Improving Understanding the Impact of Ecosystem and Demographic Factors on the Recruitment of Atlantic Herring in the Southern Gulf of St. Lawrence

By: Jacob Burbank

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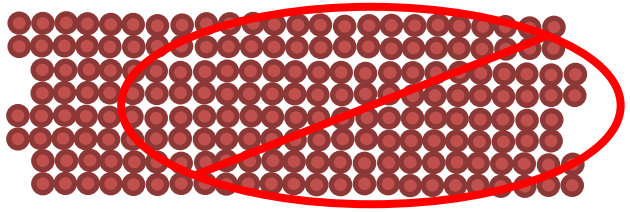
About Me

- Studied at the University of Waterloo
- Completed a PhD in Biology under supervision of Dr. Michael Power and Dr. Andrew Drake (DFO-Burlington)
- Currently a Research Scientist at Fisheries and Oceans Canada, Gulf Region, Moncton, NB since mid 2022
- Enjoy biking, family hikes and camping

Why is Recruitment Important?

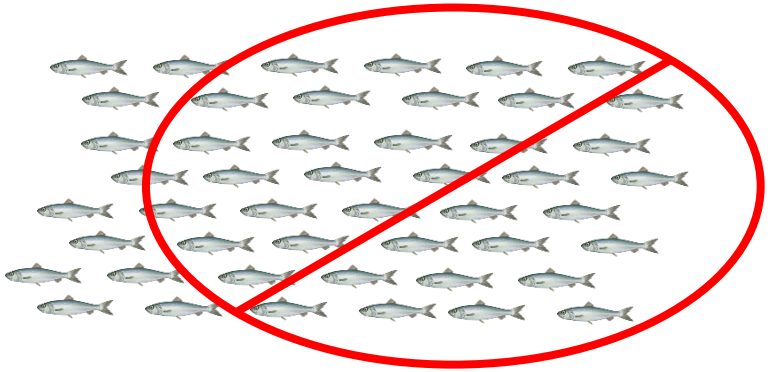
Low Recruitment: Big Problem

Eggs



Many eggs do not get to hatch

Larvae

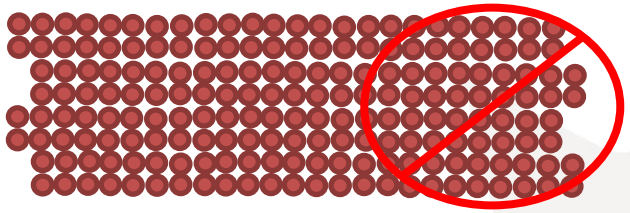


Few young survive to catchable age

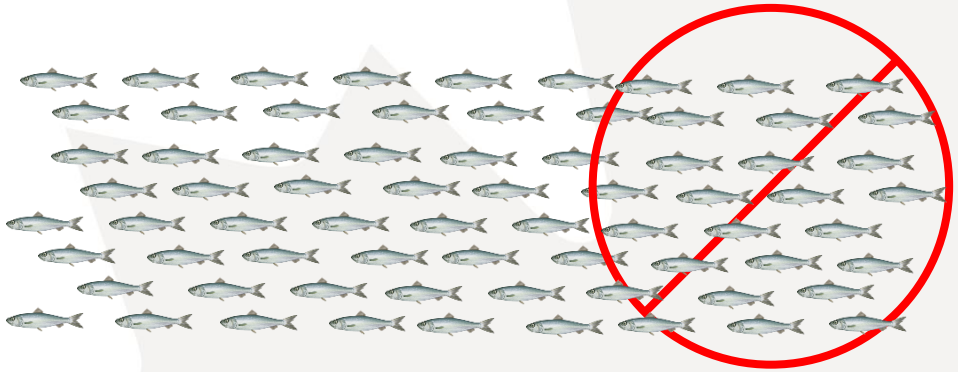
Recruits

Less adults

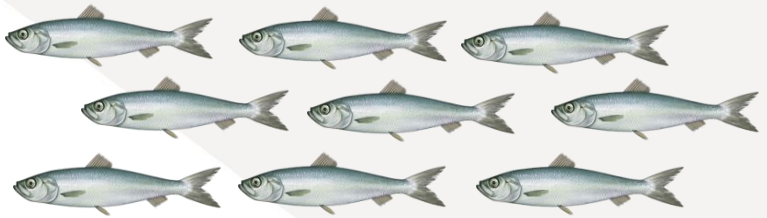
High Recruitment



More eggs hatch successfully



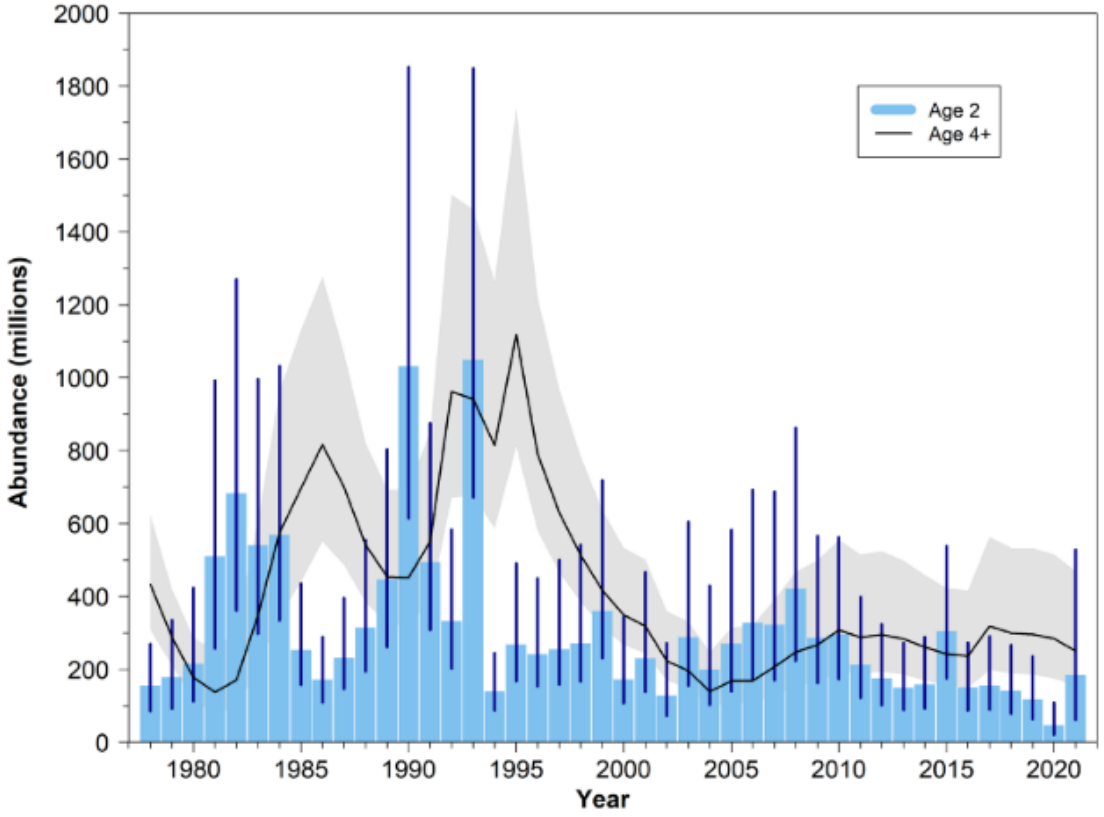
More larvae survive



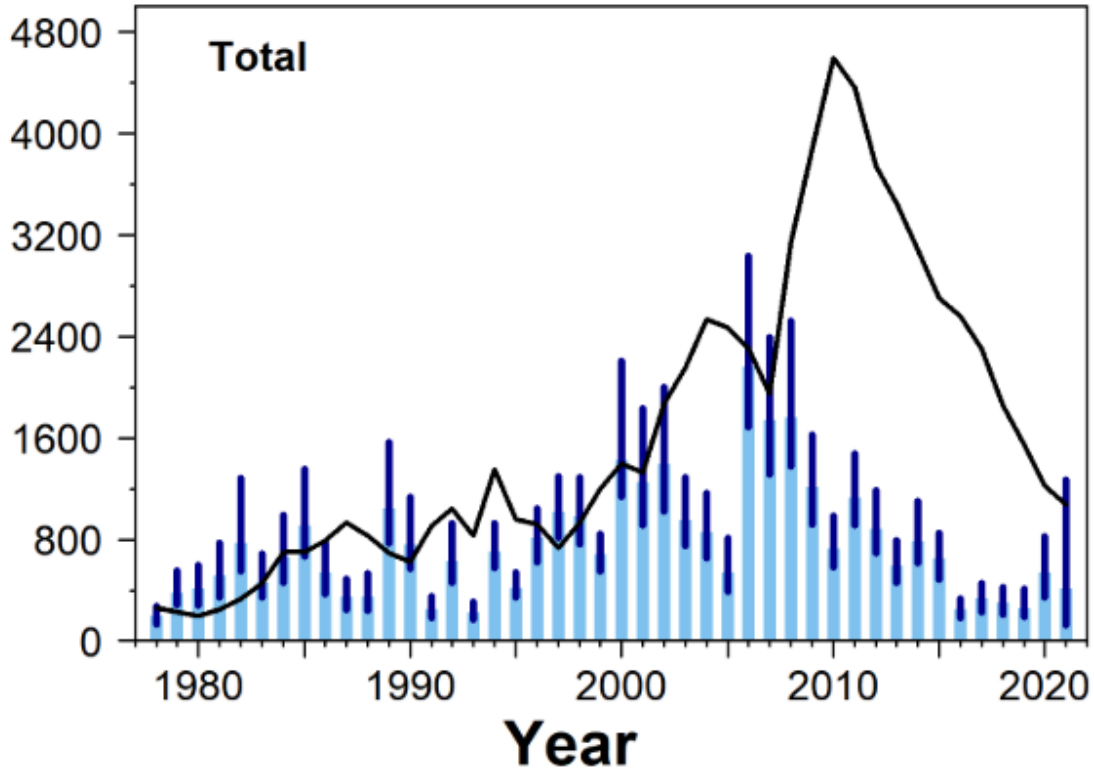
More adults

Recruitment of 4TVn Atlantic Herring

Spring Spawners



Fall Spawners



Rolland et al (2022)

FISH and FISHERIES

FISH and FISHERIES, 2015, **16**, 633–648

Examining common assumptions about recruitment: a meta-analysis of recruitment dynamics for worldwide marine fisheries

Cody S Szuwalski[1,3], *Katyana A Vert-Pre*[1,2], *André E Punt*[1], *Trevor A Branch*[1] & *Ray Hilborn*[1]

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Global forage fish recruitment dynamics: A comparison of methods, time-variation, and reverse causality

Cody S. Szuwalski[a,*], Gregory L. Britten[b], Roberto Licandeo[c], Ricardo O. Amoroso[d], Ray Hilborn[d], Carl Walters[c]

Identifying Factors Impacting Recruitment : Literature Review

- Upon arrival in Gulf Region, I commenced a literature review on Atlantic Herring Recruitment
- Examined research from North America and Europe
- Specifically examined the factors influencing survival at each early life history stage
- Worked to identify what abiotic and biotic factors are important for recruitment and knowledge gaps pertaining to our understanding of recruitment in the species

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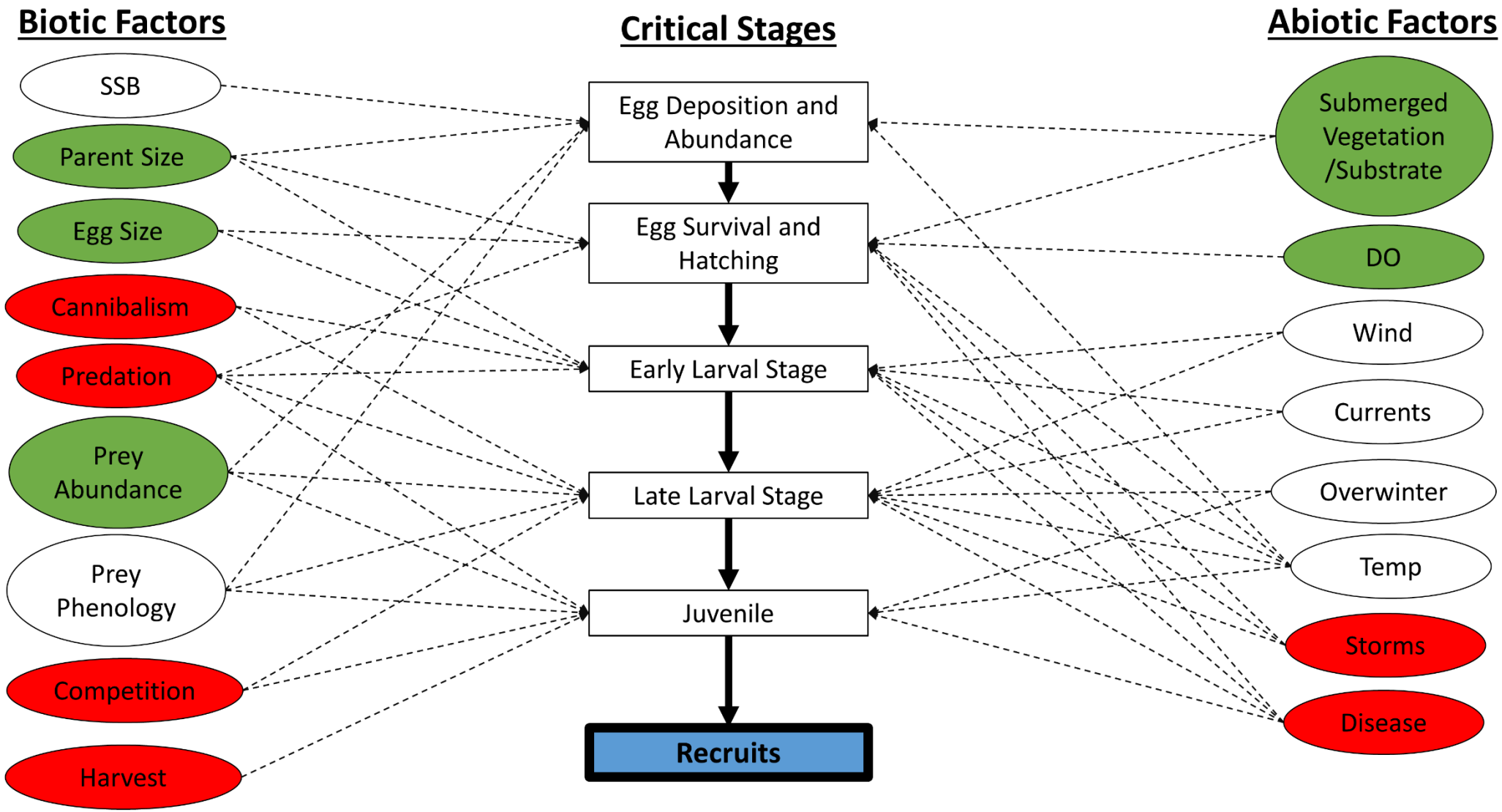
DOI: 10.1111/fog.12621

INVITED REVIEW

FISHERIES OCEANOGRAPHY WILEY

Understanding factors influencing Atlantic herring (*Clupea harengus*) recruitment: From egg deposition to juveniles

Jacob Burbank | Rachel A. DeJong | François Turcotte | Nicolas Rolland


Biotic Factors
SSB
Parent Size
Egg Size
Cannibalism
Predation
Prey Abundance
Prey Phenology
Competition
Harvest
Critical Stages
Egg Deposition and Abundance
Egg Survival and Hatching
Early Larval Stage
Late Larval Stage
Juvenile
Recruits
Abiotic Factors
Submerged Vegetation /Substrate
DO
Wind
Currents
Overwinter
Temp
Storms
Disease

Identifying Factors Impacting Recruitment

- Determined there is not one specific factor dictating recruitment,

RATHER

- A wide range of abiotic and biotic factors act to produce observed trends in recruitment.
- Several important knowledge gaps remain:
  - The impacts of habitat quality on hatching success and early larval survival
  - The influence of prey availability and quality on the growth and survival of larvae
  - The relative importance of the variety of factors identified to impact recruitment of Atlantic Herring

Canadian Science Advisory Secretariat (CSAS)

Research Document 2022/047

Gulf Region

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ORIGINAL ARTICLE

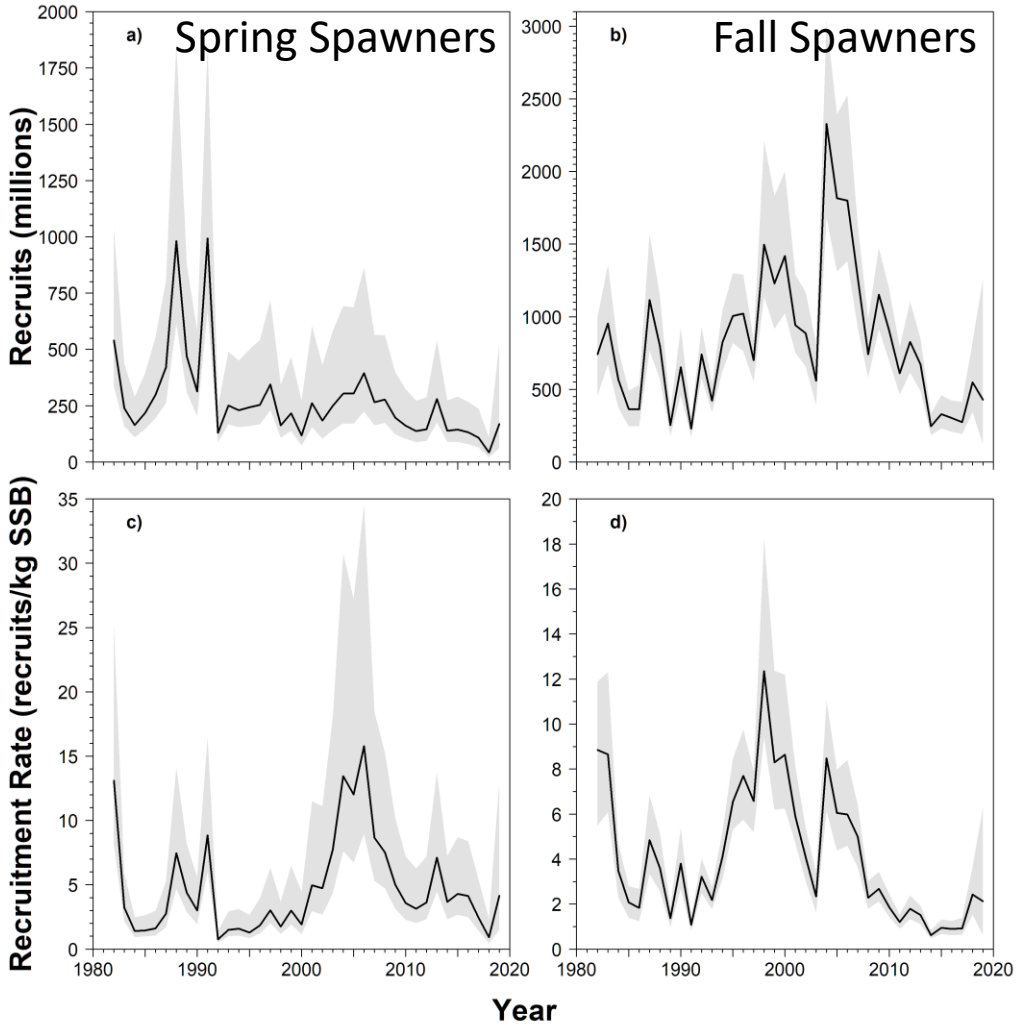
WILEY FISHERIES OCEANOGRAPHY

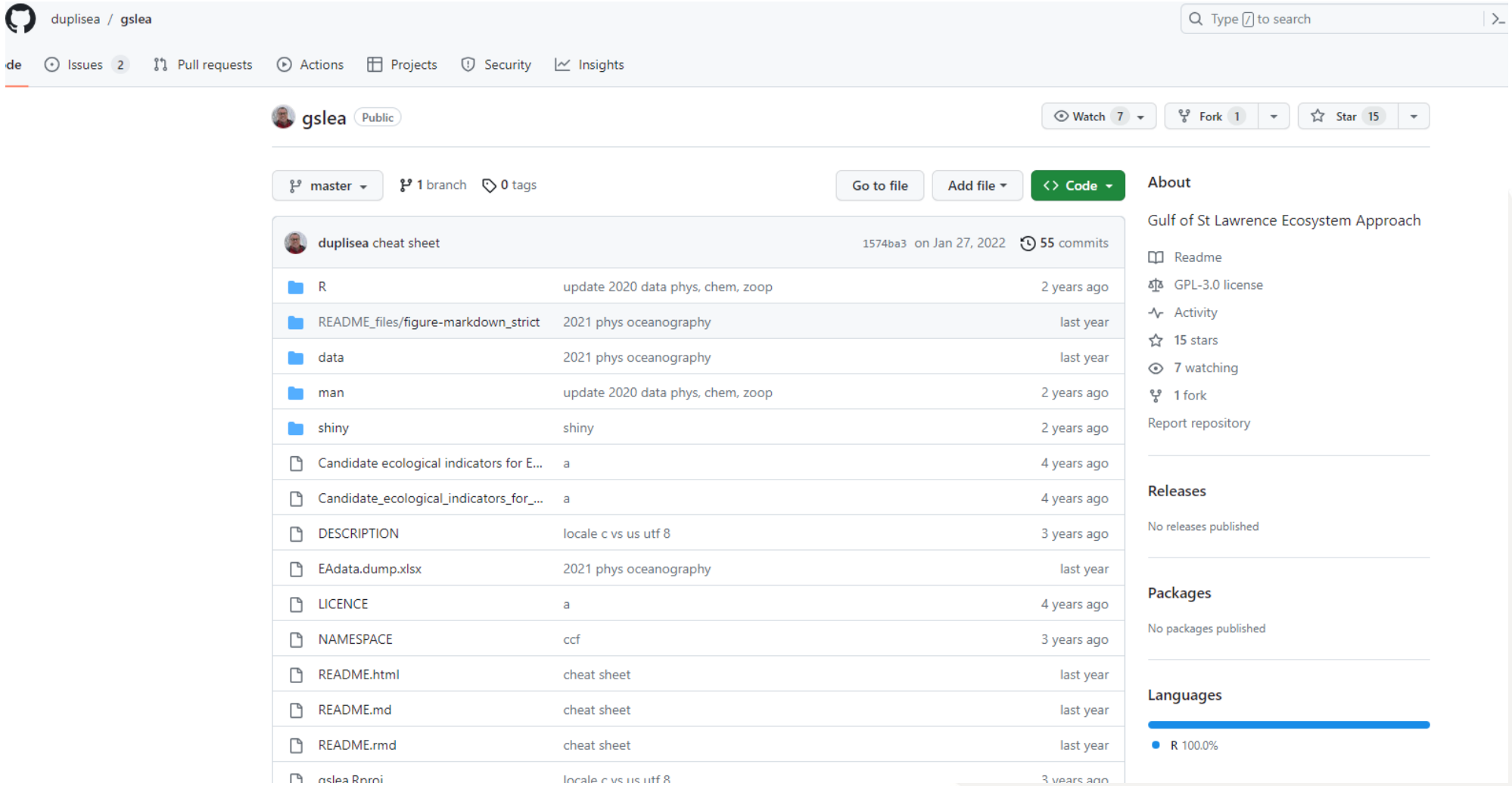
Environmental variability controls recruitment but with different drivers among spawning components in Gulf of St. Lawrence herring stocks

Pablo Brosset[1] | Thomas Doniol-Valcroze[1] | Douglas P. Swain[2] | Caroline Lehoux[1] | Elisabeth Van Beveren[1] | Baye C. Mbaye[1] | Kim Emond[1] | Stéphane Plourde[1]

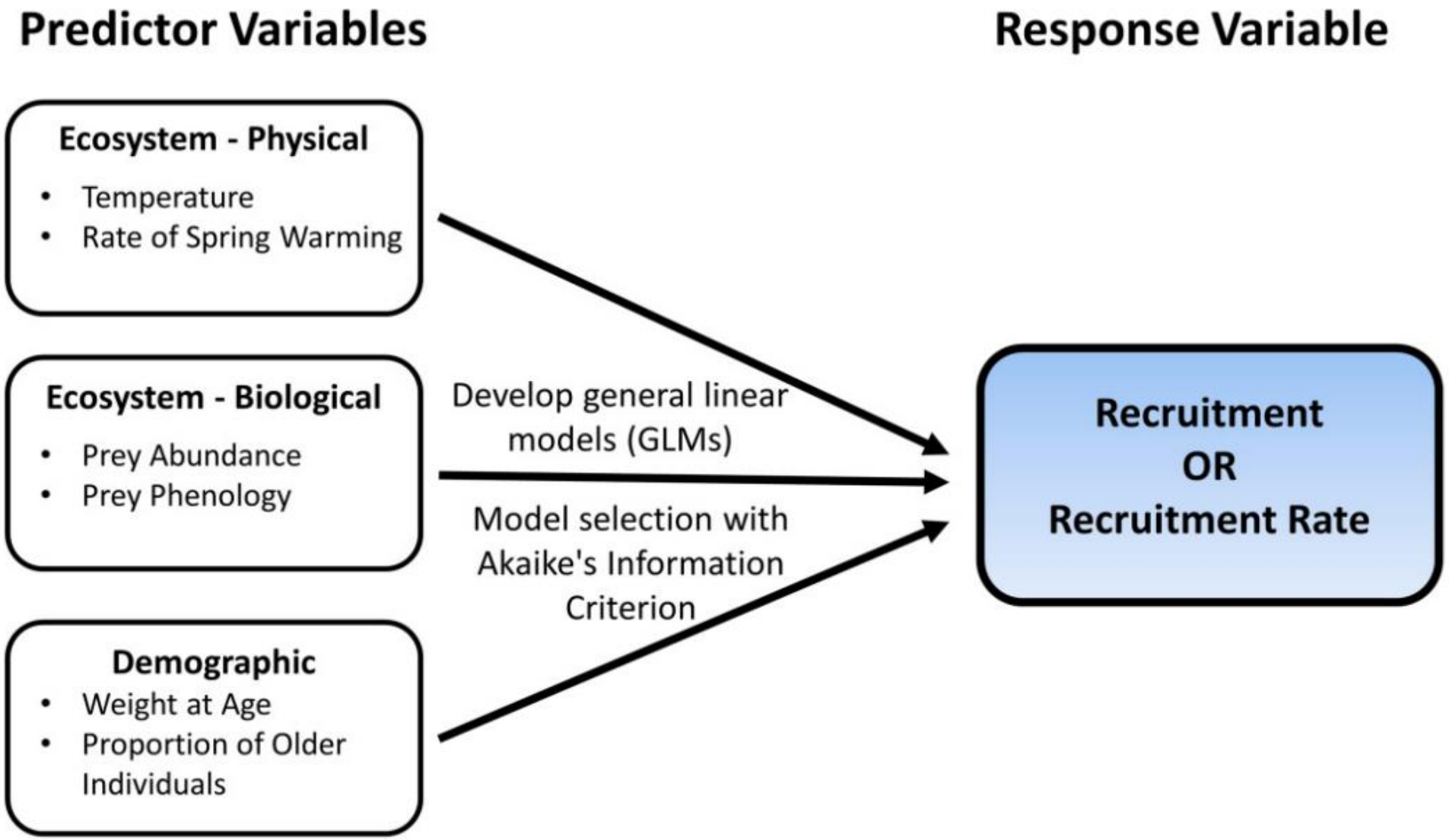
Atlantic Herring Recruitment Modelling in sGSL

- Evaluate the relative influence of ecosystem (biological and physical) and demographic factors on the recruitment of Atlantic Herring
- Develop predictive models to estimate recruitment based on ecosystem conditions and stock structure in the year they were spawned
- Overall improve understanding of recruitment, which will improve confidence in stock assessments and the science advice provided



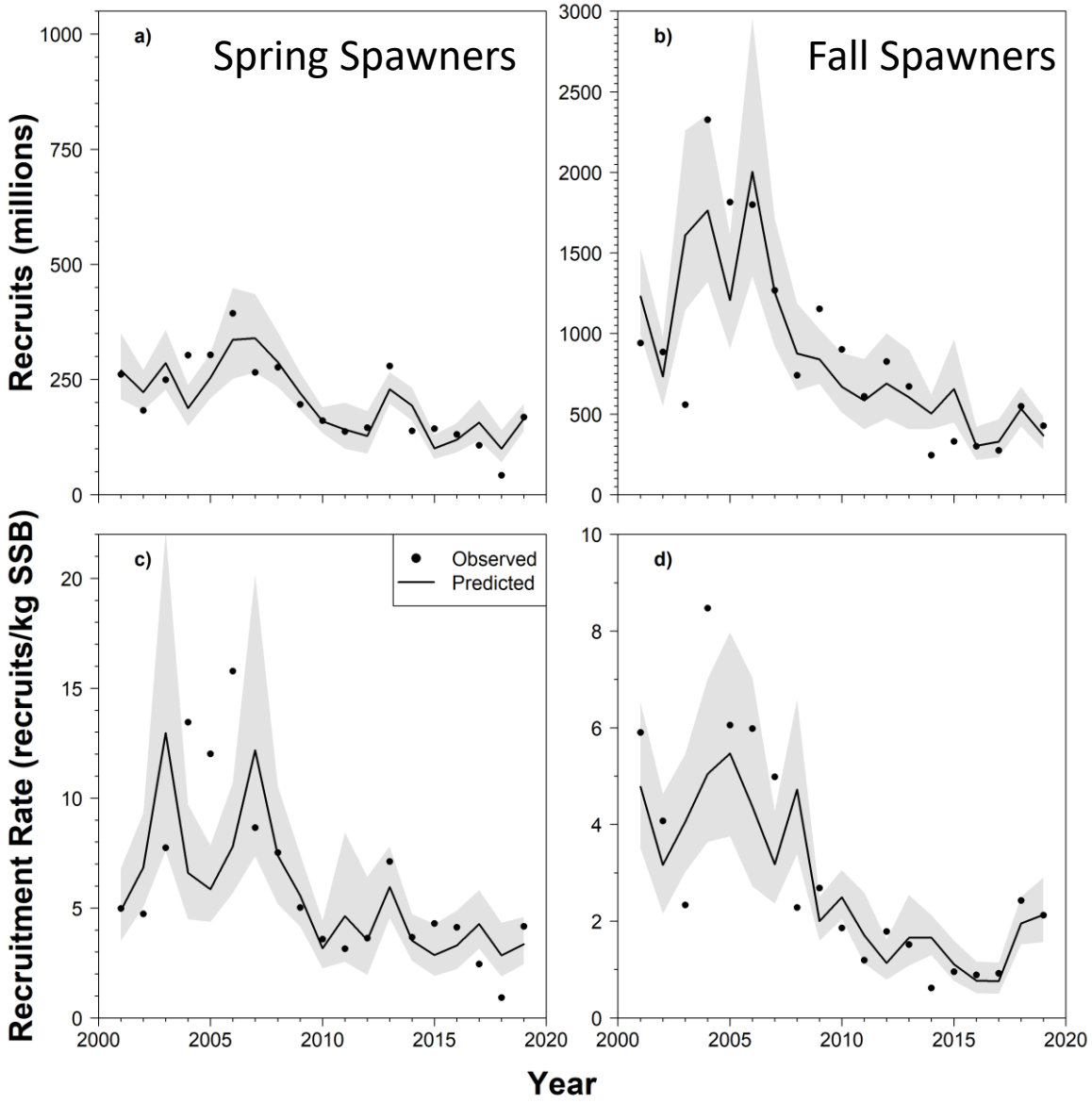


Duplisea, DE. Merette, D., Roux, M-J., Benoît, H., Blais, M., Galbraith, P., Plourde, S. 2020. gslea: the Gulf of St Lawrence ecosystem approach data matrix R-package. R package version 0.1 https://github.com/duplisea/gslea.


Predictor Variables
Response Variable
Ecosystem - Physical
• Temperature
• Rate of Spring Warming
Ecosystem - Biological
• Prey Abundance
• Prey Phenology
Demographic
• Weight at Age
• Proportion of Older Individuals
Develop general linear models (GLMs)
Model selection with Akaike's Information Criterion
Recruitment OR Recruitment Rate

Dependent variable	Biological variables	Predictor variables	log likelihood	AICc	Δ	wi	acc
Spring recruits	Yes	**WarmZoo + AugSST + S10**	**−233.1**	**480.8**	**0.00**	**0.27**	**0.27**
		WarmZoo + S10	−235.5	481.9	1.16	0.15	0.42
		WarmZoo + AugSST + S10 + WeightatAge	−231.6	482.2	1.47	0.13	0.55
		WarmZoo + JuneSST	−236.1	483.1	2.33	0.08	0.64
		WarmZoo + AugSST + JuneSST	−234.3	483.3	2.52	0.08	0.71
		WarmZoo + AugSST + WeightatAge + JuneSST	−232.3	483.6	2.87	0.06	0.78
		WarmZoo + S10 + CIVHypES	−234.6	483.8	3.08	0.06	0.84
		AugSST + WeightatAge + JuneSST	−234.7	483.9	3.16	0.06	0.89
		WarmZoo + AugSST + S10 + CIVHypES	−232.5	484.0	3.21	0.05	0.95
Fall recruits	Yes	**CICIVCFinF + ZDW + LgCal**	**−263.5**	**541.5**	**0.00**	**0.26**	**0.26**
		CICIVCFinF + ZDW + WarmZoo	−263.8	542.2	0.63	0.19	0.45
		CICIVCFinF + ZDW + LgCal + OctSST	−261.6	542.3	0.74	0.18	0.63
		CICIVCFinF + WarmZoo	−266.0	542.9	1.37	0.13	0.76
		CICIVCFinF + ZDW	−266.1	543.0	1.44	0.13	0.89
		CICIVCFinF + ZDW + LgCal + OctSST + P8to11	−260.2	544.5	3.00	0.06	0.95

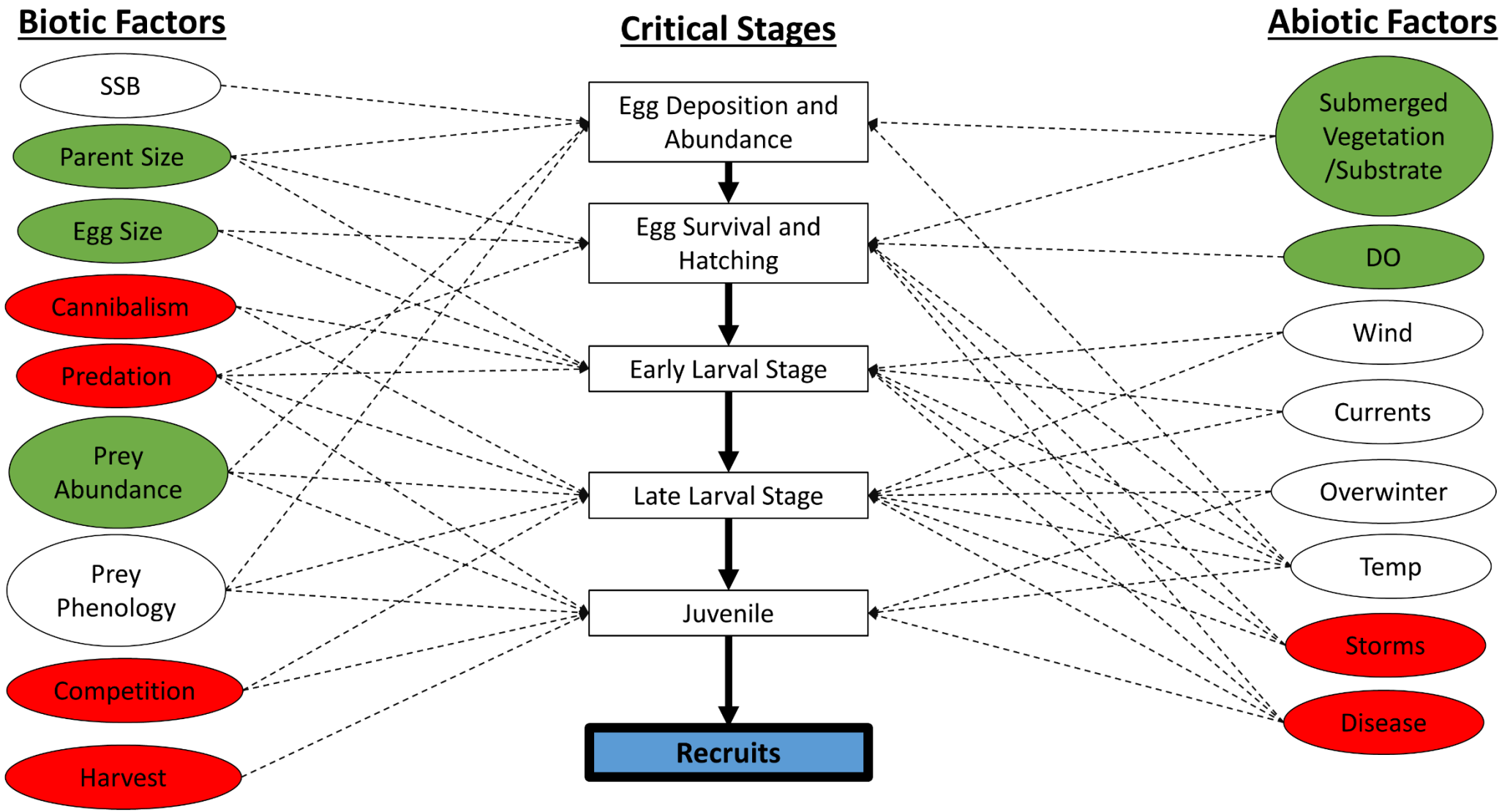
Symonds, M. R. E., & Moussalli, A. (2011). A brief guide to model selection, multimodel inference and model averaging in behavioural ecology using Akaike's information criterion. *Behavioral Ecology and Sociobiology*, *65*, 13–21.


a)
Spring Spawners
b)
Fall Spawners
c)
d)
Observed
Predicted
Recruits (millions)
Recruitment Rate (recruits/kg SSB)
Year
0
250
500
750
1000
1500
2000
2500
3000
5
10
15
20
2
4
6
8
2000
2005
2010
2015
2020

Herring Recruitment Modelling

Predictor type	Predictor	Spring spawning		Fall spawning	
		Recruits	Recruitment rate	Recruits	Recruitment rate
Prey abundance	WarmZoo	0.89	0.28	0.32	0.79
	ZDW	–	0.40	0.81	0.22
	LgCal	–	–	0.50	0.07
Prey phenology	CIVHypES	0.11	–	–	–
	CIVGlacF	–	–	–	0.16
	CICIVCFinES	–	0.21	–	–
	CICIVCFinF	–	–	0.95	0.55
Physical conditions	S10	0.66	0.41	–	–
	JuneSST	0.28	0.10	–	–
	AugSST	0.65	0.80	–	0.06
	OctSST	–	–	0.24	–
Demographic Factors	P8to11	–	–	0.06	–
	WeightatAge	0.20	0.19	–	0.42

- A combination of biological, physical, and stock structure factors impact recruitment
- Prey abundance, prey phenology, water temperature and adult weight-at-age seem most important
- Important to consider a range of factors simultaneously
- Future studies should develop approaches to understand impact of predation, storm events and currents on recruitment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Prey Phenology
Competition
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Critical Stages
Egg Deposition and Abundance
Egg Survival and Hatching
Early Larval Stage
Late Larval Stage
Juvenile
Recruits
Abiotic Factors
Submerged Vegetation /Substrate
DO
Wind
Currents
Overwinter
Temp
Storms
Disease

Canadian Journal of Fisheries and Aquatic Sciences

OPEN ACCESS | Article

A statistical framework for identifying the relative importance of ecosystem processes and demographic factors on fish recruitment, with application to Atlantic herring (*Clupea harengus*) in the southern Gulf of St. Lawrence

Jacob Burbank, François Turcotte, François-Étienne Sylvain, and Nicolas Rolland

Fisheries and Oceans Canada, 343 Université Avenue, Moncton, NB E1C 9B6, Canada

Corresponding author: **Jacob Burbank** (email: Jacob.Burbank@dfo-mpo.gc.ca)

What's Next

- This is a start and a valuable move towards estimating recruitment through an EAFM lens

BUT

- How to incorporate this type of approach formally into Stock Assessment….Integrated stock assessment model??

Thank You
Questions?
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