Practices and practicalities of MAR Region Herring Acoustic Survey Design

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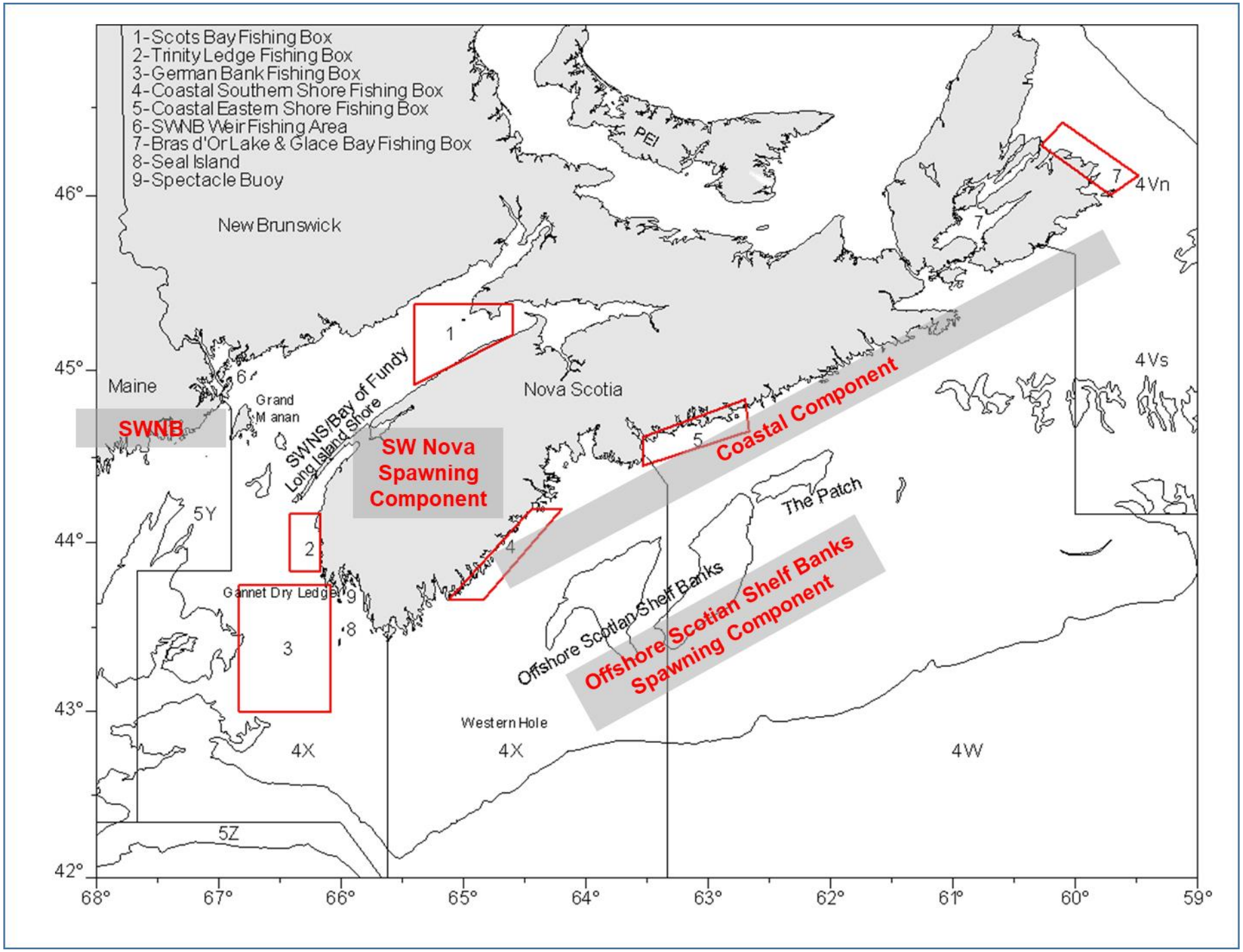
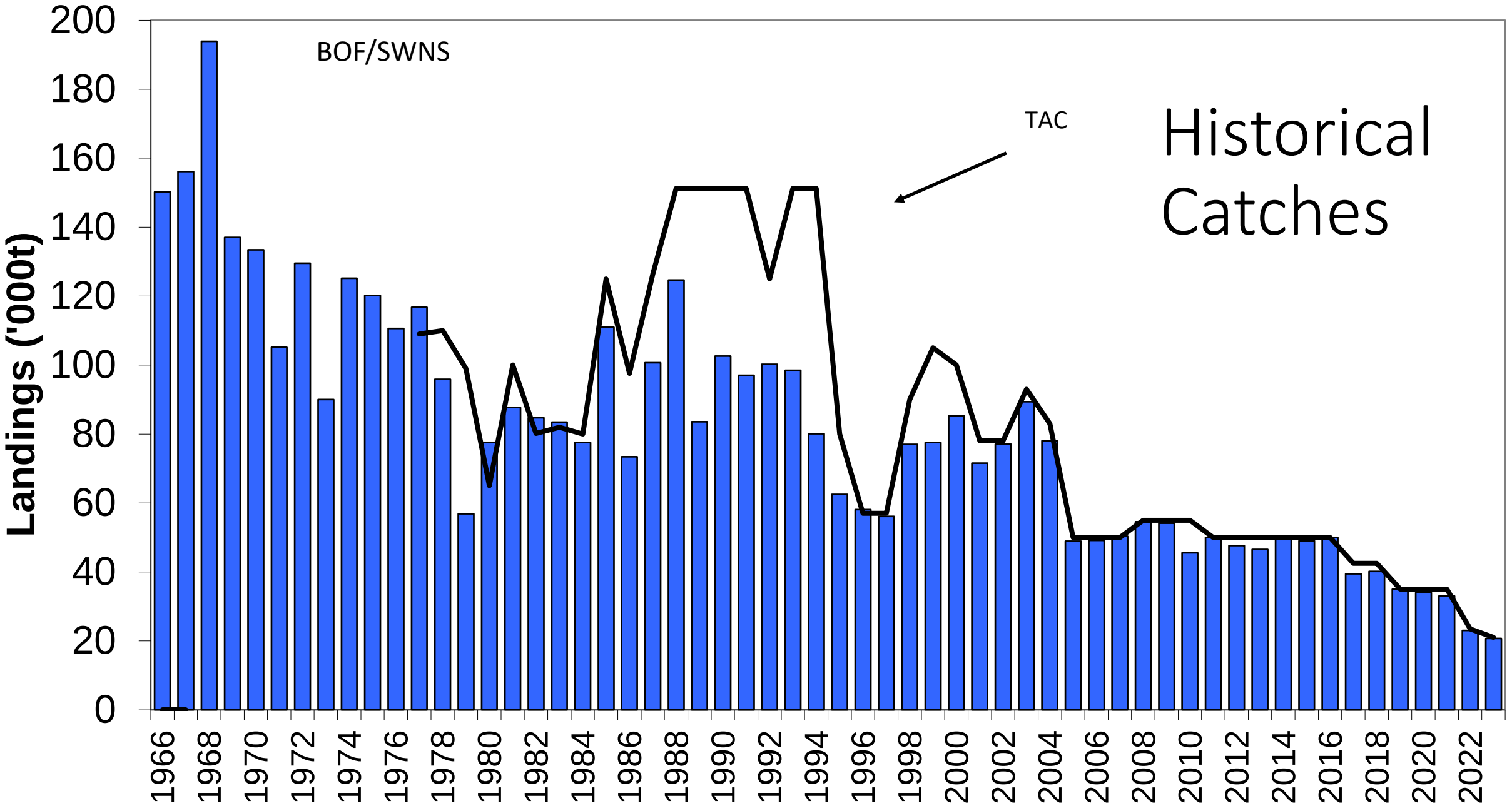
St. Andrews Biological Station

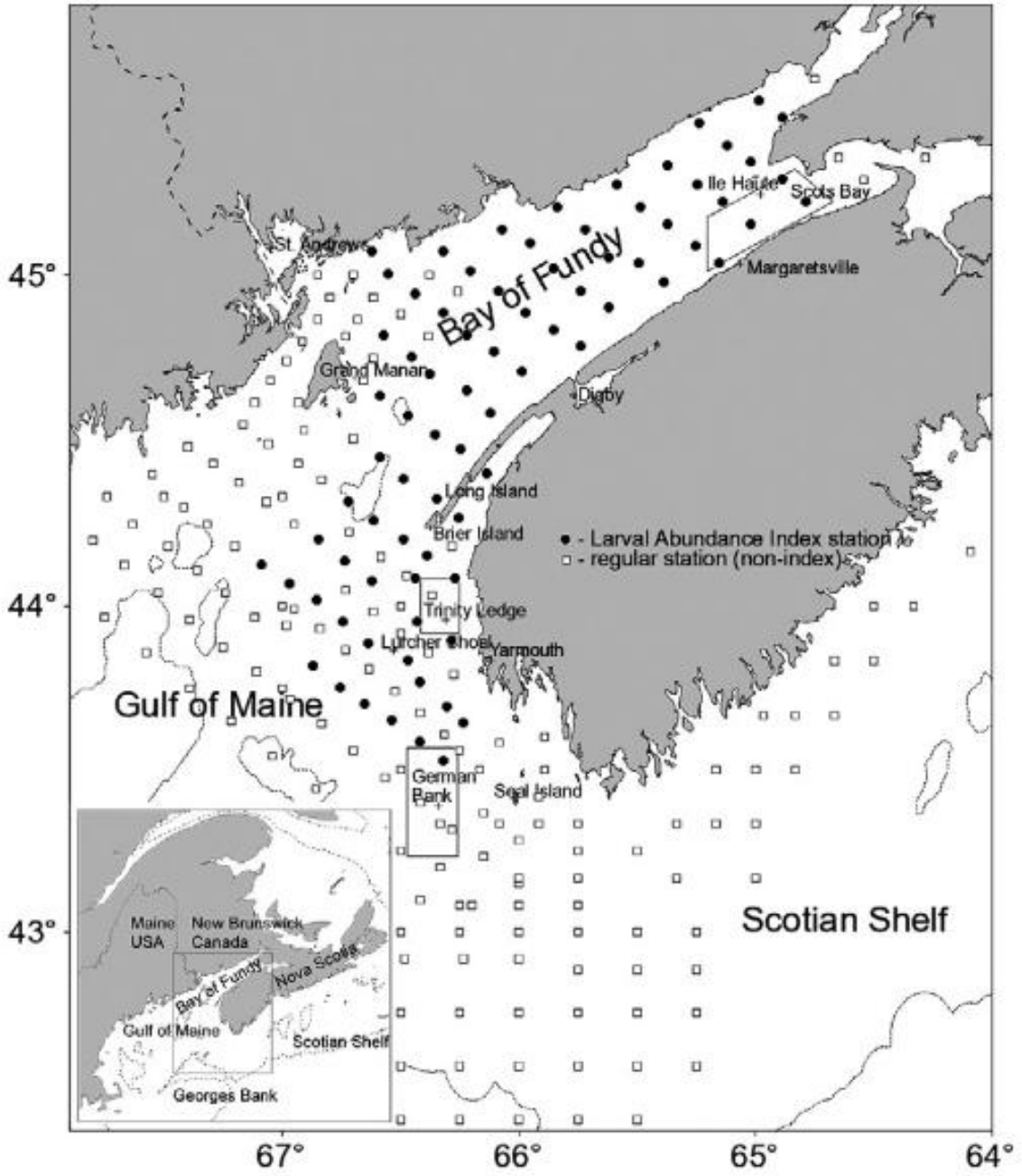

1-Scots Bay Fishing Box
2-Trinity Ledge Fishing Box
3-German Bank Fishing Box
4-Coastal Southern Shore Fishing Box
5-Coastal Eastern Shore Fishing Box
6-SWNB Weir Fishing Area
7-Bras d'Or Lake & Glace Bay Fishing Box
8-Seal Island
9-Spectacle Buoy
New Brunswick
PEI
Nova Scotia
Maine
Grand Manan
SWNS/Bay of Fundy
Long Island Shore
SWNB
SW Nova Spawning Component
Coastal Component
Offshore Scotian Shelf Banks Spawning Component
Offshore Scotian Shelf Banks
The Patch
Gannet Dry Ledge
Western Hole
5Y
5Z
4X
4W
4Vn
4Vs
46°
45°
44°
43°
42°
68°
67°
66°
65°
64°
63°
62°
61°
60°
59°


BOF/SWNS
TAC
Historical Catches
Landings ('000t)
200
180
160
140
120
100
80
60
40
20
0
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022

Monitoring Development & History

Larval Egg study

Figure 1. Bay of Fundy larval herring survey stations and geographic place names used in the text (●, 79 standard larval abundance stations; □, other stations occupied from 1972 to 1998). The boxed regions indicate locations of major herring spawning grounds off Margaretsville (mid summer), Trinity Ledge (autumn) and German Bank (autumn) based on acoustic surveys (Melvin and Power, 1999).



Herring Samples

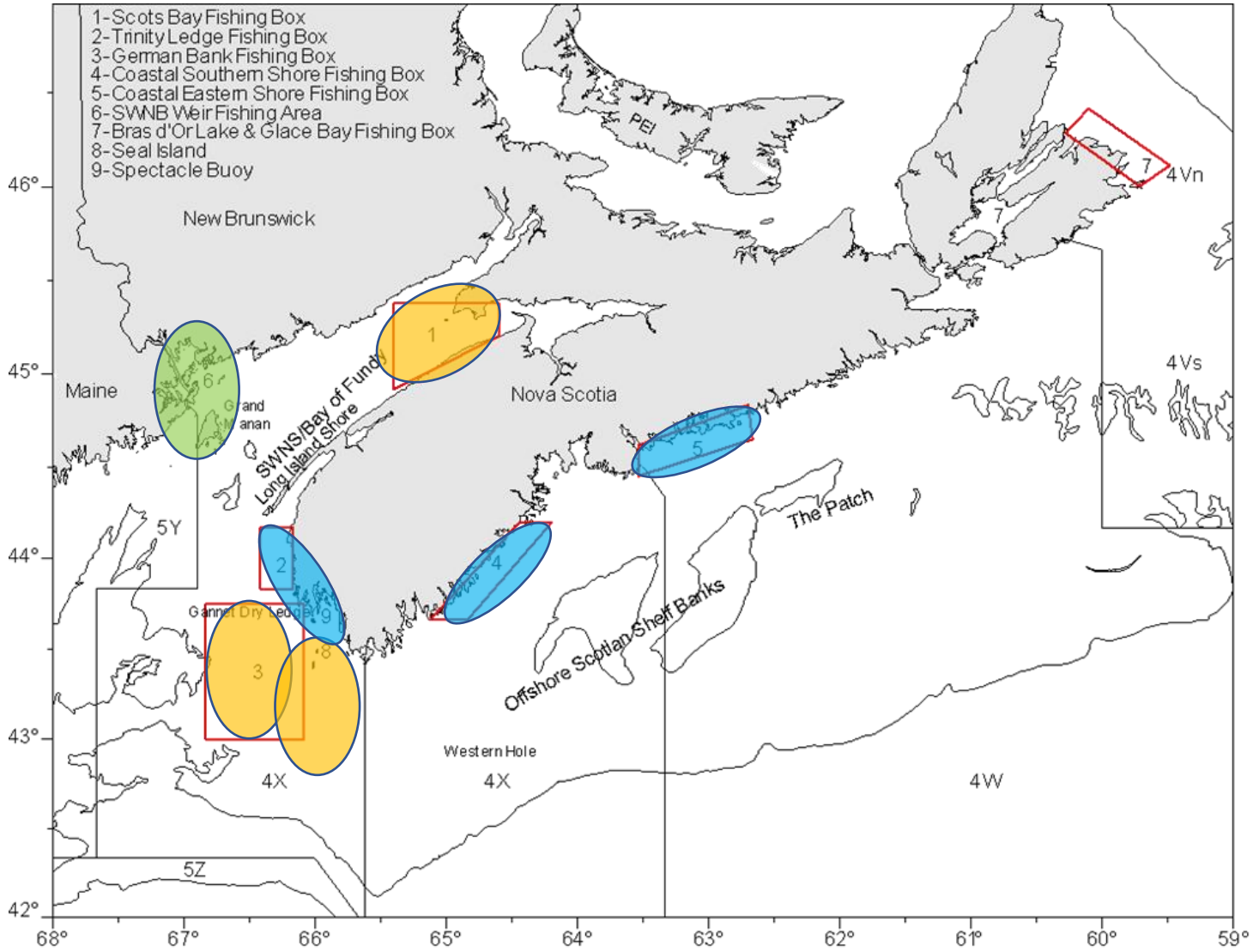


Figure A1. Place names and fishing locations for Southwest Nova Scotia/Bay of Fundy, Coastal NS (South Shore, Eastern Shore, Cape Breton), Offshore Scotian Shelf, and SWNB weirs. The vertical line between the two 4X labels indicates the outer boundary of the Southwest Nova Scotia/Bay of Fundy (SWNS/BoF) stock component.

Stock Structure and Movement among Grounds

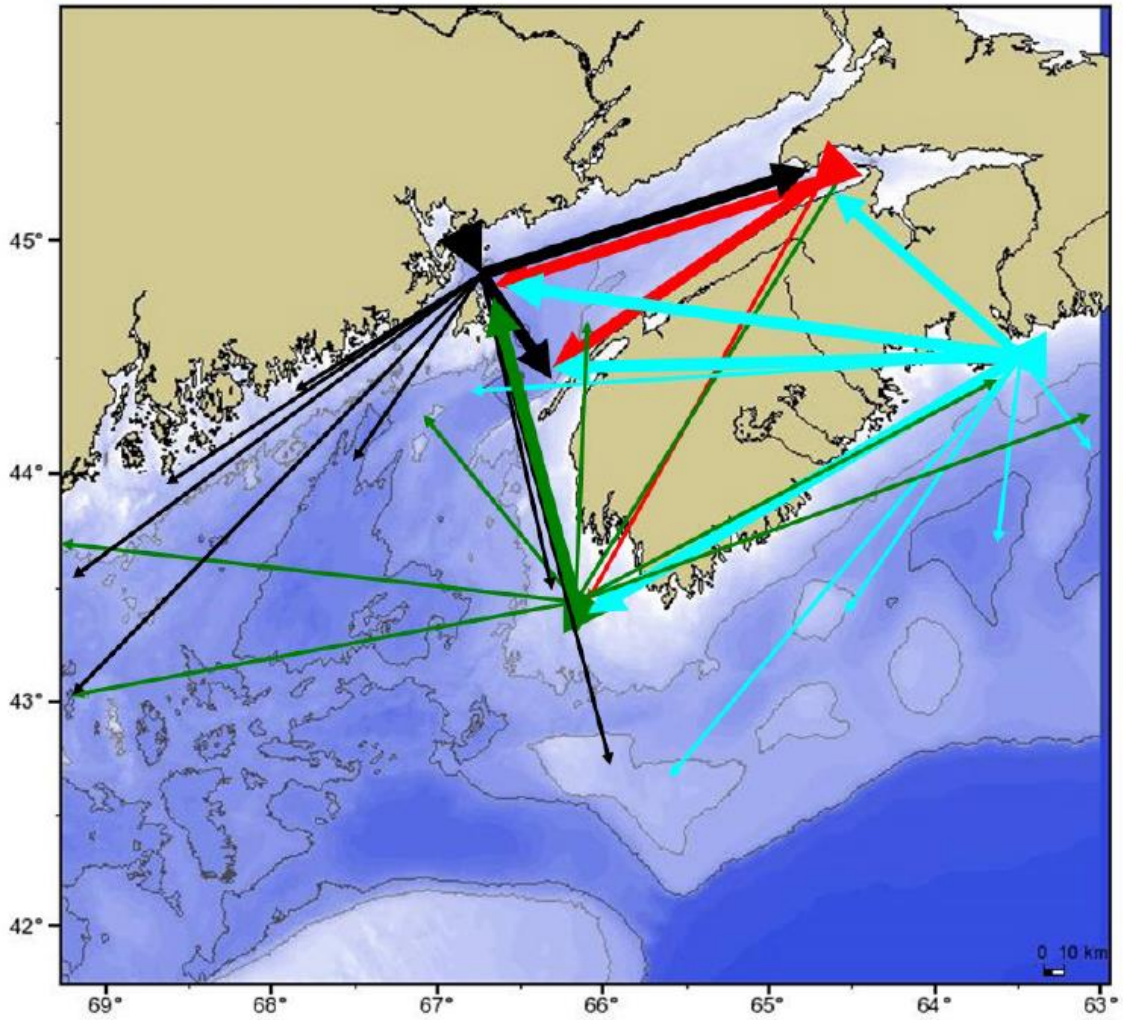
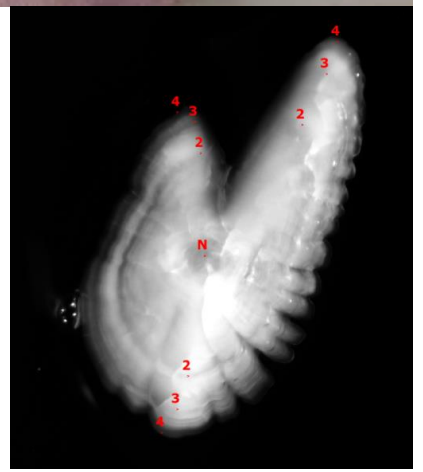


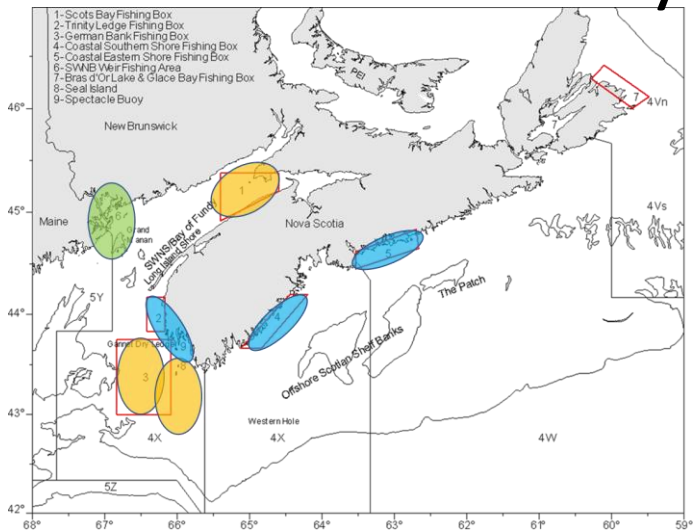
Figure 11. Movement of Herring tagged in Scots Bay (1998–2006), NB Weirs (1999–2004), German Bank (1998–2011) and off Chebucto Head (1999).

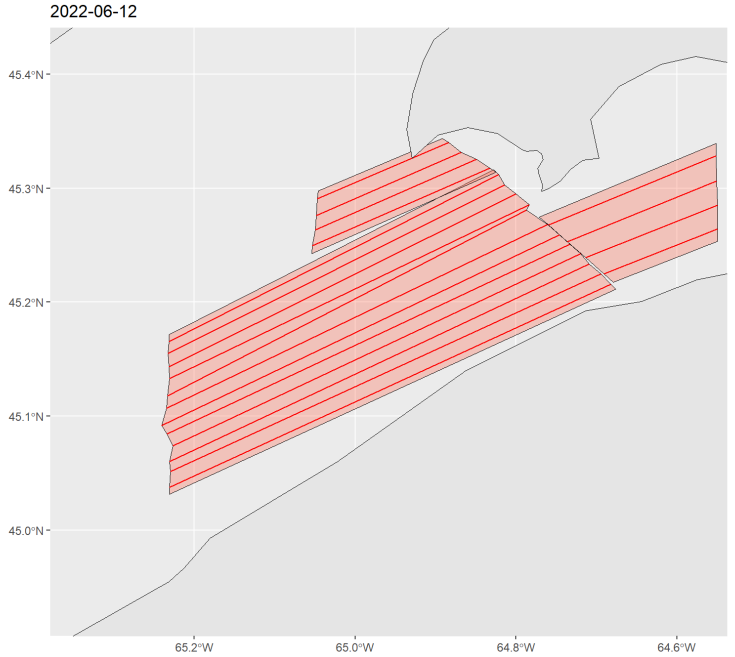
Setup a sampling database

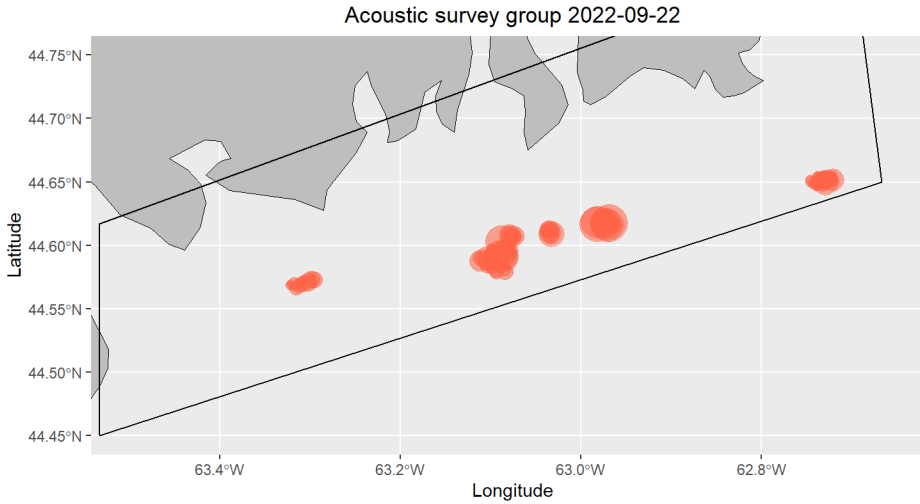
- Maritime Region relies on a the Small Pelagics Database setup (Oracle) to input industry-based samples.
- We perform the following:
  - A) Length-Frequency sheets from industry/port sampler
  - B) Frozen-Samples
    - i) Thaw
    - ii) Weigh (wet)
    - iii) Measure Length (apply 2% correction – Hunt et al. 1986)
    - iv) Gonads (Stage and weight)
    - v) Stomach Content (fullness, wet weight)
    - vi) Otoliths (Age)

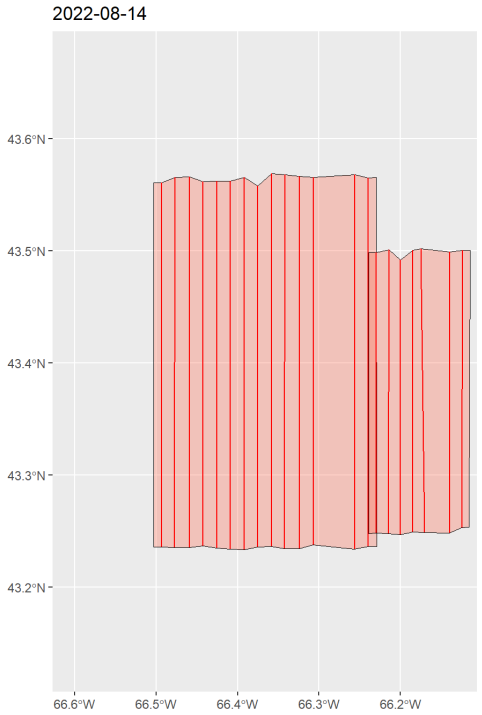


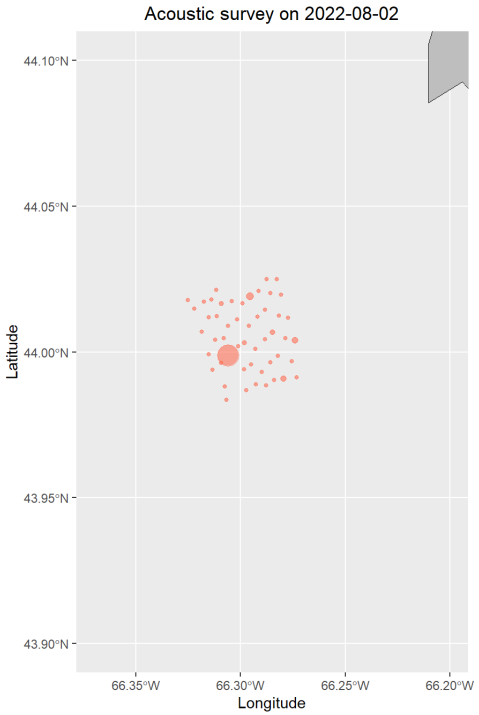
Acoustic Surveys

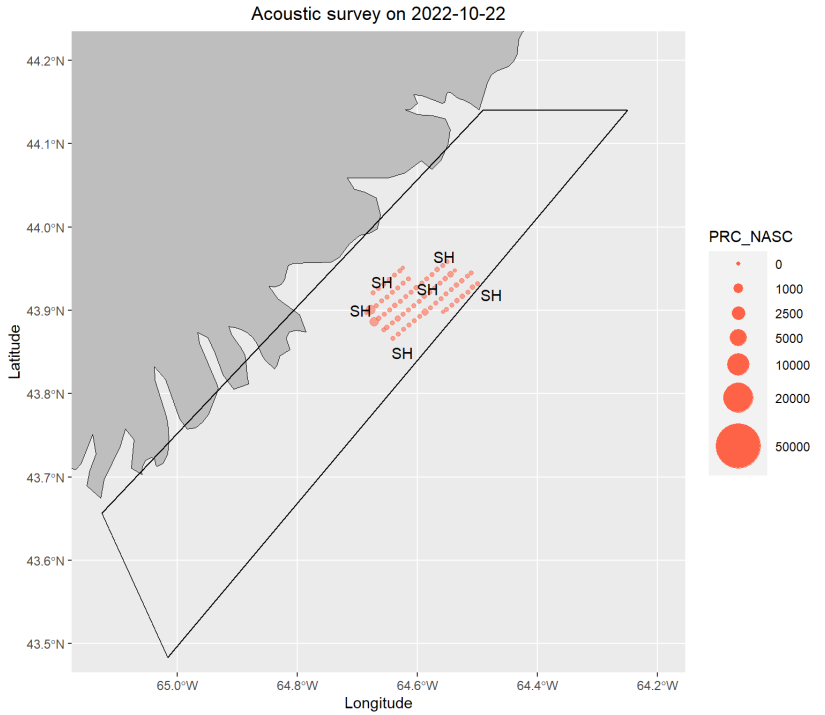












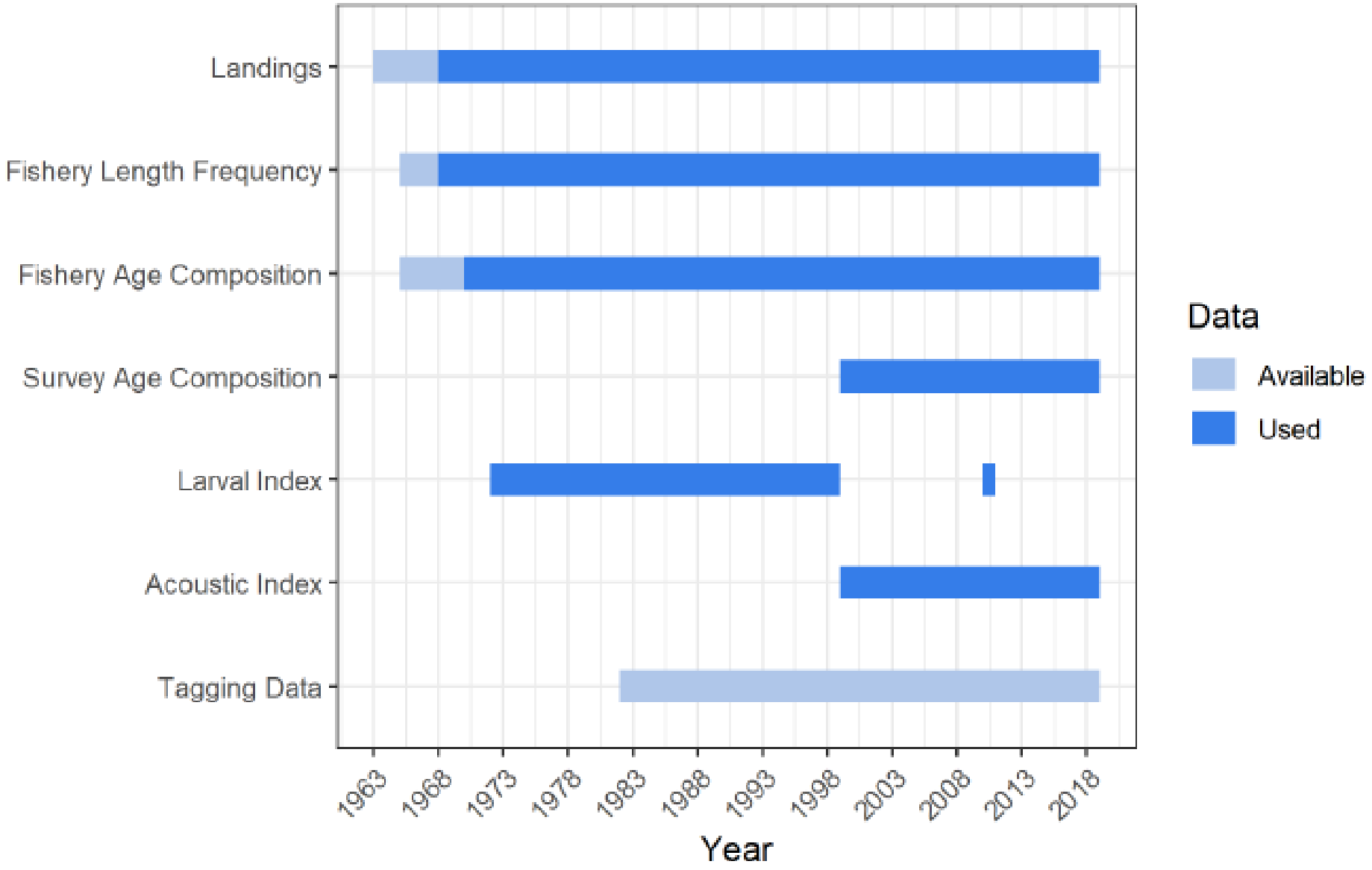


Figure 6. Data types and availability (light blue) and year ranges data were used for conditioning of operating models (dark blue).

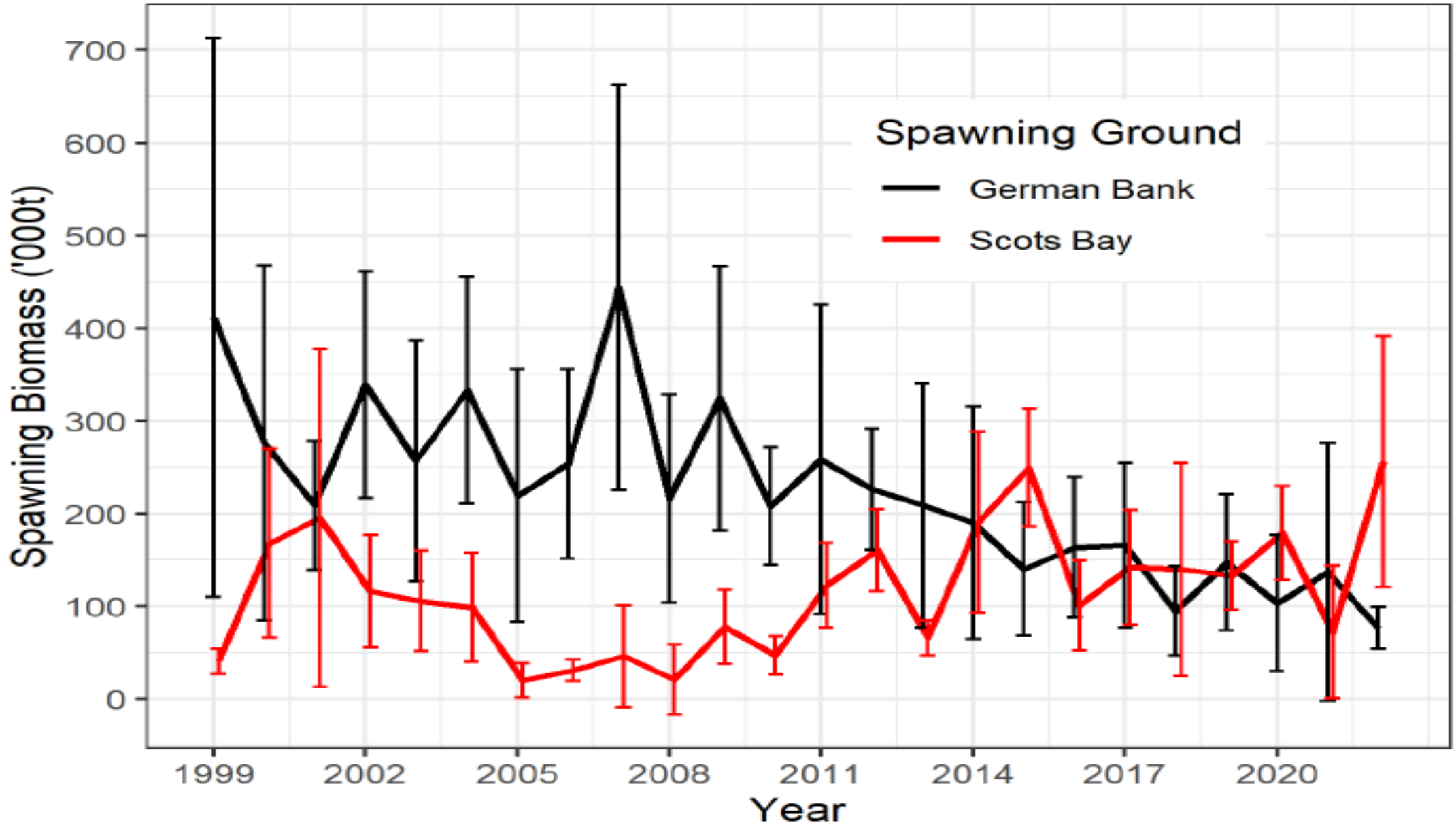


Figure 7. Acoustic index of SSB from 1999 to 2022 (in thousands of metric tonnes) for German Bank (black) and Scots Bay (red) (with 95% confidence intervals; error bars).

Observation vs fit for “Base Model” of Operating Models

See CSAS 2023/022

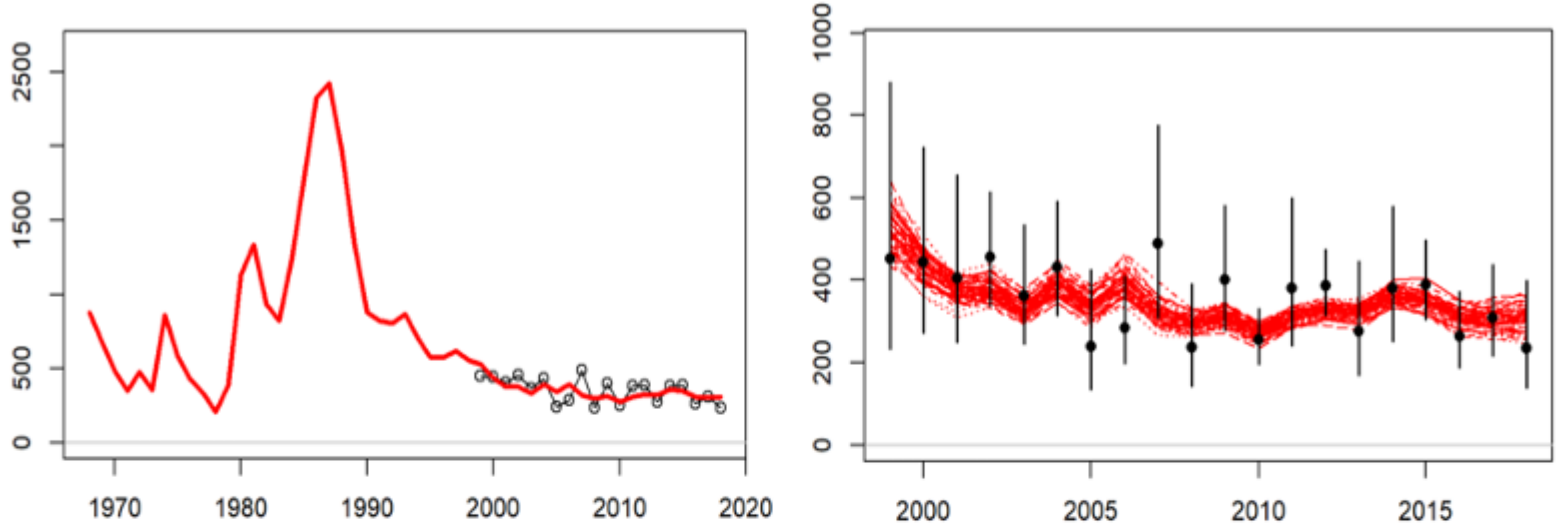


Figure 9. Base model fit to the acoustic survey index. Black points and line are observations, the red line is the model estimate (the left panel shows the maximum likelihood fit, the right panel shows the 48 stochastic simulations). Note that the observed acoustic survey is provided here in units of kilotons, the model fit is converted to the same scale as the observed index via the estimated catchability coefficient (q = 2.85)

Our Analytical Framework now considers the indices to be relative estimates of abundance vs absolute. Absolute biomass wouldn’t converge without extreme tweaking.

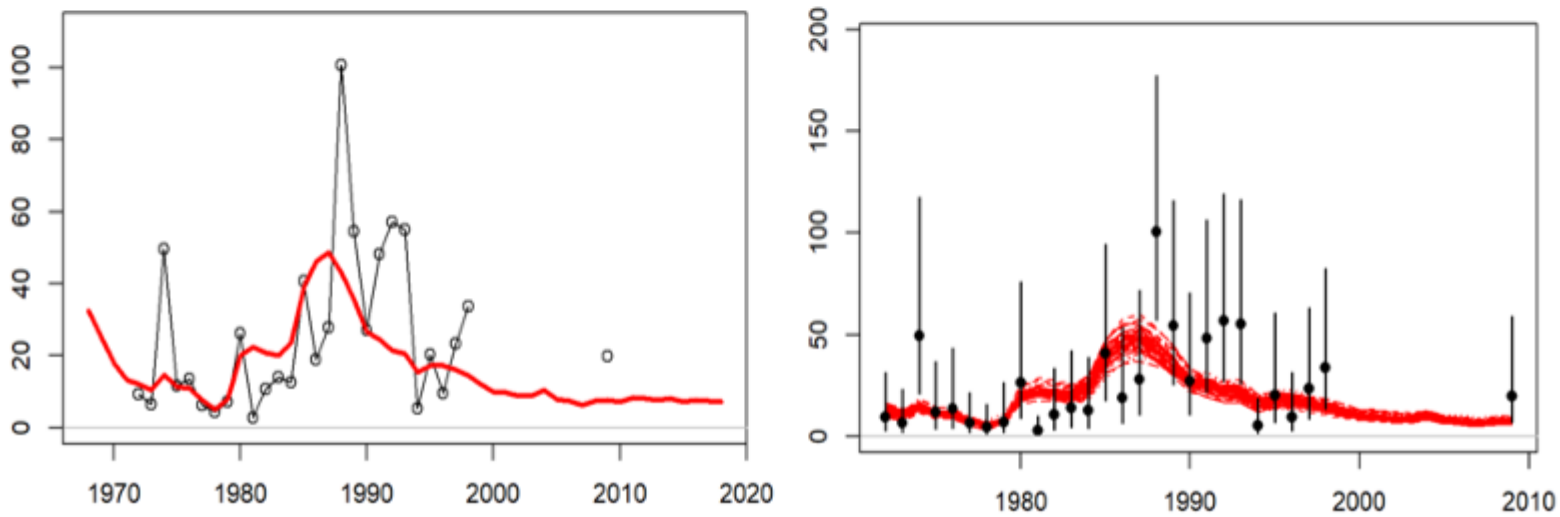
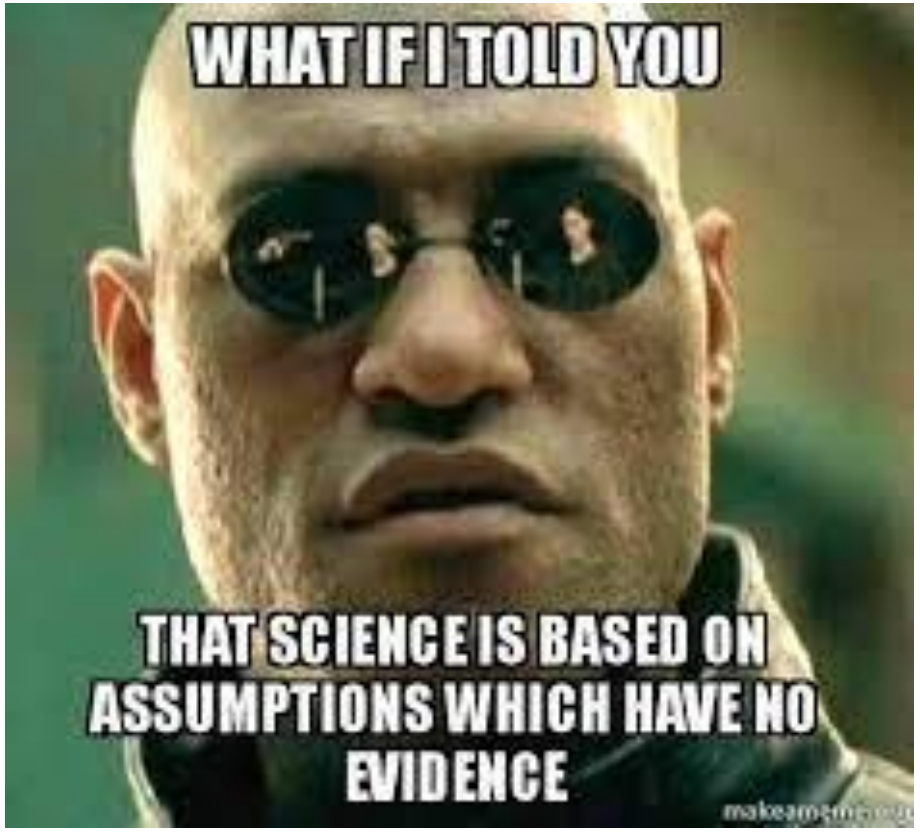


Figure 10. As Figure 9 but for the larval survey index.

We could just be happy with Survey design…



Absolute Biomass -> Relative Index

1) Calculate Target Strength

- For MAR region Herring TS @ other frequencies….
- Love Equation:

$$TS_f = m \log L + m_f logf - b$$ Love 1977

$$TS_f = 20 \log L - 10 \log W + (0.9 logf - 1.422) - 71.9$$

-ish
(I've never seen a documented formula…)

Big Assumption

But see Nakken and Oslen, 1977
& Dunning et al. 2023

1) Calculate Target Strength

- For MAR region Herring TS, we rely on the Foote, 1987.

$TS = 20 \log L - 71.9 - 10 \log W$ in dB kg^{-1} @ 38 kHz

TS - Target Strength distribution
L – Length distribution
W- Weight distribution.

Ona, 2003*

$TS = 20 \log L - 2.3 \log(1 + D/10) - 65.4$ in dB kg^{-1} @ 38 kHz

Potential Issues Raised

1) Target Strength frequency response assumption
2) Standard Target by Year or Spawning Ground

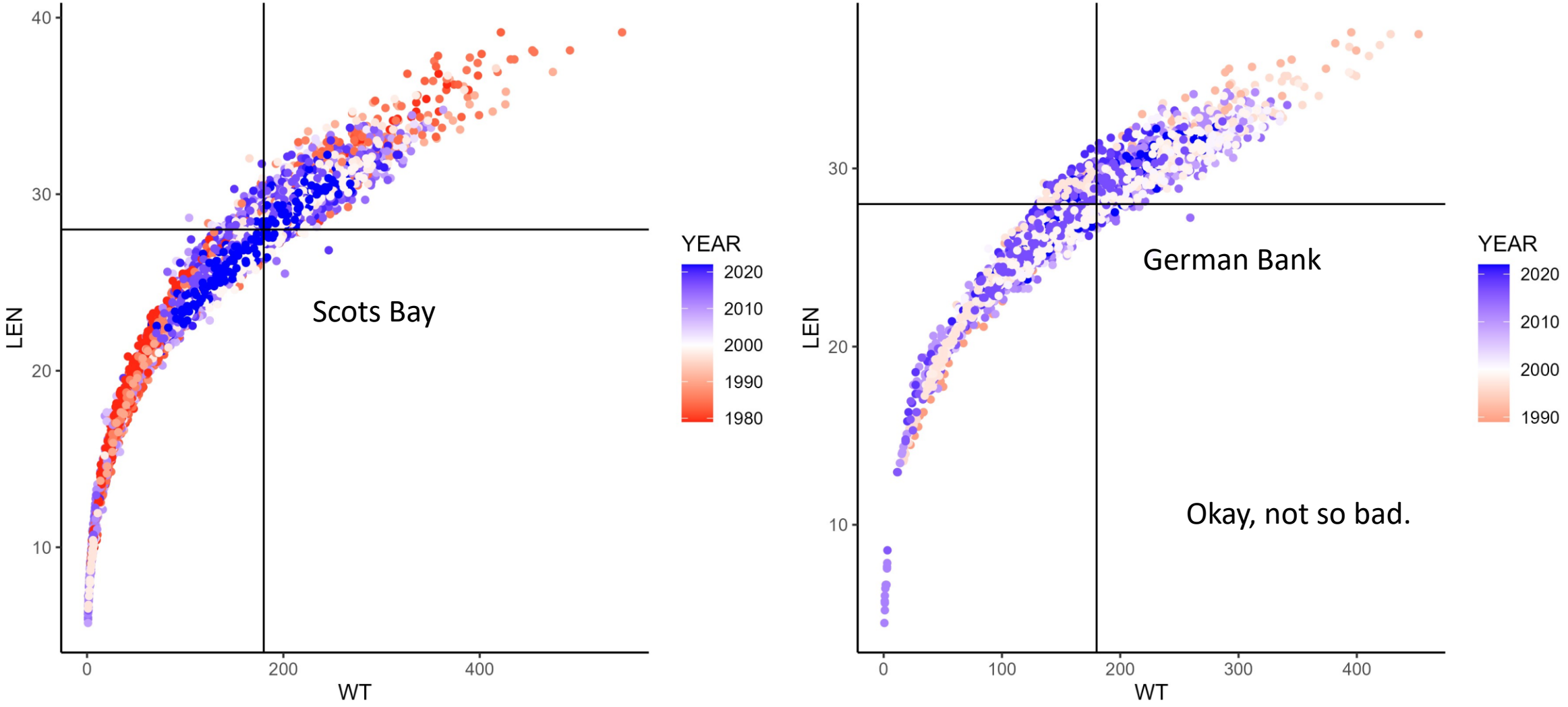
Missing Samples? Standard Target

Fish are 28.0 cm and 0.180 kg (Make sure these units)

$$TS = 20 \log L - 71.9 - 10 \log W$$

Therefore, standard is -35.5 for a 38 kHz fish.

Missing Samples? Standard Target



Potential Issues Raised

1) Target Strength frequency response assumption
2) Standard Target by Year or Spawning Ground

Changes in Weight-at-age

CSAS 2023

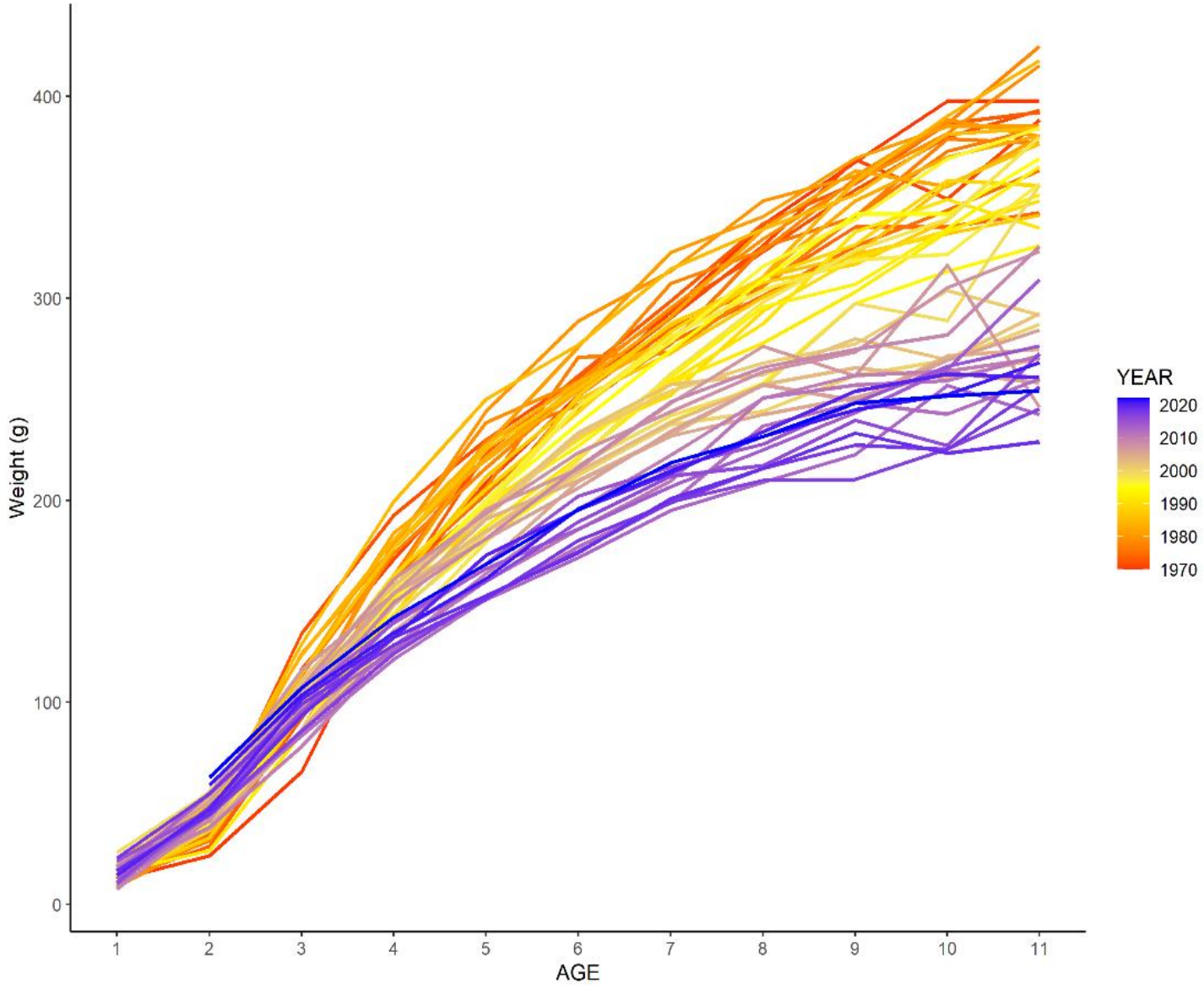


Figure. Fishery mean weights-at-age for the SWNS/BoF component from 1970 to 2022. Red lines indicate earlier in the time series and purple to blue lines are later in the time series.

L50

CSAS 2019

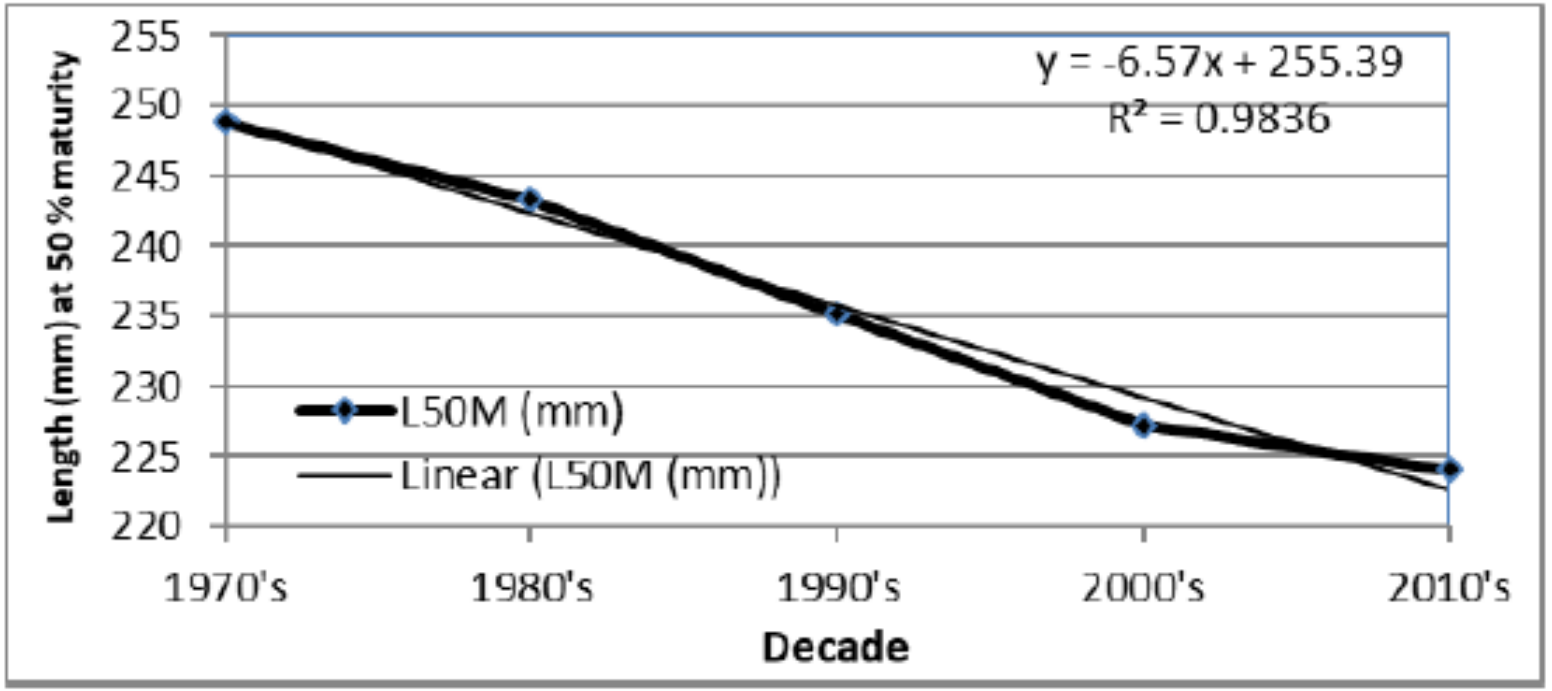
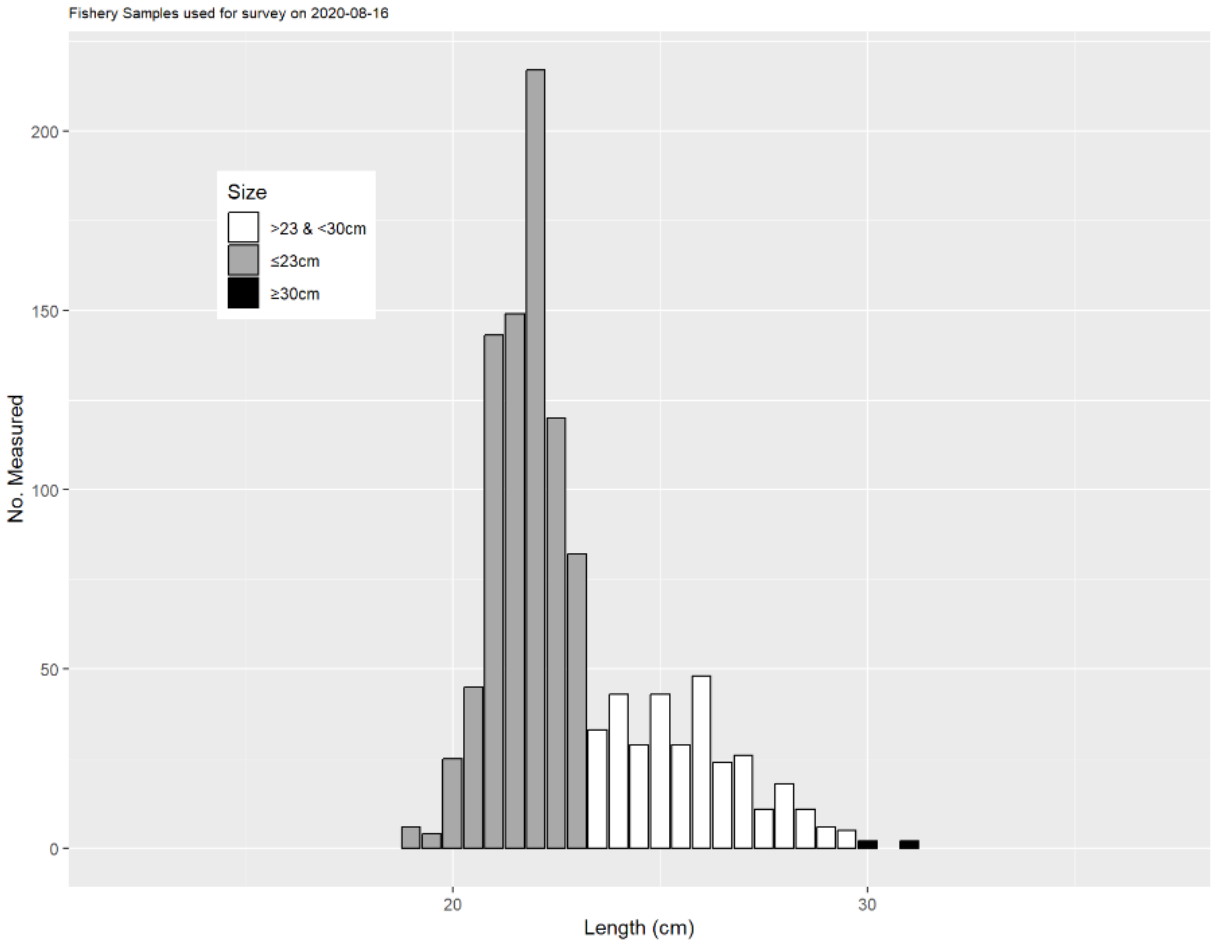
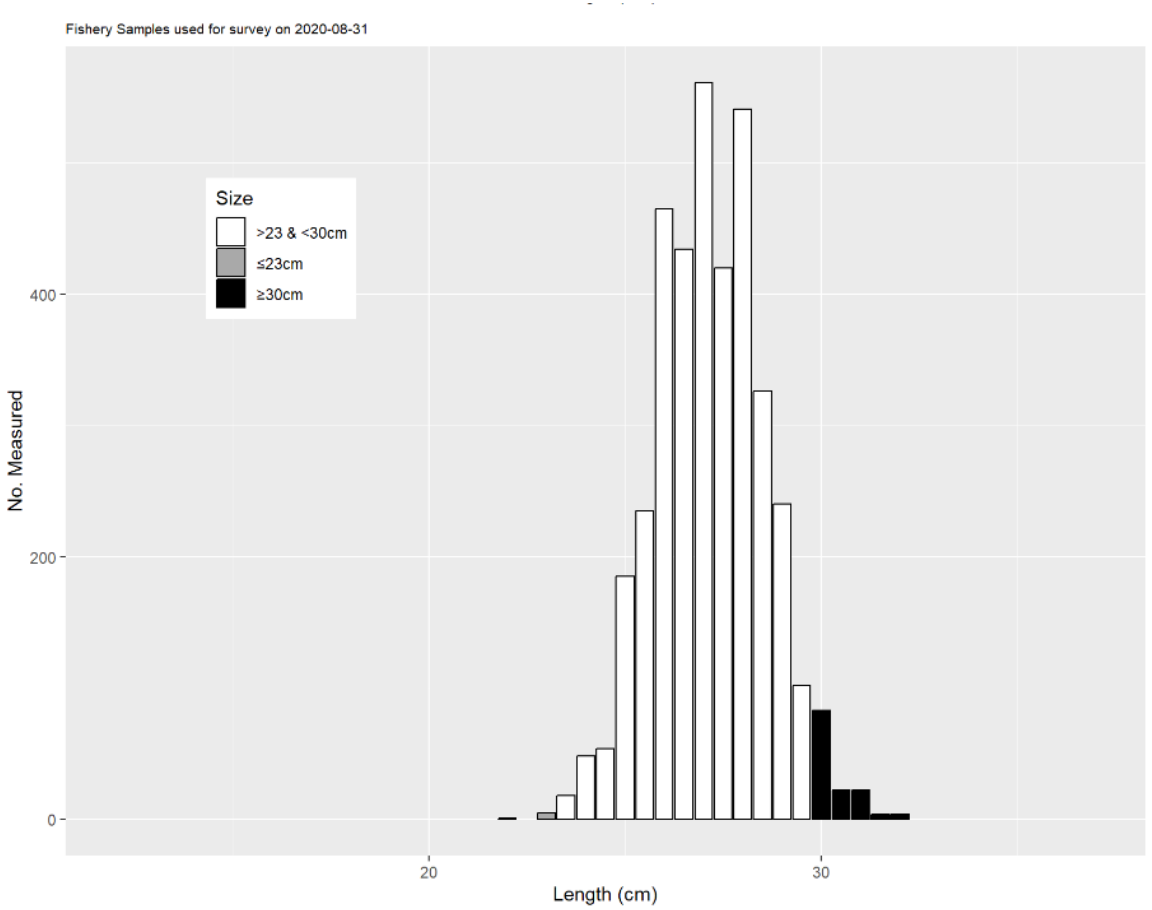


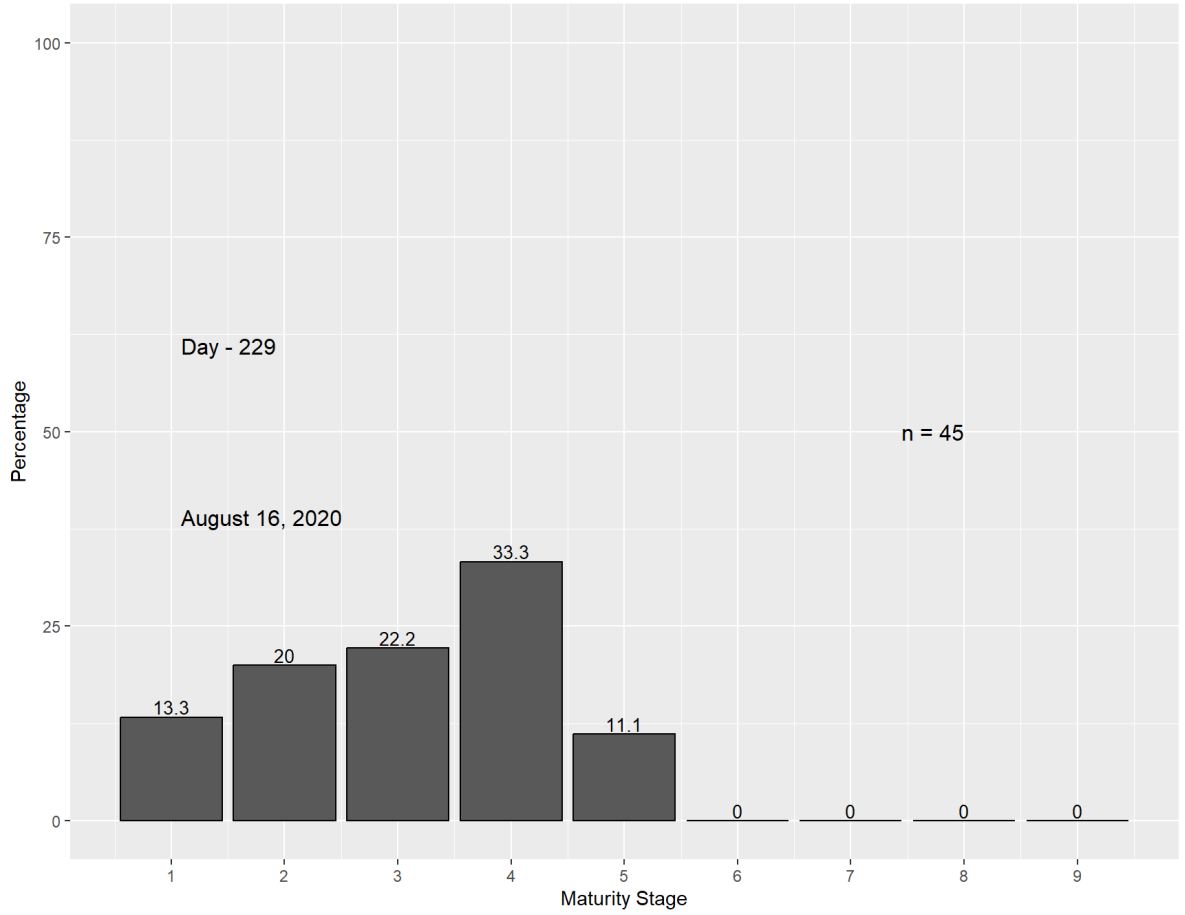
Figure 25. Regression of average length (mm) at 50% maturity by decade for the SWNS/BoF component of the 4WX Herring.

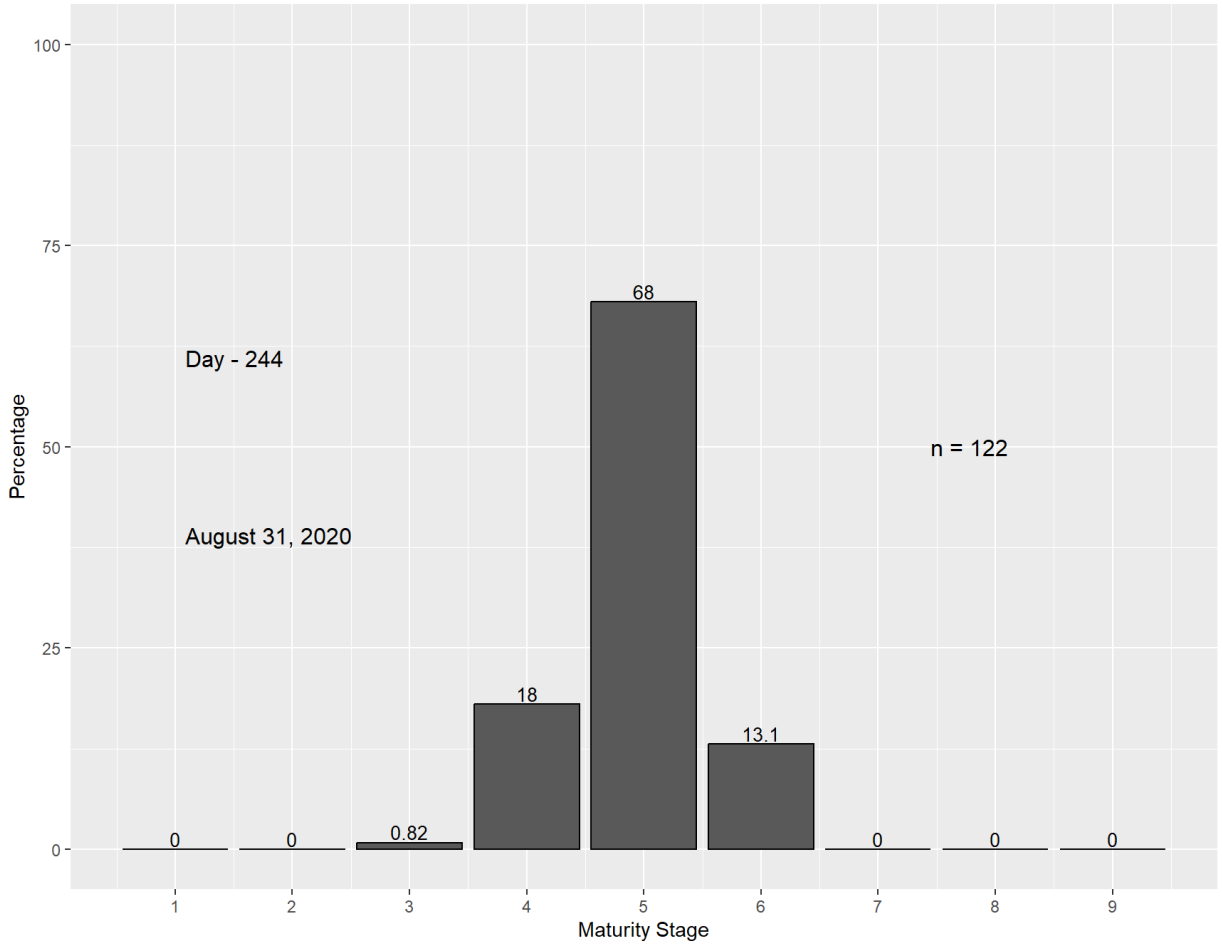
4) Biomass Estimates – SSB vs Juveniles?





4) Biomass Estimates – SSB vs Juveniles?



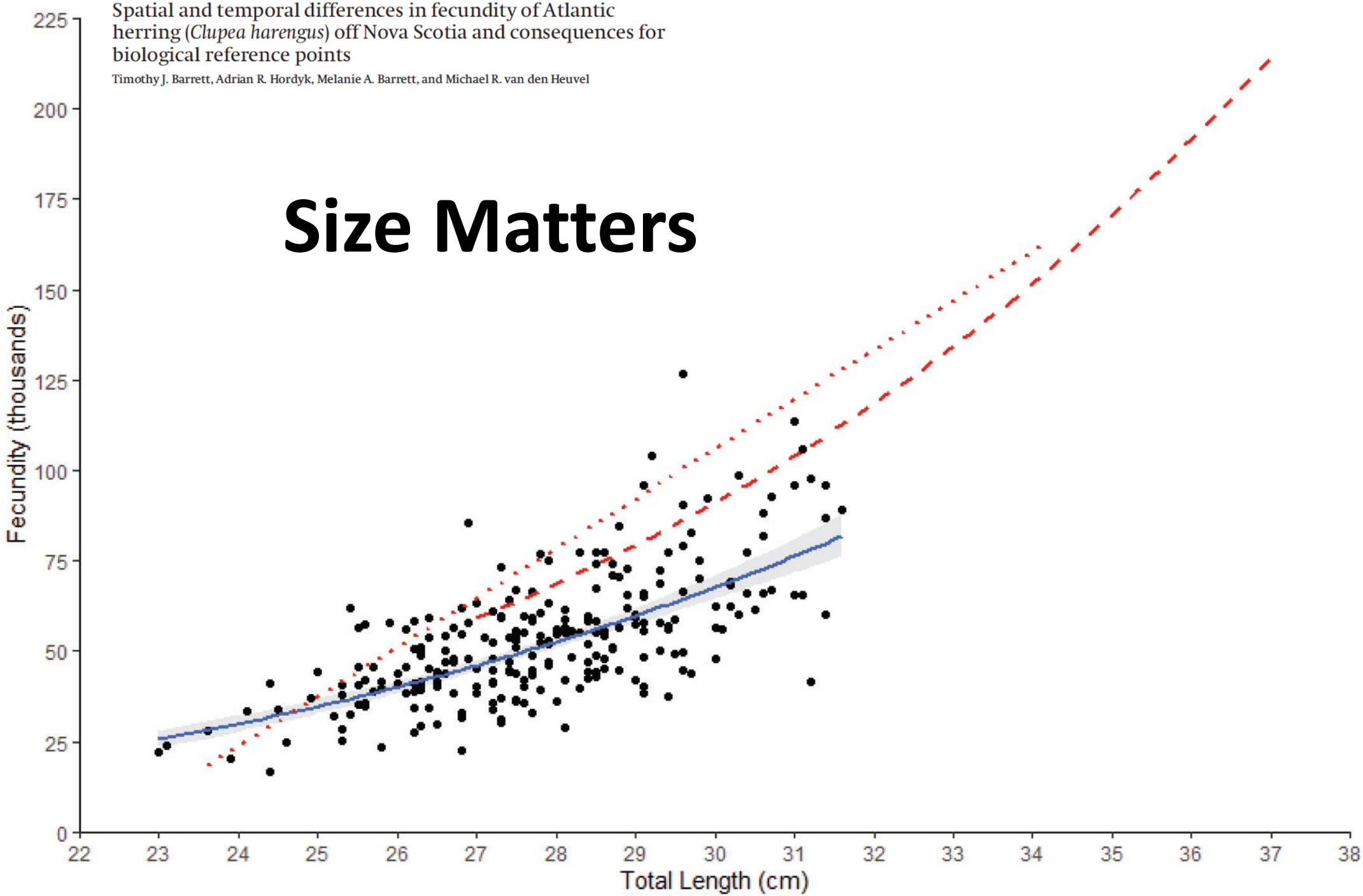


- If >10% of sample is stage 2 or less, discount sample at 23cm mark.

Spatial and temporal differences in fecundity of Atlantic herring (*Clupea harengus*) off Nova Scotia and consequences for biological reference points

Timothy J. Barrett, Adrian R. Hordyk, Melanie A. Barrett, and Michael R. van den Heuvel

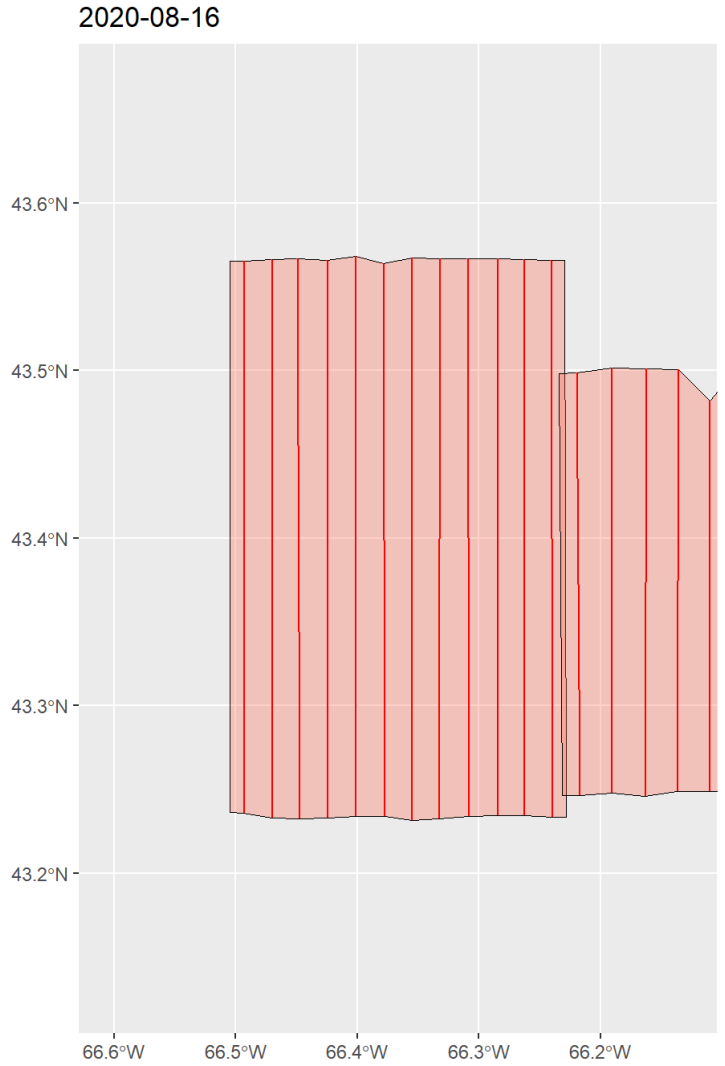
Size Matters



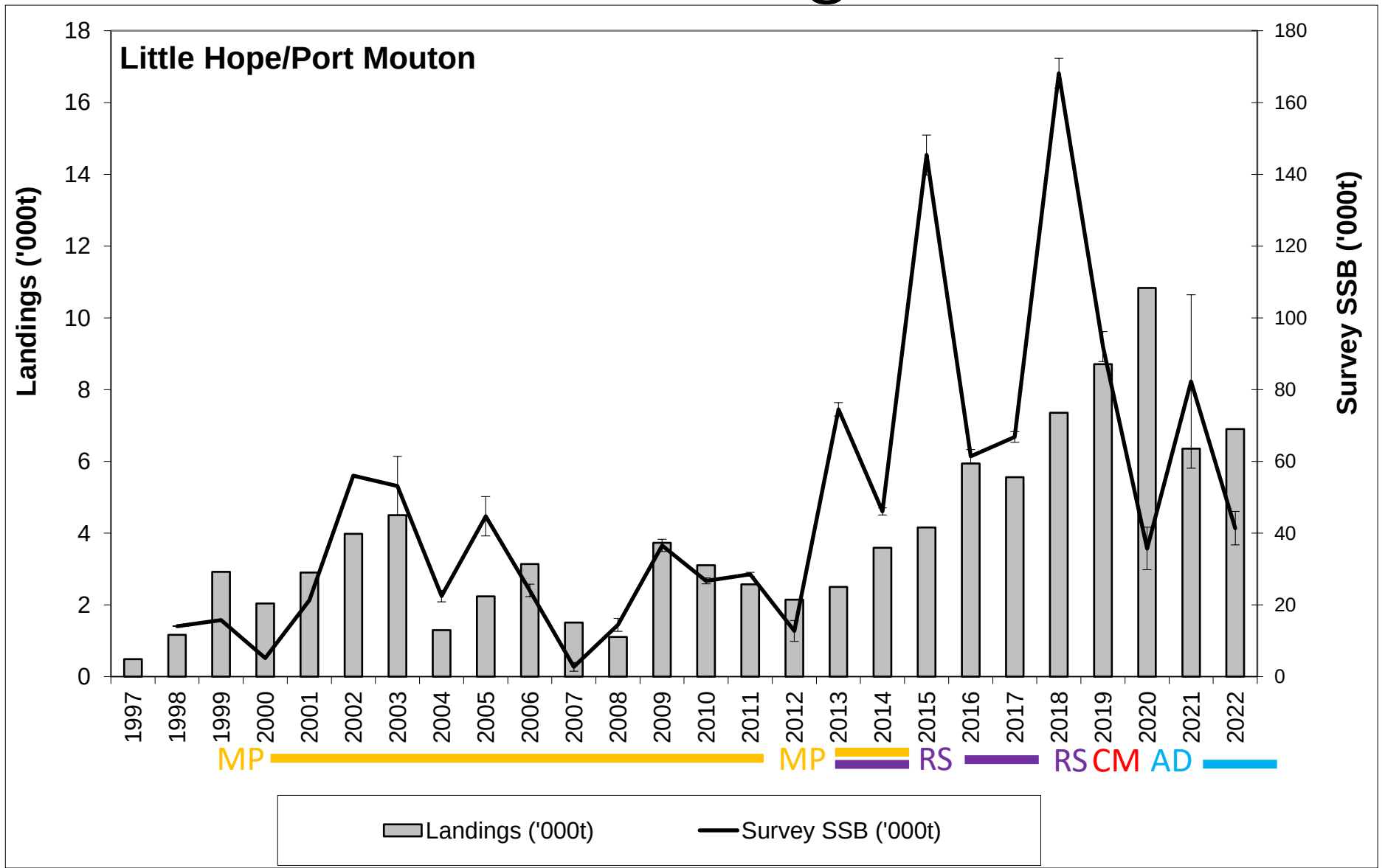
Potential Issues Raised

1) Target Strength frequency response.
2) Standard Target by Year or Spawning Ground.
3) Changes in L50, Discount acoustic SSB <23cm?

2) Calibrate Vessels & Collect acoustic Data



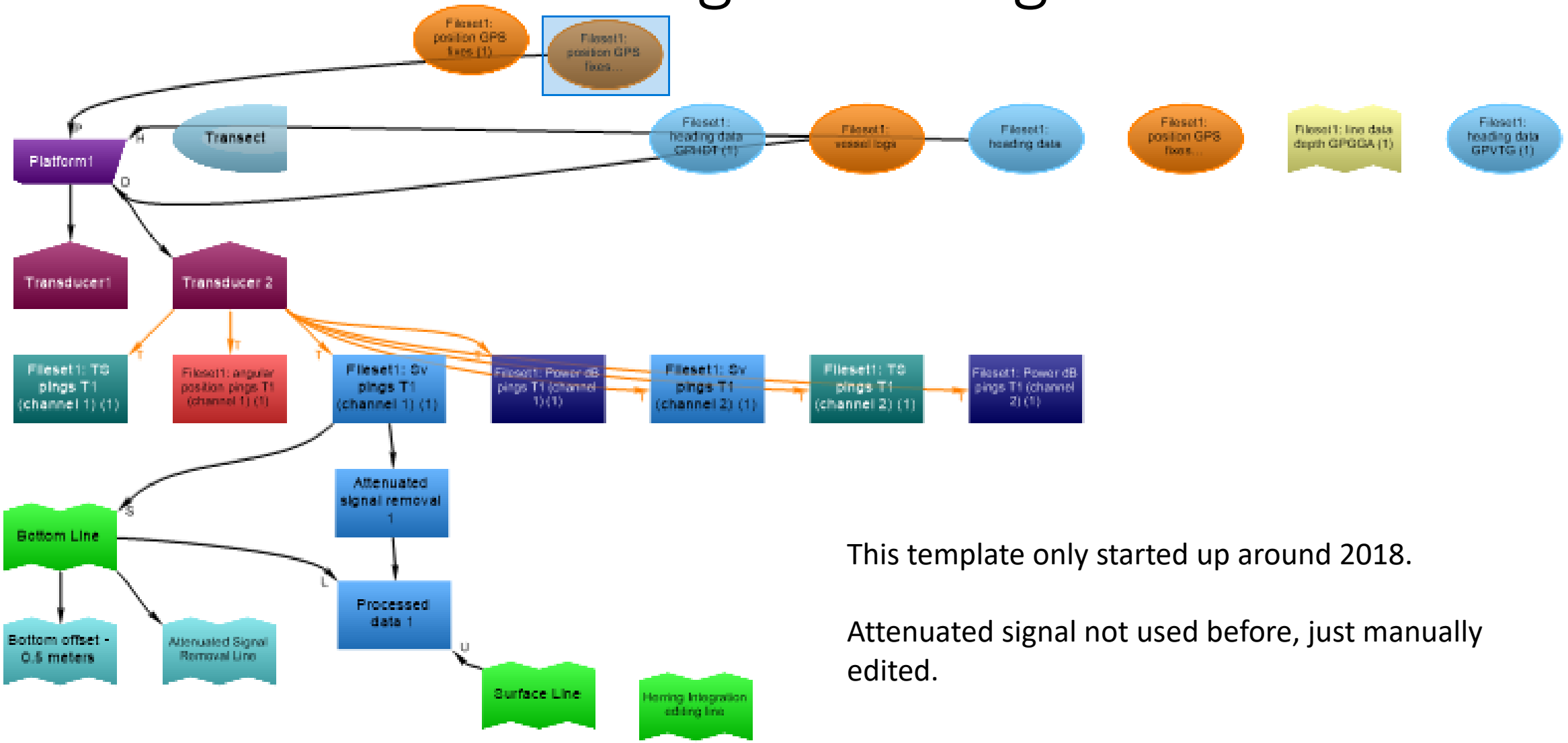
Acoustician Editors Changed overtime.



Potential Issues Raised

1) Target Strength frequency response.
2) Standard Target by Year or Spawning Ground.
3) Changes in L50, Discount acoustic SSB <23cm?
4) Acoustic Editor changes.

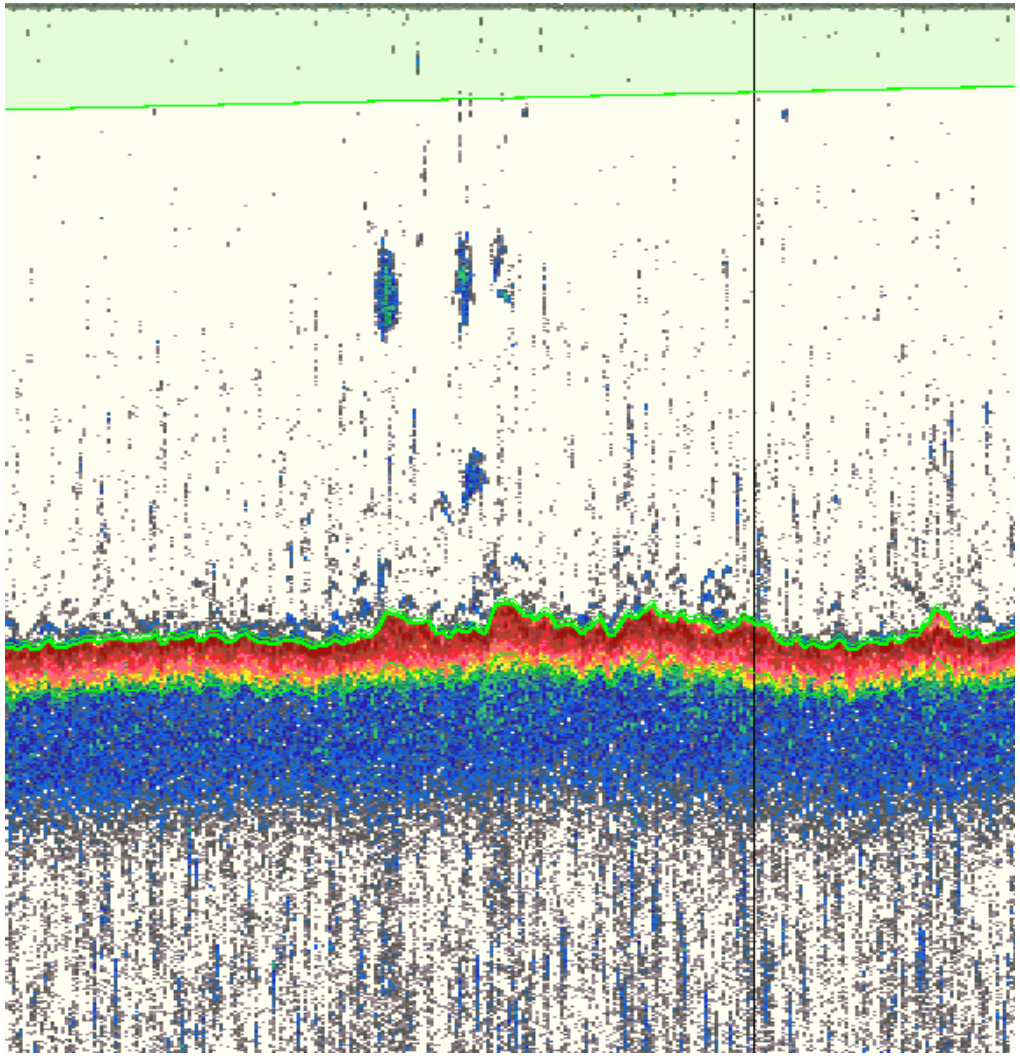
Acoustic Data Editing and Integration.

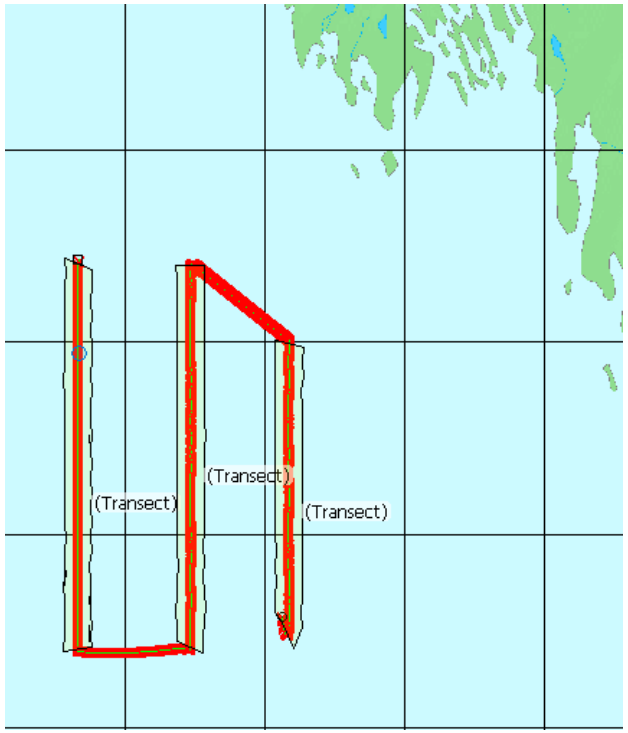


This template only started up around 2018.

Attenuated signal not used before, just manually edited.

Acoustic Data Editing and Integration.





Integrate between
(-10 to -70 dB re @1m^2/m^3)

Many folks would apply a minimum Sv at **-60dB.**

Update Noise algorithms and bottom-backscatter.

echoview
SOUND KNOWLEDGE

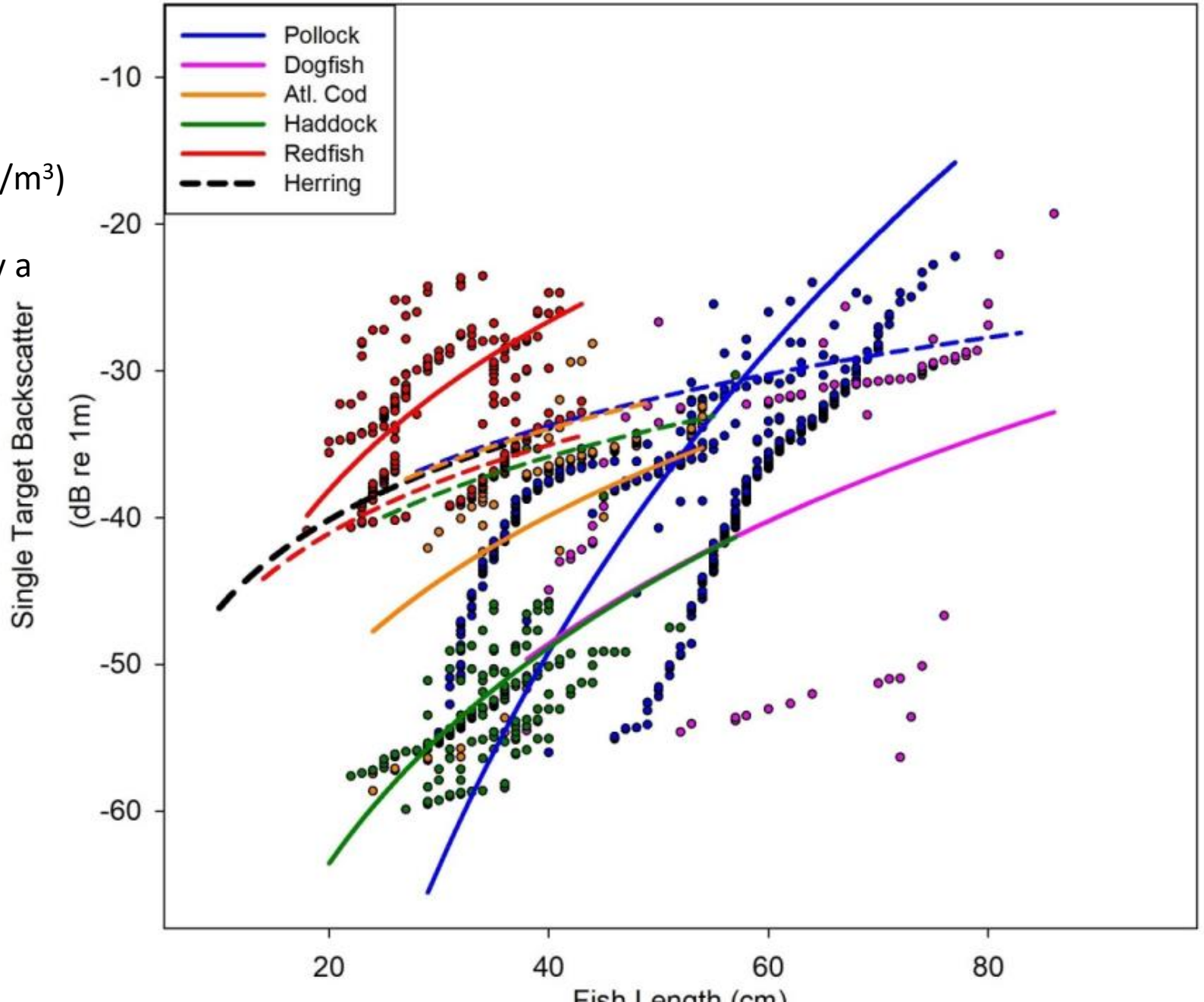
Integrate between
(-10 to -70 dB re @1m^2/m^3)

Many folks would apply a minimum Sv at **-60dB.**

A 23 cm herring is
-**35.5 dB**

A 10 cm herring is in theory **-42 dB.**

Convert minimum Sv (i.e. one herring in 1m^3) **-42 dB.**



Noise through Time. Equipment and Algorithm

Equipment Changes and Noise:

- FEMTO systems used from 1999 to 2015. (nosiest data)
- ES60 started to be used around 2012.
- EK80 was used exclusive since 2020. (cleanest data)

Tides: Bubbles in Scots Bay a big challenge.

If noise was consistent across surveys, no big deal. Relative Index so relatively stable.

If noise is likely inconsistent across surveys, then could explain variation.

Potential Issues Raised

1) Target Strength frequency response.
2) Standard Target by Year or Spawning Ground.
3) Changes in L50, Discount acoustic SSB <23cm?
4) Acoustic Editor changes.
5) Including Noise algorithms

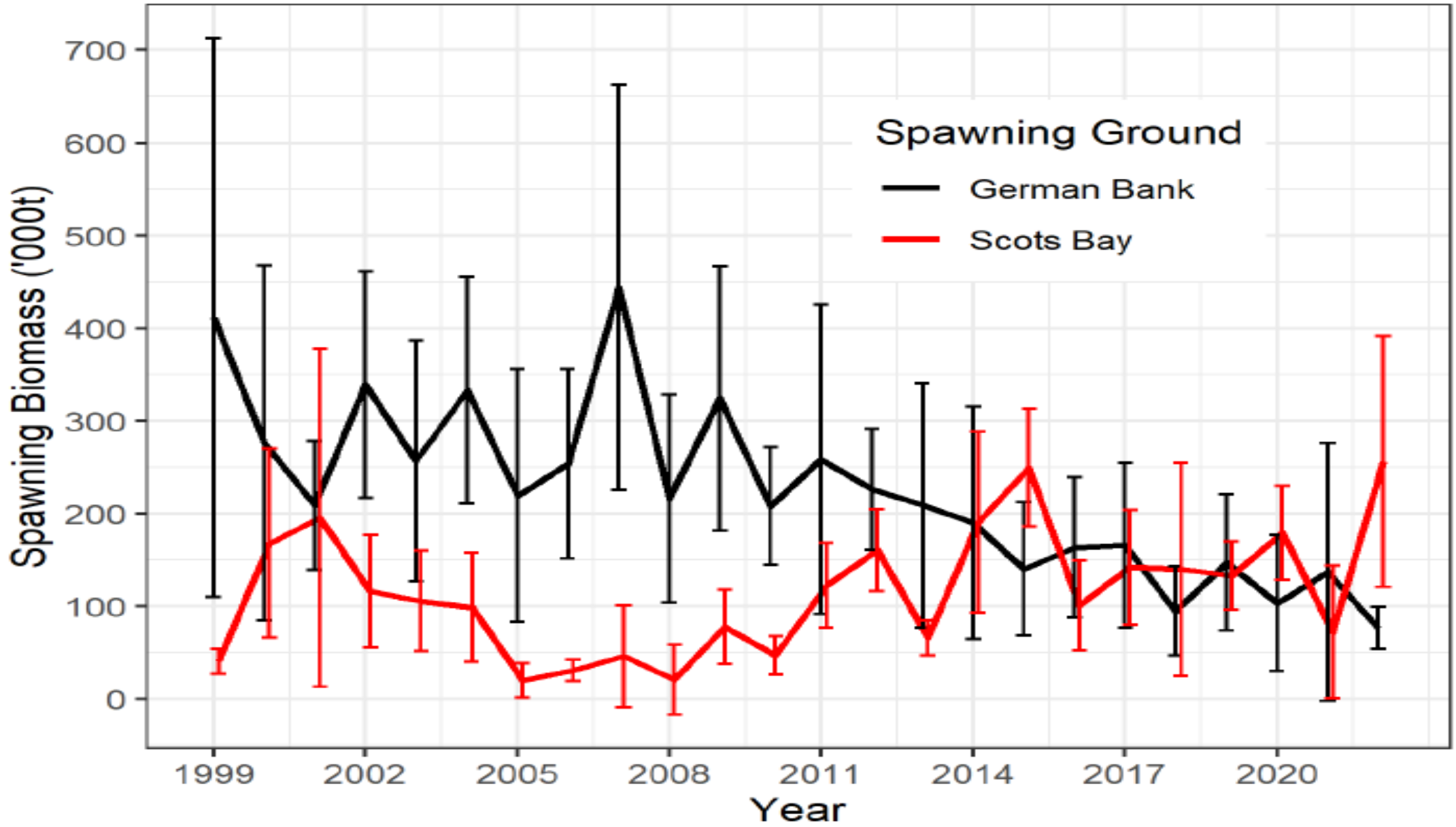


Figure 7. Acoustic index of SSB from 1999 to 2022 (in thousands of metric tonnes) for German Bank (black) and Scots Bay (red) (with 95% confidence intervals; error bars).

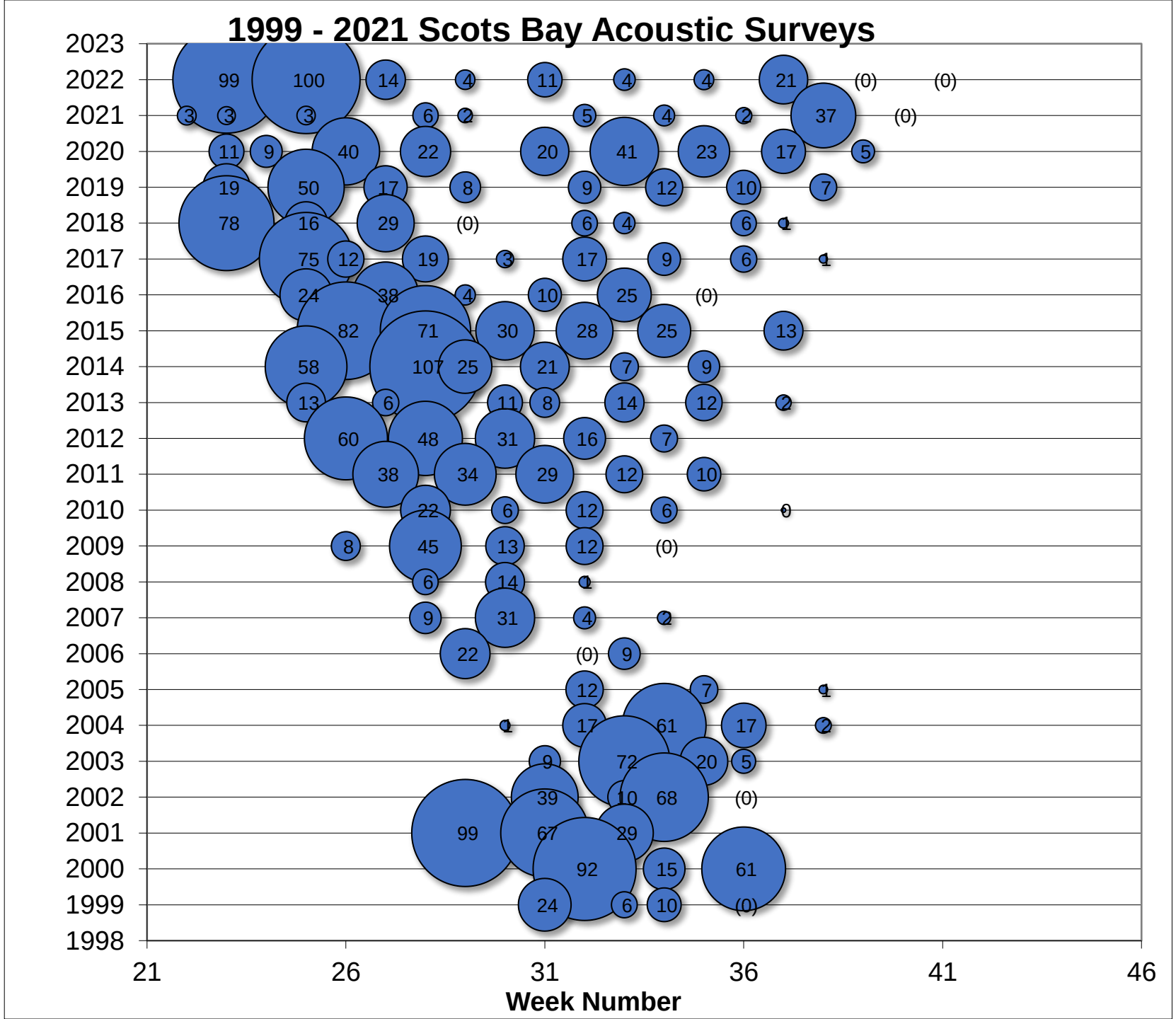
Scots Bay 1999-2022

Surveys:

- June 27 – Sept. 8 (2015)
- June 18 – Aug. 27(2016)
- June 21 – Sept. 23 (2017)
- June 9 – Sept. 15 (2018)
- June 8 – Sept. 15 (2019)
- June 2 – Sept. 20 (2020)
- May 25 – Sept. 26 (2021)
- May 29 – Oct. 3 (2022)

Changes in spawning timing!

Changes in Effort too!

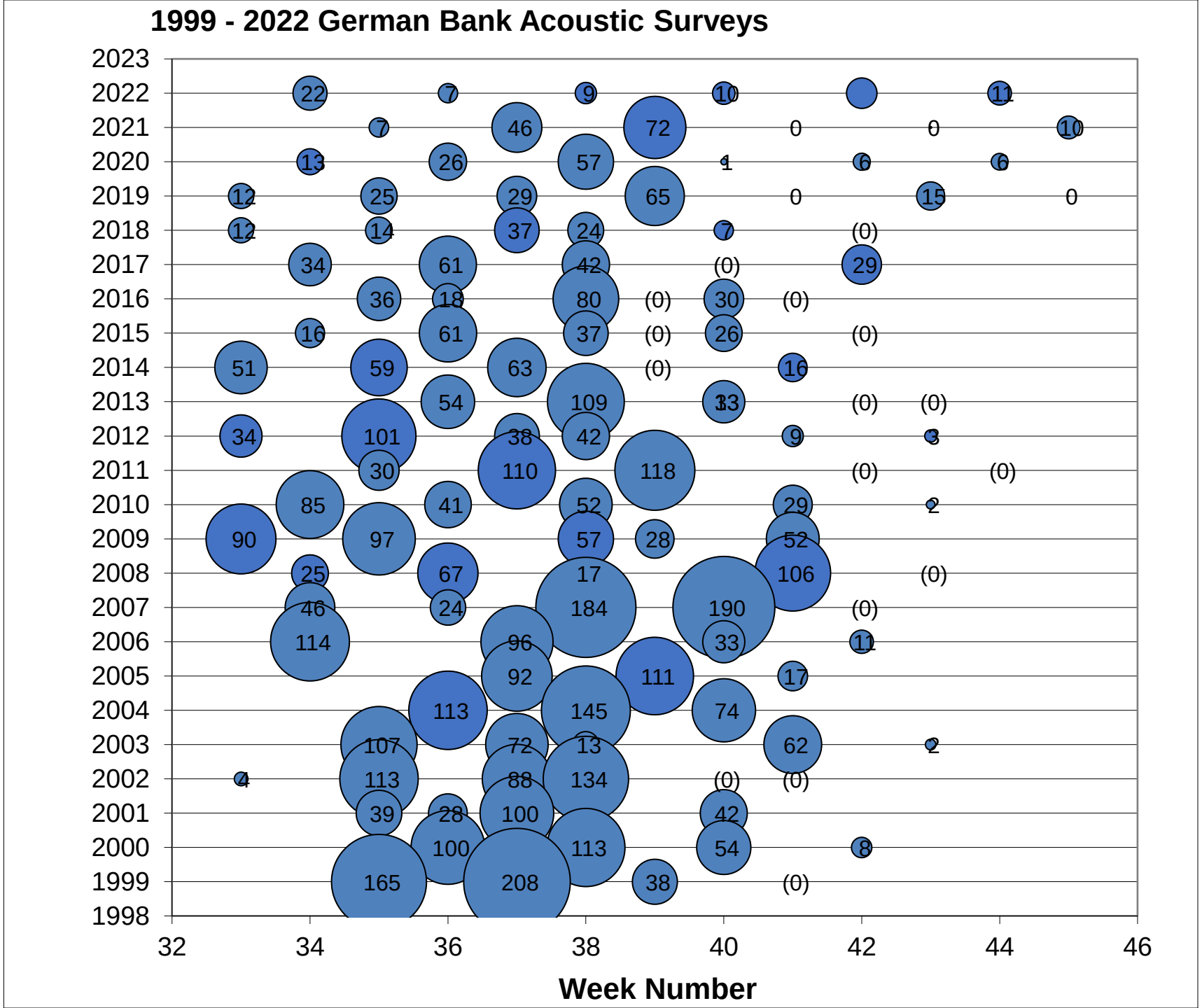


German Bank
1999-2021

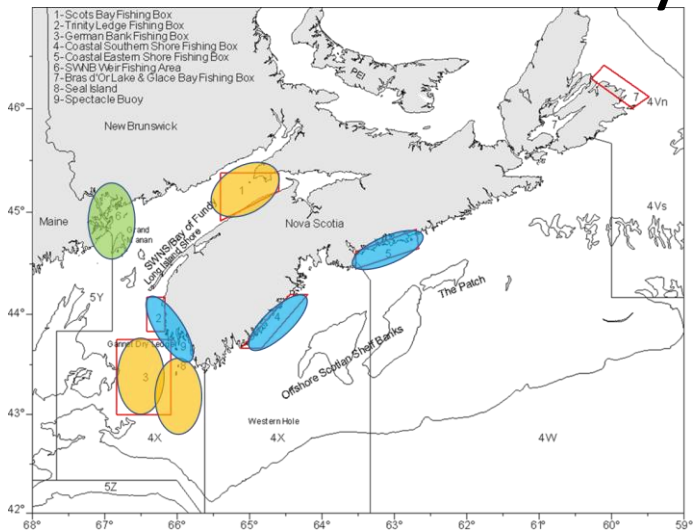
Survey date ranges:

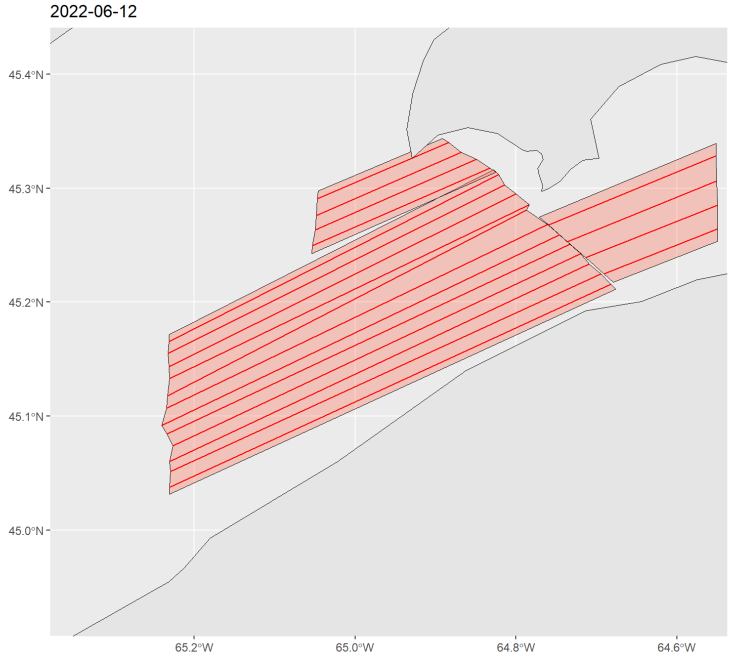
- Aug. 17 – Oct. 12 (2015)
- Aug. 21 – Oct. 7 (2016)
- Aug. 17 – Oct. 18 (2017)
- Aug. 12 – Oct. 22 (2018)
- Aug. 11 – Nov. 3 (2019)
- Aug. 16 – Oct. 25 (2020)
- Aug. 23 – Nov. 3 (2021)
- Aug. 14 – Oct. 23 (2022)

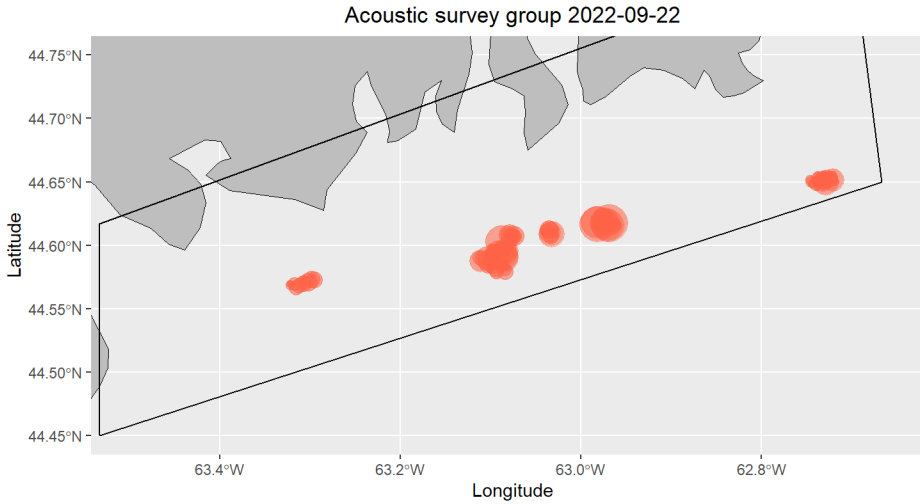
Effort more consistent, just Less fish.

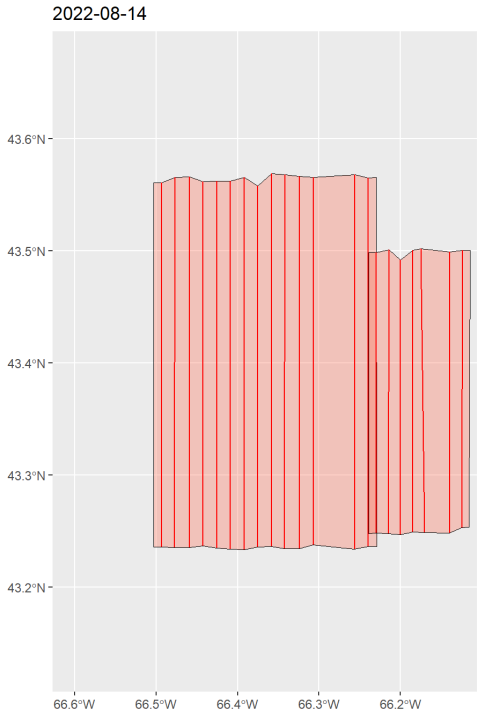


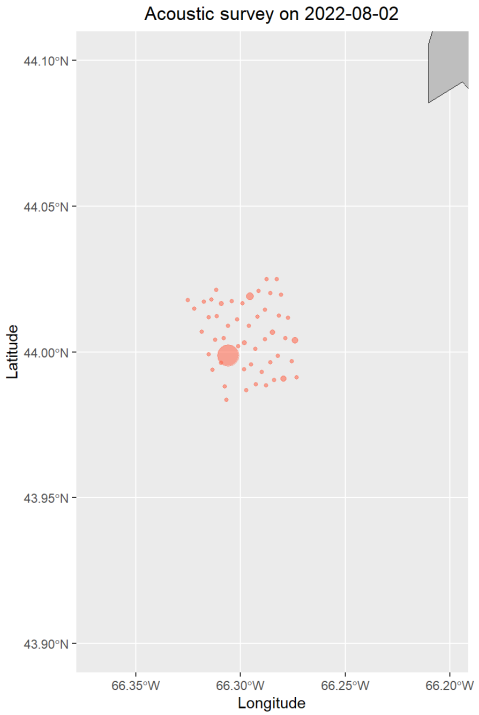
Acoustic Surveys

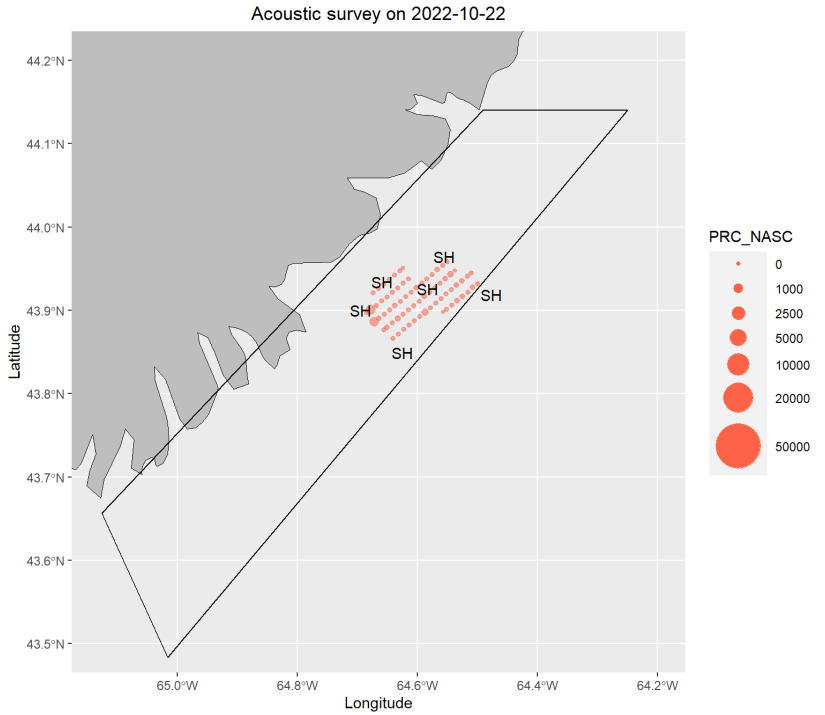












Absolute Biomass vs Relative Index

"The acoustic survey results have been used in previous assessments as absolute estimates of Spawning Stock Biomass (DFO, 2005)" – CSAS 2023/022

Yet – Changes in Survey Effort!

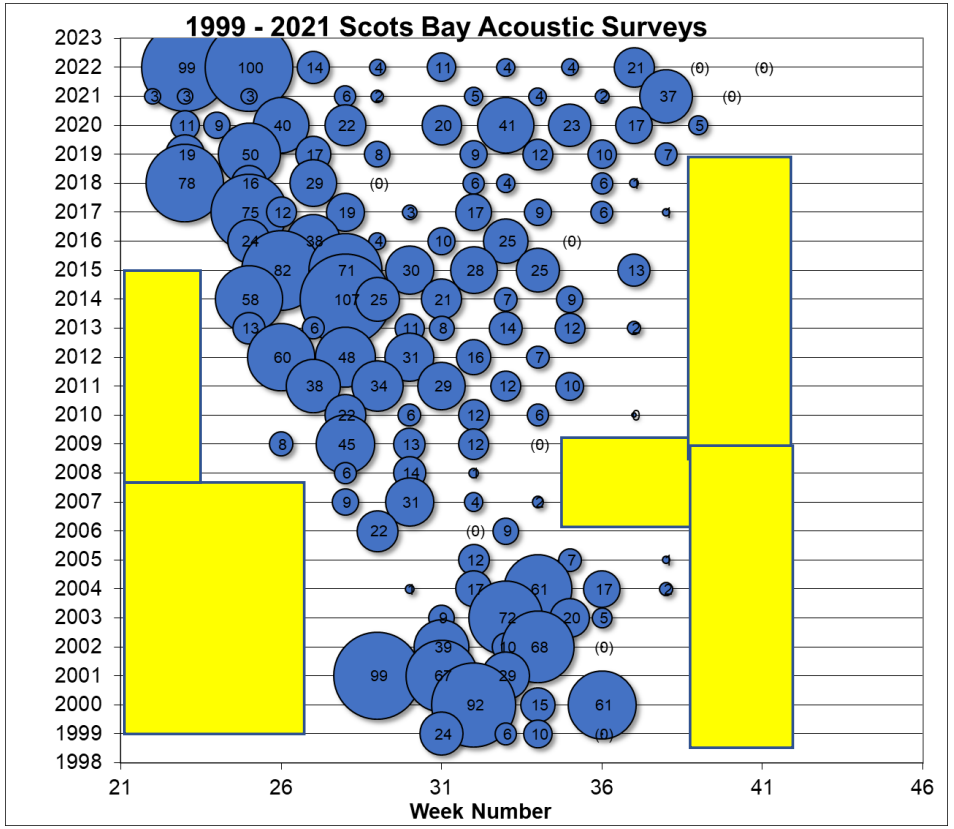
Survey estimates should probably change

Catch per effort series.

And/or

Create GLM with trend

to fit missing gaps in data?



Potential Issues Raised

1) Target Strength frequency response.
2) Standard Target by Year or Spawning Ground.
3) Changes in L50, Discount acoustic SSB <23cm?
4) Acoustic Editor changes.
5) Including Noise algorithms
6) Changes in Temporal Distributions, # Surveys

So, Adhoc Surveys…. Yep…

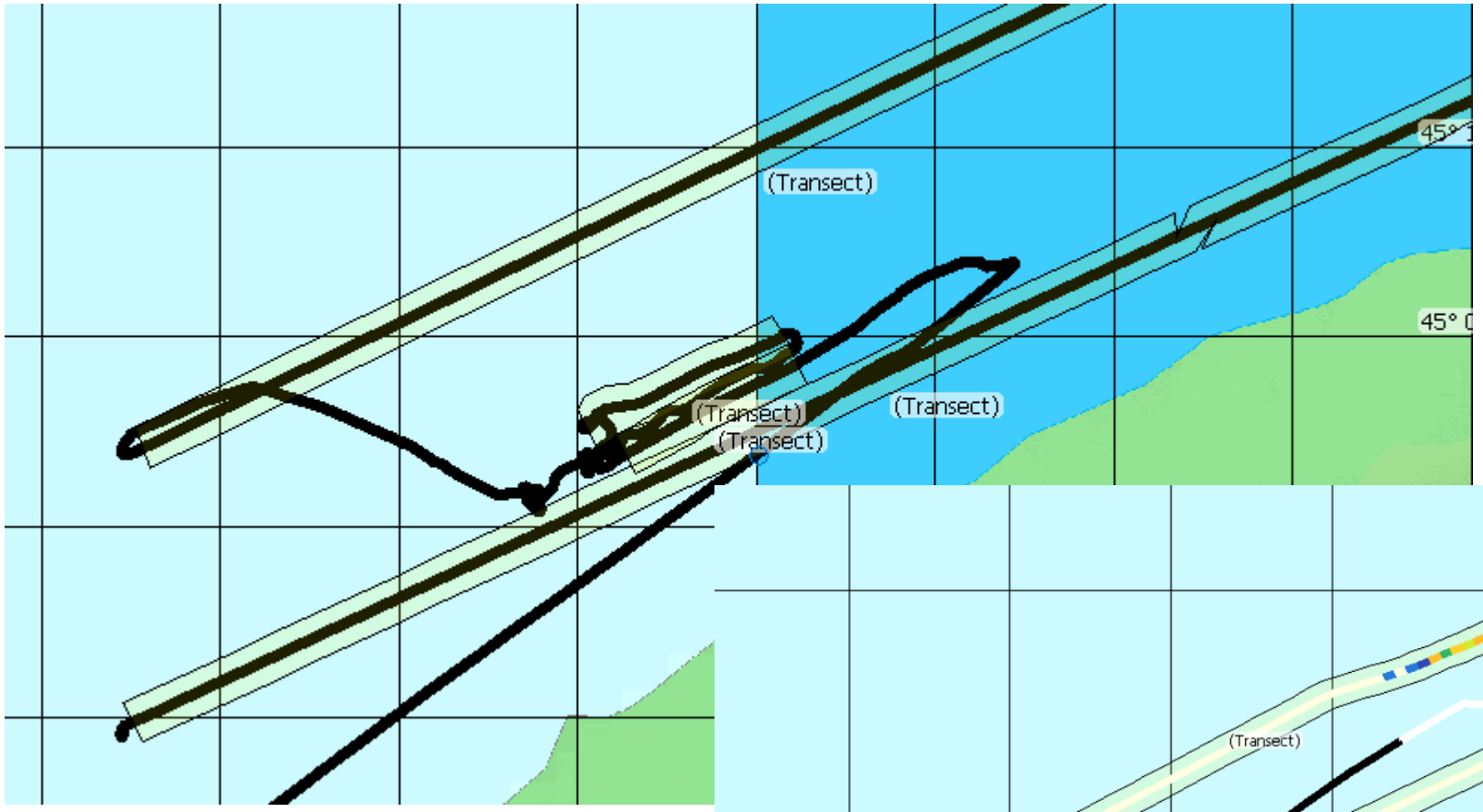
Abstract:

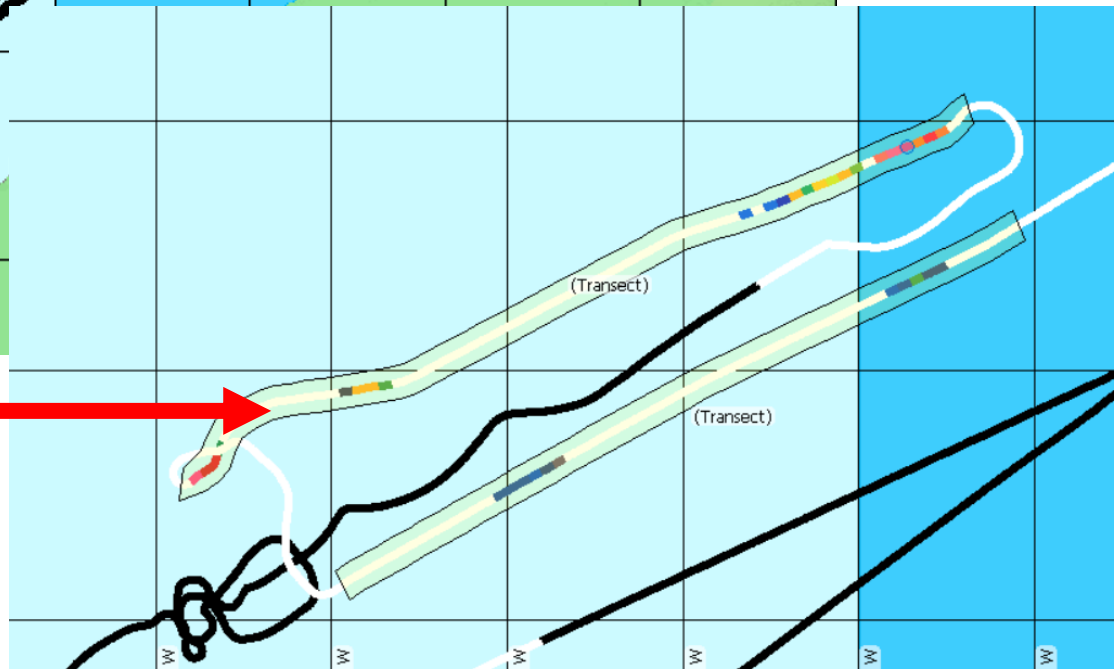
Over the past several years the 4WX herring stock complex has been assessed using input from industry based acoustic surveys and fishing excursions. Unfortunately, the data have been collected in somewhat of an *ad hoc* manner. The results, while providing valuable information on the abundance of herring on specific spawning grounds, are not comparable from year to year due to restricted coverage and only provide a minimum biomass of the fish observed on the day surveyed. To overcome this problem, data from the fishery are used to identify potential survey areas from the distribution of catches during the spawning season. The survey coverage area is further reduced by isolating the locations which contains more than 90% of reported landings. Thereafter, standard random transects are selected within the survey area and a protocol recommended for instances when fish are observed beyond the survey boundaries. Standarization of the survey area provides a means to compare observations from year to year and forms the basis for an index of abundance in years to come.

Melvin & Power, 1999

Yet, adhoc allowed after this report?
Assumption of absolute biomass in assessment

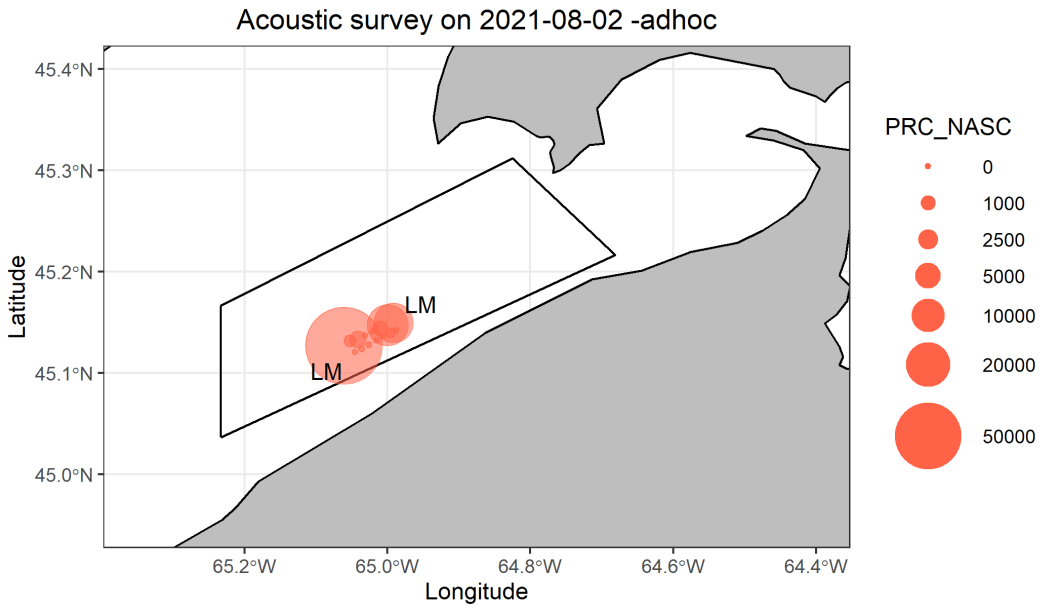
SCOTS BAY SURVEY #6 – ADHOC – AUGUST 2,2021
ADJUSTED SSB = 4042T



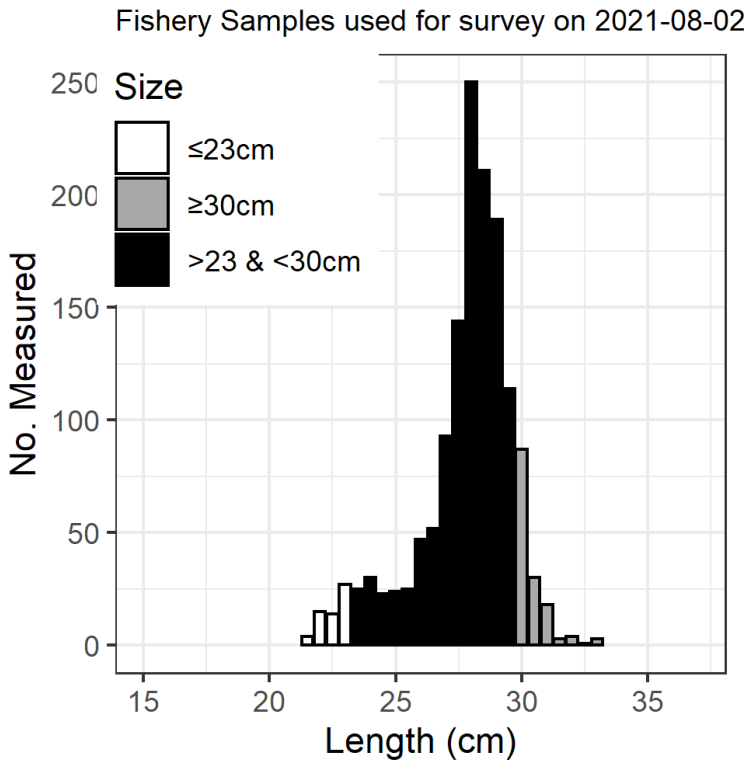


- Line Could be a little better…

Scots Bay Survey #6 – Adhoc – August 2,2021
adjusted SSB = 4042t



- 51.18% Stage 5 (maturing)
- 3.94% stage 6 (ripe and running)
- 4.19% less than 23 cm
- 5 detailed samples (n = 127)



SCOTS BAY SUMMARY
ADHOC SURVEYS NOT COUNTED

Location	Date	Target Strength* (dB/kg)	Area (km²)	mean Sa (dB/m²)	Unadjusted Biomass (t)	Standard Error (t)	SE %	Adjusted Biomass (t)
Scots Bay #1	5/25/2021	-35.50	389.2	-51.58	3,269	2,092	64%	3,270
Scots Bay #2	6/6/2021‡	-35.36	560.2	-57.30	2,879	1,918	67%	2,288
Scots Bay #3	6/20/2021	-34.80	724.7	-51.78	3,739	1,047	28%	3,268
Scots Bay #4	7/5/2021	-35.50	724.7	-51.09	6,317	1,172	19%	5,861
Scots Bay #5	7/18/2021	-35.19	725.4	-54.51	2,949	985	33%	1,994
Scots Bay #6	8/2/2021‡	-35.43	730.1	-54.53	4,922	1,608	33%	4,540
Scots Bay #7	8/16/2021‡	-35.46	662.6	-56.29	4,670	3,302	71%	4,006
Scots Bay #8	8/30/2021	-35.28	574.7	-56.99	3,876	1,129	29%	3,228
Scots Bay #9	9/14/2021	-35.13	569.5	-46.86	38,224	32,367	85%	36,587
Scots Bay #10	9/27/2021	-35.50	281.7	-55.65	2,716	756	28%	0
Summary			**5942.82**	**-53.66**	**73,561**	32,779	45%	**65,043**

SCOTS BAY SUMMARY MAXIMUM BIOMASS

Location	Date	Target Strength* (dB/kg)	Area (km²)	mean Sa (dB/m²)	Unadjusted Biomass (t)	Standard Error (t)	SE %	Adjusted Biomass (t)
Scots Bay #1	5/26/2021	-35.50	389.2	-51.58	3,269	2,092	64%	3,269
Scots Bay #2-adhoc	6/7/2021‡	-35.36	2.4	-31.98	5,236	1,882	36%	4,699
Scots Bay #3	6/20/2021	-34.80	724.7	-51.78	3,739	1,047	28%	2,876
Scots Bay #4	7/5/2021	-35.50	724.7	-51.09	6,317	1,172	19%	5,842
Scots Bay #5	7/18/2021	-35.19	725.4	-54.51	2,949	985	33%	1,872
Scots Bay #6-adhoc	8/2/2021‡	-35.43	6.6	-37.15	4,424	4,079	92%	4,078
Scots Bay #7	8/16/2021‡	-35.46	662.6	-56.29	4,670	3,302	71%	4,130
Scots Bay #8	8/30/2021	-35.28	574.7	-56.99	3,876	1,129	29%	3,164
Scots Bay #9	9/14/2021	-35.13	569.5	-46.86	38,224	32,367	85%	37,144
Scots Bay #10	9/27/2021	-35.50	281.7	-55.65	2,716	756	28%	0
Summary			**4661.45**	**-49.39**	**75,419**	32,990	44%	**67,074**

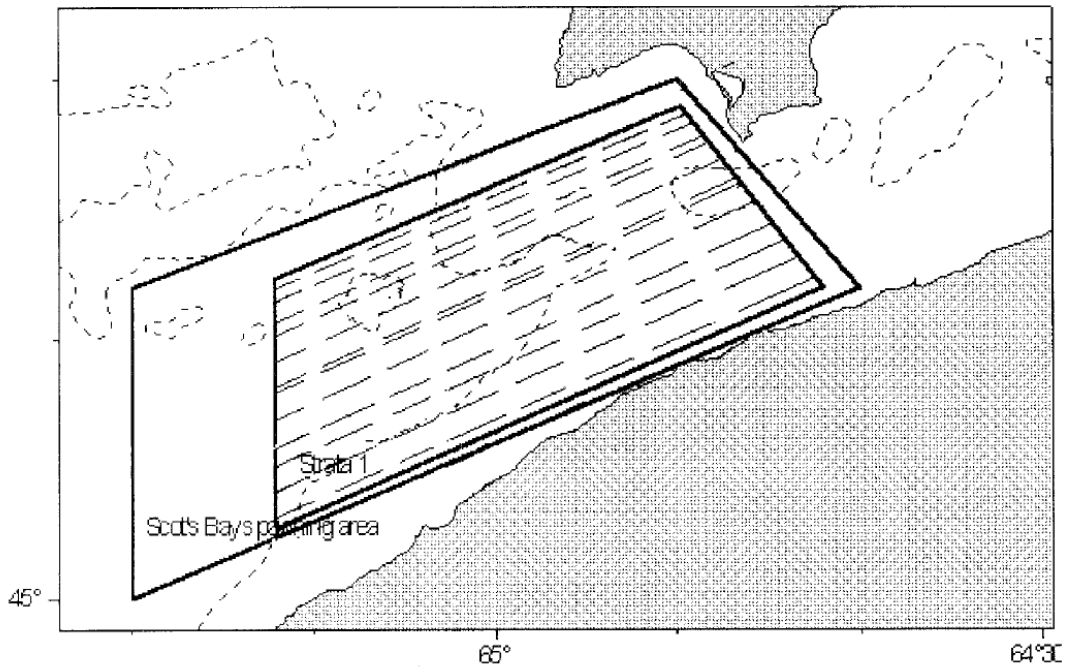
This is fine, if we are trying to get the absolute biomass of herring, but we are not now.

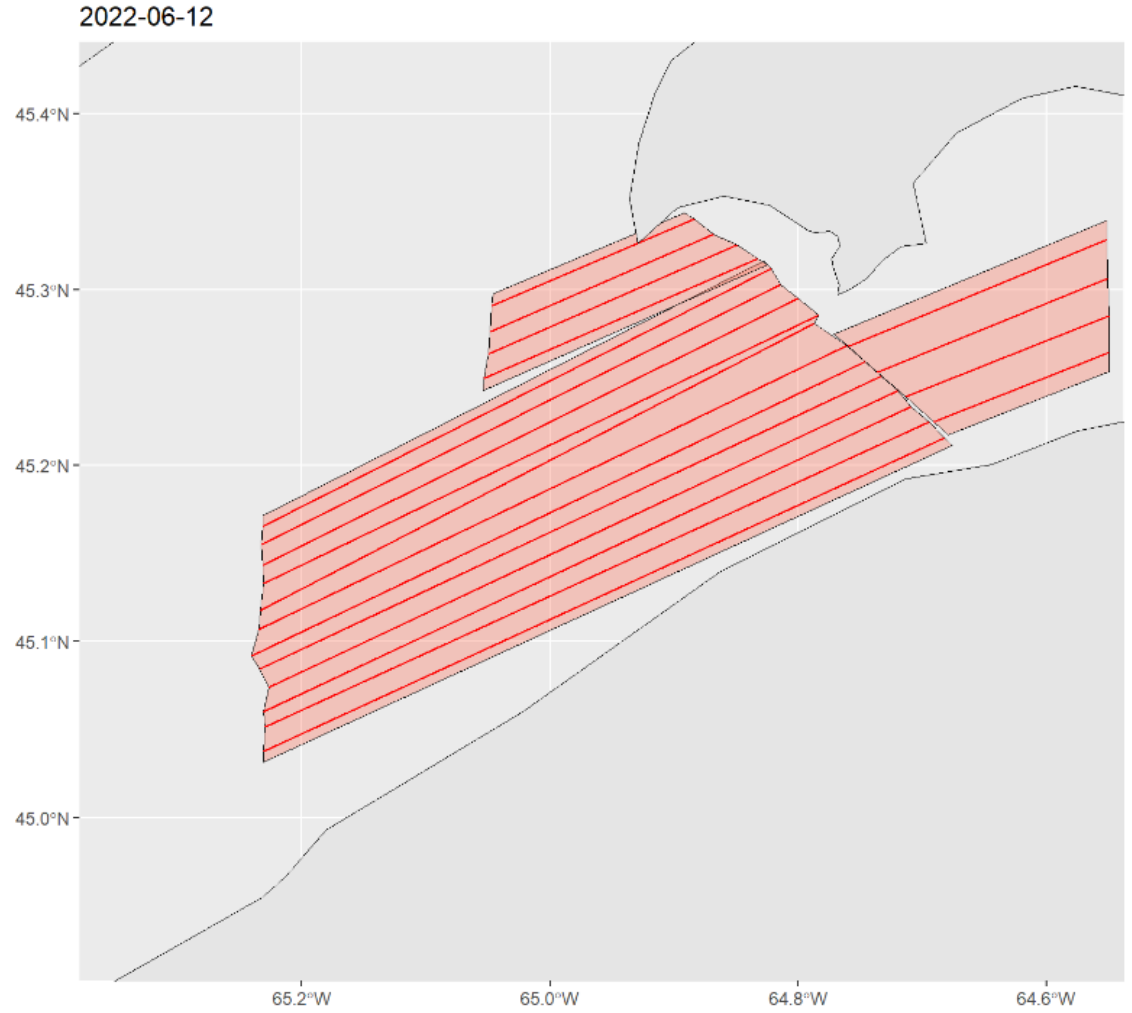
Potential Issues Raised

1) Target Strength frequency response.
2) Standard Target by Year or Spawning Ground.
3) Changes in L50, Discount acoustic SSB <23cm?
4) Acoustic Editor changes.
5) Including Noise algorithms
6) Changes in Temporal Distributions
7) Changes in # Surveys (CPUE)
8) Adhoc Surveys

4) Biomass Estimates – Strata and EDSU

Original Strata





4) Biomass Estimates – Strata and EDSU

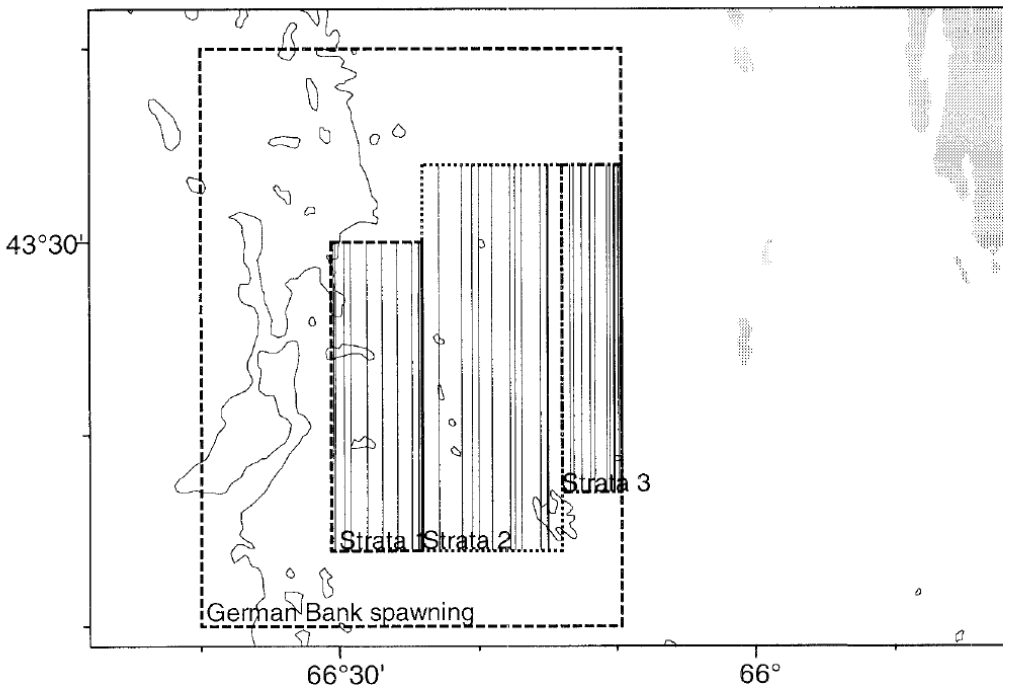
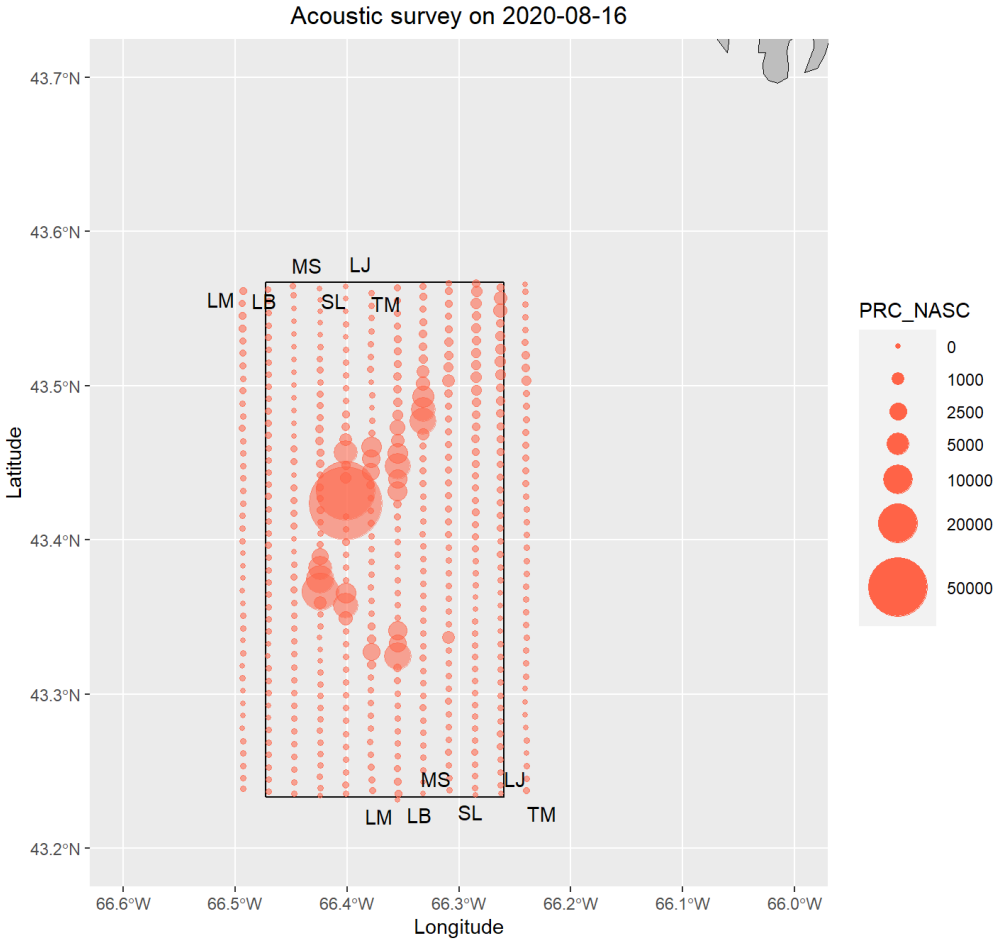


Figure 2b. German Bank spawning area boundaries, strata and random



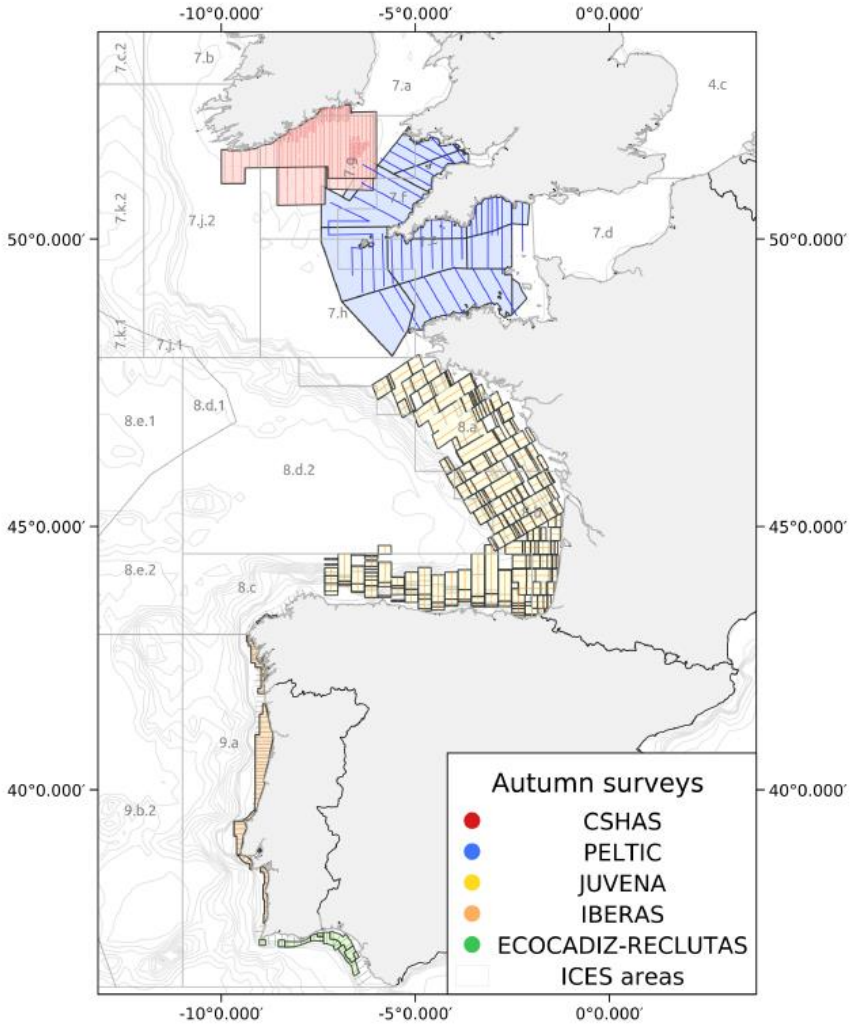
4) Biomass Estimates – Strata and EDSU

ICES Survey Protocols – Manual for Acoustic Surveys Coordinated under ICES Working Group on Acoustic and Egg Surveys for Small Pelagic Fish (WGACEGG)

Volume 64 I April 2021

Recommends to post-stratify areas if there are consistent size-differences and/or species-mixes.

See also Debertin 2020. https://doi.org/10.1139/cjfas-2019-0152



Potential Issues Raised

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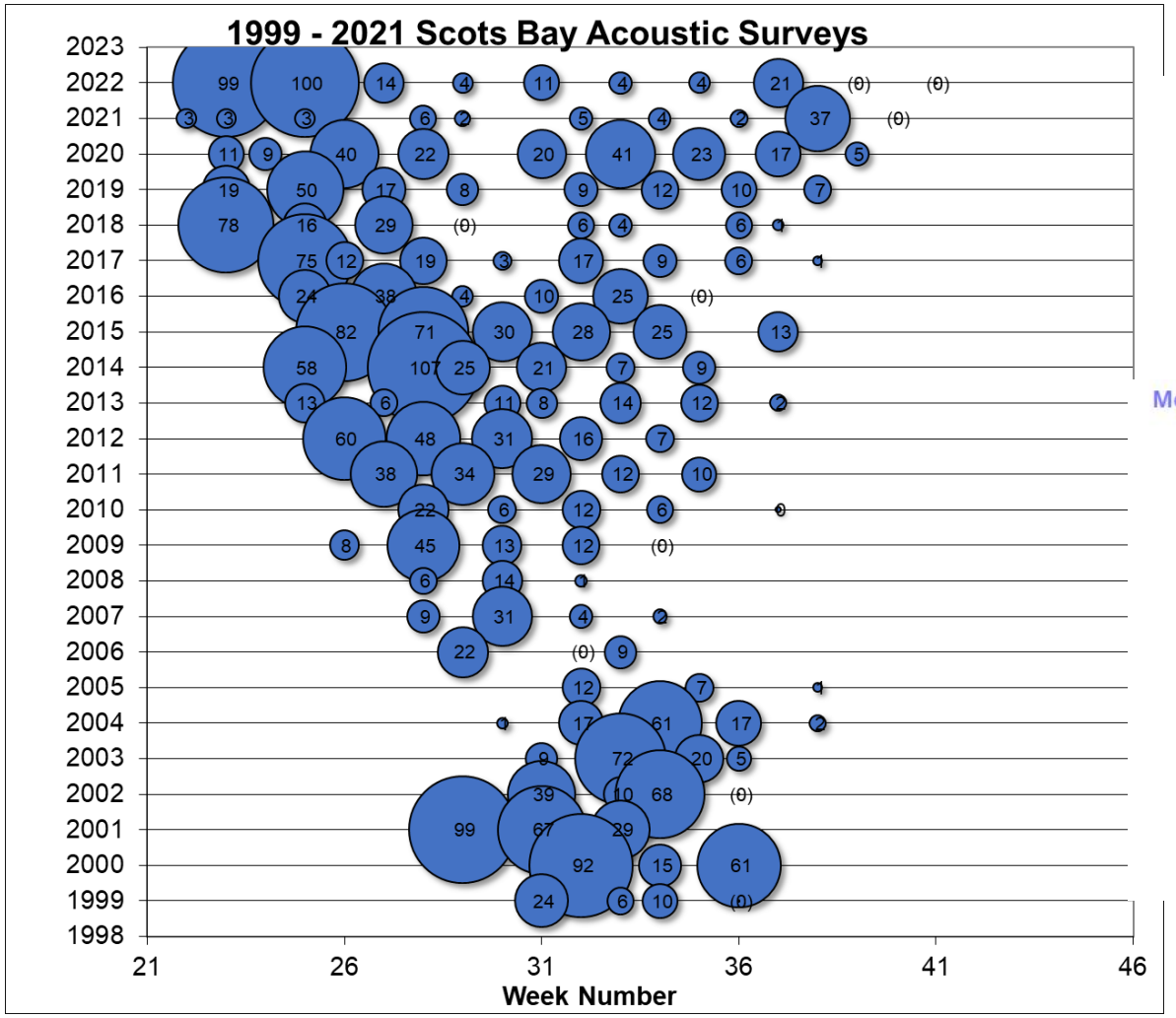
6) Changes in Temporal Distributions
7) Changes in # Surveys (CPUE)
8) Adhoc Surveys
9) Changes in Spatial Coverage

Double-Counting and Turnover Equation.



ETIQUETTE

HOW TO HANDLE HOUSE GUESTS WHO STAY TOO LONG

Author: **Wikihow** | Co – Author/ Expert Contributor: **Tami Claytor**

Method 4: Being a Bad Host

Tagging studies

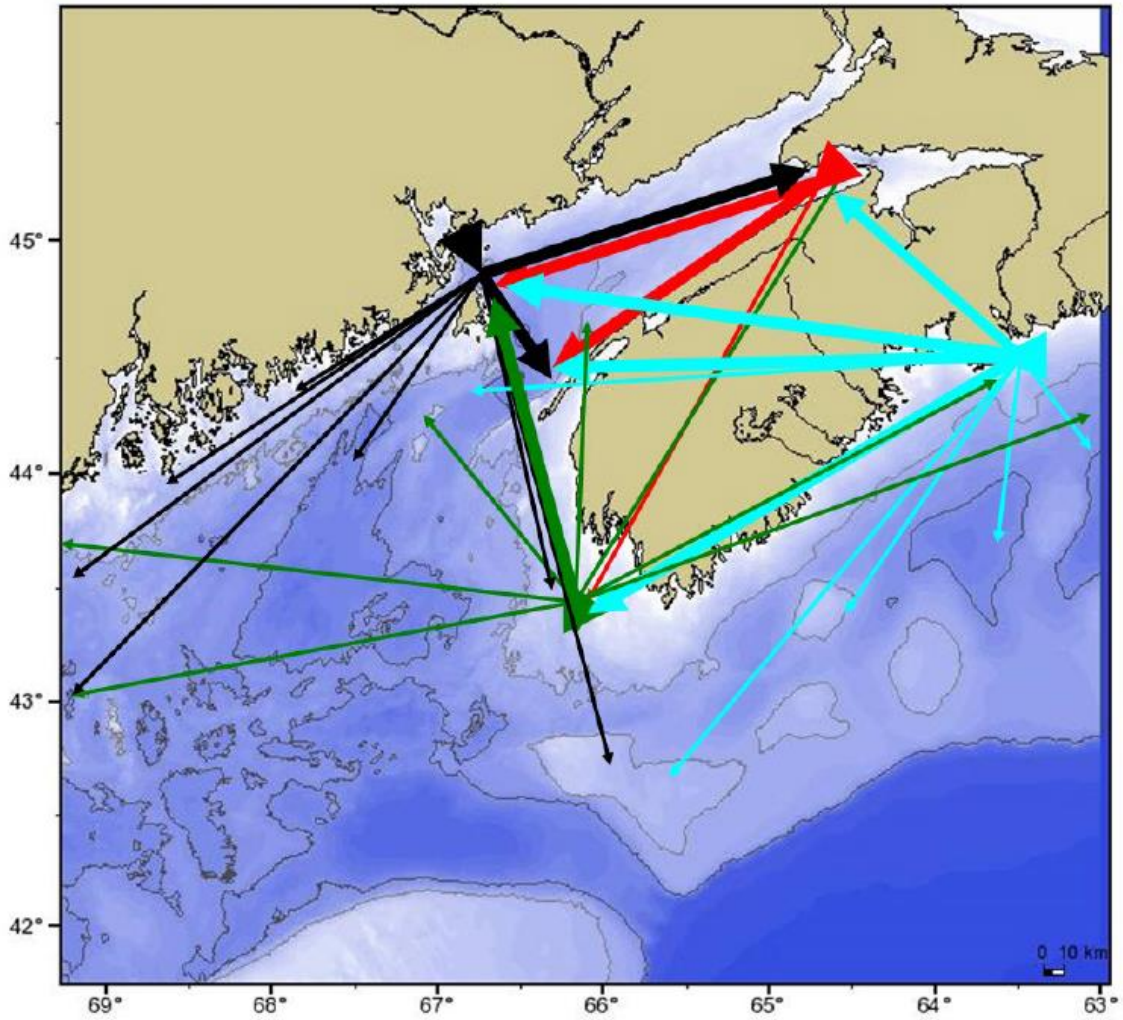
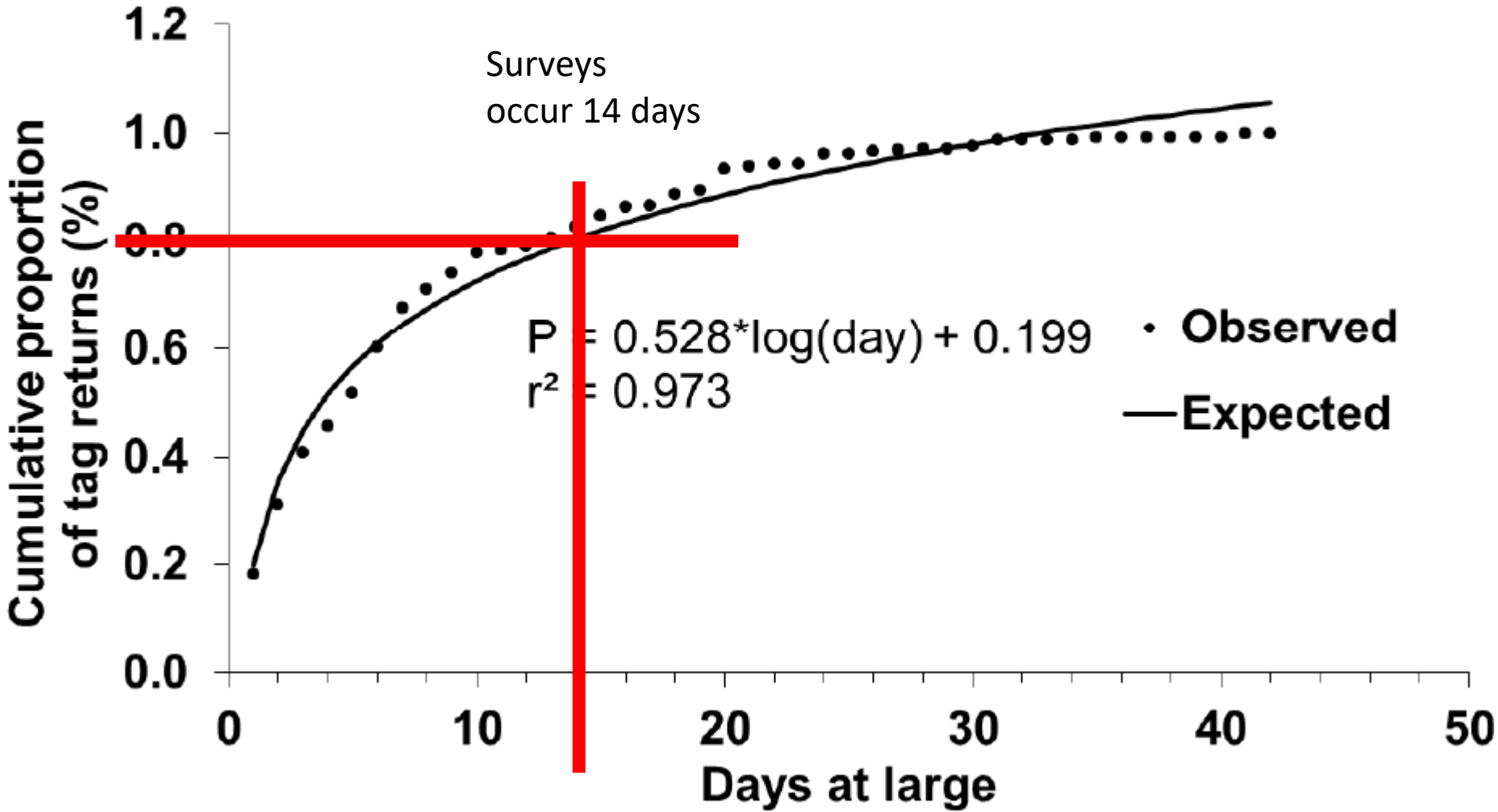


Figure 11. Movement of Herring tagged in Scots Bay (1998–2006), NB Weirs (1999–2004), German Bank (1998–2011) and off Chebucto Head (1999).

5) Double-Counting and Turnover Equation.



5) Double-Counting and Turnover Equation.

$$P = 0.528*\log(day) + 0.199$$

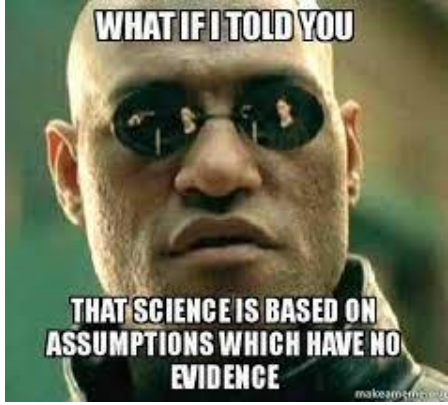
>31 days is 0

Table 19. German Bank 2002 survey biomass estimates (diagonal), elapsed time between surveys (below diagonal), and estimated tonnes remaining (above diagonal) at the time of a subsequent survey. Table includes only those surveys used to estimate total annual biomass. A "-", indicates no information.

Survey Date	Survey Number	Surveys						Total
		1	2	3	4	5	6	
11-Aug-02	1	3,843	689	0	0	0	0	-
26-Aug-02	2	15	114,119	20,448	8140	0	0	-
10-Sep-02	3	0	15	108,837	32,260	13,598	3,913	-
19-Sep-02	4	0	24	9	174,042	47,379	21,744	-
29-Sep-02	5	0	0	19	10	4,857	1,440	-
08-Oct-02	6	0	0	28	19	9	10,403	-
-	-	-	-	-	-	-	-	416,101
Adjusted total		3,843	113,430	88,389	133,642	0	0	339,305

Go to the CODE!

Turnover Equation.



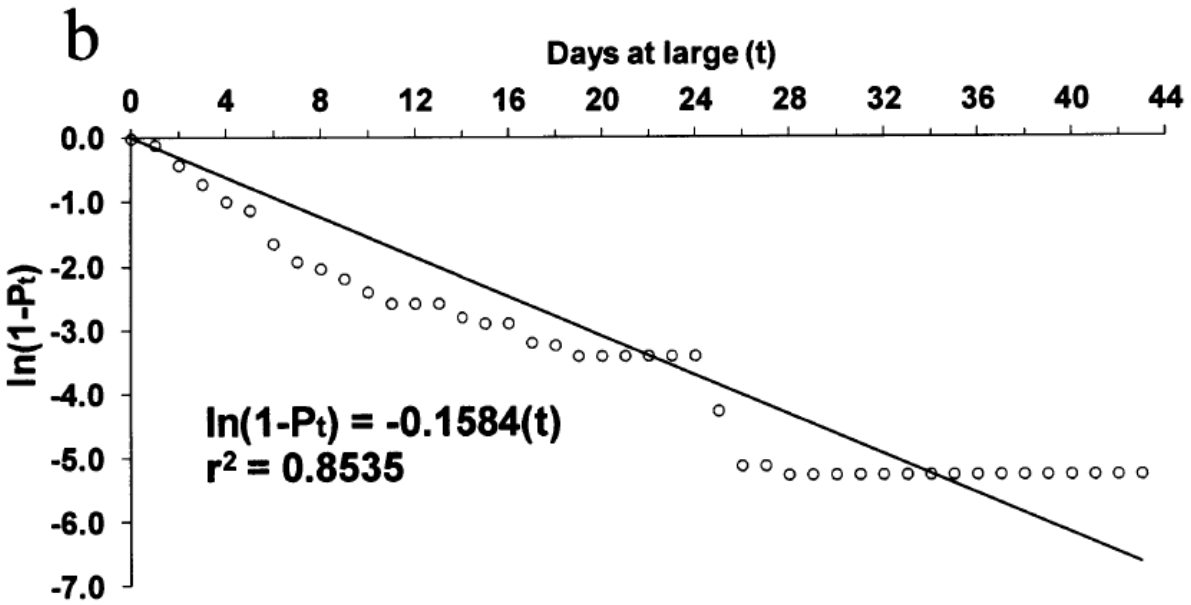


Figure 2.4: Example of regression analysis of the mean cumulative proportion of recaptured herring ($\ln(1- P_t)$) on (a) German Bank and at (b) Scot's Bay for the catch adjusted method where the slope is equal to the instantaneous rate of change (k) of recaptures during the spawning season.

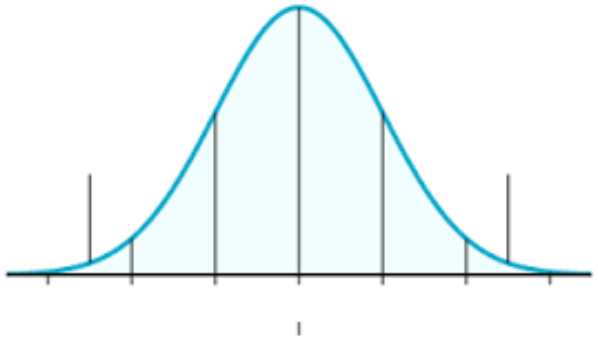
Uses Instantaneous Rate of Change.

Two Assumptions used $P_t = 1 - e^{(-kt)}$

1) Assumed Equation is best approximation of natural processes. Cumulative Distribution function instead?

2) Assumes that herring tag at Day 0 arrived at Day 0. (Probably should assume a distribution).

Day 0



Potential Issues Raised

1) Target Strength frequency response.
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7) Changes in # Surveys (CPUE)
8) Adhoc Surveys
9) Changes in Spatial Coverage
10) Turnover Equation Improvements.

Potential Issues Raised

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5) Including Noise algorithms
6) Changes in Temporal Distributions.
7) Changes in # Surveys (CPUE)
8) Adhoc Surveys
9) Changes in Spatial Coverage
10) Turnover Equation Improvements.

Solutions?

Go to Solutions Slide to see…

Go to Acoustic Index Review Database.

Other Issues

Stock Structure and Movement among Grounds

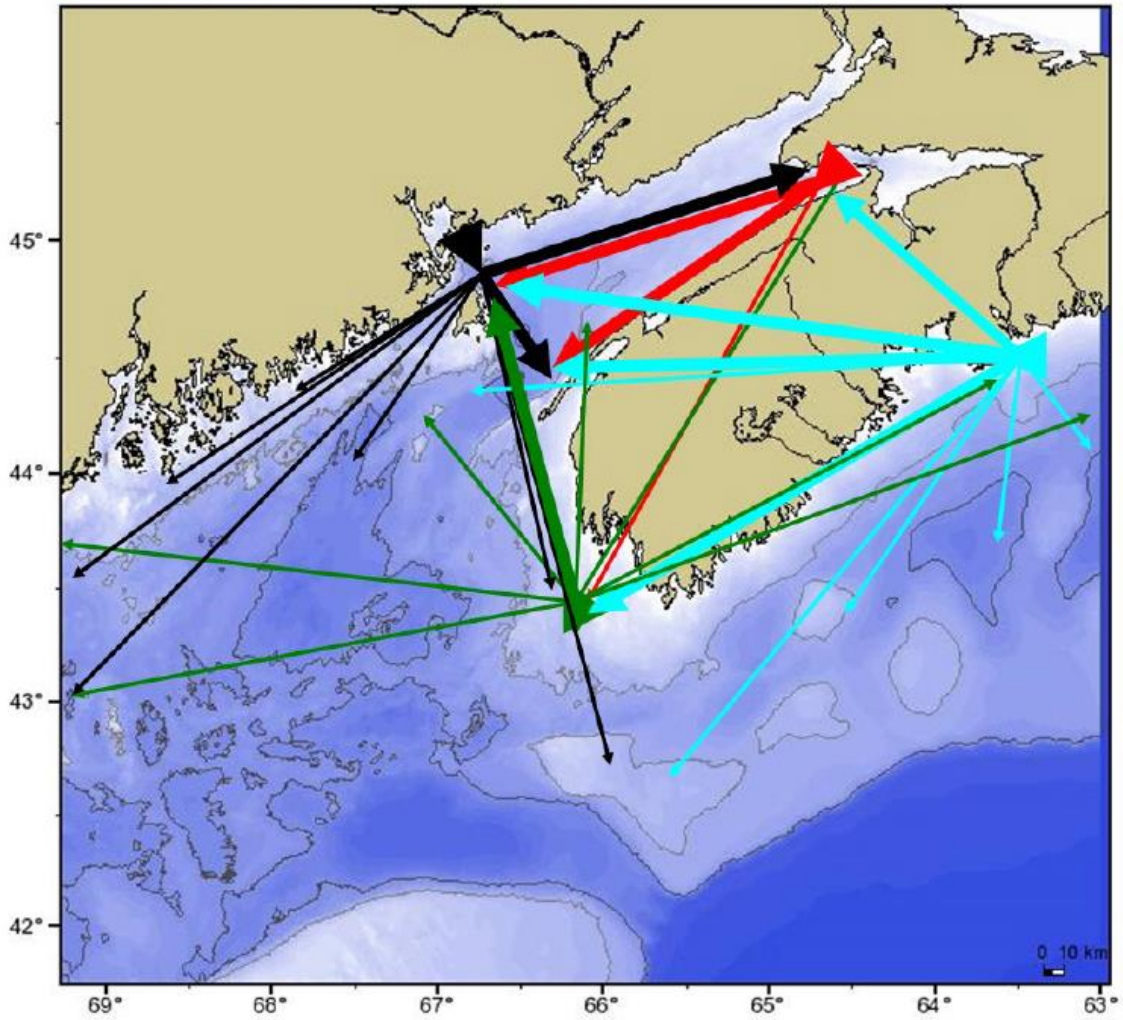
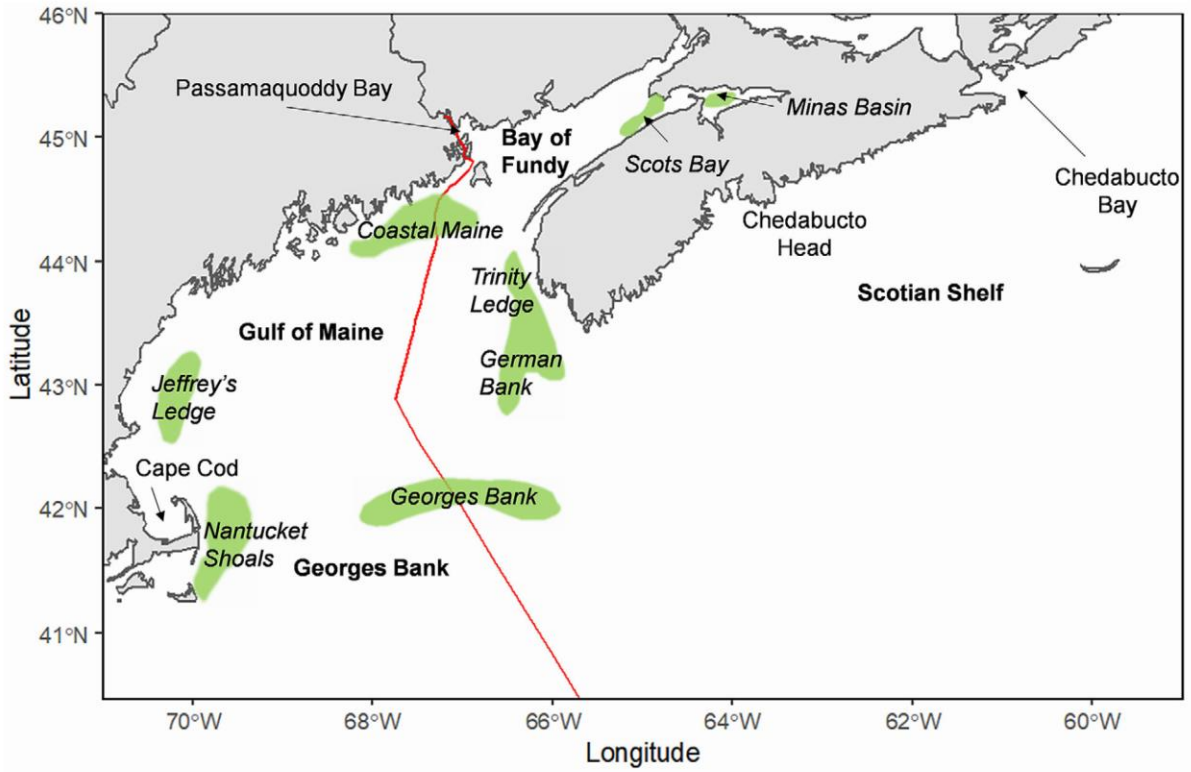


Figure 11. Movement of Herring tagged in Scots Bay (1998–2006), NB Weirs (1999–2004), German Bank (1998–2011) and off Chebucto Head (1999).

J. Northw. Atl. Fish. Sci., Vol. 53: 19–34 Publication (Upload) date: 08 Aug 2022

Review of tagging studies on Atlantic herring (*Clupea harengus*) in relation to transboundary movement in the Bay of Fundy/Gulf of Maine/Scotian Shelf region of the Northwest Atlantic

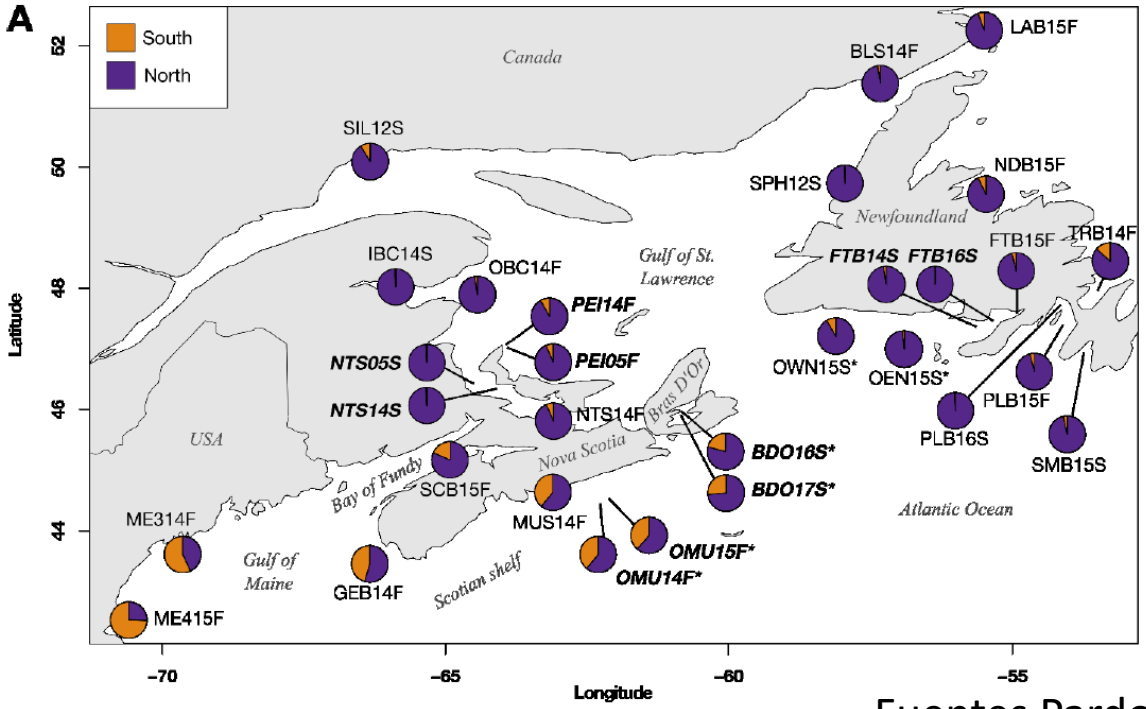
Gailene A. Tobin-van den Heuvel[1], Michael R. van den Heuvel[1], Jonathan J. Deroba[2], and Timothy J. Barrett[3*]

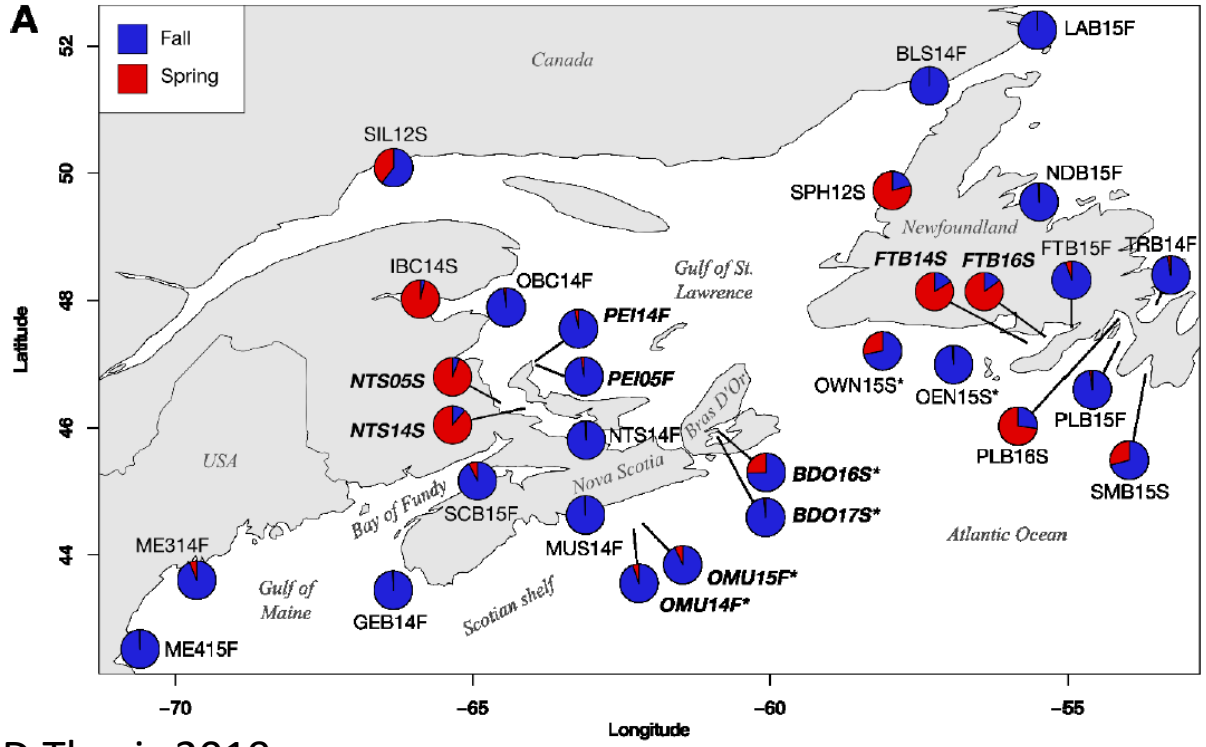


<u>Conventional Wisdom</u> – Herring caught in SWNB weirs are US origin.

Tagging studies – They come from NAFO areas 4VWX5YZ. i.e. above is bogus.

Really need to determine the extent to which juvenile feeding ground is mixed. Could inform both US/CAN assessments.





Fuentes Pardo – PhD Thesis 2019

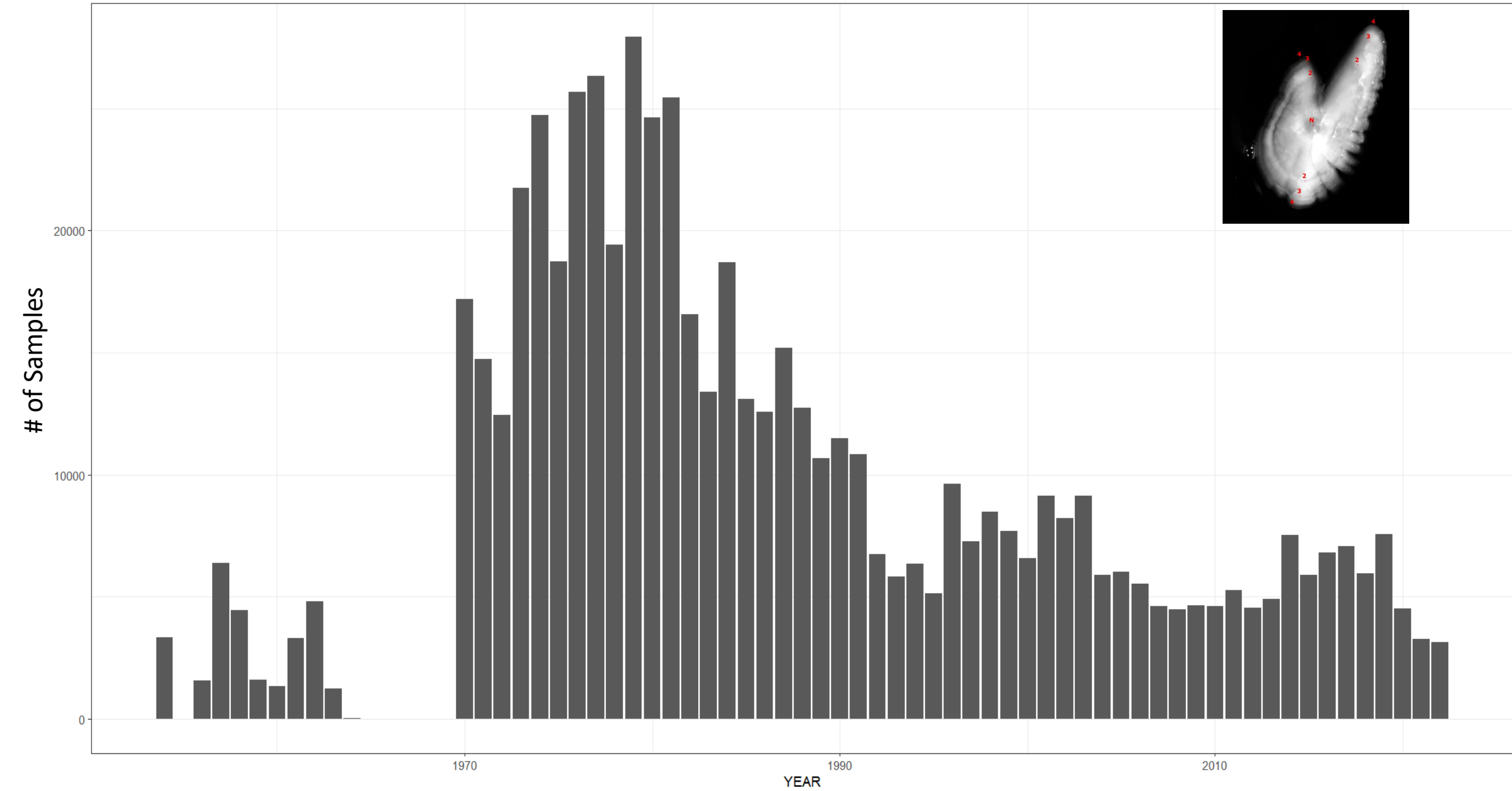
Genetic diversity of coastal Northwest Atlantic herring populations: implications for management

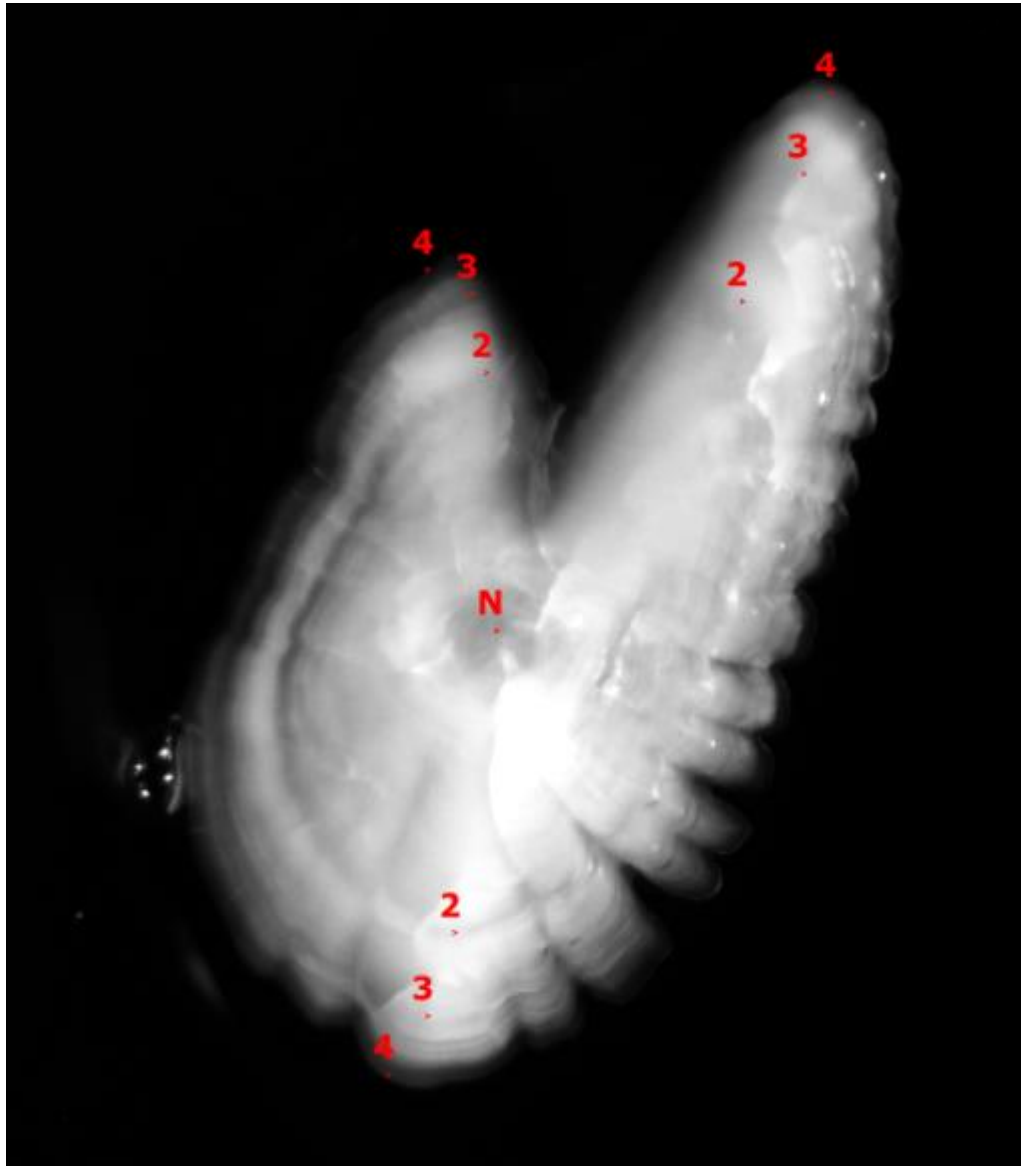
A. A. McPherson*†§, R. L. Stephenson‡, P. T. O'Reilly†¶, M. W. Jones† and C. T. Taggart*†

Journal of Fish Biology (2001) **59** (Supplement A), 356–370
doi:10.1006/jfbi.2001.1769, available online at http://www.idealibrary.com on

Genetic Difference in Bras d'Or Lakes. Some flow from Gulf of Maine to Canadian side of Georges Bank .

Potential Upcoming Collaboration with USA. 2024-2027


# of Samples
20000
10000
0
1970
1990
2010
YEAR
N
4
3
2



e.g. https://doi.org/10.1139/cjfas-2016-0265

A potential approach... (there are many others)

Vast Otolith collection

~4-5000 fish samples per year, for 30+ years

Use otolith collection to perform a longitudinal study of Herring growth across fish cohorts by linking to environmental and biological indicators of mechanisms that would influence growth.

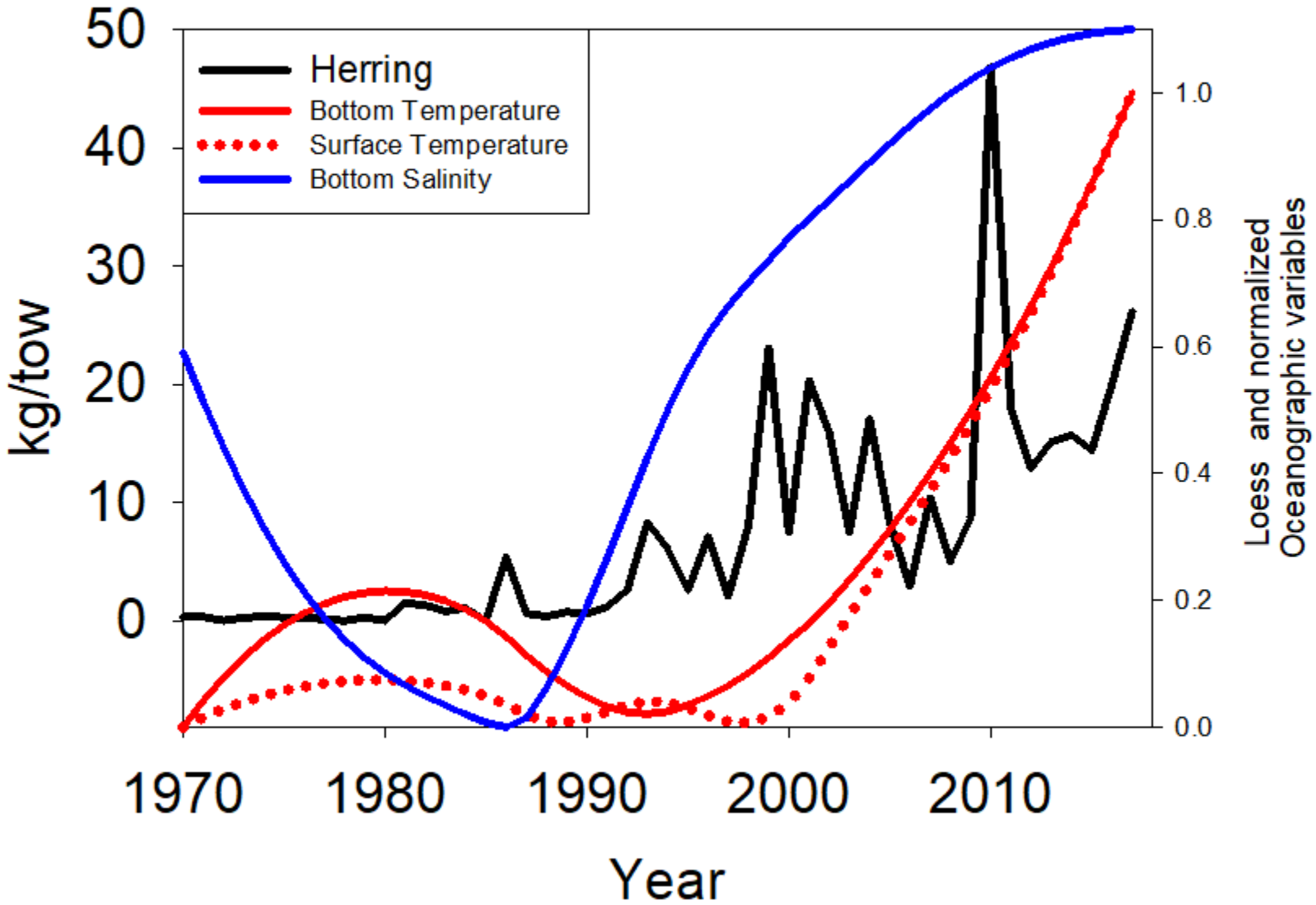
Also, use study to perform AI machine-learning on otolith images to automate aging.

Basis of Offshore Allocation

Or

Why I think bottom-trawl data for Herring isn't good.

Bottom-trawl index for 4X Herring.



NRC Research Press

PERSPECTIVE

Towards a balanced presentation and objective interpretation of acoustic and trawl survey data, with specific reference to the eastern Scotian Shelf

J. Michael Jech and Ian H. McQuinn

Abstract: A debate has developed over the ecosystem consequences following the collapse of Atlantic cod throughout the coastal waters of eastern Canada. The explosive increase in pelagic fish abundance in scientific bottom-trawl catches on the eastern Scotian Shelf has been interpreted as being due to either (*i*) a "pelagic outburst" of forage fish abundance resulting from predator release or conversely (*ii*) a change in pelagic fish vertical distribution leading to a "suprabenthic habitat occupation" thereby increasing their availability to bottom trawls. These two interpretations have diametrically opposing ecological consequences and suggest different management strategies for these important forage fish species. We argue that an objective evaluation of the available evidence supports the hypothesis that the abundance of forage fish has not increased in response to the demise of cod and other top predators, and the reliance on a single sampling gear with low catchability has biased and will continue to bias the interpretation of demographic trends of pelagic fish populations. We advocate that multiple sampling technologies providing alternative perspectives are needed for the monitoring and management of the various trophic levels if we are to achieve a balanced and objective understanding of marine ecosystems.

Canadian Stock Assessment Secretariat
Research Document 98/52

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 98/52

1998 EVALUATION OF 4VWX HERRING

BY

R.L. Stephenson, M.J. Power, K.J. Clark, G.D. Melvin, F.J. Fife and S.D. Paul

3) Offshore Scotian Shelf Banks Spawning Component

Herring taken on the offshore Scotian Shelf by foreign fisheries prior to the extension of jurisdiction, were presumed to be part of an overall 4VWX stock. A foreign fishery is estimated to have removed as much as 60,000 tons in a year from the offshore Scotian Shelf banks during the period 1963-1974 (Stephenson et al. 1987). There had been little effort or herring catch after the extension of jurisdiction until 1996 when a fishery was initiated by the 4WX purse seine fleet and 11,745 tons was taken. Evidence of increasing presence of herring (e.g. in research vessel surveys) and of spawning offshore from research surveys and occasional fishing excursions within the past decade has suggested that there is a discrete offshore spawning component. The presence of spawning herring in catches in 1986 and of larvae in scientific surveys (1991-93), the consistent presence of large herring on the Scotian Shelf in summer trawl surveys and broad age distribution of the catch during the 1996 fishery are all consistent with the treatment of the offshore banks as a separate management.

3.1 The 1997 fishery

This was the second year since a fishery was reestablished on the offshore Scotian Shelf banks. Exploration started in mid-April, but fishing began on May 19 and continued until July 15 (Fig. 3). Total landings were 20,261t (Table 3). The weekly distribution of landings and the distribution of fleet activity is documented by Paul (1998).

Unlike 1996 when activity was concentrated in the vicinity of "The Patch", the 1997 fishery took place on several banks. Fish were seen on and between all of the banks and catches were widely distributed. On most nights, the fleet was distributed on several banks, spanning a distance of 30 to 220 nautical miles. At times, fish size and condition differed on and between the banks; fat content was very high, greater than 20% at times.

The majority of the fish stayed too deep in the water column to be caught by purse seine. Several nights where characterized by good sightings of fish, but few catches. Many comments such as "we have been seeing a lot of bunches of fish over a 3 - 4 mile area, but they won't come up enough to be caught" were made by fishers throughout the fishery.

Several quantitative observations from various banks were made and submitted by fishers, documenting abundance on twelve fishing nights (Paul 1998).

3.4 Resource Status and Outlook

There is insufficient information on which to base an evaluation of stock status. Industry records show that herring were widely distributed on Scotian Shelf banks in May and June of 1997. Although a considerable amount of herring was seen, there was little quantitative information from the fishery. The decrease in numbers of herring taken in the July bottom trawl survey, and the narrow age composition in the catch are considered to be negative signals. The catch should be reduced unless there is information during the season which demonstrates that these concerns are unfounded.

3.5 Management Considerations

It has been previously recommended that a strategy for assessment and exploration of the Scotian Shelf component be developed. Industry and DFO have reviewed results of the Regional Herring Workshop (Sinclair 1997) and the Workshop on Ecosystem Considerations for Krill and Other Forage Fisheries (Head et al. 1997) and have established a committee to investigate the range of possible approaches to the management of the Offshore Scotian Shelf herring fishery.

Projects to be initiated by the Pelagics Research Council in 1998 will focus on improving the information base on which to evaluate resource status for the next assessment. Of particular interest will be an acoustic survey in the autumn of 1998 to document the abundance of spawning aggregations on the offshore banks.

Industry and Management have proposed a two-step approach for this year;

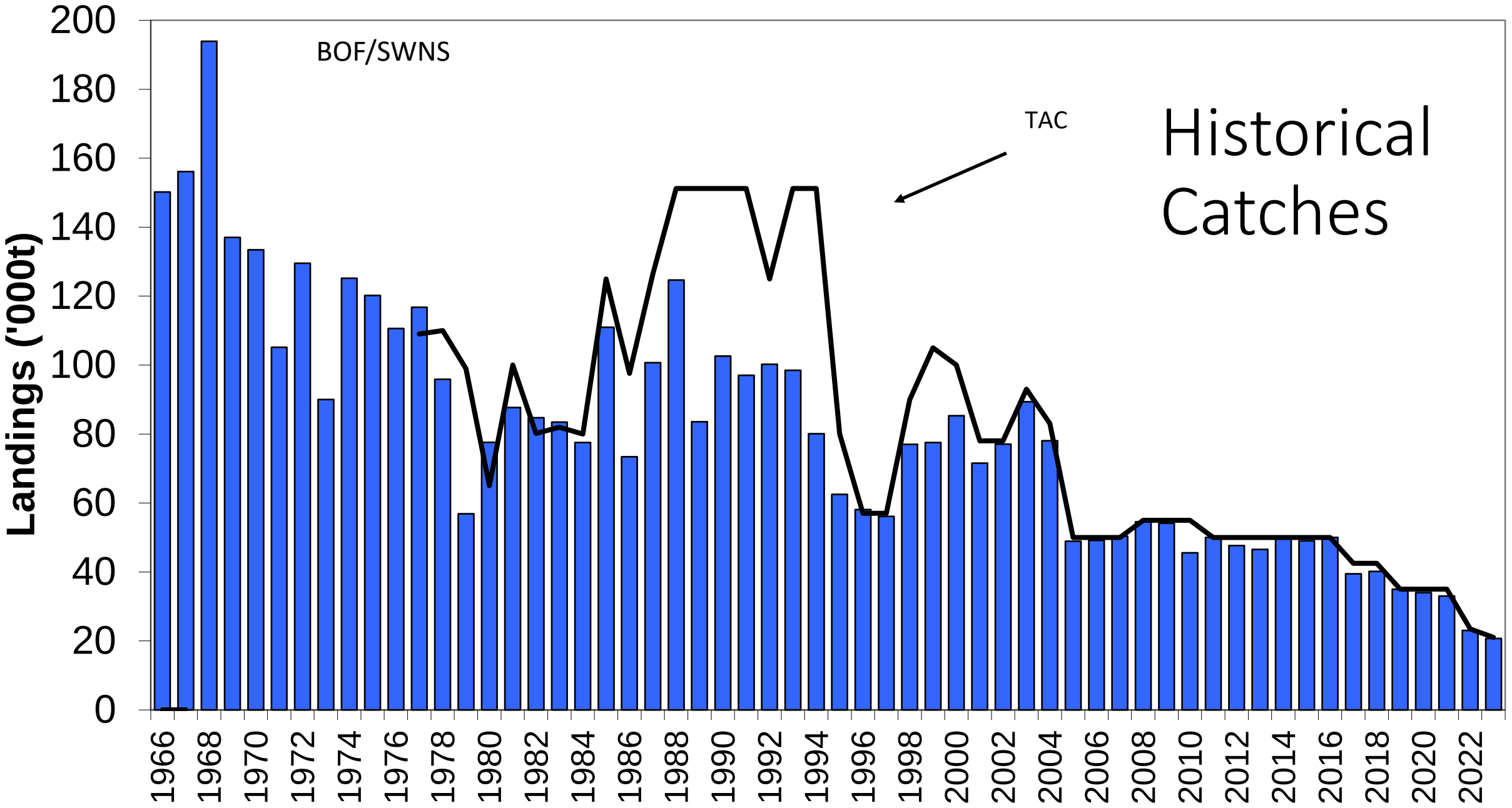
"The management approach for 1998 will be generally as follows. An initial catch limit will be established following review by RAP, probably in the range between the previous two years catch i.e. 12,000 - 20,000t.

After the fish have aggregated sufficiently to survey and prior to the initial catch level being caught, a detailed survey utilizing the recording acoustic equipment will be undertaken by the industry to determine the relative stock abundance. Changes as considered appropriate and in line with the recommendations by RAP, will be made to the initial catch level."

The caution expressed in the Resource Status and Outlook (section 3.4 above), suggests that the initial catch limit should be low.

Foreign fisheries took relatively large amounts (as much as 60,000t per year) from the offshore Scotian Shelf banks during the period 1963-1973. These fisheries did not sustain large catches over a number of years and the average recorded catch for the 1970 - 1973 period was 30,000t. Industry, science and management are encouraged to work together to develop a medium term strategy (i.e. over the next few years) for assessment and exploitation of the herring on the Scotian Shelf outer banks.

Landings!


BOF/SWNS
TAC
Historical Catches
Landings ('000t)
200
180
160
140
120
100
80
60
40
20
0
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022

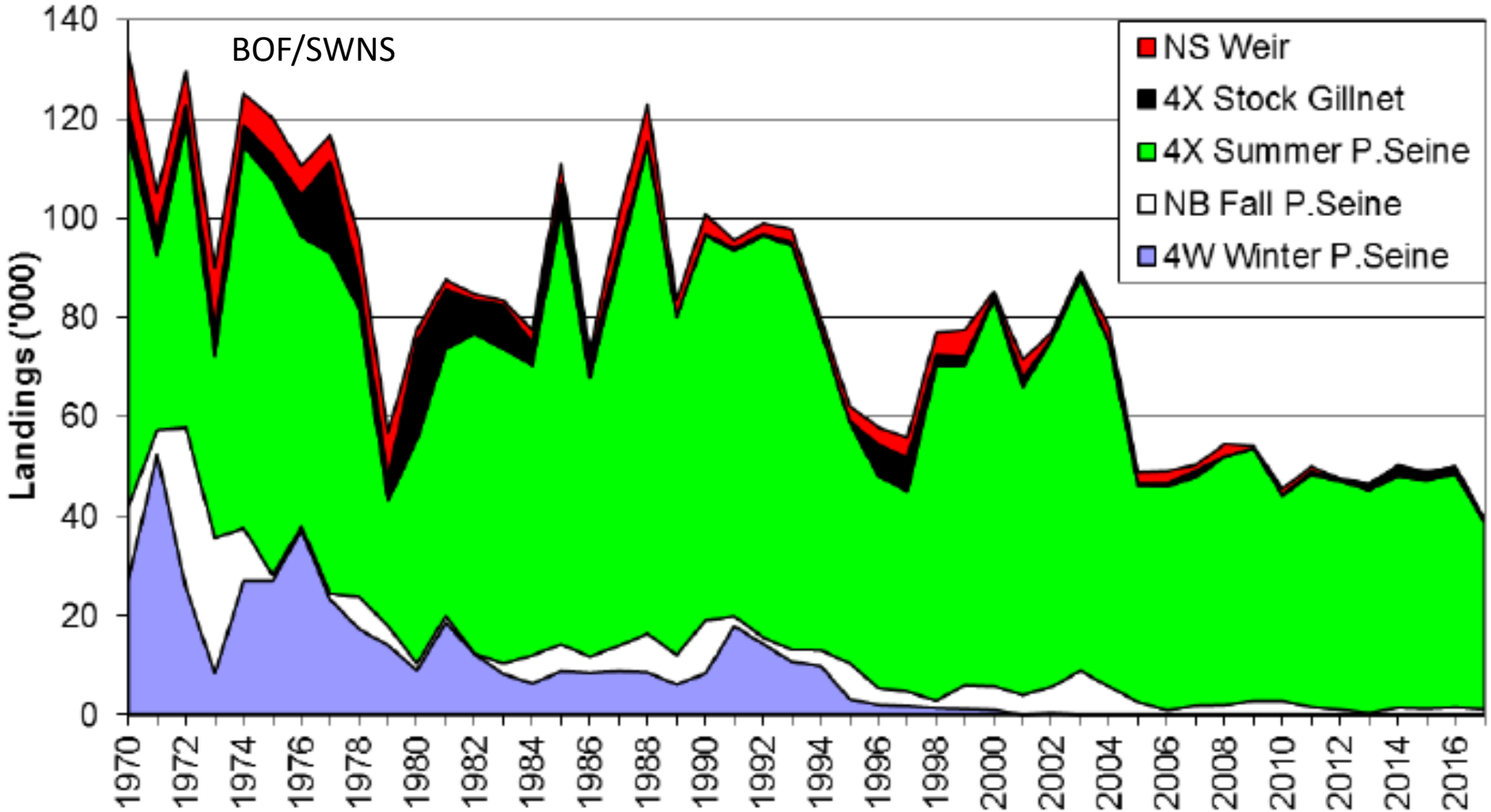


Figure 10. Annual Herring landings by gear component for the SWNS/BoF spawning component (4WX stock) from 1970–2017.

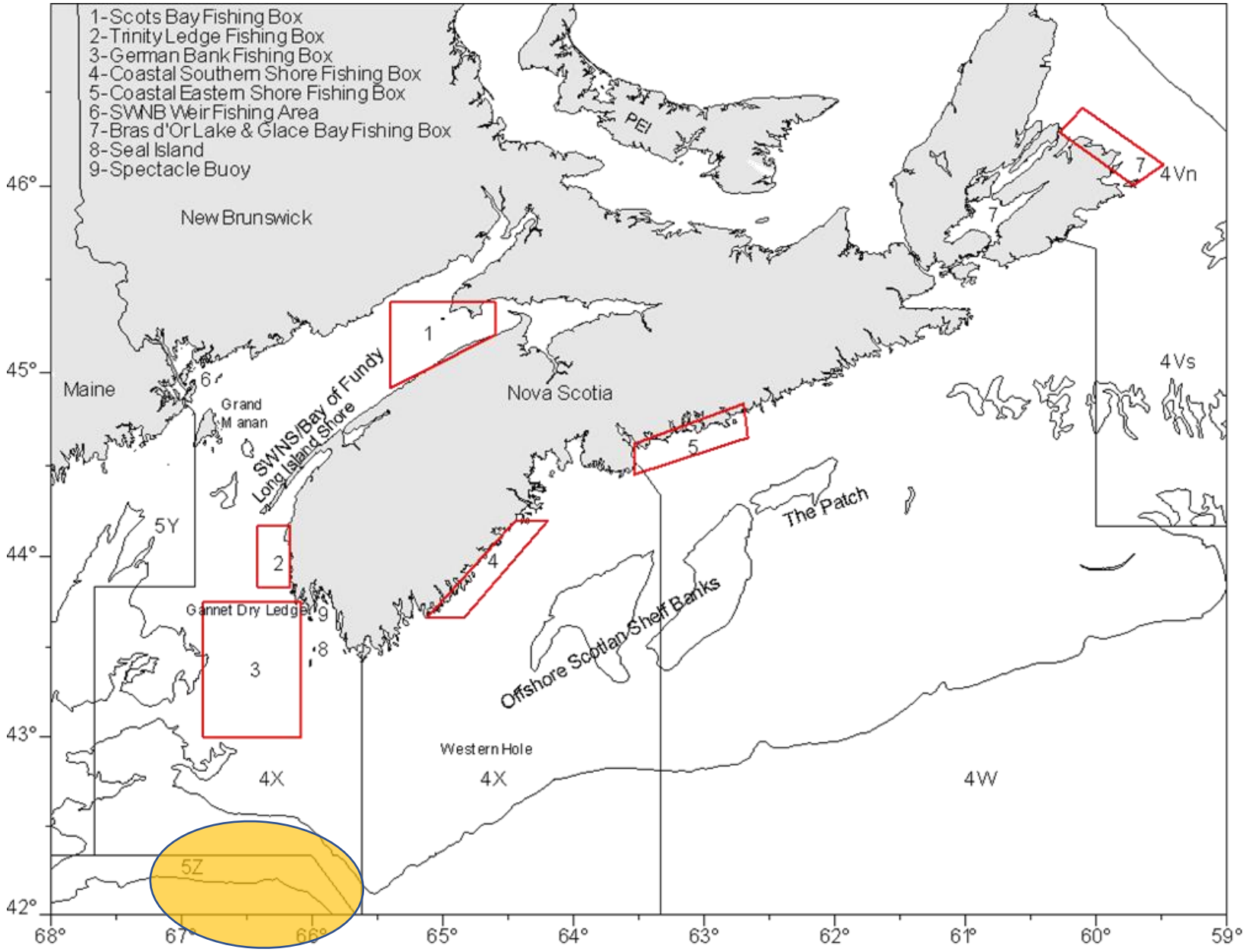
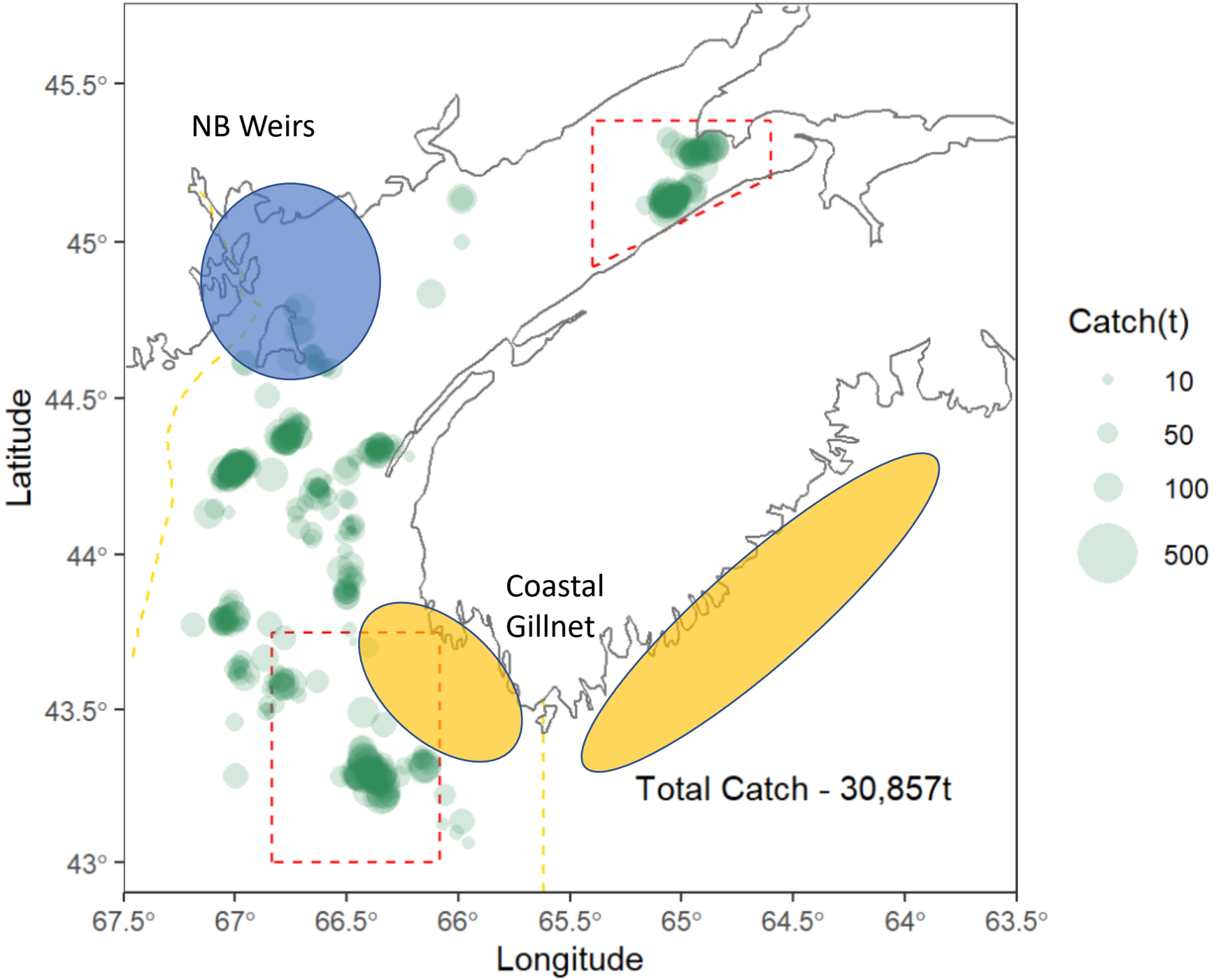


Figure A1. Place names and fishing locations for Southwest Nova Scotia/Bay of Fundy, Coastal NS (South Shore, Eastern Shore, Cape Breton), Offshore Scotian Shelf, and SWNB weirs. The vertical line between the two 4X labels indicates the outer boundary of the Southwest Nova Scotia/Bay of Fundy (SWNS/BoF) stock component.

Georges Bank Landings in tonnes - HUGE

Year	USA	Canada	FRG	GDR	USSR	Poland	Japan	Bulgaria	France	Iceland	Norway	Romania	Cuba	Others	Total
1961..	105	–	–	–	67 550	–	–	–	–	–	–	–	–	–	67 655
1962..	101	–	–	–	151 864	277	–	–	–	–	–	–	–	–	152 242
1963..	322	–	–	–	97 646	–	–	–	–	–	–	–	–	–	97 968
1964..	489	–	–	–	130 914	35	–	–	–	–	–	–	–	–	131 438
1965..	1 191	–	–	–	38 262	1 447	–	–	–	–	–	1 982	–	–	42 882
1966..	4 308	–	–	1 133	120 113	14 473	–	–	–	–	–	2 677	–	–	142 704
1967..	1 211	1 306	28 171	22 159	126 759	36 677	40	–	–	–	–	1 420	–	–	218 743
1968..	758	13 674	71 086	67 719	143 097	75 080	171	–	–	292	–	1 656	–	65	373 598
1969..	3 678	945	61 990	44 624	138 673	45 021	583	812	–	12 786	1 224	337	–	85	310 758
1970..	2 011	7	82 498	28 063	61 579	70 691	1 412	348	–	–	–	685	–	–	247 294
1971..	3 822	12 863	54 744	18 447	81 258	88 325	2 466	4 551	–	–	–	898	–	–	267 374
1972..	2 782	53	27 703	40 016	48 072	49 392	1 161	2 355	500	–	–	2 156	–	–	174 190
	(4 000)	(5 800)	(31 600	–	(48 200)	(49 400)	(200)	–	–	–	–	(600)	–	(8 200)	(150 000)
1973..	4 627	5 083	31 501	53 326	52 340	49 275	1 722	1 380	2 784	–	–	297	–	–	202 335
	(5 250)	(5 050)	(31 600)	–	(48 200)	(49 400)	(1 200)	–	–	–	–	(1 300)	(8 000)	–	(150 000)
1974..	3 370	217	23 690	31 530	41 541	39 312	4 242	1 773	3 617	–	–	2 018	–	–	149 510
	(6 955)	(2 980)	(23 900)	(31 440)	(41 725)	(39 000)	–	–	–	–	–	–	(4 000)	–	(150 000)
1975..	4 582	0	22 957	30 901	40 945	38 392	1 878	421	3 304	–	–	1 544	10	1 162	146 096
	(8 400)	(3 000)	(23 750)	(31 150)	(41 100)	(38 400)	–	–	–	–	–	–	(4 200)	–	(150 000)
1976..	744	–	8 806	7 891	12 996	10 517	868	105	1 166	–	–	115	296	3	43 507
	(12 400)	(1 000)	(9 200)	(9 300)	(12 190)	(11 000)	(1 100)	(900)	(1 100)	–	–	(800)	(10)	(1 000)	(60 000)
1977..	361	2	–	–	1 492	119	–	1	–	–	–	–	152	–	2 127
	(12 000)	(1 000)	(4 725)	(4 825)	(3 400)	(5 100)	–	(100)	(1 000)	–	–	(100)	(50)	(700)	(33 000)

[a] National allocations in parentheses.


NB Weirs
Coastal
Gillnet
Total Catch - 30,857t
Catch(t)
10
50
100
500
45.5°
45°
44.5°
44°
43.5°
43°
Latitude
67.5°
67°
66.5°
66°
65.5°
65°
64.5°
64°
63.5°
Longitude