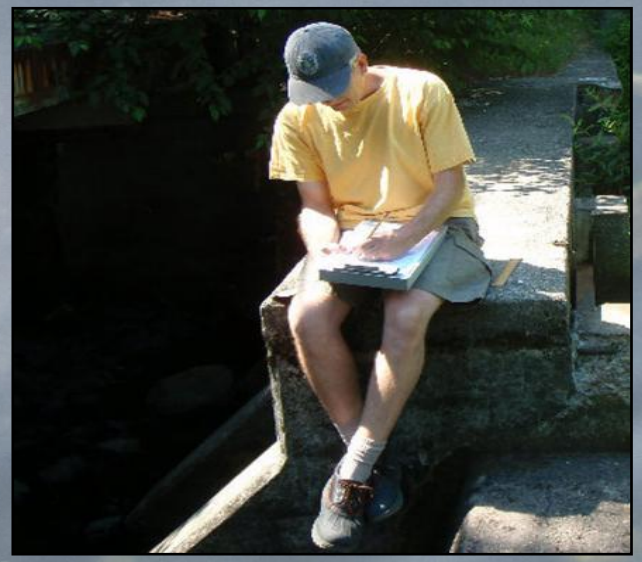
RESULTS AND LESSONS LEARNED USING THE DMF VISUAL COUNTING PROGRAM



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MarineFisheries
Commonwealth of Massachusetts

Presented at the University of Massachusetts, Dartmouth
(March 12, 2025)

CONTENTS

Volunteers count river herring entering Upper Mystic Lake

1. WHAT'S IN A VISUAL ESTIMATE?

1. Visual count estimates are not a true estimate of the total population or run size

2. Estimates derived from visual counts are indices of relative abundance

   • Why?
   - Counts conducted during a specified daily observation period (i.e. 12-hrs)
   - Estimates extrapolated based on sample observations

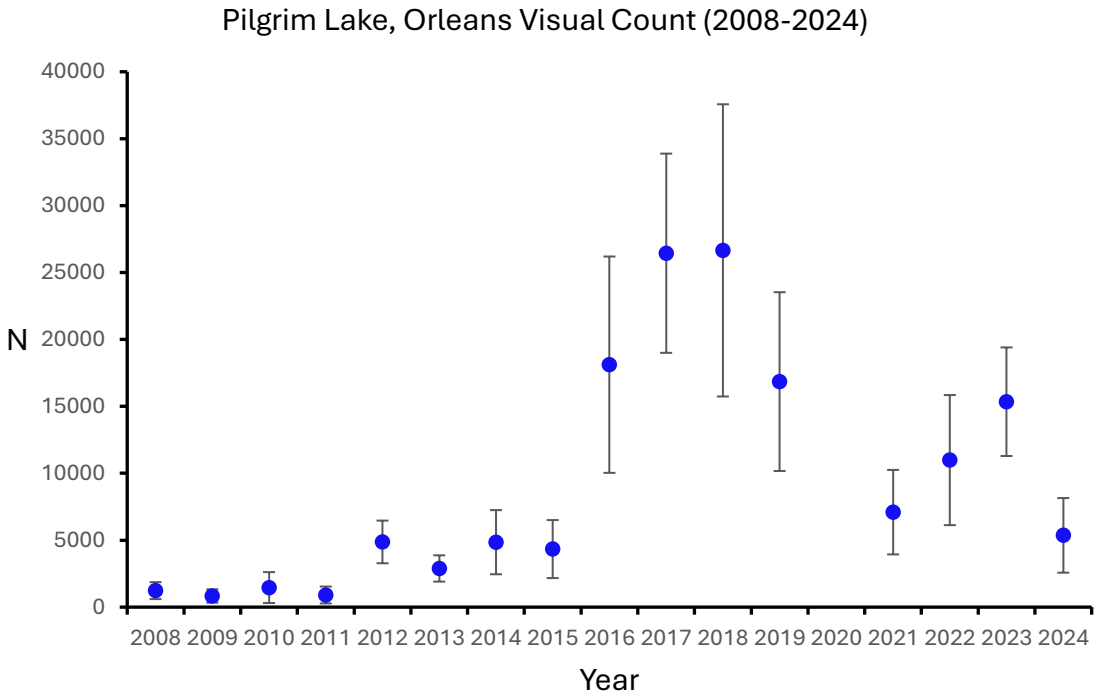
      • Higher Variance, SE in comparison to ERC, video monitoring

   - Subsamples of counts conducted randomly within daily observation period

      • **Reduces bias:** Random sampling avoids unintentionally choosing individuals that might favor a certain outcome (skewed towards any specific group within a population)

      • **Statistical validity:** Allows for use of statistical methods to calculate confidence intervals and assess significance of findings

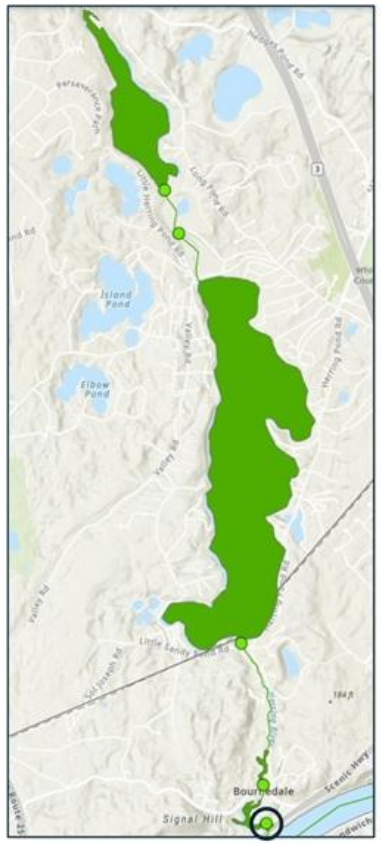
3. Indices of relative abundance can be tracked over time



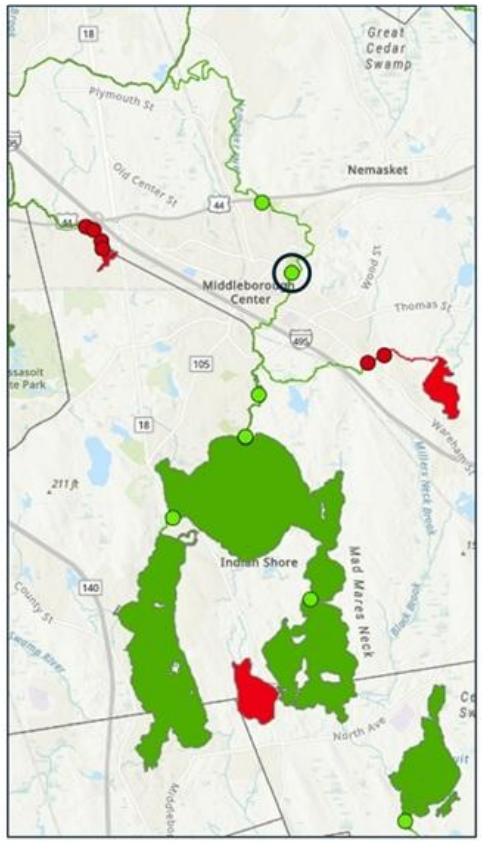
1. WHAT'S IN A VISUAL ESTIMATE? (cont.)

1. Estimates derived from visual counts are indices of relative abundance

2. Indices redefined based on counting location and method



A. Relative Abundance (Full Watershed)



B. Relative Abundance (Partial Watershed)

C. Relative Abundance (Restoration Response)

2. GOALS OF THE DMF VISUAL COUNTING PROGRAM (cont.)

1. DMF recommendations (2005 Herring Counting Workshop; Nelson 2006):

   • Counts conducted every day during the spring spawning season

   • Counting programs follow a 2-way stratified random sampling design
      - Counting duration: April 1 – June 15
      - 12-hr daily observation period: 7am – 7pm
      - 3 10-minute counts during each of three daily sub-periods (2W-3P: 7am – 11am; 11 am – 3pm; 3pm – 7pm)

   • Metrics to remain consistent year after year to reduce uncertainty
      - Count duration
      - Daily observation period
      - Count interval
      - Sampling intensity (for sampling design requirements)

Middleboro-Lakeville Herring Commission members conducting visual counts at the Wareham Street ladder (Nemasket River)

2. GOALS OF THE DMF VISUAL COUNTING PROGRAM

1. Establish a time series of indices of abundance that can be tracked over time to infer population trends

2. Produce scientifically and statistically defensible estimates

3. Establish long-term data sets for inclusion into state and federal (ASMFC) stock assessments, SFMPs, DMF Shad & River Herring Monitoring Technical Reports

Massachusetts river herring counting stations accepted for the ASMFC river herring management as stock assessment indices of abundance and/or Sustainable Fisheries Management Plans. Visual count stations are highlighted. Source: DMF Standard Operating Procedures for River Herring Counting (*in preparation*).

River	Town	Watershed	Count Method	Count Onset	Index of Abundance	Biological Data	SFMP
Parker River	Newbury	North Shore	Video	1997	X	X	
Mystic River	Medford	Boston Harbor	Visual/Video	2012	X	X	
Back River	Weymouth	Boston Harbor	Visual/Electronic	1986	X	X	
Town Brook	Plymouth	South Shore	Video/visual	2008	X	X	
Monument River	Bourne	South Shore	Electronic	1980	X	X	
Stony Brook	Brewster	Cape Cod	Visual/Electronic	2007	X		
★ Herring River	Wellfleet	Cape Cod	Visual	2009	X		
Agawam River	Wareham	Buzzards Bay	Electronic	2001	X		
Wankinco River	Wareham	Buzzards Bay	Electronic	2007	X		
Mattapoisett River	Mattapoisett	Buzzards Bay	Electronic	1988	X		
★ Nemasket River	Middleborough	Taunton River	Visual	1996	X	X	X
Herring River	Harwich	Cape Cod	Visual/Electronic	2009		X	X
Herring Brook	Pembroke	South Shore	Visual/Electronic	2015			X

3. DMF REVIEW/RE-ESTIMATION OF HERRING COUNTS

- In 2022, DMF conducted an internal review of all visual count data from all sites and for all years counted

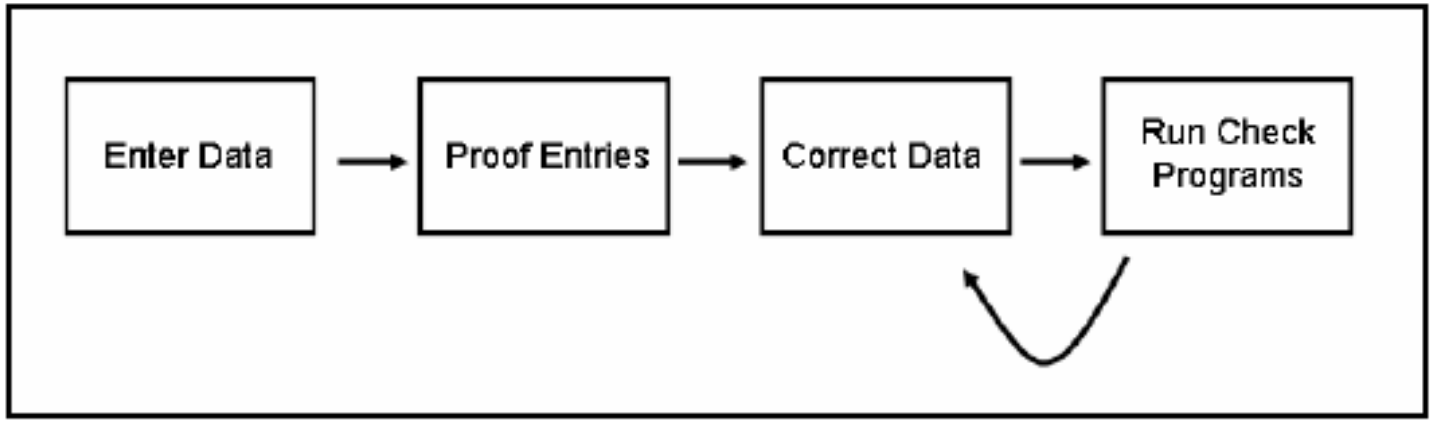
- Review was conducted to determine the reliability of estimates and identify datasets for potential inclusion into state and coast-wide stock assessments

    - i.e.) 2024 ASMFC River Herring Stock Assessment Update

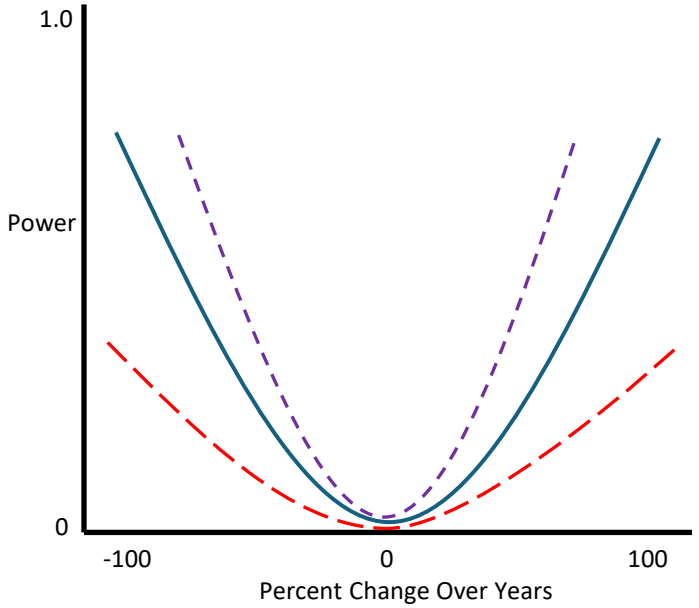
- Review to identify errors and inconsistencies in count metrics:

High school students participate in counting river herring in the Shawsheen River (Spring 2017)

3. DMF REVIEW/RE-ESTIMATION OF HERRING COUNTS (cont.)
QA/QC & SOURCES OF ERROR



Power Analysis



Power: The ability to detect changes when they are occurring.

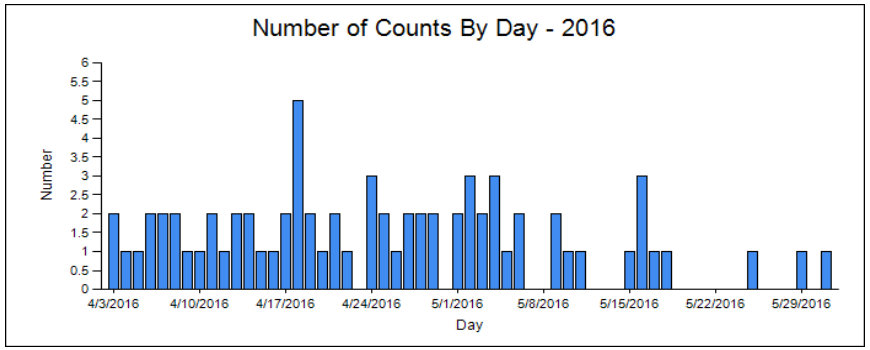
Related to:

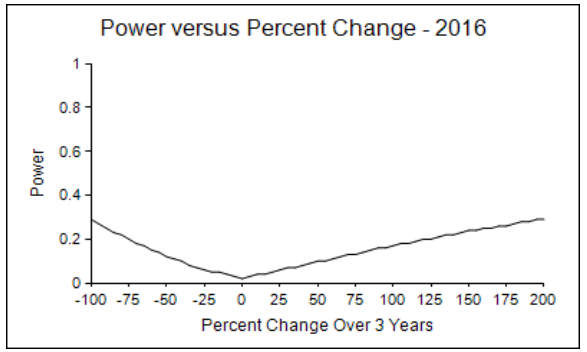
1. Natural variability in fish passing
2. Sample size taken to estimate daily totals
3. Significance (α) level
4. Size of change to be detected

As Power increases, the more likely change will be detected (Nelson 2006; Sokal and Rolfe 1981)

3. DMF REVIEW/RE-ESTIMATION OF HERRING COUNTS (cont.)

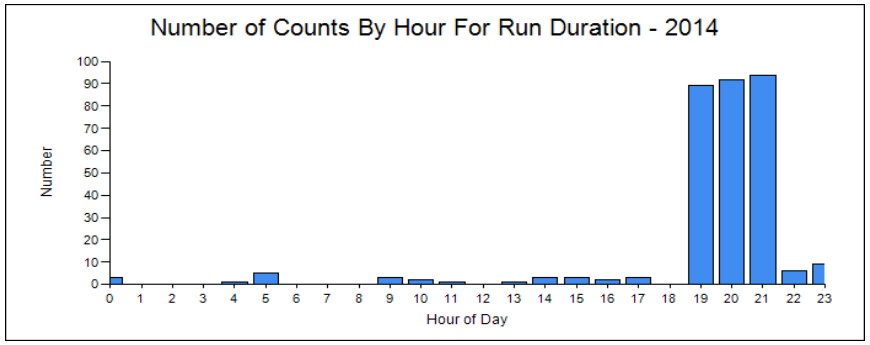
EXAMPLES: SOURCES OF ERROR IN ABUNDANCE ESTIMATION

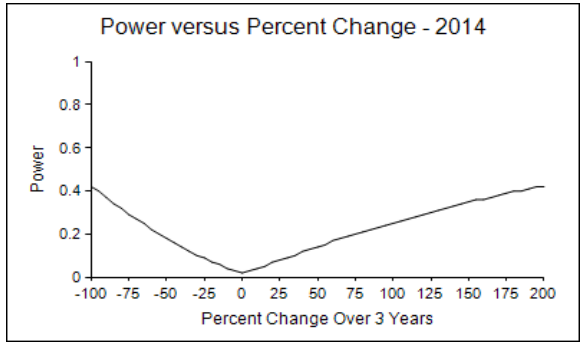




Low sample size (1-way design)

Several days of missing counts





Aggregate sampling

Counts concentrated within one period

Sparse number of counts in other periods

4. DMF REVIEW/RE-ESTIMATION OF HERRING COUNTS

Challenges in maintaining visual counting programs

1. Difficulty maintaining sampling intensity:

    - Adherence to sampling design
        - Minimum number of counts required for sampling design
    - Adherence to random counting schedule
        - Non-randomized (Aggregate) sampling
        - Over-weighting passage activity during certain periods
        - Increases variance and SE when extrapolated to estimate daytime passage
        - Mean passage (morning) = ≠ Mean passage (afternoon)
    - Days with insufficient and/or missing counts

2. Maintaining consistent metrics and strata over time:

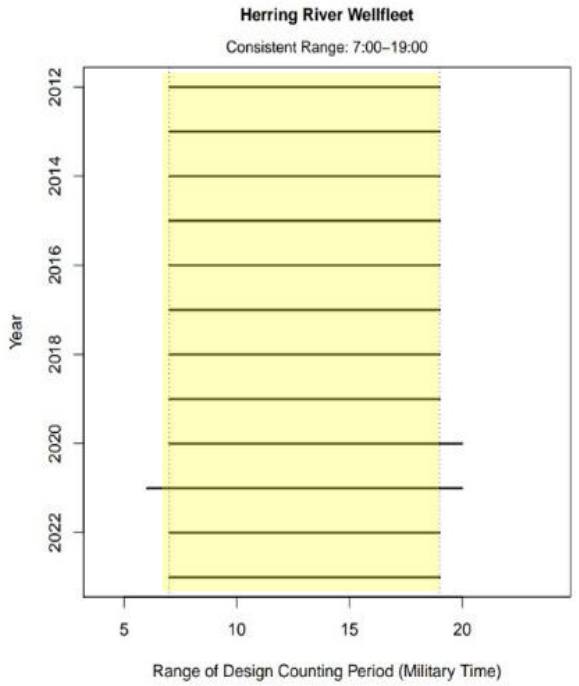
    - Count duration (Start / End Dates)
    - Daily observation period
    - Counting interval
    - Sampling intensity

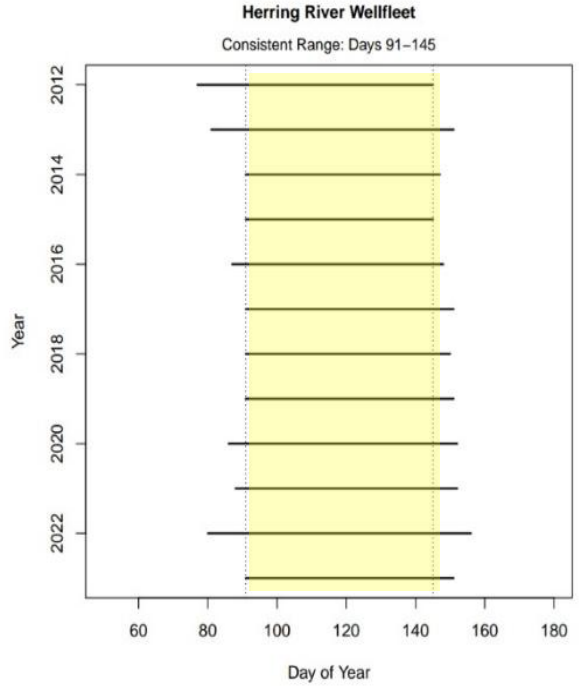
3. Inconsistent metrics = Inconsistent statistical sampling = ***UNCERTAINTY***

    - Uncertainty in identifying population trends (inconsistent sampling design) over time
    - Lower statistical power to predict probability of change in abundance over time

4. DMF REVIEW/RE-ESTIMATION OF HERRING COUNTS (cont.)

Example: Herring River, Wellfleet (2012 – 2023)





- Counts metrics were standardized for consistency
  - Start date
  - End date
  - Daily observation period
  - Count interval
  - Sampling design

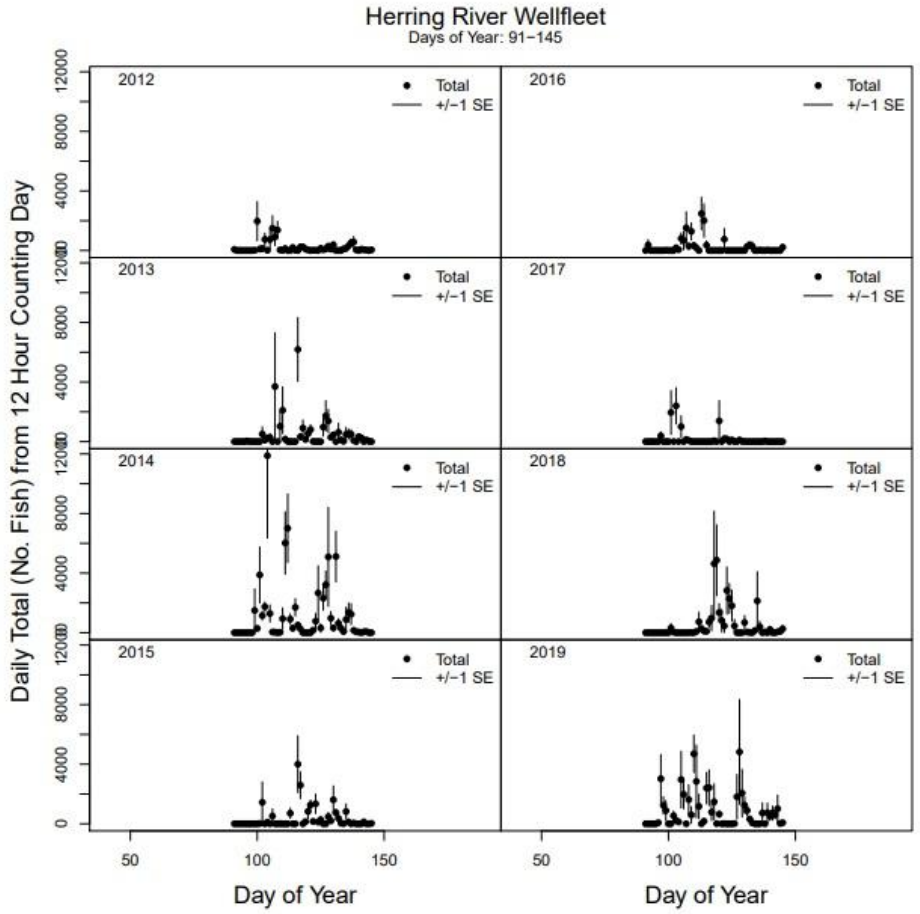
- Run sizes re-estimated using standardized count metrics
  - Some years removed

Herring River Wellfleet

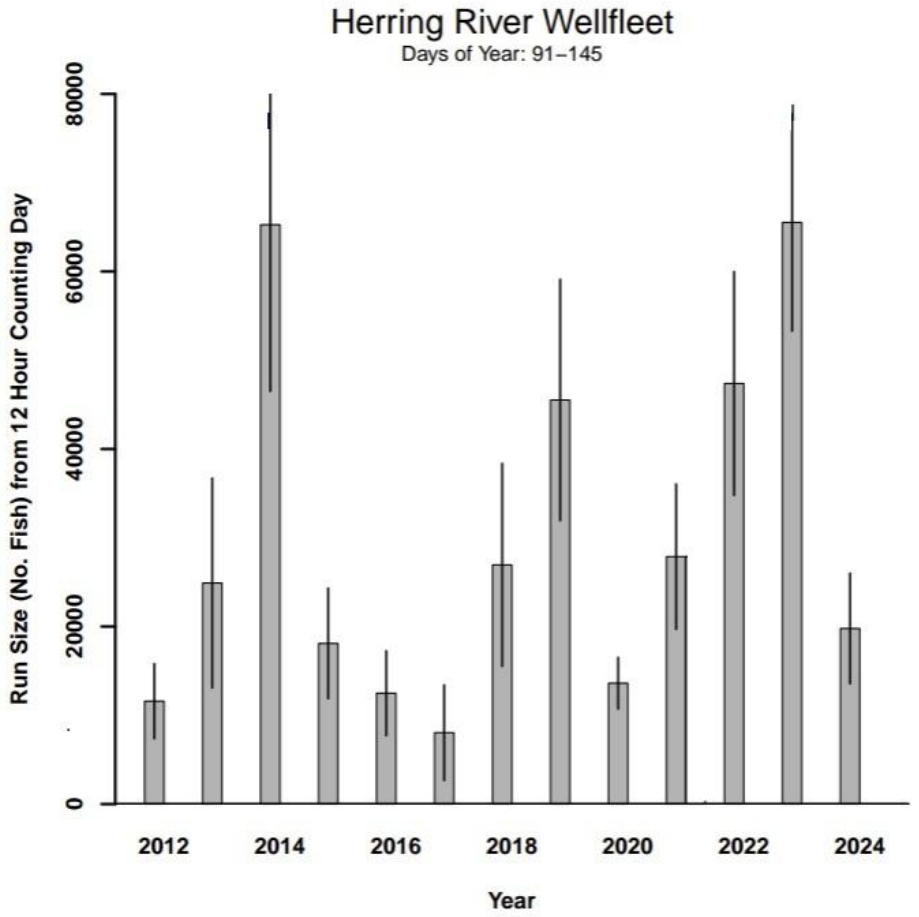
Year	First.Day	Last.Day	Length	Missing	Count.Days	One.Sample	P.Start	P.End
2012	77	145	69	0	69	1	07:00	19:00
2013	81	151	71	8	63	4	07:00	19:00
2014	91	147	57	0	57	2	07:00	19:00
2015	91	145	55	0	55	1	07:00	19:00
2016	87	148	62	0	62	1	07:00	19:00
2017	91	151	61	0	61	1	07:00	19:00
2018	91	150	60	0	60	0	07:00	19:00
2019	91	151	61	0	61	0	07:00	19:00
2020	86	152	67	0	67	4	07:00	20:00
2021	88	152	65	1	64	2	06:00	20:00
2022	80	156	77	0	77	0	07:00	19:00
2023	91	151	61	0	61	0	07:00	19:00

4. DMF REVIEW/RE-ESTIMATION OF HERRING COUNTS (cont.)

Example: Herring River, Wellfleet (2012 – 2023)



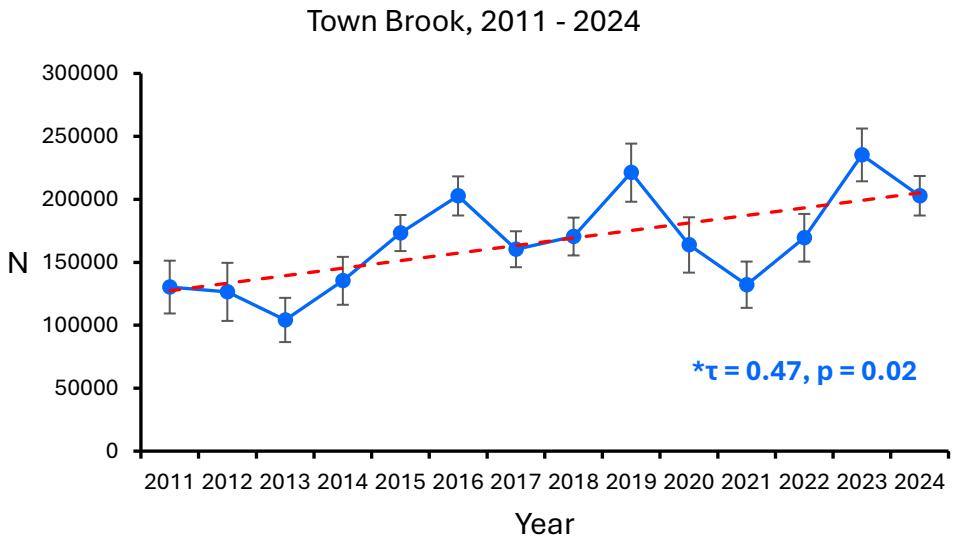
Re-estimated daily counts (DOY: 91 – 145)

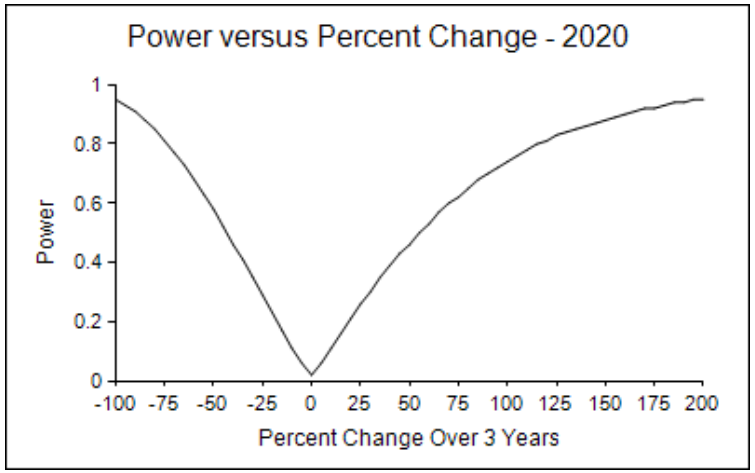


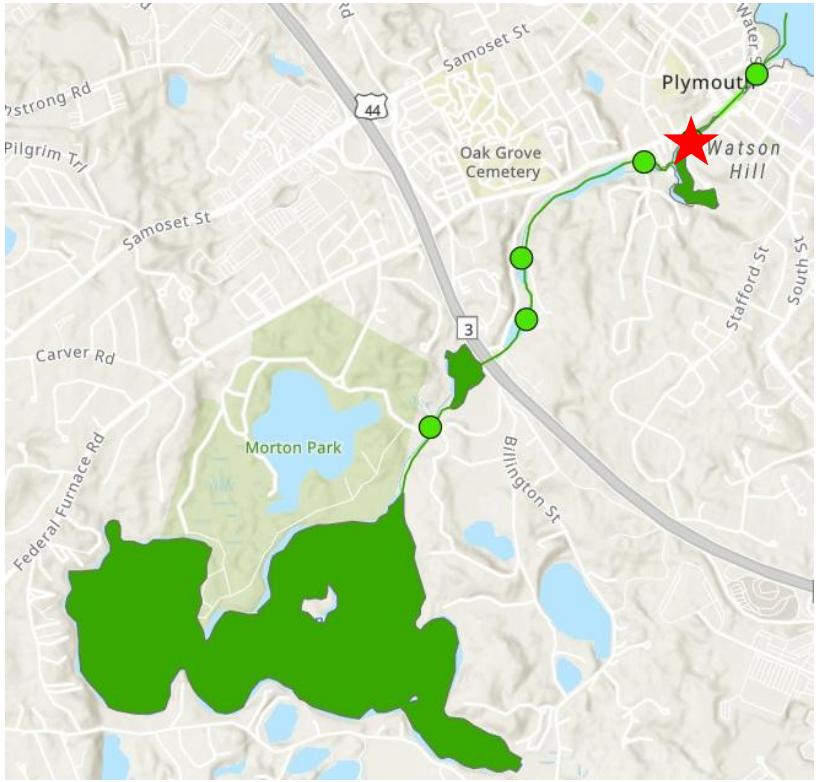
Re-estimated abundance estimates (DOY: 91 – 145)

4. DMF REVIEW/RE-ESTIMATION OF HERRING COUNTS (cont.)

Case Study: Town Brook, Plymouth



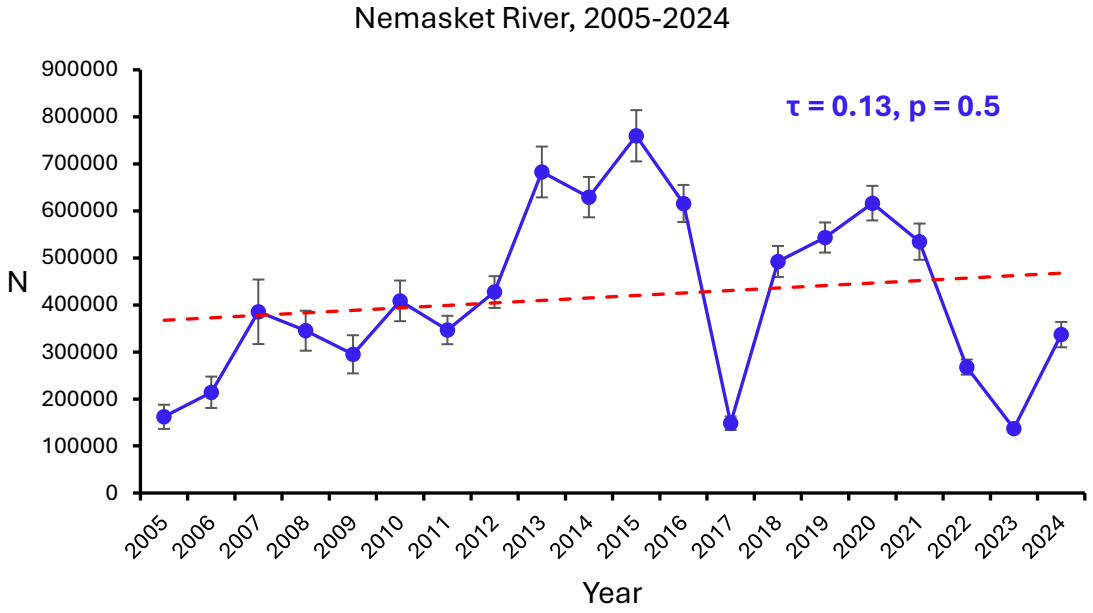


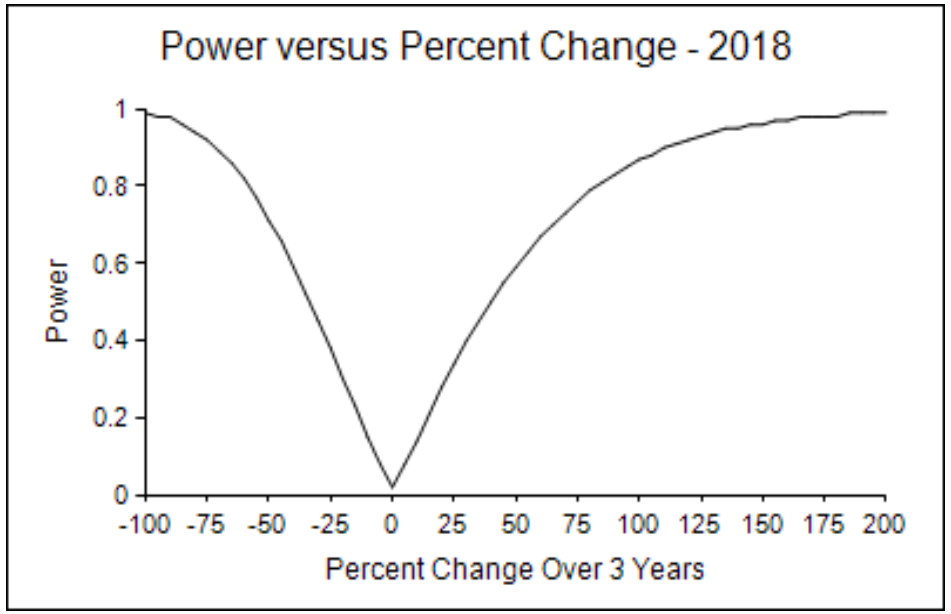


- 14-year time series (2011 – 2024)
- Counting location: Jenney Grist Mill Ladder (partial watershed)
- Counts conducted between 7am – 7pm
- Sampling conducted using 2W-3P sampling design
- Mann-Kendall (τ) indicates positive significant trend throughout monitoring period
- Good predictive power to detect change
- Visual counts augmented with video counts and biological sampling
- Data set included in 2024 ASMFC stock assessment

4. DMF REVIEW/RE-ESTIMATION OF HERRING COUNTS (cont.)

Case Study: Nemasket River, Middleborough

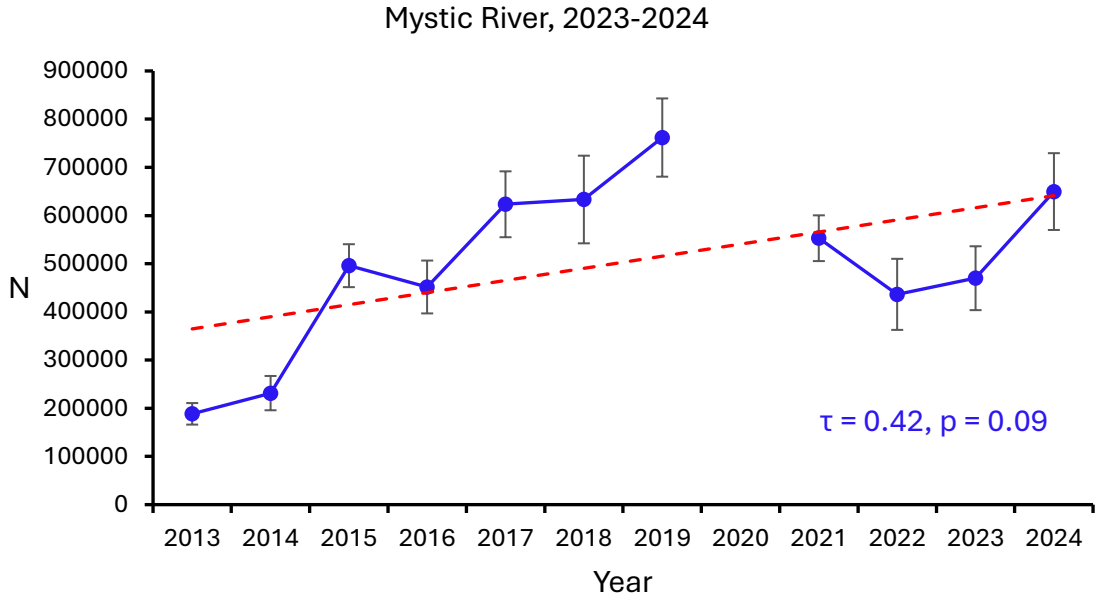


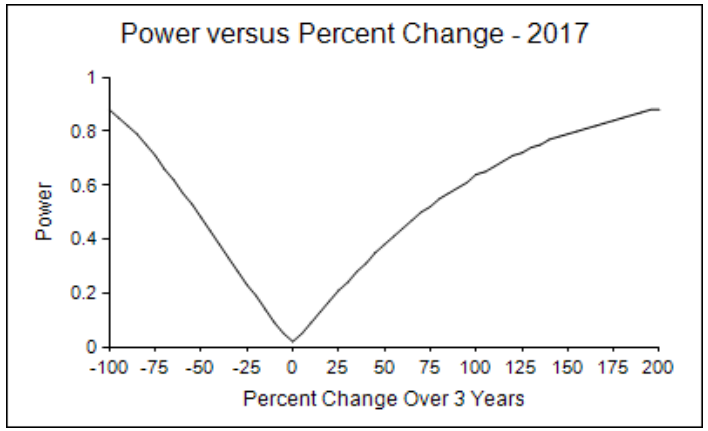


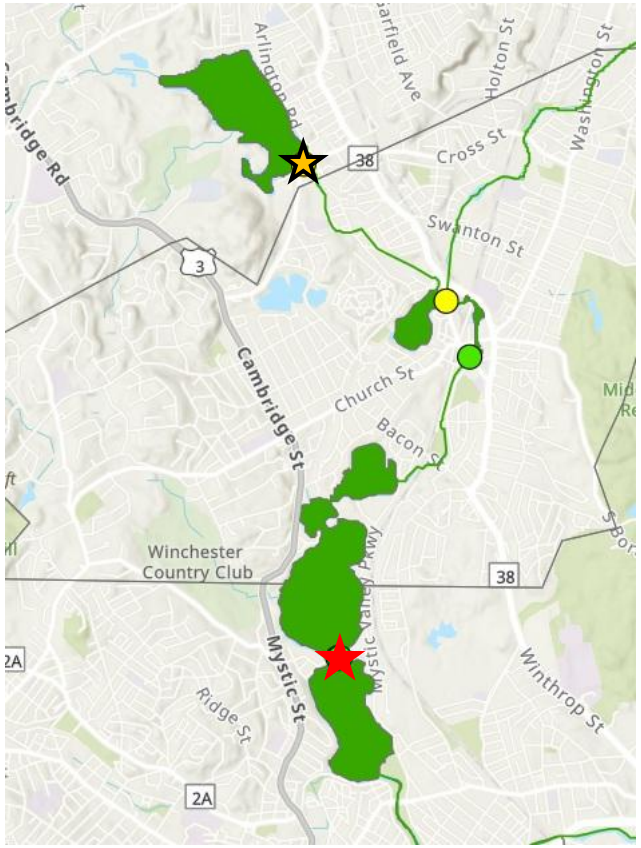
- Time series: 2005 – 2024 (20 years)
- Counting Location: Wareham St. Ladder (partial watershed)
- Counts conducted between 7am – 7pm
- Sampling conducted using 2-way, 2-period sampling design
- High predictive power to detect change
- Mann-Kendell test indicates insignificant positive trend
- Abundance data supplemented with biological sampling
- Included into ASMFC coast-wide stock assessment (2017, 2024)

4. DMF REVIEW/RE-ESTIMATION OF HERRING COUNTS (cont.)

Case Study: Mystic River, Medford / Horn Pond (Aberjona River, Woburn)





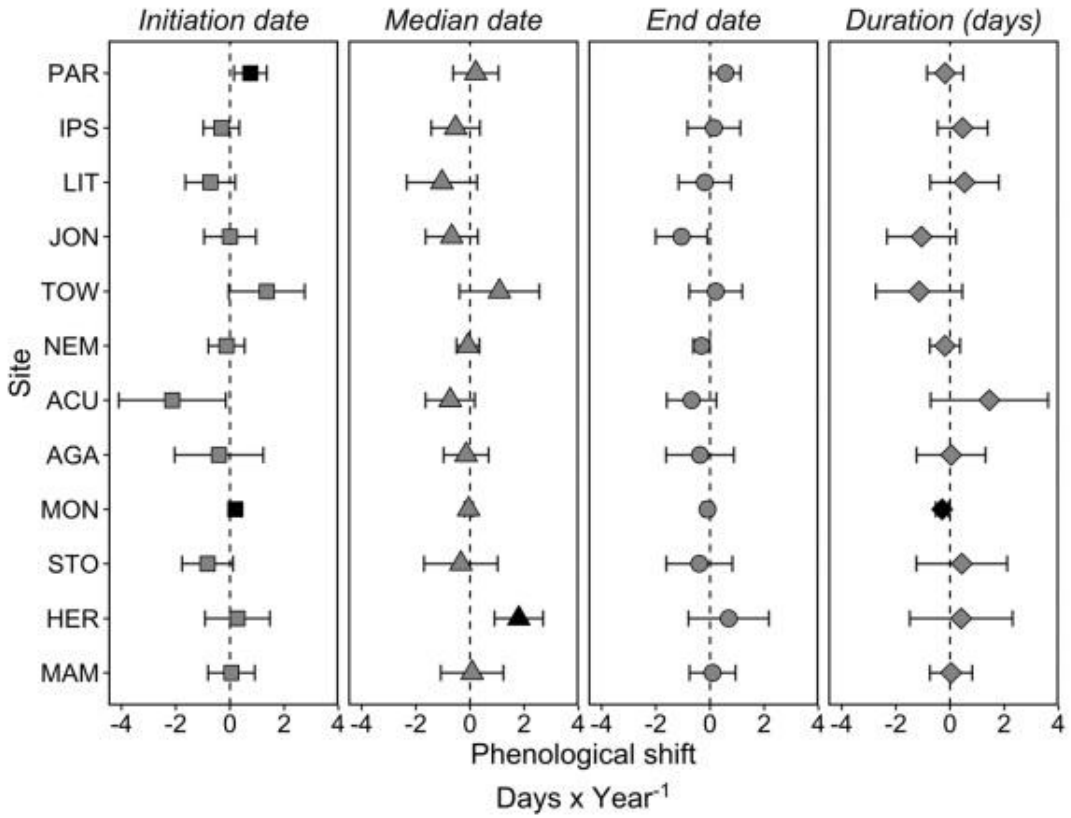


- Time series: 2013 – 2024, minus 2020 (11 years), Horn Pond (2019-2024)
- Counting Location: Upper Mystic Lake ladder (partial watershed);
  Horn Pond outlet (restoration response)
- Counts conducted between 7am – 7pm
- Sampling conducted using 2-way, 3-period sampling design
- Mann-Kendall test indicates positive trend
- Counting augmented by video monitoring and biological sampling
- Mystic count Included in 2024 ASMFC coast-wide stock assessment

5. DATA LIMITATIONS

1. Visual count estimates are not true population estimates due to non-continuous monitoring

2. The newly standardized metrics don't account for changes in phenology
   - Changes in spawning migratory patterns over time in MA coastal rivers (Legett et al. 2021; Dalton et al. 2022)

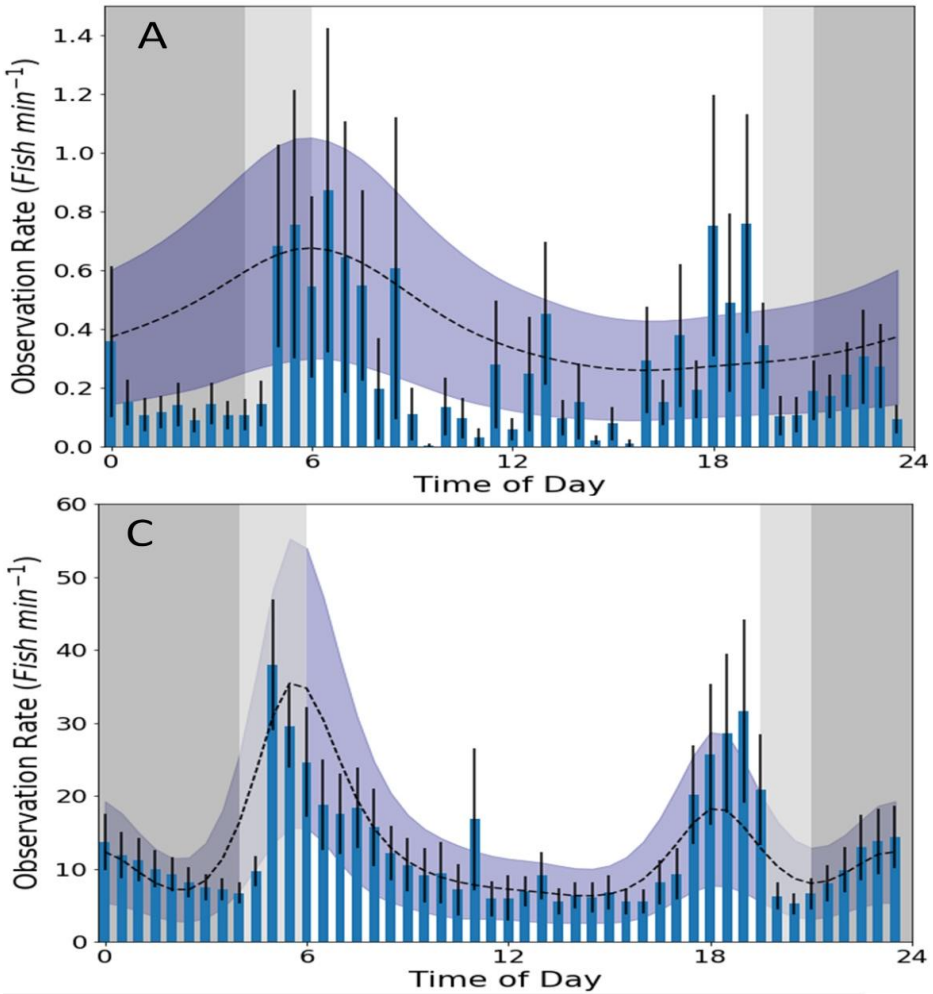


Results suggest minor shifts in run metrics toward earlier dates in most runs

Phenological shift (days per year) in Alewife run initiation, median run, run end, and duration per year across 12 Massachusetts coastal streams between 1990 and 2017. Dark symbols indicate significant shifts. Source: Dalton et al. (2022).

5. DATA LIMITATIONS (cont.)

The standardized metrics don't account for changes in diel migration patterns
- i.e.) early morning/evening movements



(A) Mattapoisett River
(C) Herring River (Harwich)

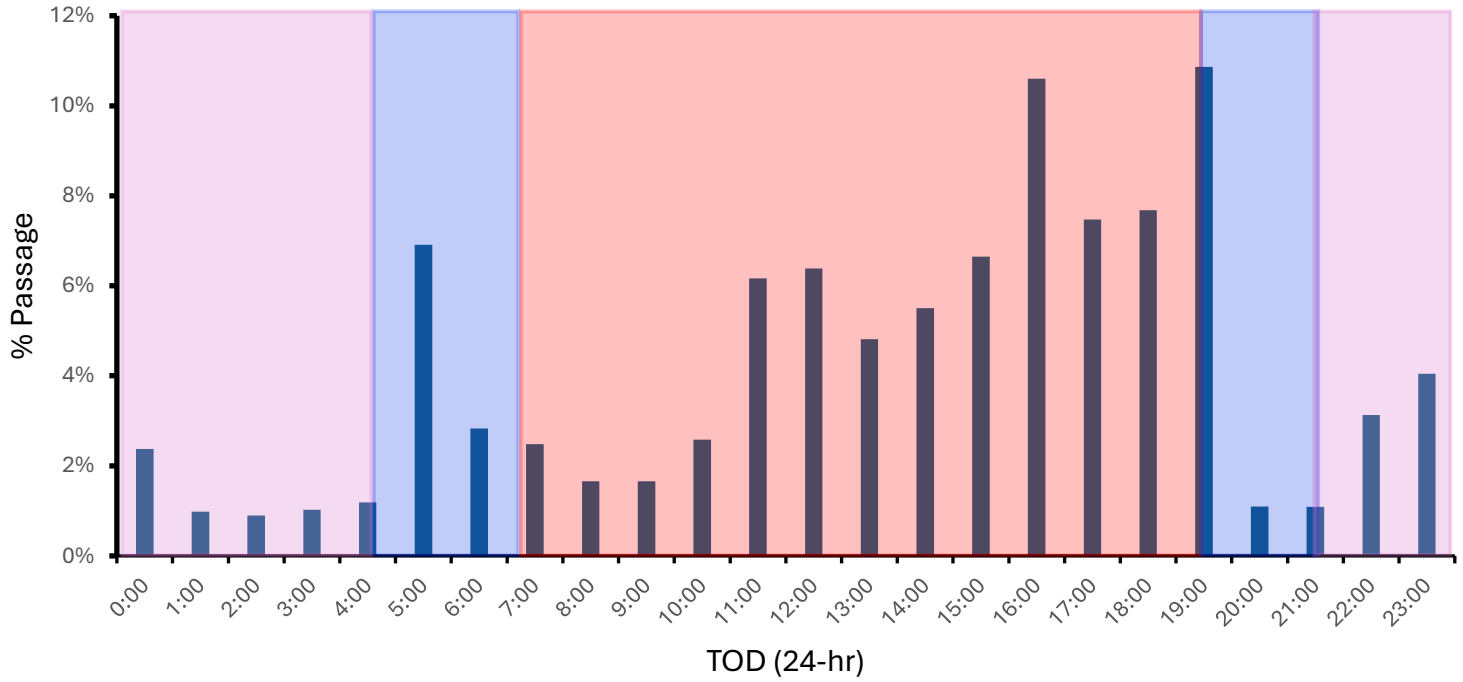
Rillahan and He (2023)
- Monitoring via high-resolution acoustic SONAR
- No artificial lighting used
- Fine-scale movements associated with the interaction between time-of-day and tidal stage
- Elevated activity early morning-late afternoon

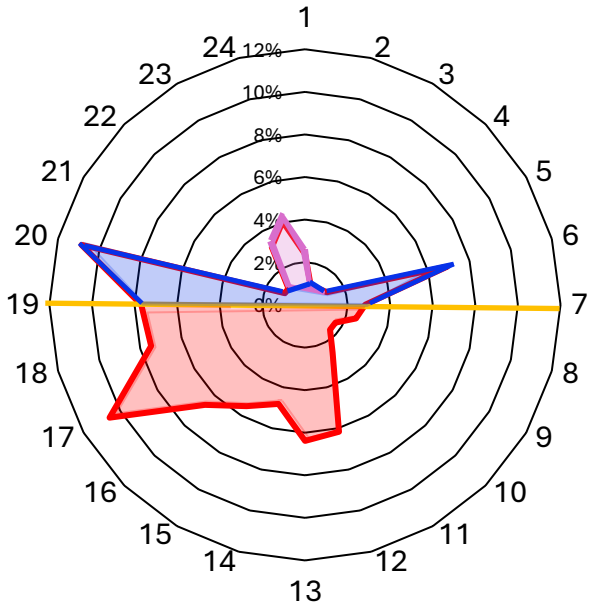
Time of Day (24-hr)	Mattapoisett	Herring
Day (0600-1930)	63%	57.3%
Night (2100-0400)	20.3%	23.6%
Crepuscular (0400-0600/1930-2100)	16.7%	19.1%

5. DATA LIMITATIONS (cont.)

The standardized metrics don't account for changes in diel migration patterns
- i.e.) early morning/evening movements

Mean % river herring passage/hr in the Monument River during the 2024 spring spawning season (Source: DMF)





TOD	% Passage
Day (0700-1900)	64
Night (2100-0359)	12
Crepuscular (0400-0659/ 1901-2059)	24

- Data recorded via S-R 1601 ERC with HOBO Event Logger
- No artificial lighting used
- 10+ year time series shows similar migration patterns
- Majority of movement occurs during the day with increased activity during crepuscular hours

6. SUMMARY & RECOMMENDATIONS

1. *Visual count estimates are indices of relative abundance and not total population estimates*

   RECOMMENDATION: Sampling location will determine type of estimate

2. *Counts must be conducted using consistent protocols to infer populations trends over time*

   RECOMMENDATIONS:

   - Maintain consistent metrics (start, end periods, daily observation periods, sampling design and intensity)
   - Avoid aggregate (cluster) sampling
   - ZERO (“0”) COUNTS ARE IMPORTANT DATA!!
   - Maintain the integrity of existing counting programs

3. *Visual counts have limitations*

   - Bias and error associated with extrapolating estimates based on sampling
   - Do not account for changes in phenology or diel movement patterns

   RECOMMENDATION: Begin counting once herring are observed to document any changes in migratory patterns

4. ***ESTABLISHING AND MAINTAINING VISUAL COUNTING PROGRAMS IS DIFFICULT!***

   - Low start-up costs for equipment
   - Challenges in establishing and maintaining volunteer effort
   - Challenges in maintain random sampling schedule

6. SUMMARY & RECOMMENDATIONS (cont.)

5. *Counting at Night*
   - ***RECOMMENDATION***: Maintain sampling period by Nelson (2006)
   - Difficult to sustain volunteer effort
   - ISSUES (bias and uncertainty):
     - Visibility issues
     - Safety concerns
     - Artificial lighting shown to affect natural migration patterns, feeding behavior and predation risk (Bassi et al. 2021; Dragesund 1958; Perkin et al. 2011; Moser and Terra 1999)
     - Changes in daily observation periods = bias estimates due to inconsistent metrics, aggregate sampling during periods of strong movement
     - Estimates standardized as indices for daytime abundance or passage
     - Consideration for ERC/Video monitoring for locations with strong night movements (case-by-case basis)*

6. *RECOMMEND Maintain existing visual count programs for the following locations using the guidelines recommended by Nelson (2006)*
   - 10+ Years: Town Brook, Mystic River, Marstons Mills River, Nemasket River, Herring River (Wellfleet), Pilgrim Lake, Stony Brook, Ipswich River, Little River

   - <10 years: Trunk River, Herring Brook (Eastham), Herring River (Eastham), Centerville River, Red Lily Pond, 1st Herring Brook, Herring River (Hinkleys), Concord River, Charles River, Furnace Brook (Soules), Shawsheen River

7. *RECOMMEND Evaluate sites to augment or discontinue counting*

8. *RECOMMEND Convert to technological monitoring **
   - Mystic, Town, Ipswich, Back, Stony, Herring (Harwich), Herring Brook (Pembroke), Coonamessett

* Determined on a case-by-case basis (site prioritization, counting site conditions, personnel and resources to operate/maintain systems); Maintain visual counting until continuous monitoring systems are firmly in place and estimates are assessed with high confidence

THANK YOU

- USFWS (CNEFRO & CTRO)
- Association to Preserve Cape Cod
- North & South River Watershed Association
- Buzzards Bay Coalition
- NOAA Restoration Center
- Massachusetts River Herring Network
- Municipal Wardens & DNR Personnel
- Watershed Associations
- Barnstable Clean Water Coalition
- ***VOLUNTEERS!!***

www.mass.gov/marinefisheries