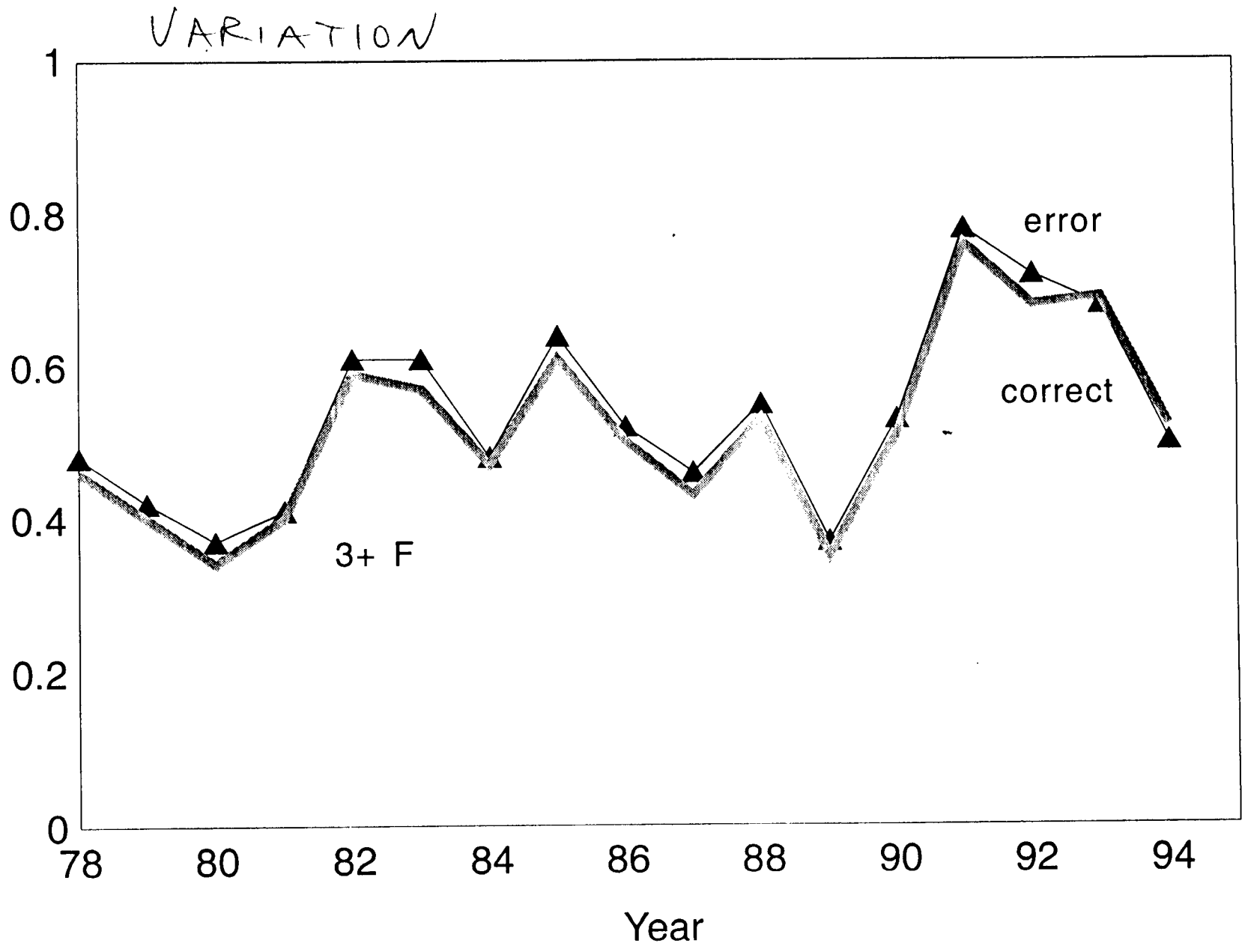

Population estimates derived

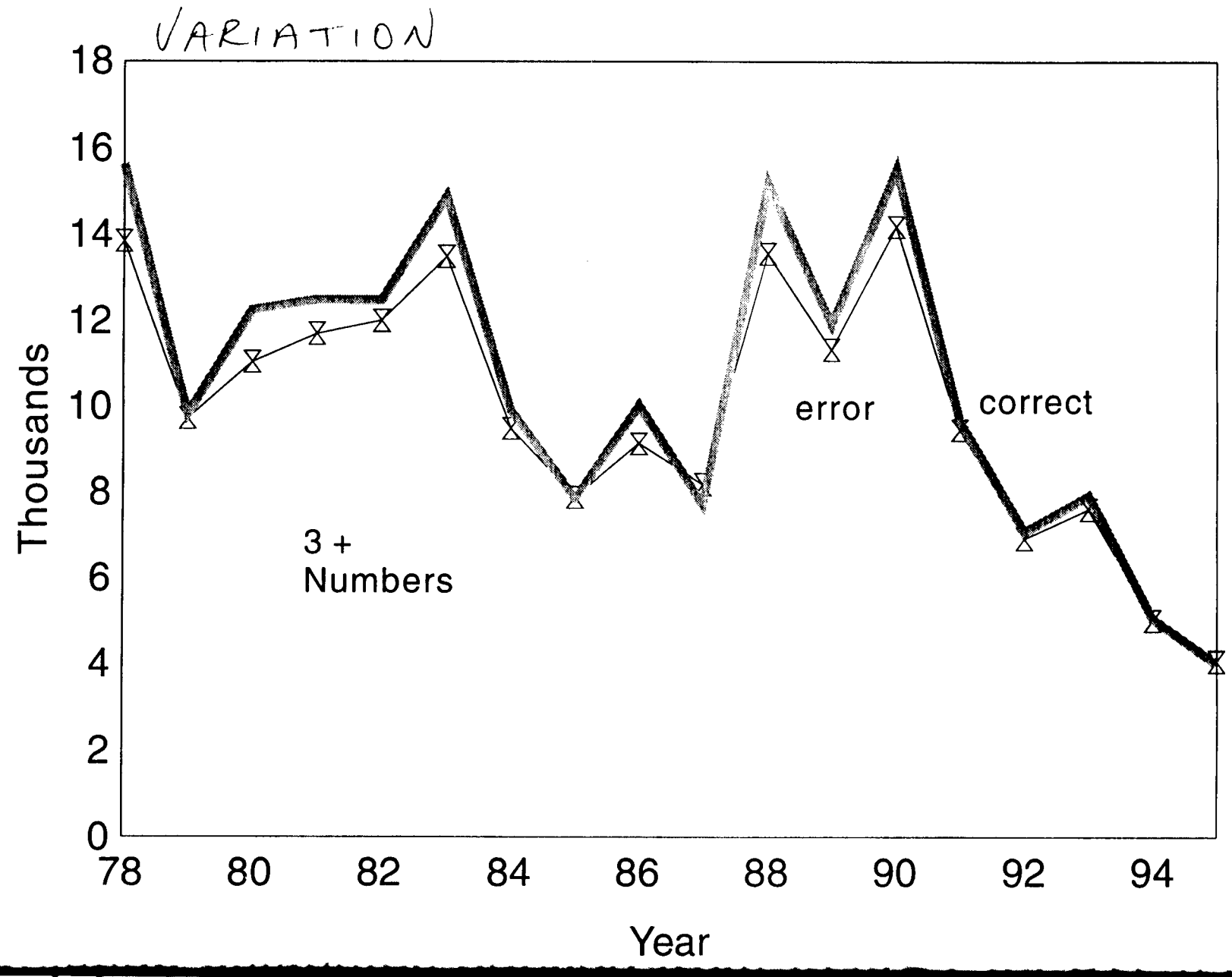
Population estimates derived from ADAPT for 5Zj,m cod



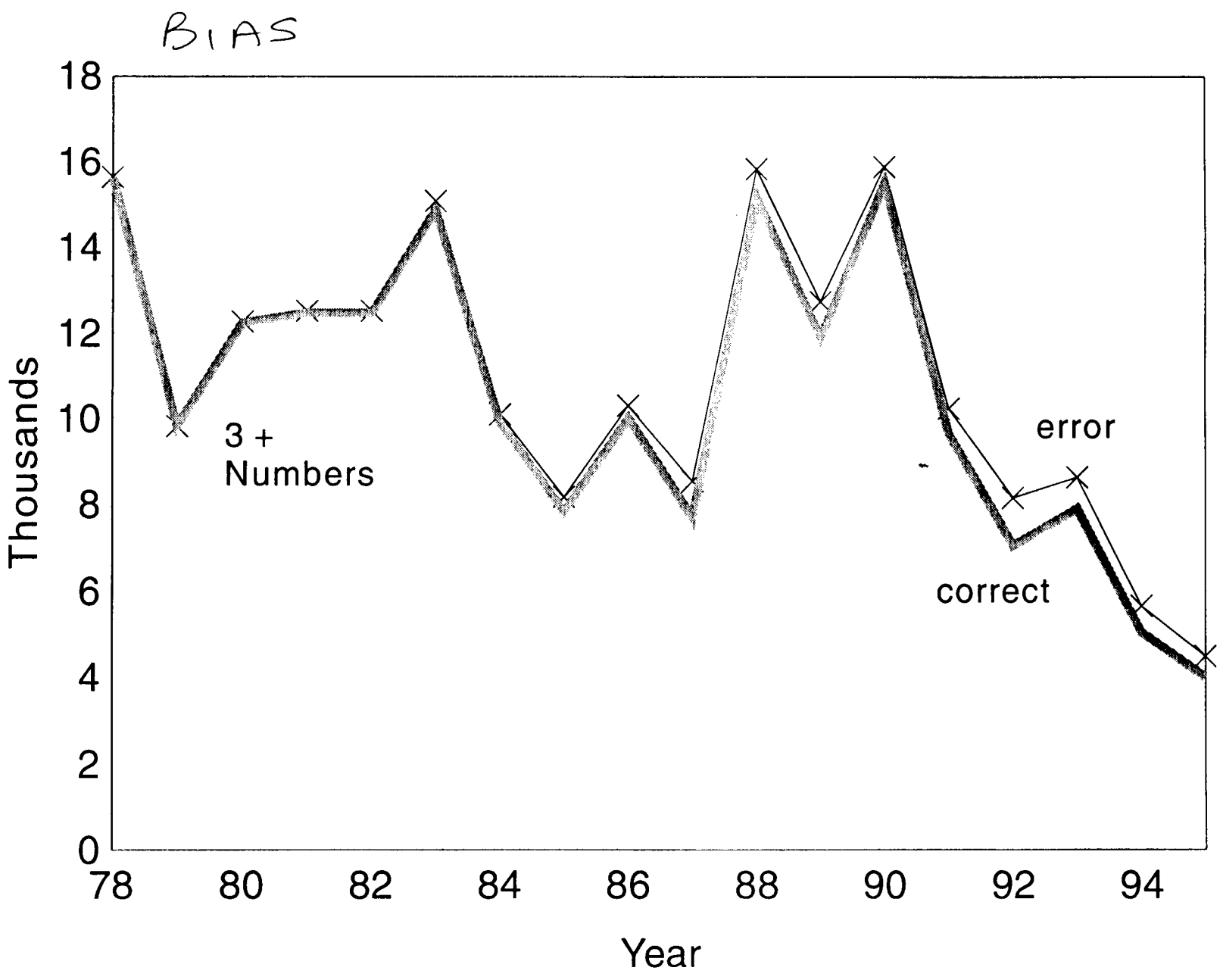
Population estimates derived from ADAPT for 5Zj,m cod



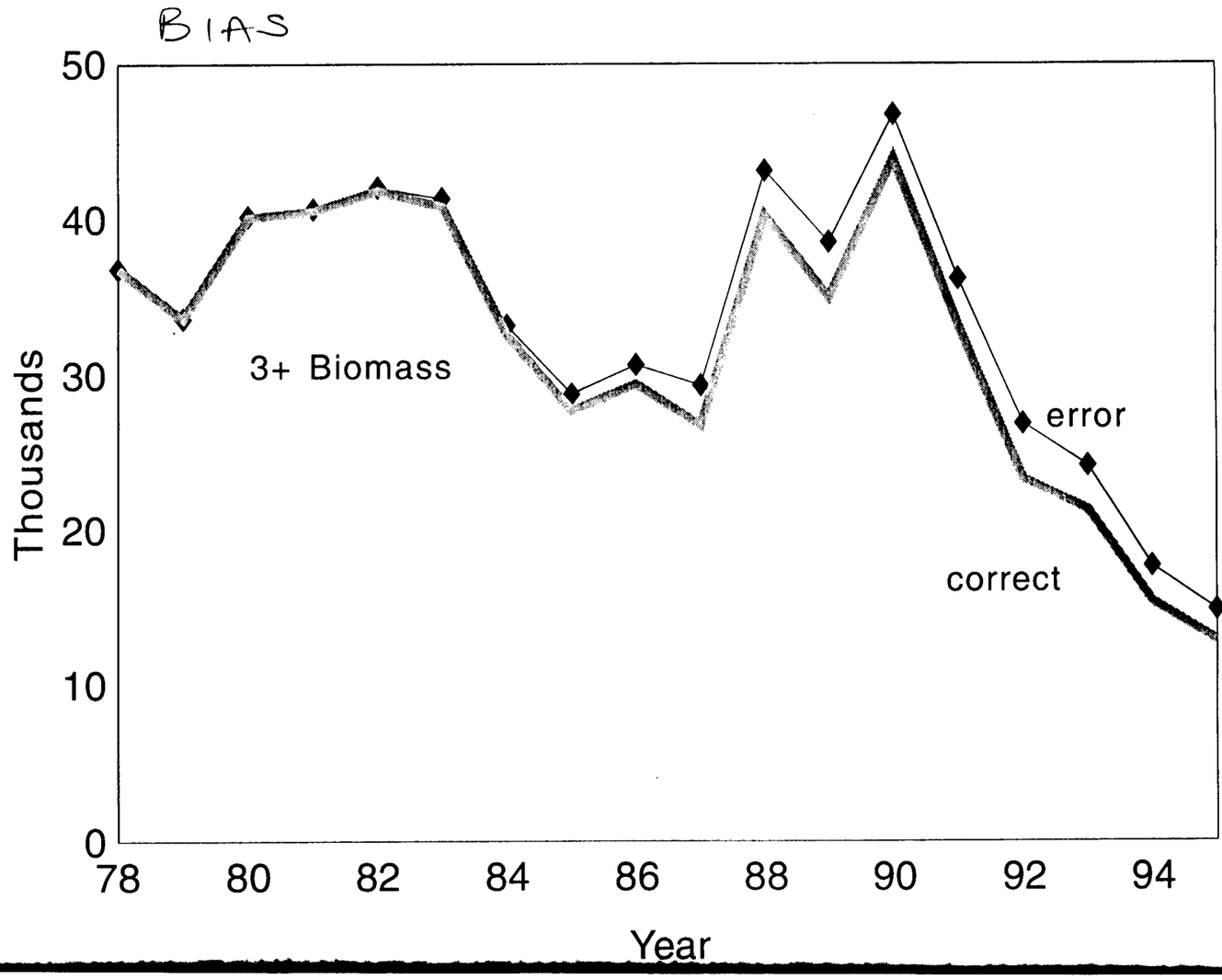
Population estimates derived from ADAPT for 5Zj,m cod

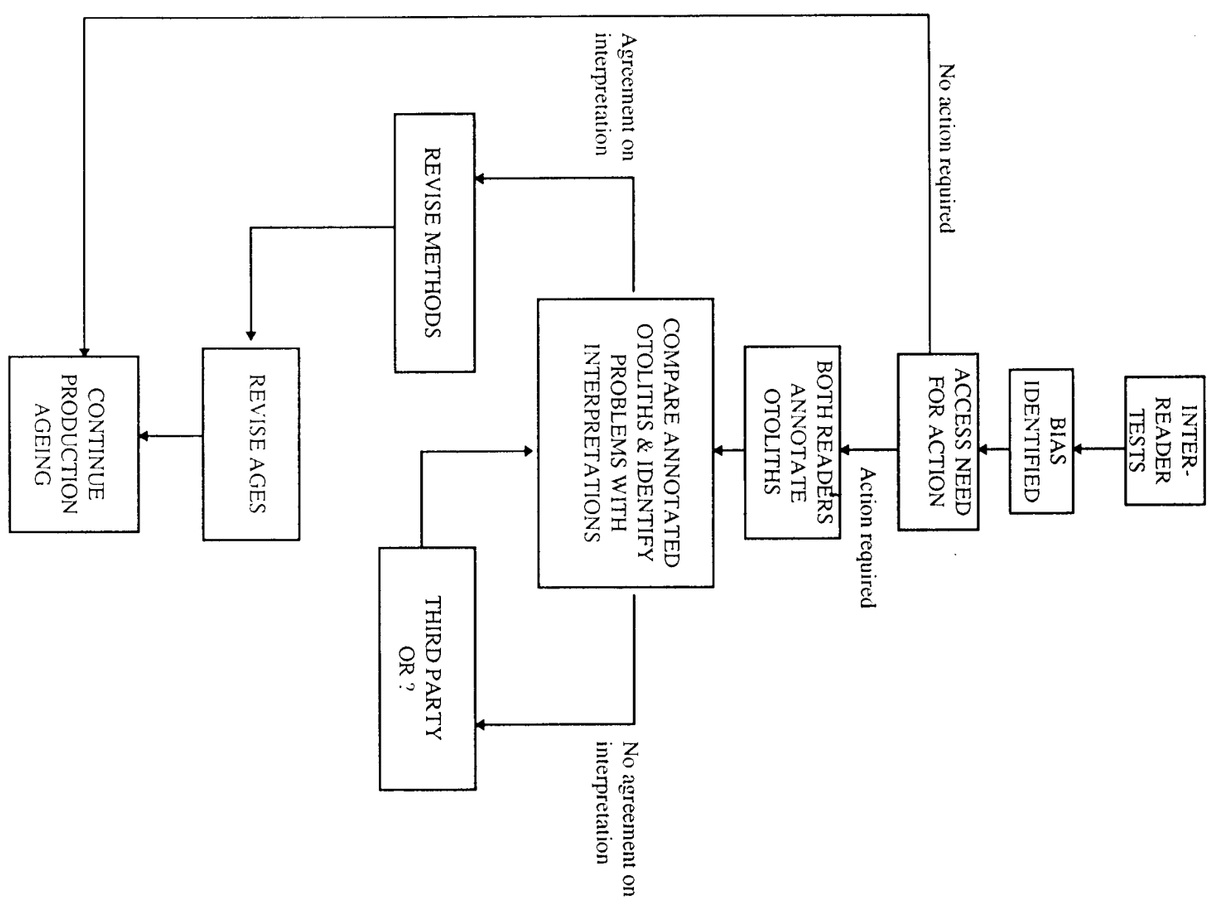


Population estimates derived from ADAPT for 5Zj,m cod



Population estimates derived from ADAPT for 5Zj,m cod





Annotation of otolith ages using the OPTIMAS image analysis system*

Prepared for: SABS Workshop on Age Determination Methodology for Fish Stock Assessments, Dec. 7, 1995.

Prepared by: Lou Van Eeckhaute

Note: to be able to save overlay only, set File, Setup Image Driver, Full Gray-on (see 1-16 to 19 in manual).

TO SAVE OTOLITH IMAGE AND ANNOTATIONS SEPARATELY:

- save otolith image with identifiers (image plus overlay)
- each reader opens otolith image, identifies annuli and annotates, then saves overlay only

TO ADD AN INSET:

- display image to capture inset portion
- select inset portion, ie. Edit, Select Region of Interest (ROI)
- copy ROI to clipboard (inset portion), ie. Edit, Copy Image
- acquire and freeze 2nd image
- position ROI on screen, ie. Edit, Move ROI
- paste inset, ie. Edit, Paste Image
- Edit, Select Full Screen

Note: I have had to restart OPTIMAS when I have not followed the steps above.

TO COMBINE IMAGE AND OVERLAYS:

- under Image, Arithmetic Ops
- use File to List and open each file
- use Copy and Go! to overwrite screen with filename highlighted
- use Add or Subtract with filename highlighted to add overlay over top of otolith image (Add brings in white overlay, Subtract brings in black overlay)

*m:\lou\age\y95\OPTIMAS.DOC

Proposed Training Outline for New Age Reader

1. Literature review by trainee of relevant documentation for the species/stock. (done)

2. Aging of 50 otoliths from each of the Bay of Fundy and Scotian Shelf by trainee without assigned age to assess initial problems. (1/2 done)

3. Side by side discussion of above sample with trainer using the "training scope".

4. Aging of 100 - 150 otoliths from various locations within 4X by trainee with assigned ages available. This process may be enhanced by using the image analysis system so that, as well as knowing the assigned age, the manner in which it is derived can be examined.

5. Discussion of above samples with trainer to identify problems, conventions, correct bias, etc. Reanalysis to ensure any identified problems have been addressed.

6. Independent aging of sample of 100 otoliths from each of the Bay of Fundy and the Scotian Shelf by the trainnee ("blind"). Conduct comparison of results with trainer, and determine what further work is required to achieve adequate correspondence.

This initial phase could be expected to take approximately 2 weeks. The amount of time which may be required to reach acceptable levels of agreement cannot be forecast.

Once an adequate level of agreement is reached, the new ager can take on otolith interpretation duties as assigned.

Possible additional comparisons: Comparisons can be made with 'historical" ages by both readers. Using otoliths from 1980's we can explore whether any bias is creeping in as agers change (i.e. if I am getting acceptable agreement with Laura, am I also getting acceptable agreement with the previous ager, or is their some progressive change). Independent age readings from readers familiar with other stocks could be examined. This may show good agreement with current interpretation, but may also uncover differences which merit exploration.

Additional work: developing a representative otolith collection for 4X cod, and storing a reference collection on the image analysis system.

Establishment and Use of Archived Age Determination Material

Peter Perley
John Neilson

What is Meant by Archived Age Determination Material?

The scope of the discussion here is limited to the electronic creation, storage and retrieval of a database of otolith images (referred to here as a reference collection). We will not be considering the physical equivalents.

Why Bother?

1) It would provide us with longterm reference collection. By reviewing archived images the ager can ensure ages are being interpreted in the same way as time passes. Over time, this may include the terms of several age readers.

2) It is a useful tool in the training new agers, allows discussion of the otolith and archiving for future reference with comments.

3) An archived library of otoliths can be referred to at anytime. This would ensure that the method of interpreting the otolith is the same over time.(ie it would check against "drift")

4) By storing images as graphics files, otoliths can be transmitted electronically via the net to other labs (ie Woods Hole, Bio etc) for comparison of ages.

5) It is also a cheaper method of storage compared with hardcopy photographic images as well as much quicker to access at anytime. Images can be stored into any account and be brought back at anytime or anywhere and you can choose the images you want to bring back.

What Procedures and Criteria are Useful for Establishing Archived Age Determination Material?

We scanned available literature on this subject and concluded there was no literature to guide us here, at least in our discipline. Therefore, we need to develop our own approachs which are based on our needs. As guidelines, the collection should include:

- the range of ages seen in the fishery and survey.
- include individuals collected throughout the and the management unit.
- since the interpretation of the first annulus if often difficult, it is helpful to have images of otoliths of fish of known age one stored to provide a check.
- reference collection should be updated every 3-5 years, since fish growth patterns can change over time.
- as a guide, at least 100 images should be archived, more if there is spatial diversity in growth rates (4X cod, pollock are examples)
- include both "good" preparations and also ones which could be difficult. In the past, we have tended to place insufficient emphasis on the inclusion of difficult sections.

Annuli should be identified using the annotation/overlay function of the image analyses software, and also other features such as checks should be identified. Liberal annotation is highly desirable. Images should be stored at the highest resolution possible. We note it is important to back up the collection of images since they are invaluable! The invertebrates group has a "double-headed" vcr unit which facilitates quick copies of high-8 tapes.

How Are Recommended Practices for Using the Reference Collection?

- Typically, the frequency of review of the reference collection will be dictated by the individual situation. For example, in the case of Georges Bank stocks, otoliths only become available in the latter half of the year when the fisheries occur. Thus, it might be

helpful for agers to review the reference collection in the midyear period, just prior to when otoliths start arriving.

-Incumbent agers should refer to the archive library every so often, especially if there has been an elapsed period of time when the last sample was aged. This would get them refamilialized with the stock they are aging. The reference collection is to be used for the benefit of the agers, not to score consistency in some formal fashion (ie. not to be used as a test of consistency, since it may not be useful in that regard anyway).

What are Archived Material Now in Place at SABS?

Three collections currently exist on high-8 tape (4VsW cod (done in 1990 with transition from R. Robicheau to P. Perley, includes some (38) 4T images as well), 4VWX5Zc pollock (1995, with transition from H. Sampson to C. Nelson, about 122 images available) and 5Zjm cod (done during the transition of ageing responsibilities from R. Robicheau to Maria). All of these are annotated with the position of the annuli noted, and backups have been made.

Improvements in Procedures Which are Foreseen

We currently have both Optimas 4 and Optimas 5 on the system but only Optimas 4 supports the Matrox frame grabber currently on the system. The options are to either get a new frame grabber that Optimas 5 supports or go with a digital camera in which case a frame grabber is not needed. Currently we can save the image in Optimas 4 and then open up the image in Optimas 5 but image quality is poor. Optimas 5 displays images on the same monitor as the program and as a result a high resolution 17" monitor is on order. At the present time hardcopy capability is not considered critical given the costs of hardware options.(ie 10 - 15 k for a digital printer.)