NOAA FISHERIES

Northeast Fisheries Science Center

Age, growth, and reproduction

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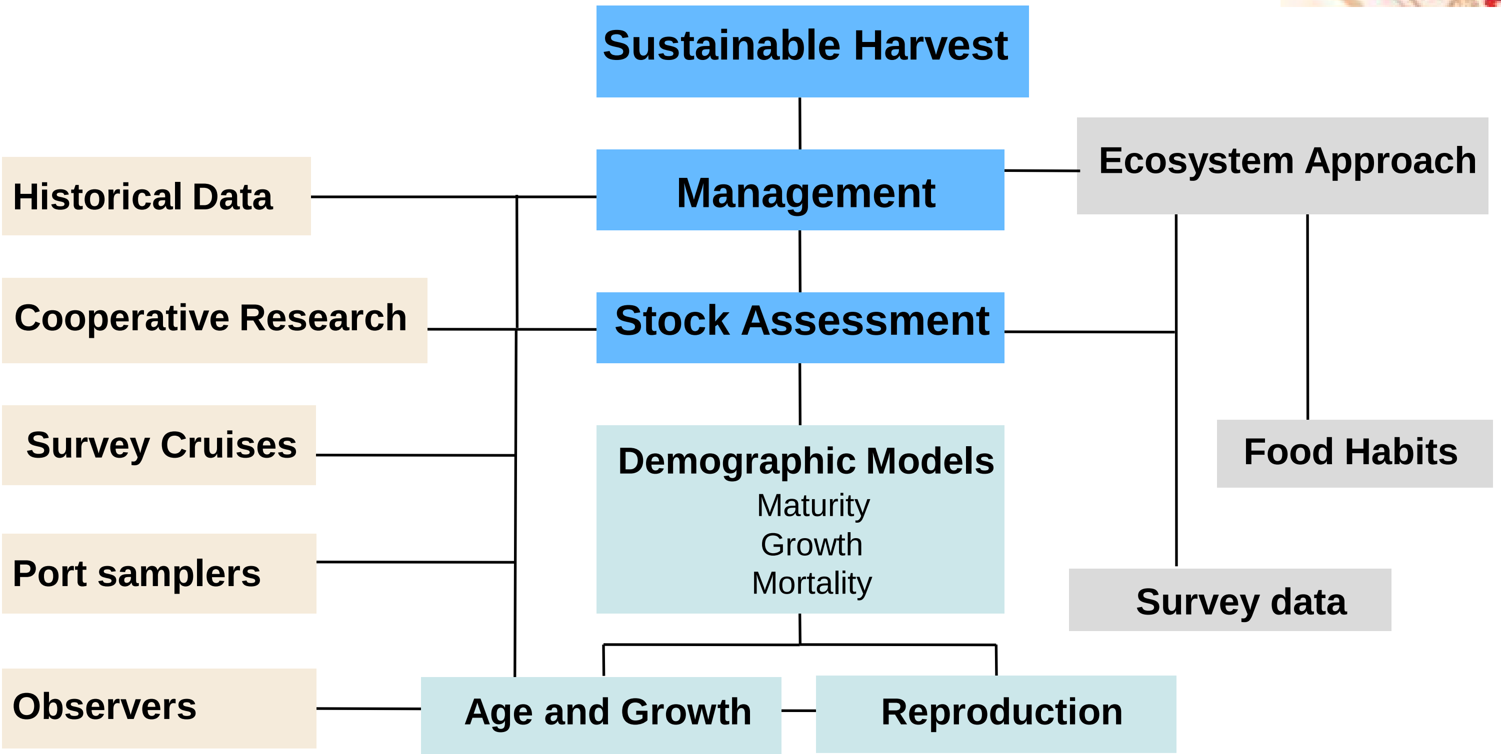
August 5, 2013

Organizational structure

Meeting the mandates of the Magnuson-Stevens Act



Population Biology Branch

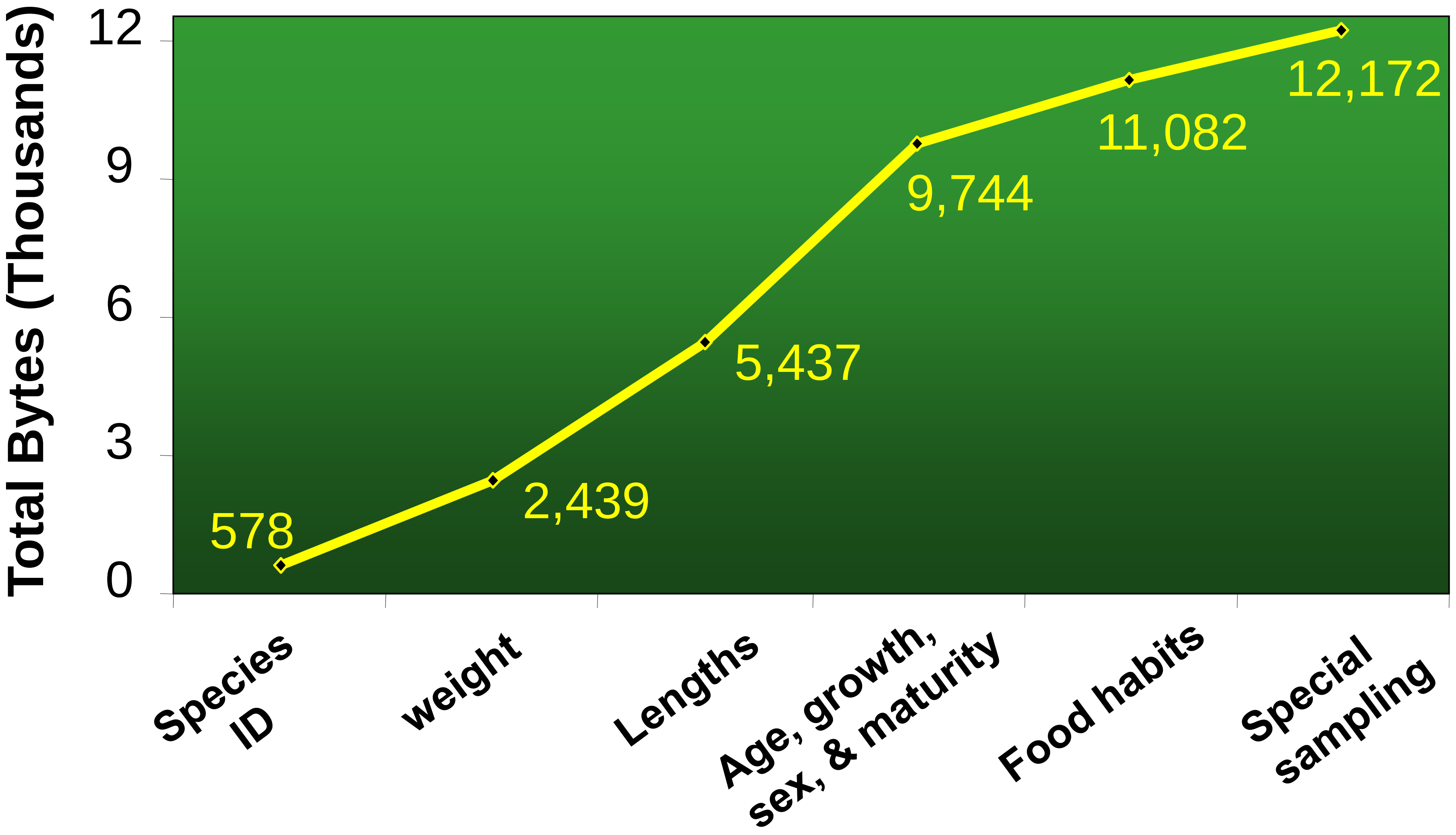
Biological sample processing

→ Data

- Types (age, reproductive)
- Quantity (production)
- Quality (QA/QC)
- Entry & audits
- Archive & accessibility
- Summaries & analyses

Extracting otoliths from Atlantic herring

Relative contribution of data types from surveys

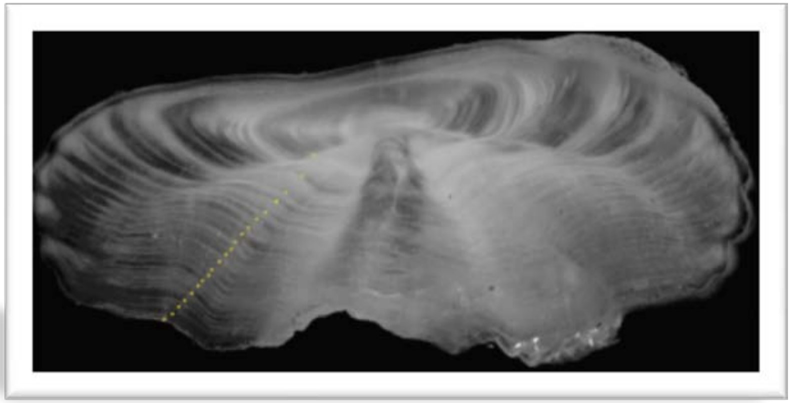


Link et al. (2008). Fish. Res. 93: 229-33.

Routine purpose & sample types

'Hardparts' for estimating age

- Scale impressions
- Otoliths (whole, sectioned)
- Chondrophores



Winter flounder, sectioned otolith
(21 years old; Thornton & Robillard, in prep.)

Gonads for identifying spawners

- Sex (macroscopic examination)
- Maturity class (macroscopic)

Dissected winter flounder, Female with hydrated eggs (McBride et al. 2013)

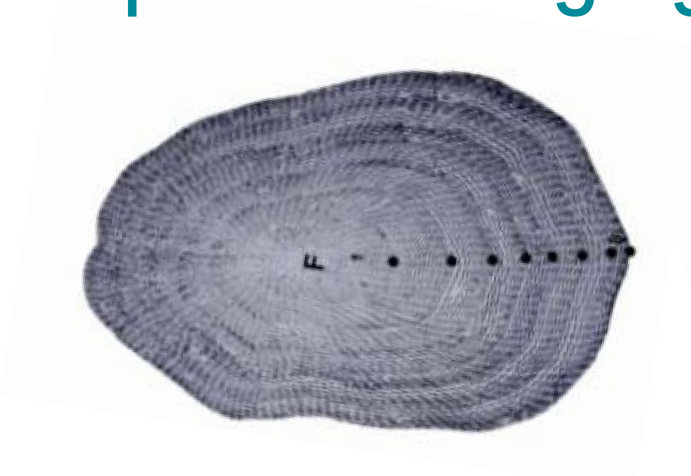
Production aging (2012)

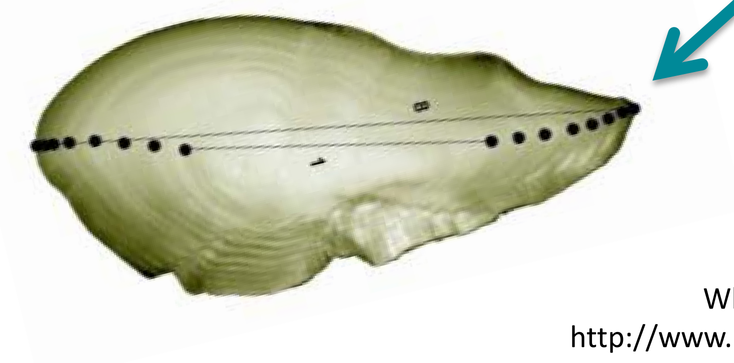
2.2 scientists, 7.6 technicians, 2.0 contractors

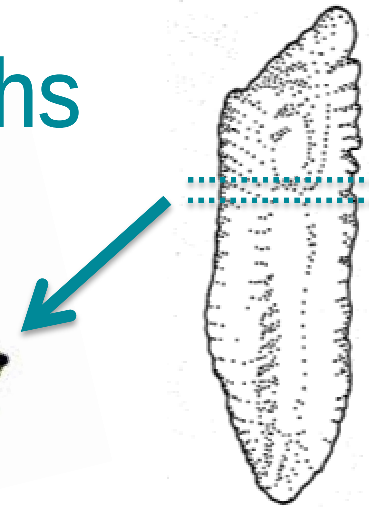
Species	Method	Number aged
Atlantic Cod	Otoliths (sectioned)	12,167
Haddock	Otoliths (sectioned)	9,421
White Hake	Otoliths (sectioned)	7,468
Yellowtail Flounder	Scales	7,175
Winter Flounder	Scales, Otoliths (whole, sectioned)	3,600
Summer Flounder	Scales, Otoliths (sectioned)	3,463
Butterfish	Otoliths (whole)	2,843
Scup	Scales	2,821
Witch Flounder	Otoliths (sectioned)	2,785
Black Sea Bass	Scales, Otoliths (whole)	2,115
Acadian Redfish	Otoliths (sectioned)	2,018
Atlantic Herring	Otoliths (whole)	1,276
Atlantic Mackerel	Ototiths (whole)	1,006
American Plaice	Otolith (sectioned)	710
Surfclam	Chondrophore (sectioned)	443
Total (2012)		59,311

Data from NAFO reports (Does not include ages for constituents, workshops or exchanges, or QA/QC exercises)

A primer on aging scales vs. otoliths

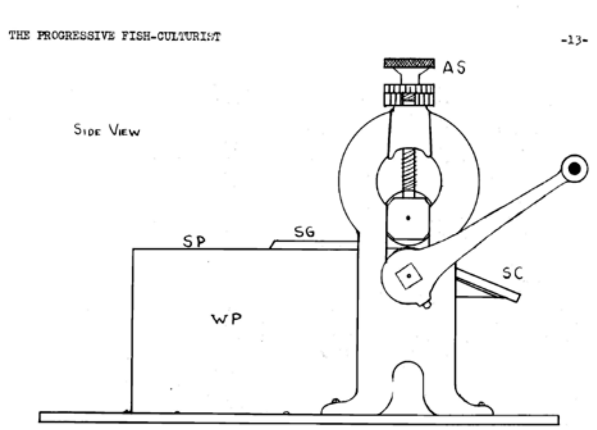






Whole haddock otolith
http://www.nefsc.noaa.gov/fbp/oto-guide/

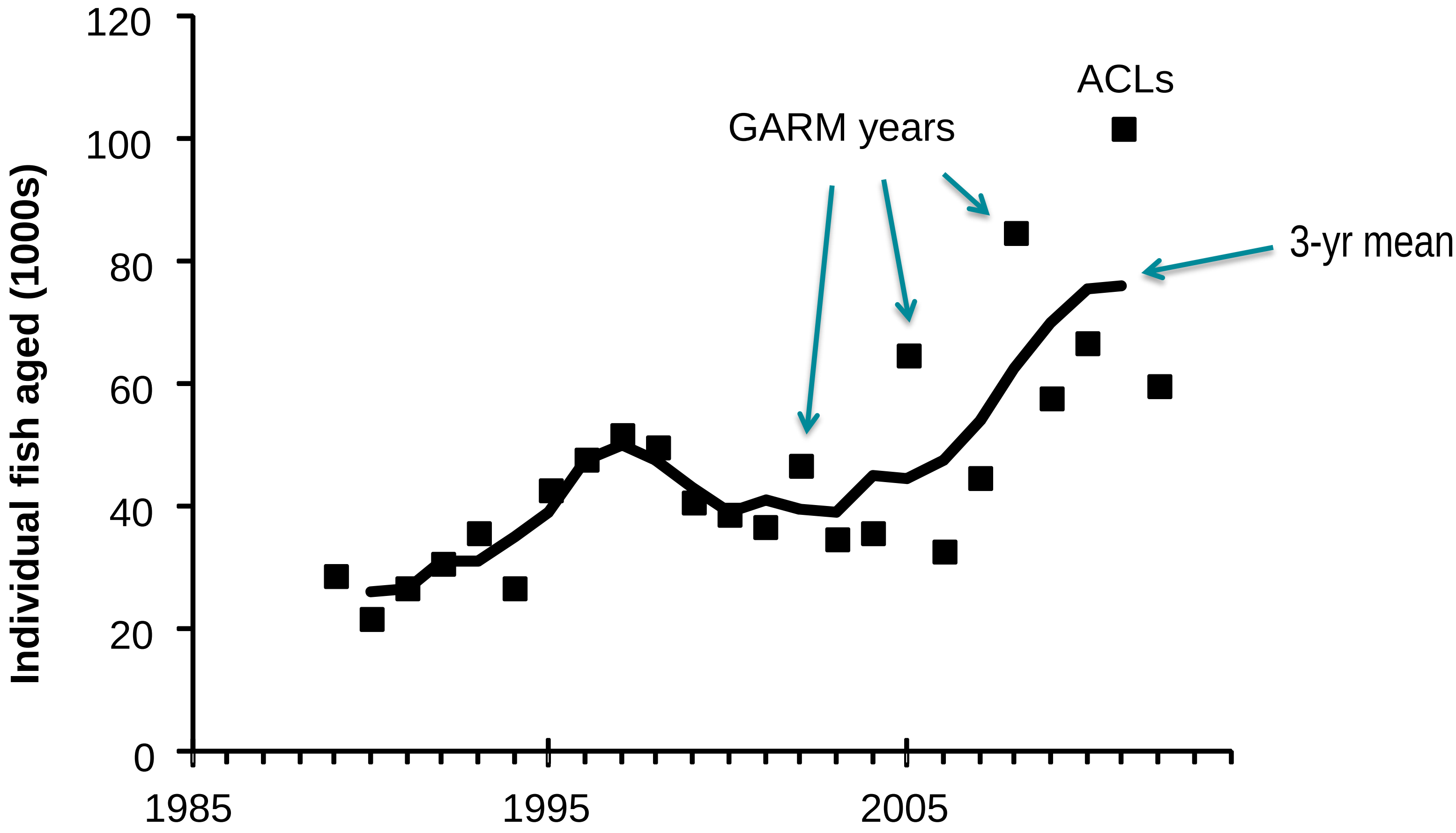
Impressed scale (l) and sectioned otolith (r) of haddock : Baumann et al.(2013) Trans. Am. Fish. Soc. 142:184–192



Roll press image: Arnold (1951) Prog. Fish-Cult. 13: 11-16

Benetec sectioning system
www.nefsc.noaa.gov/fbp/sectioning.htm

Production aging (1989-2012)
22-102 K individuals of 8-19 species per year



Data from NAFO reports (Does not include ages for constituents, workshops or exchanges, or QA/QC exercises)

How have we increased quantity?

More staff

- Funded contractors

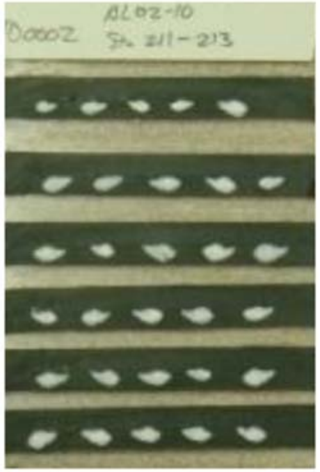
Technology upgrades

- FSCS 2.0, bar coding

Equipment upgrades

- 3 Isomet (3" blade) saws
- 2 Benetec (6" blade) saws
- Additional scopes, microfiches, chairs, etc.

Following the samples with bar codes



Batch embedding, sectioning, & reading otoliths; direct data entry at microscope

How have we increased quality?

More expertise

- Expand Annual Stock Assessments-funded contractors focus on processing

FSCS 2.0, bar coding

- FSCS sample selection; bar codes reduce errors at all steps

Switch to otoliths

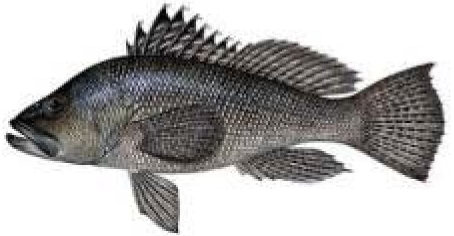
- When it improves accuracy or precision (usually of older ages)

Broad use of QA/QC practices

- Training, standard methods, testing, etc.

→ The last two elements slow down production

Cost/benefit comparison



Scales (*n* = 20)

Impressed = 40 min

Read = 15 min

***Total 230 hrs**

Loose scales, set on laminate, ready to impress

Otolith (*n* = 20)

Sectioned = 90 min

Read = 10 min

***Total 415 hrs**

Whole otoliths, unsectioned

*Test sample of 20 black sea bass; average number of black sea bass processed each year = 5000
Does not include time extracting otoliths, which takes longer than removing scales (Robillard et al. in review)

QA/QC – Age data

Quality Assurance (Accept the method)

- Standardization & Documentation
- Validation (accuracy)
- Training & Certification
- Inter-reader tests for repeatability (precision)

Quality Control (Accept the sample)

- Inspection of data
- Intra-reader tests for repeatability (precision)

QA: Standards & documentation

NOAA Technical Report NMFS 72 December 1988

Age Determination Methods for Northwest Atlantic Species

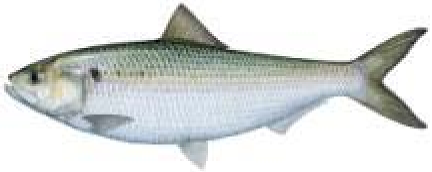
Judy Penttila
Louise M. Dery (editors)

http://www.nefsc.noaa.gov/publications/classics/penttila1988/

→ Allow for innovation
within a framework of best practices

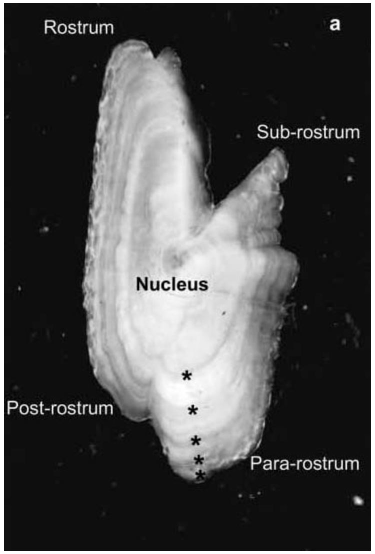
Updated manual: http://www.nefsc.noaa.gov/fbp/age-mannf.htm

QA: Age validation



Minimize process error

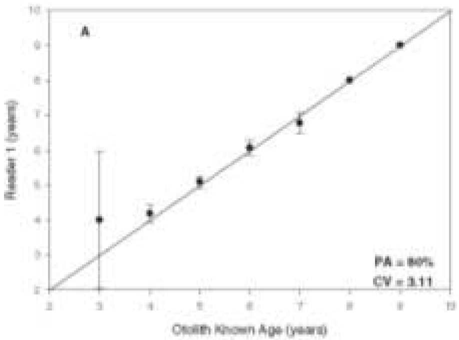
- Identify the 1st & last annulus
- Periodicity of other rings



American shad whole otolith
* annuli

→ Validate early and often

Build reference collections



American shad annulus counts vs. known age

Validation study: Duffy et al. (2012) Trans. Am. Fish. Soc. 141: 1664-1671

QA: Training and certification

Minimize interpretation error

Mentoring, continuity of staffing, & networking

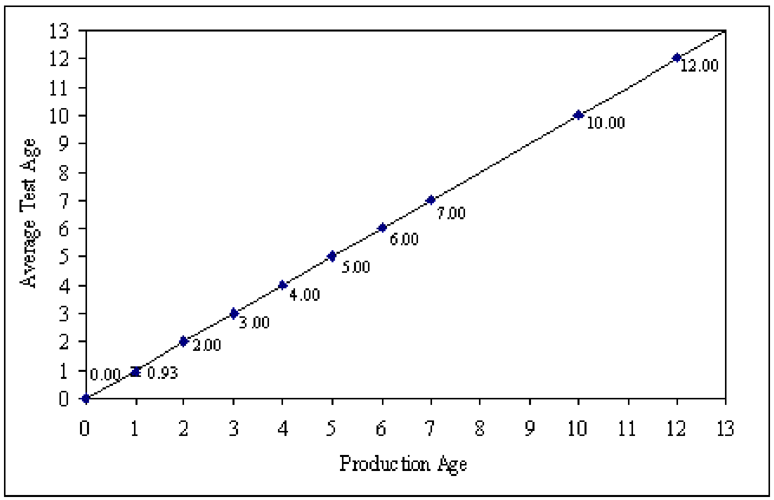
- Age sample exchanges
- Aging workshops
- Age-related conferences
- Build and share reference collections
- Report best practices

Reading otolith samples with a dissecting scope

→ A reader must meet acceptable levels before starting production aging

Precision tests (intra-reader QC example)

Species:	Haddock	Test Type:	Precision
Sample Source:	2010 Autumn Survey (201004)	Age Reader:	SJS
Date Completed:	January 2011	Sample Size:	110
CV:	1.29%	Agreement:	99.1%

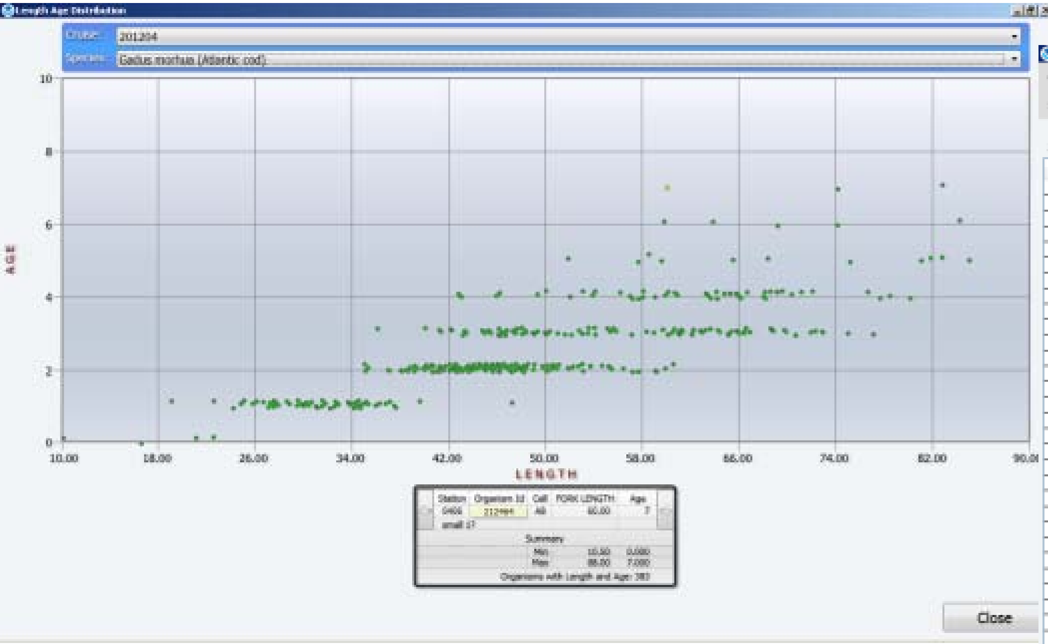


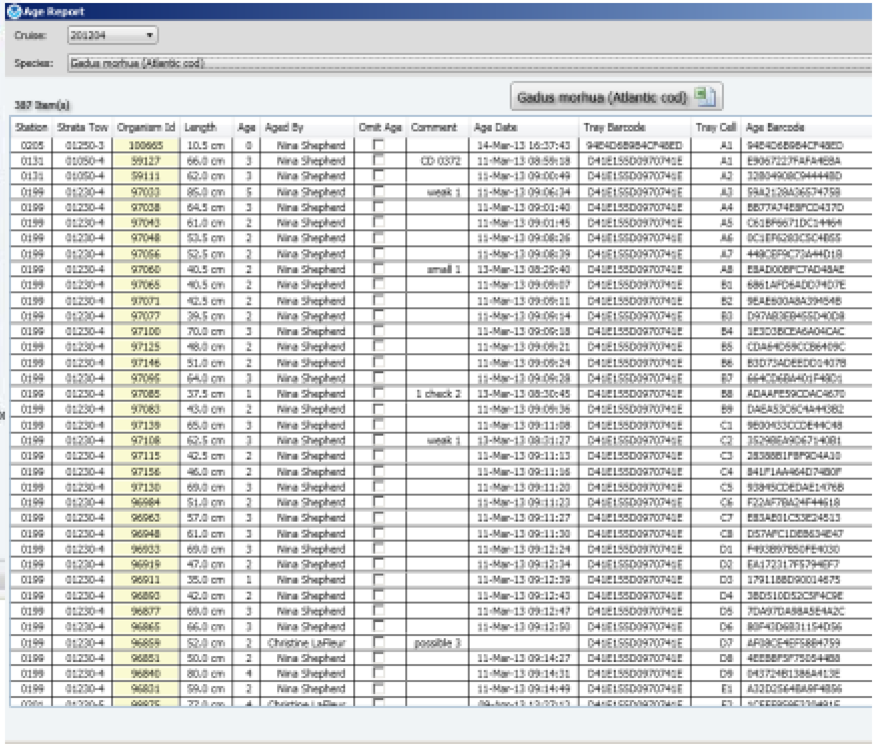
Prod Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
0	21	1																22
1		13																13
2			5															5
3				5														5
4					4													4
5						11												11
6							3											3
7								41										41
8																		
9																		
10											2							2
11																		
12													4					4
13																		
14																		
15																		
16																		
Total	21	14	5	5	4	11	3	41			2		4					110

→ Methods, readers, and subsamples are continuously tested.

Results available from: http://www.nefsc.noaa.gov/fbp/QA-QC/index.html

QC: Inspecting the data



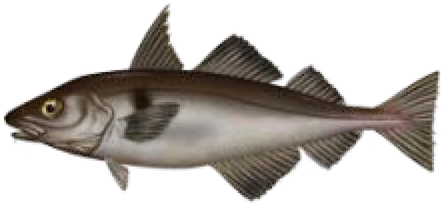


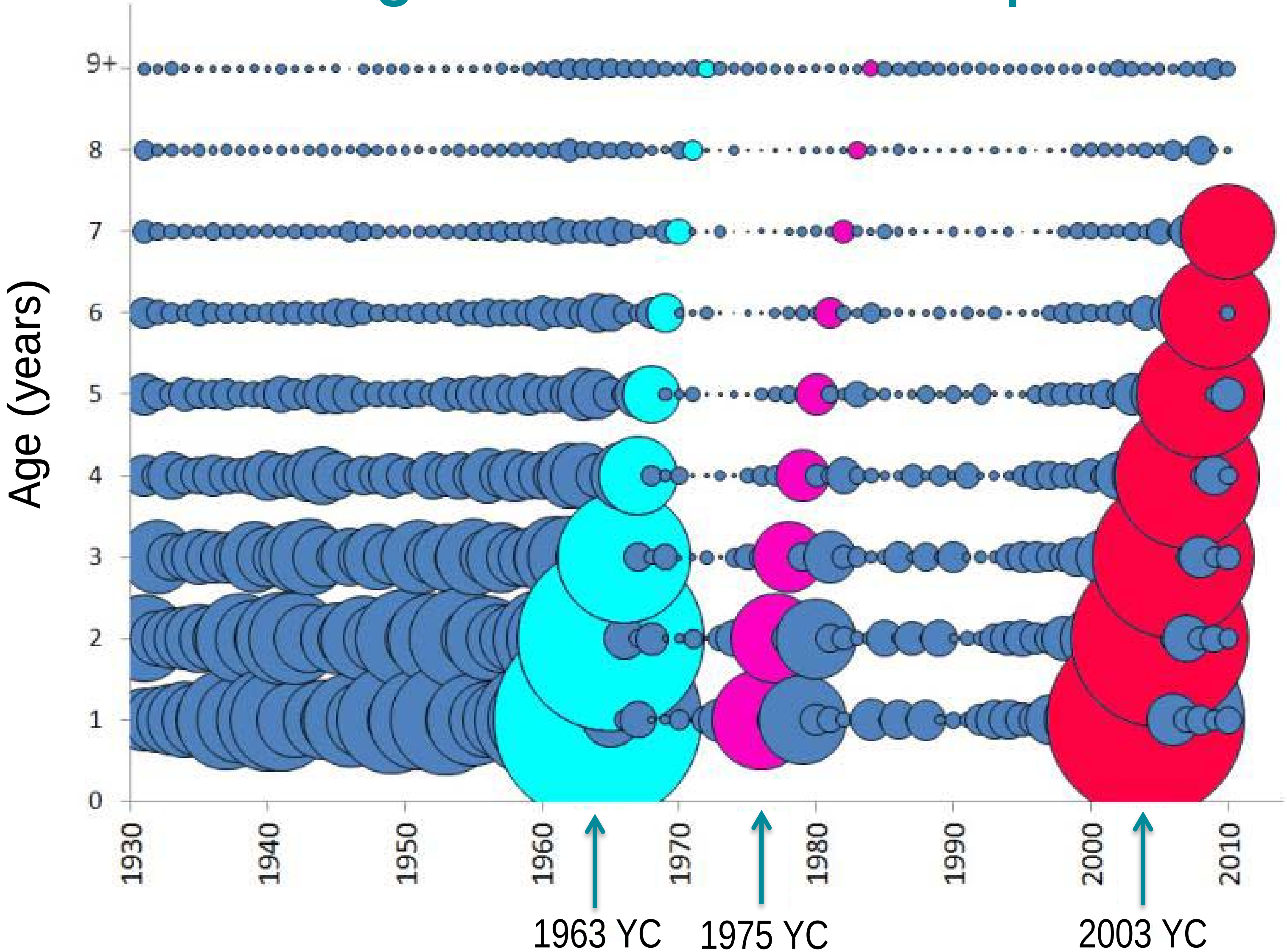
→ Using custom-designed software we can ask:

"Are these ages reasonable?"

and quickly re-evaluate outliers

Result: Age-based model output



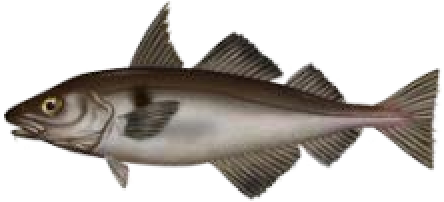


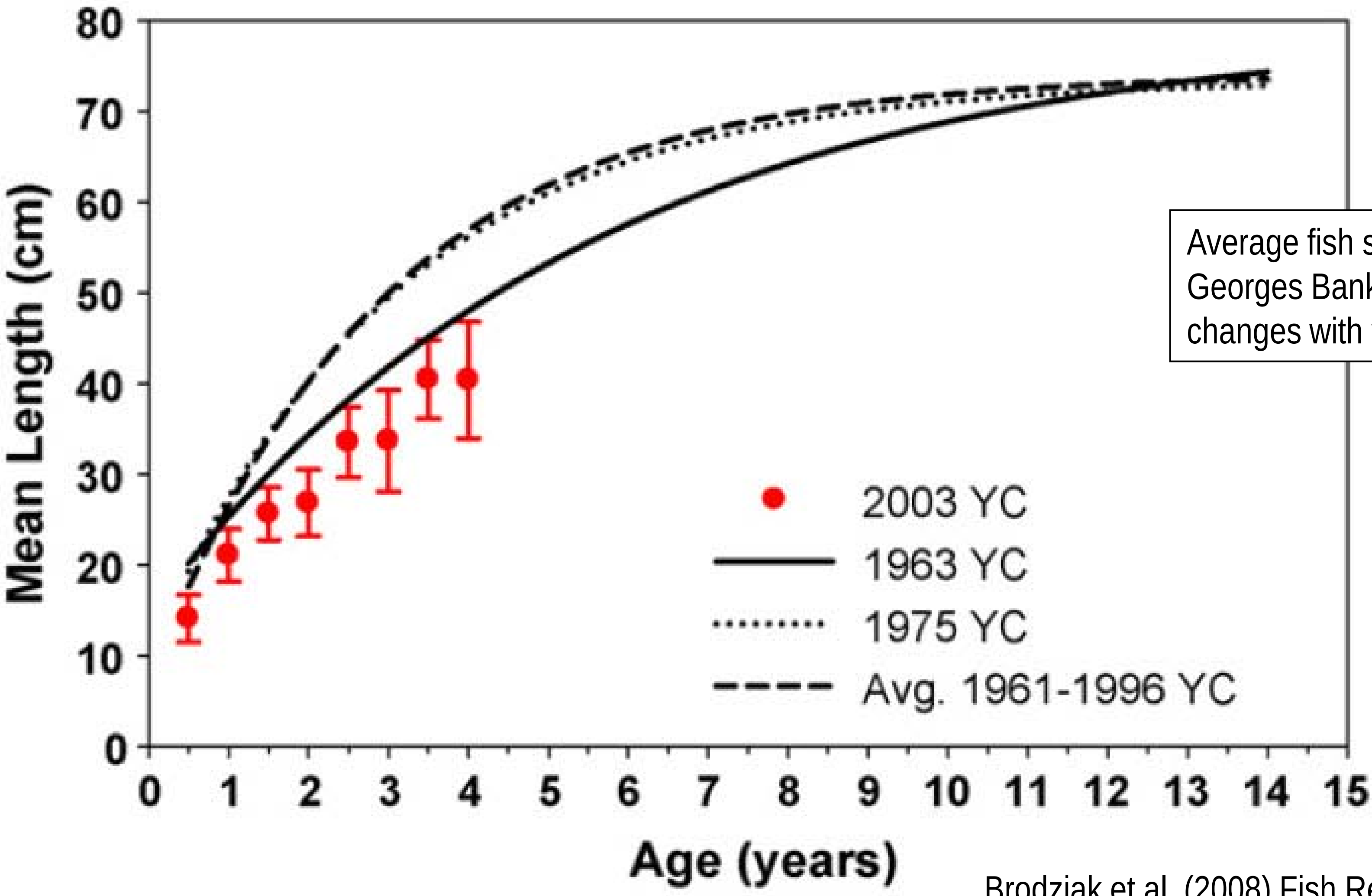
Haddock (Georges Bank) Abundance at age 1931-2010

3 strong year classes (YC):
- 1963
- 1975
- 2003

VPA model estimates: NOAA Fisheries, NEFSC unpublished data

Result: haddock growth dynamics





Average fish size at age of Georges Bank haddock changes with year class (YC)

Brodziak et al. (2008) Fish.Res. 94: 123-132

Sex & maturity classifications (2012)

0.8 scientists, 3.0 contractors

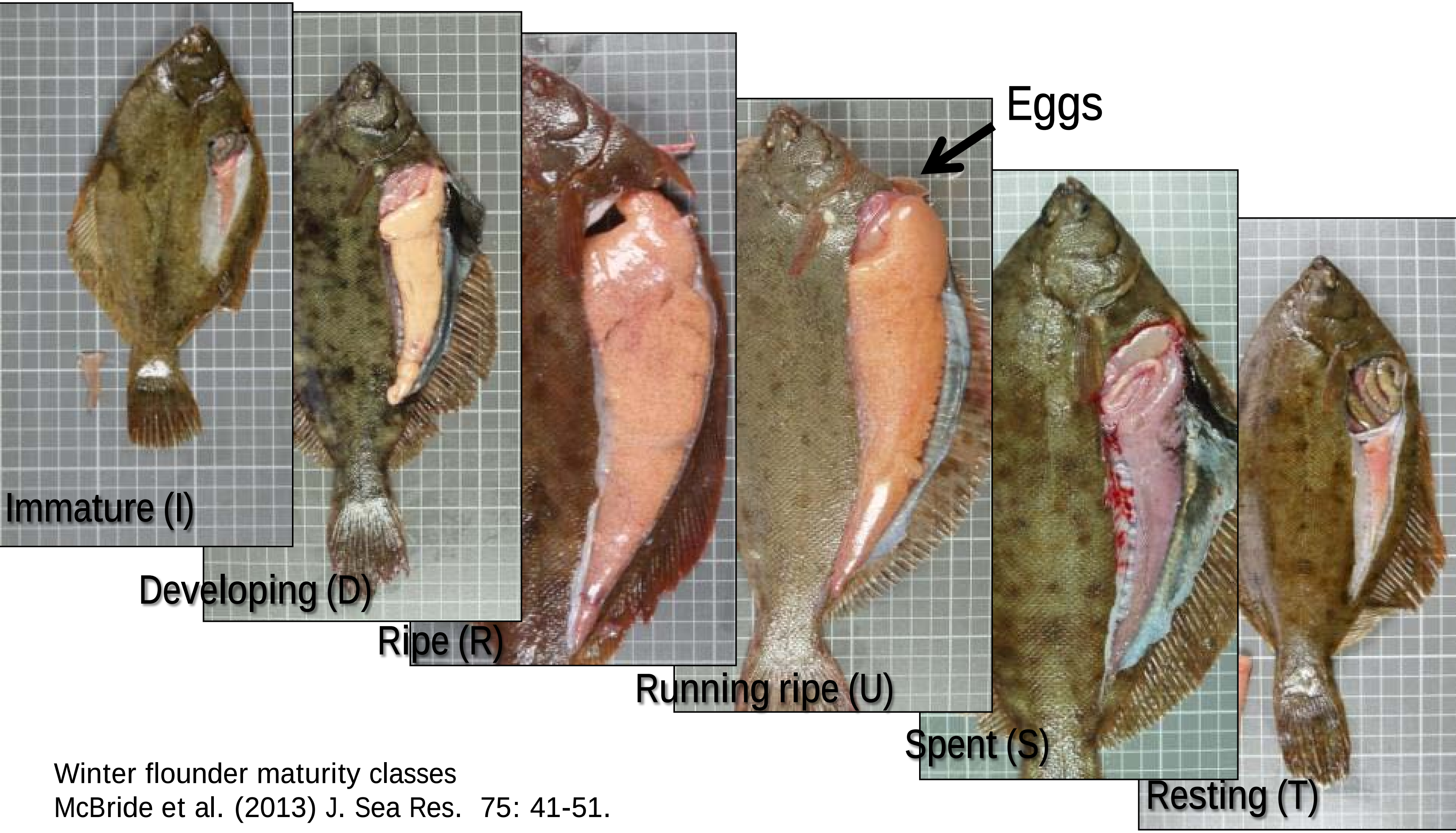
Plus sea-going staff, who make maturity classifications aboard the spring and autumn groundfish surveys (FSV Bigelow)

2012 sex determinations
74 species, 46,089 individuals

2012 maturity determinations →
31 species, 34,170 individuals

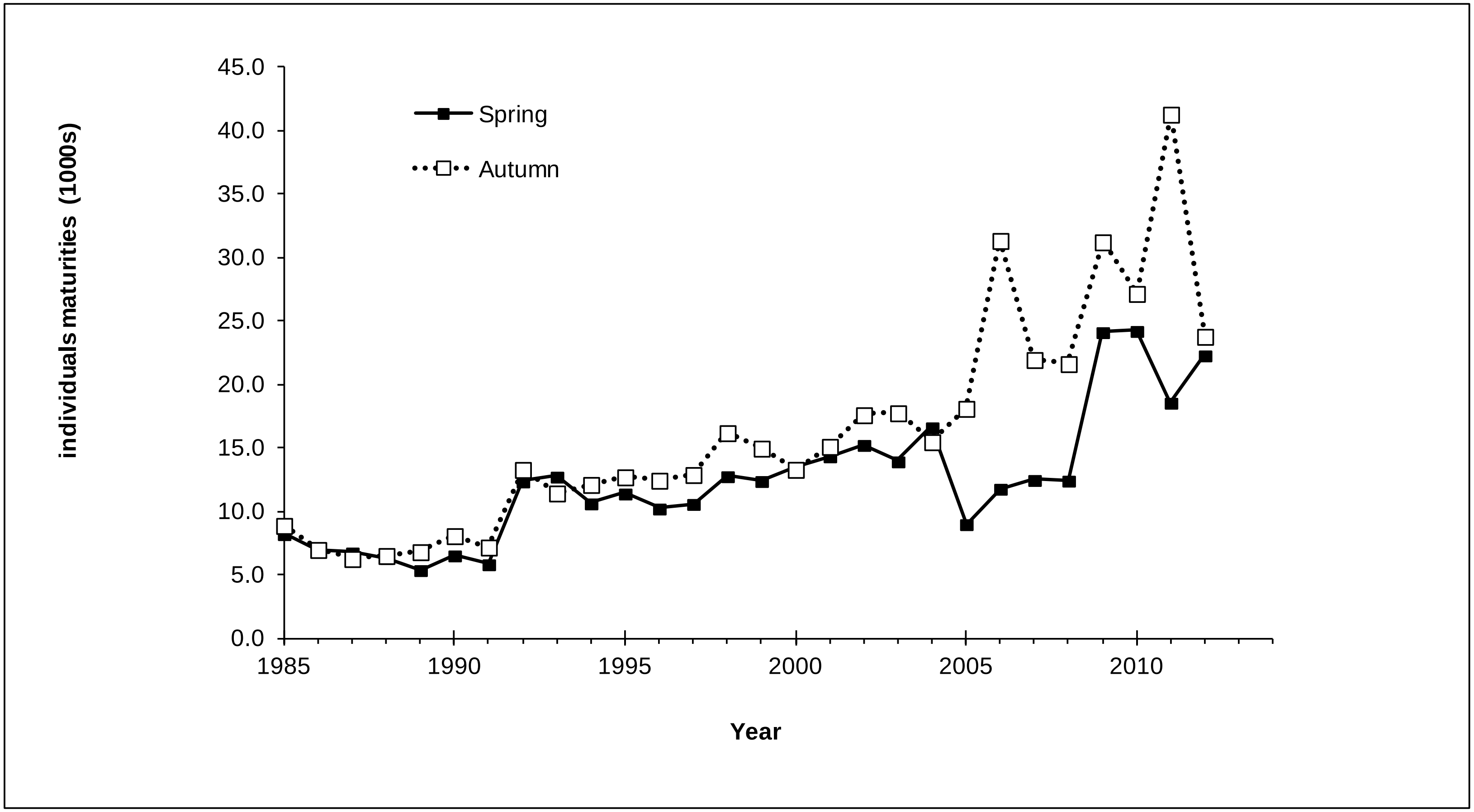
Species	Spring	Autumn
Acadian Redfish	903	1,176
American Plaice	935	751
Atlantic Cod	866	386
Atlantic Croaker	33	323
Atlantic Halibut	37	28
Atlantic Herring	1,417	888
Atlantic Mackerel	581	128
Atlantic Wolffish	26	3
Black Sea Bass	169	334
Bluefish	9	188
Butterfish	946	692
Cusk	8	5
Fourspot Flounder	301	350
Goosefish	629	612
Haddock	1,194	807
Northern Shrimp	0	3,484
Ocean Pout	264	117
Offshore Hake	123	153
Pollock	150	213
Red Hake	953	747
Scup	182	453
Silver Hake	1,354	1,256
Spotted Hake	235	329
Striped Bass	42	3
Summer Flounder	617	560
Weakfish	29	193
White Hake	711	817
Windowpane	565	610
Winter Flounder	1,208	1,065
Witch Flounder	694	482
Yellowtail Flounder	1,076	760
Total	16,257	17,913

A primer in macroscopic maturity classification



Winter flounder maturity classes
McBride et al. (2013) J. Sea Res. 75: 41-51.

Maturity classifications by year (1985-2012)



QA/QC – Sex and maturity data

Quality Assurance (Accept the method)

- Standardization & Documentation
- Validation (accuracy)
- Training & Certification
- Inter-reader tests for repeatability (precision)

Quality Control (Accept the sample)

- Inspection of Data
- Intra-reader tests for repeatability (precision)

QA: Standards & documentation

NOAA Technical Memorandum NMFS-F/NEC-76

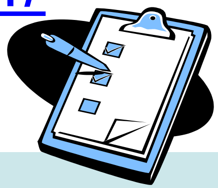
This TM series is used for documentation and timely communication of preliminary results, interim reports, or special purpose information, and has not undergone external scientific review.

Finfish Maturity Sampling and Classification Schemes Used during Northeast Fisheries Center Bottom Trawl Surveys, 1963-89

Jay Burnett, Loretta O'Brien, Ralph K. Mayo, Jeffrey A. Darde, and Margot Bohan

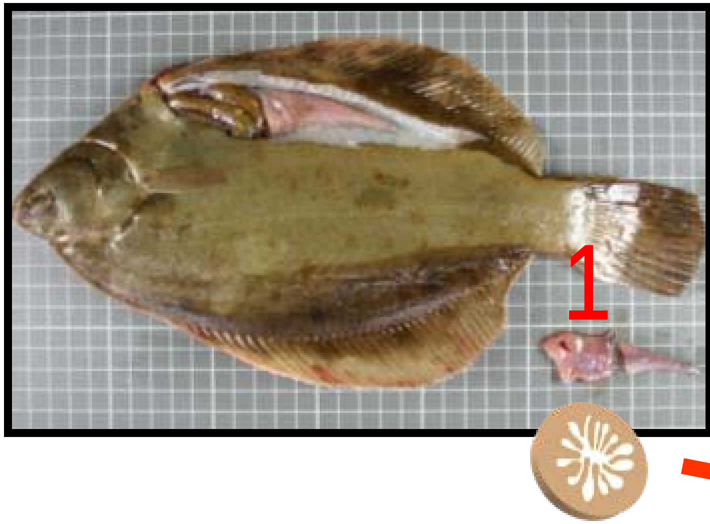
Woods Hole Lab., National Marine Fisheries Serv., Woods Hole, MA 02543

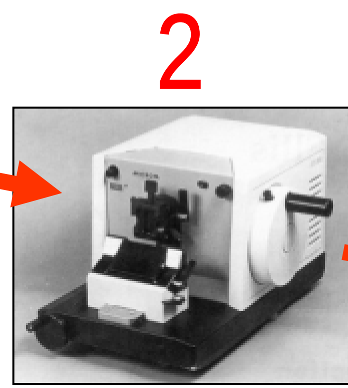
http://nefsc.noaa.gov/publications/tm/pdfs/tmfnec76.pdf/

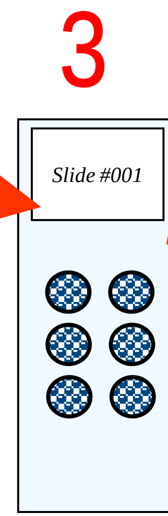


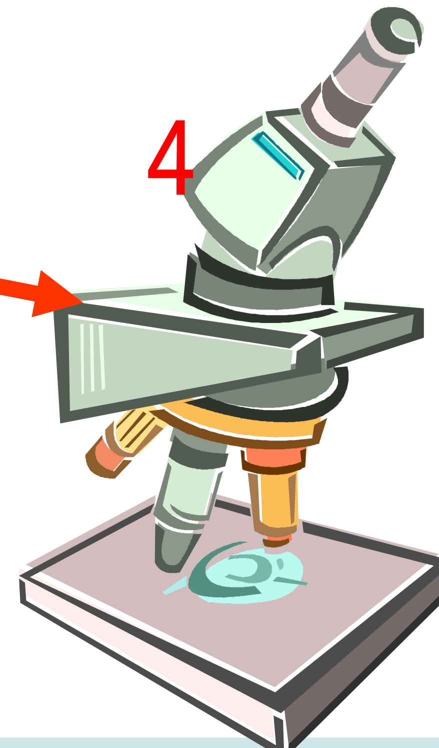
See also: http://www.nefsc.noaa.gov/publications/classics/pdfs/obrien1993.pdf

QA: gonad histology for validating at-sea methods









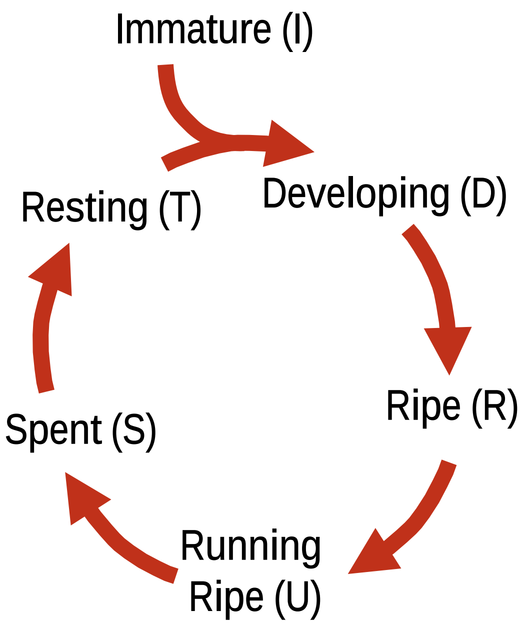
1. Excise, dehydrate
2. Thin-section (Microtome)
3. Stain & mount
4. View at 40-100 X

QA: Can macro-characters classify correctly?

Histol. class	Macroscopic class I	D	R	U	S	T
I	189	1	1	0	4	52
D	0	114	1	1	0	0
R	0	1	5	1	0	0
U	0	0	3	2	0	0
S	1	1	0	0	43	21
T	6	0	0	0	51	82

Numbers of flounder classified by each method (paired comparisons)
87% agreement (correct mature)

McBride et al. (2013) J. Sea Res. 75: 41-51



Cost/benefit comparison

Macroscopic

Cutting < 1 min

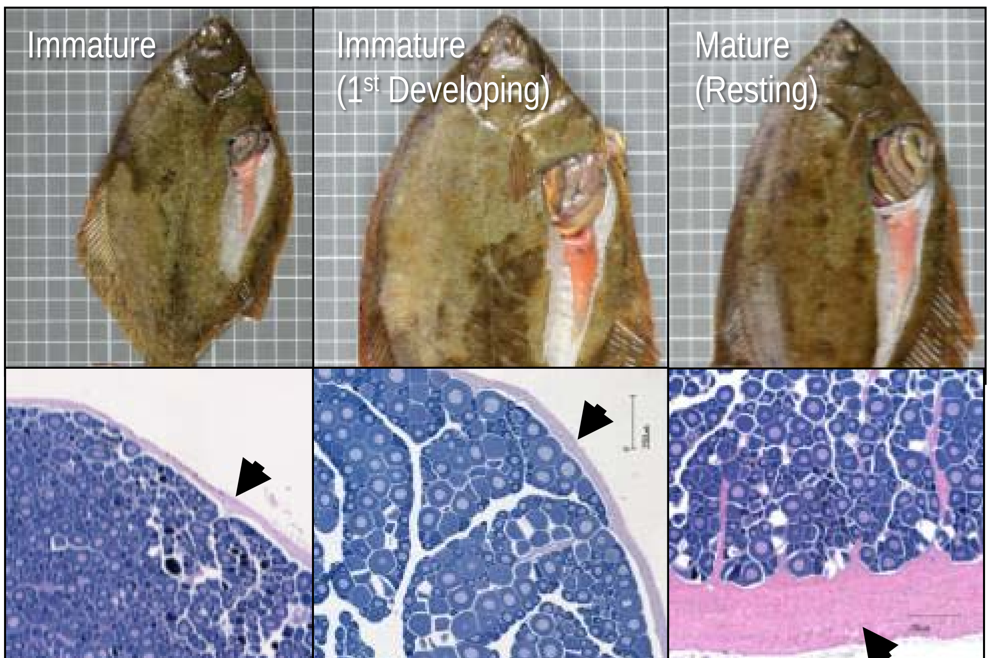
Classification < 1 min

Histology

Preparation < 5 min

Outsourced $8/slide

Classification < 5 min



Paired comparisons
(same fish)
Macroscopic vs.
gonad histology

McBride et al. (2013) J. Sea Res. 75: 41-51.

QA: Training and certification

Minimize interpretation error

Mentoring, networking

- Post-cruise workshops (6 planned annually)
- Build and share reference images (collaboration with ESB)
- Reproduction-related conferences
- Report best practices

Reference image: a ‘ripe & running’ female haddock

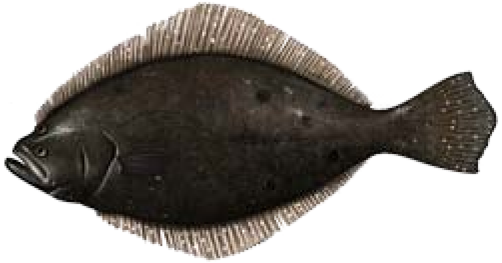
→ Criteria and acceptable levels of error are an active area of investigation

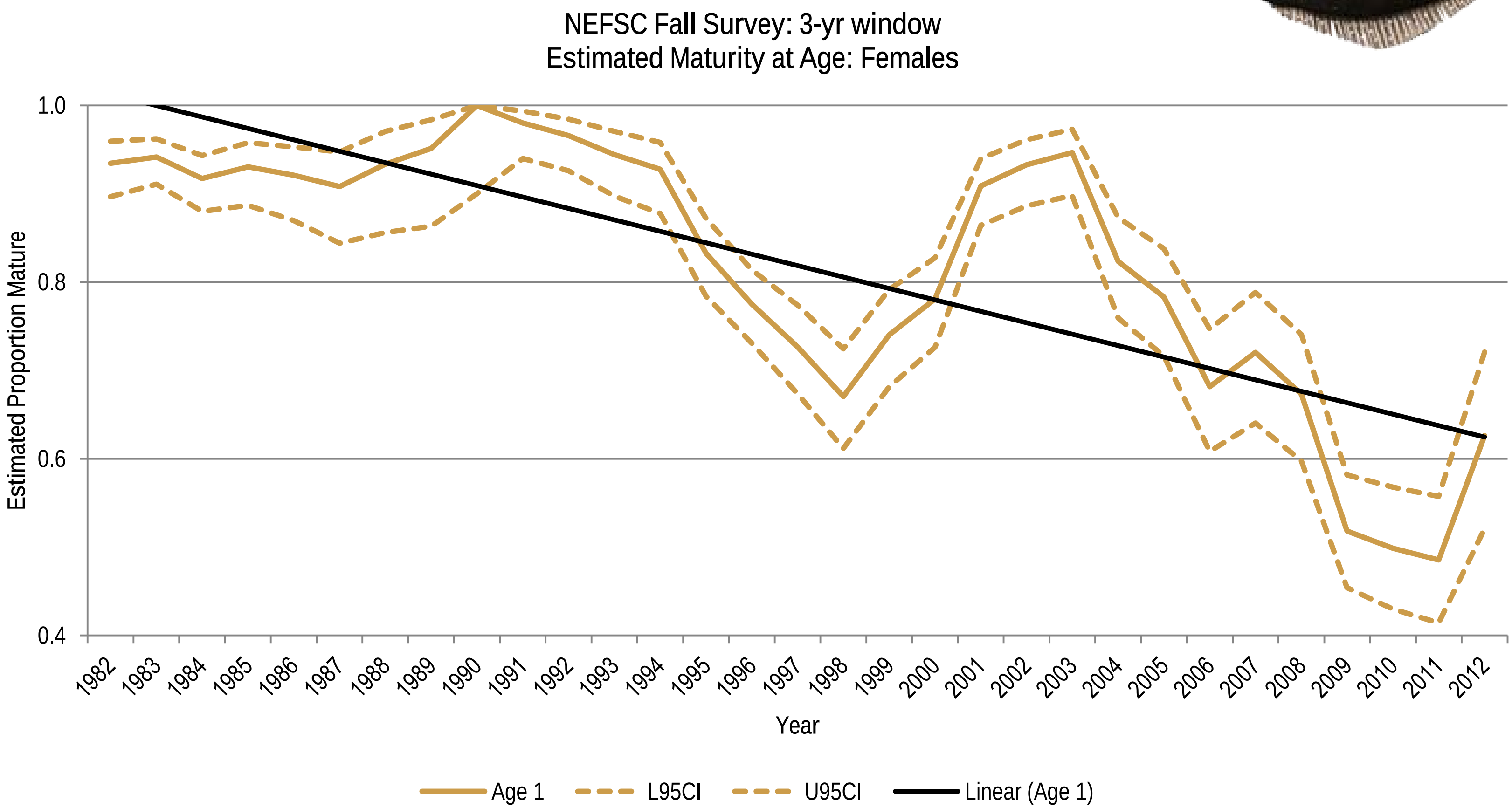
QC: Inspecting the data

Common Name	Middle Atlantic	Females L50	Females Range	Males L50	Males Range	S. New England	Females L50	Females Range	Males L50	Males Range
Alewife	Mar-Apr(APR)	31	25-34	28	24-32	Mar-Apr(APR)	31	25-34	28	24-32
Bass, Black Sea		19	15-31	19	16-28		19	15-31	19	16-28
Bluefish	May-Aug(JUL)	35		35		May-Aug(JUL)	35		35	
Butterfish	May-Sep(JUN-JUL)	12	10-15	11	10-15	May-Sep(JUL)	12	10-15	11	10-15
Cod	Nov-Apr(MAR-APR)					Nov-May(NOV-MAR)				
Cusk						Apr-Jul(APR-MAY)				
Flounder, Am Plaice	Mar-May					Feb-Jun(APR-MAY)				
Flounder, Fourspot	Apr-Nov	28	25-31	26	23-30		28	25-31	26	23-30
Flounder, Summer	Sep-Dec(OCT-NOV)	28	17-38	25	14-40	Aug-Nov(OCT)	28	17-38	25	14-40
Flounder, Windowpane	May-Nov(MAY&SEP)					May-Nov(SEP)	21	17-27	22	18-25
Flounder, Winter	Mar-May(MAY)	28	21-35	29	22-32	Feb-May(FEB-MAR)	28	21-35	29	22-32
Flounder, Witch	Apr-Aug(MAY-JUN)					Apr-Aug(MAY-JUN)				
Flounder, Yellowtail	Mar-Aug(MAY)					Apr-Aug(MAY-JUN)	26	21-32	20	18-29
Goosefish	Jun-Sep	42	30-60	37	30-50		42	30-60	37	30-50
Haddock	Feb-May					Jan-May(MAR-APR)				
Hake, Red	Mar-Oct(JUN-JUL)	25	15-32	24	15-33	Mar-Oct(AUG-SEP)	25	15-32	24	15-33
Hake, Silver	Apr-Oct(SEP)	23	17-33	23	17-31	Apr-Oct(JUN)	23	17-33	23	17-31
Hake, White	Oct-Apr(DEC-FEB)					Oct-Mar(DEC-FEB)				
Herring, Atlantic	Aug-Oct					Oct-Dec(OCT)	25	23-28	25	23-28
Mackerel, Atlantic	Apr-Jun(APR-MAY)	26	23-31	26	23-34	Apr-Jun(MAY)	26	23-31	26	23-34
Pout, Ocean	Sep-Oct					Sep-Oct(OCT)	31	24-45	32	25-50
Pollock	Oct-Mar(DEC-JAN)					Oct-Mar(DEC-JAN)				
Redfish	May-Aug					Apr-Jul(MAY-JUN)				
Sculpin, Longhorn	Nov-Feb	21	18-26	21	18-26		21	18-26	21	18-26
Scup	May-Aug(MAY-JUN)	16	12-18	16	12-18	May-Aug(MAY-JUN)	16	12-18	16	12-18
Tilefish		50	40-65	60	40-80		50	40-65	60	40-80
Weakfish	May-Jul	30	21-39	28	20-42		30	21-39	28	20-42

→ Ask: “*Are these estimates reasonable?*”

Result: Maturity dynamics

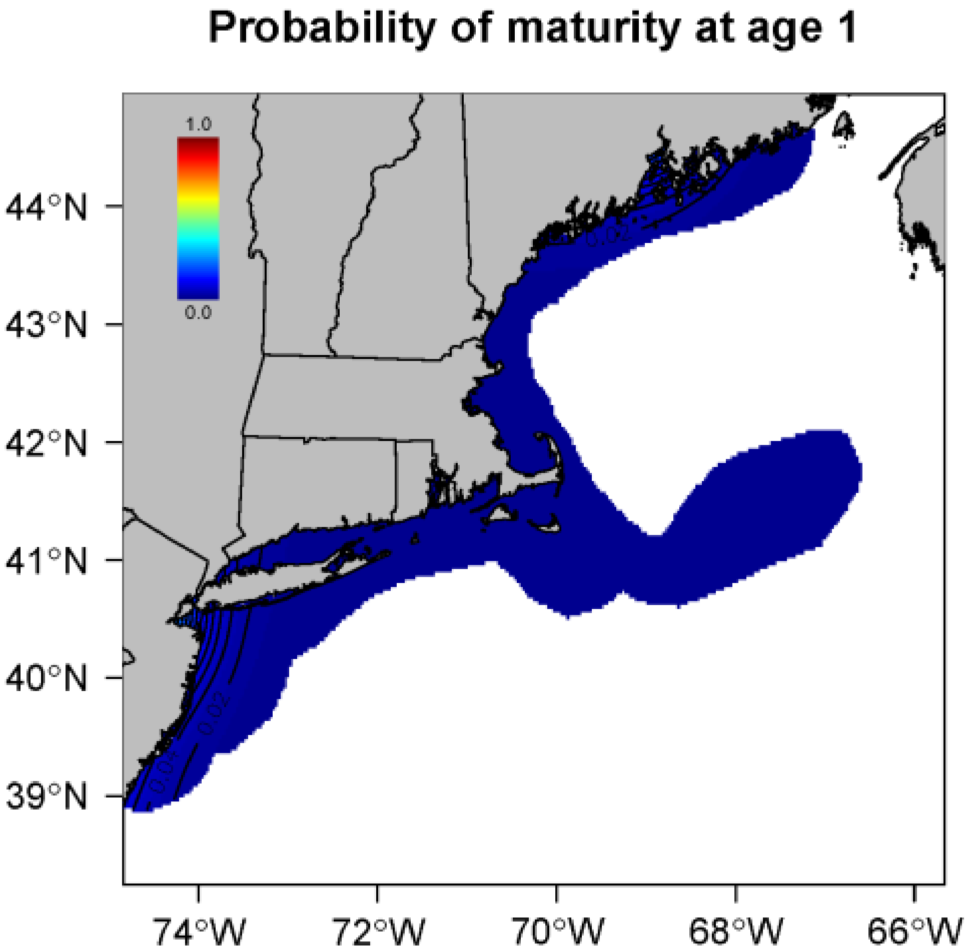




Estimated female maturity of summer flounder at age 1, by 3-year moving window and sex. Solid line is a fit linear trend.

Terceiro (2013) Biological data for summer flounder. SDWG Working Paper A1.

Repro-based model output



GAM model of spatial variation in female winter flounder maturity (movie)

M. Winton, unpublished
(NOAA HAIP funded)

Summary

Production (10,000s fish processed each year)

- Coordination of several large programs (i.e., the parfait model)
- Internal coordination, too: track, audit, sort, stage, & archive LOTS of boxes
- Immediate use for stock assessment
- A growing – in numbers and value – archive of samples and data

QA/QC (quality over quantity)

- Train, test, repeat
- Building & sharing our expertise and reference collections

Improving processes (unlike funding, this is in our control)

- Testing new methods, equipment, & organizational networks
- Attend related conferences, reporting best practices

Research & development

- Develop new products for regional assessments
- Exploring spatial and temporal life history dynamics
- Repurpose archived samples or data, typically in partnership with academia
- Process-oriented research of marine ecosystems

Strengths

Personnel

- Knowledgeable, experienced, and productive
- A critical mass of age sample processors and readers

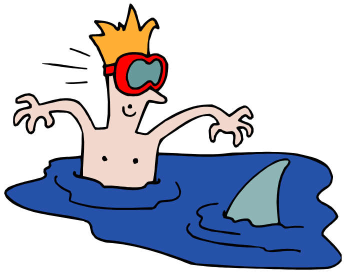
Throughput and processing

- Using, developing, sharing, and reporting best practices
- A priceless archive of samples and data
- Life history traits are dynamic so continued monitoring is a strength
- A global leader in life history data generation, both quantity and quality

Demand

- Meeting the constant cycle of hard deadlines for stock and ecosystem assessments

Challenges



Personnel and budgeting

- Hiring freezes and CRs stymie planning for success
- Contractors are important staffing elements, but their funding is uncertain

Throughput and processing

- Only fishery-independent sources use FSCS for sample selection & bar codes for tracking
- There are limits to improving efficiencies (e.g., ACLs) 
- The decentralized nature and lagging investments in reproductive data
- Gonad histology is a small fraction of macroscopic determinations
- Quality often costs more

Demand

- More ages and reproductive data are requested but funding lags
- Need lead-time and coordination from NRCC

Proposed solutions

Funding

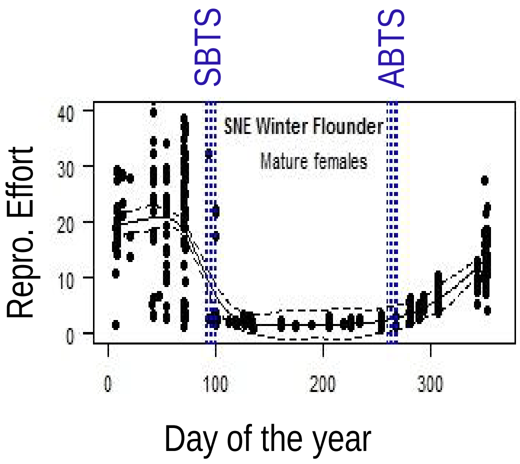
- 7-8K ages / technician: “how fast do you want to go?”
- More funds to expand R&D for age validation, reproductive QA/QC, life history dynamics, & new inputs into assessments
- Spend less and get less precise assessment results (adjust at ACL level)

Partnerships

- Continue both internally and externally to the Center and NMFS
- Strengthen the network of aging and reproductive experts

Purchase or develop new technologies

- Expand barcoding and eData systems (#1, port samples)
- There are many other new technologies – some off the shelf – to improve processes but these require investments (i.e., new otolith saws, image analysis, histochemical (gonad), microchemistry (otoliths), bio-impedence (energy), etc.



A new otolith saw?