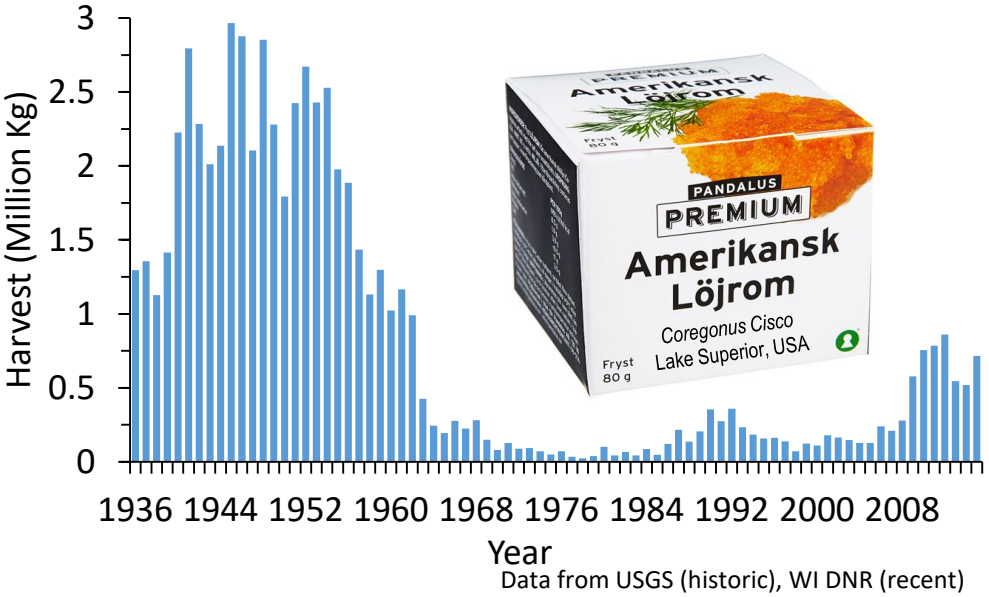
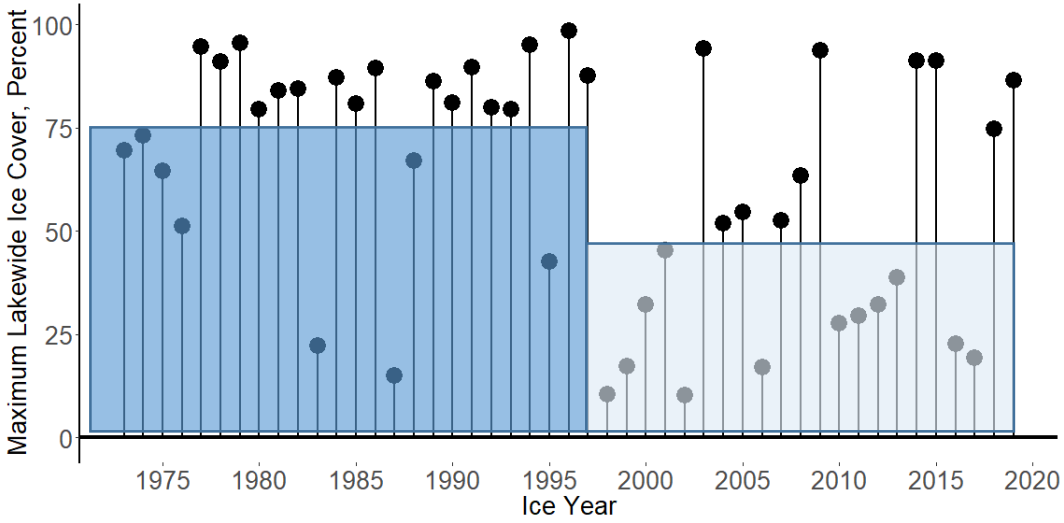
Lake Superior Ciscoe Recruitment Dynamics

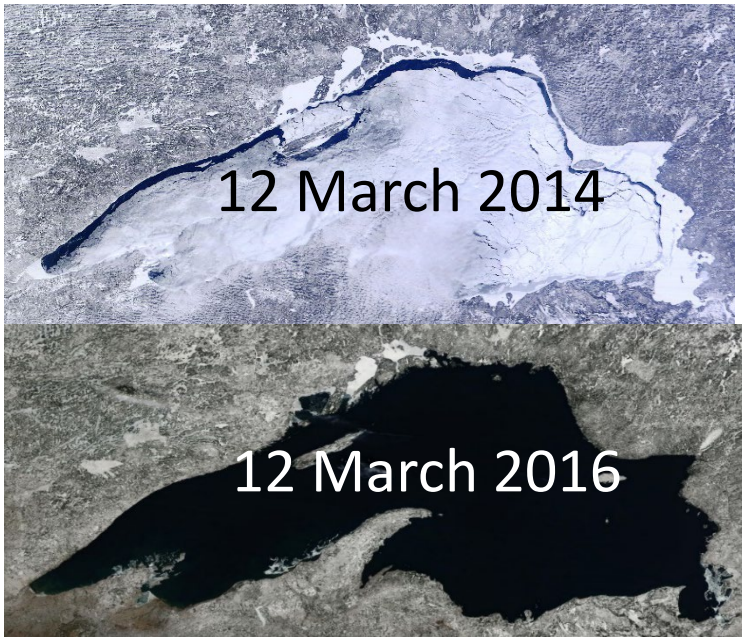


Data from USGS (historic), WI DNR (recent)

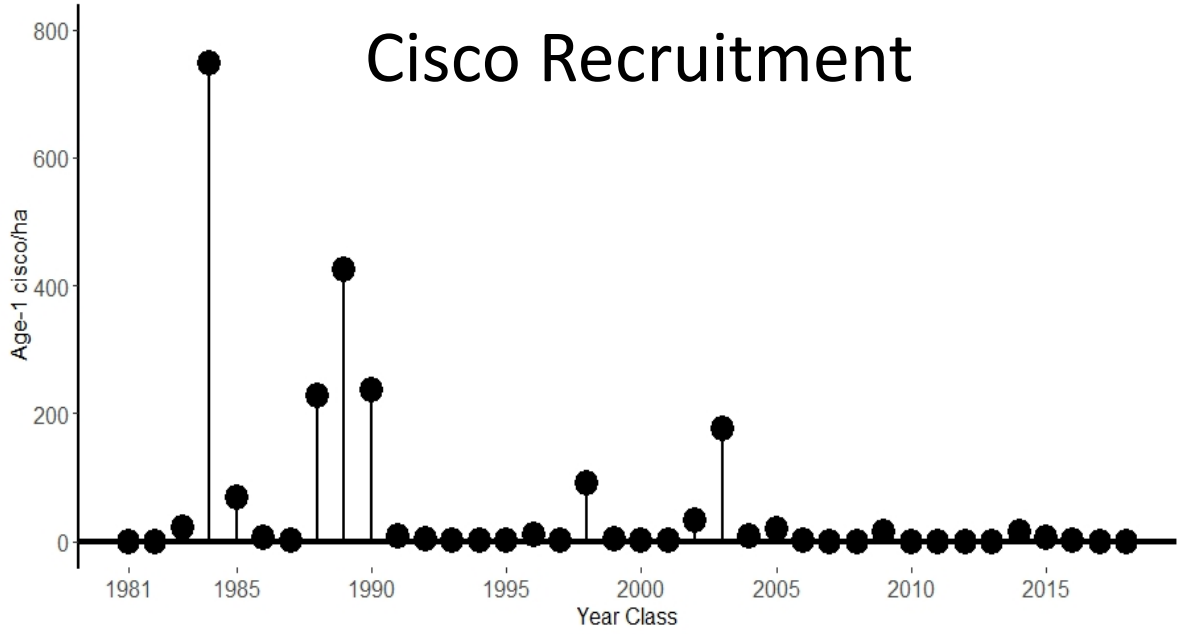
The Nature Conservancy
Great Lakes Sustainable Fisheries Annual Review & Celebration
September 12 – 13 | Duluth, MN

Lake Superior Ice



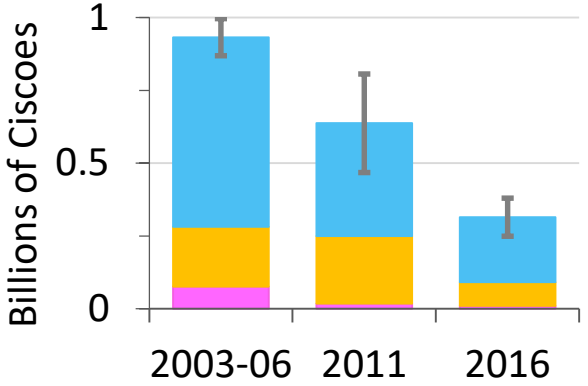


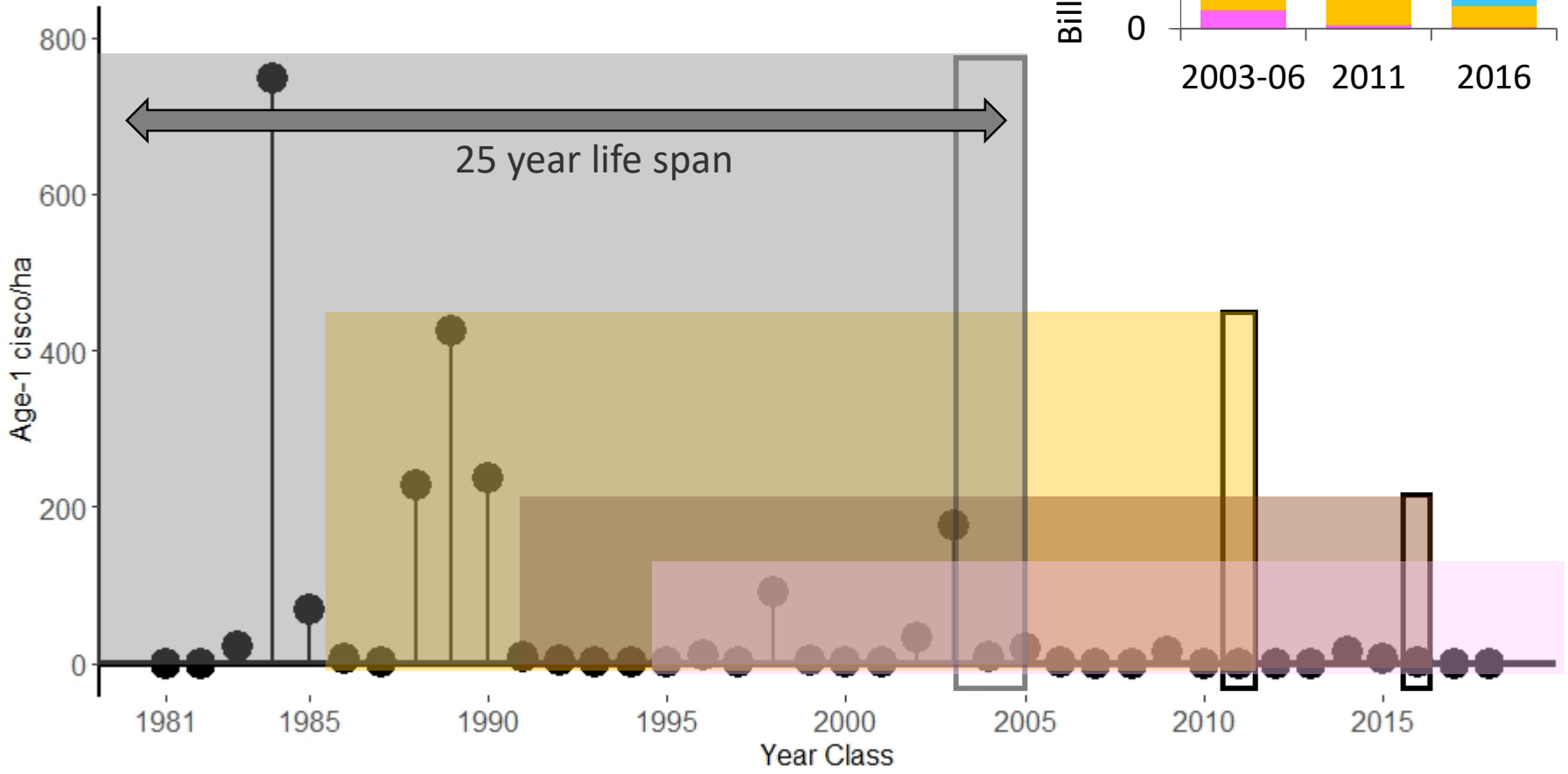
Cisco Recruitment



Satellite images from UW-Madison. Ice data from NOAA GLERL. Fish data from USGS Lake Superior nearshore fish surveys

Lake Superior Ciscoe Population Dynamics





Data from USGS Lake Superior nearshore fish surveys

Per Nyberg, Eva Bergstrand, Erik Degerman and Olof Enderlein

Recruitment of Pelagic Fish in an Unstable Climate: Studies in Sweden's Four Largest Lakes

Pelagic fish population biology was studied in the large Swedish lakes Vänern, Vättern, Mälaren and Hjälmaren. It is crucial for fish fry in temperate regions to hatch early in the growth season to survive, and achieve large before winter, and it is suggested that the key f to match the spring development of p plankton, but to avoid predation accomplished by the studied (*Osmerus eperlanus*) and *percа*) than autum *gonus albula*) shortly st

INTRODUC

The

Box 1. Ve

In the large spawners in autu spawner and ...ater. The fry hatch ...dies have found that the hatching of vend... place close to ice break (2–5). Especially from t... spawning Norwegian populations the need for a mechanical disturbance to promote hatching has been discussed, e.g. temperature-induced water movements.

The growth is fast and about 4 weeks after hatching, at a size between 20 and 30 mm, the young-of-the-year (YOY) leave the shallow shore area. At the beginning of September the YOY have reached a size of about 90 mm and a weight of 6 g. Vendace feeds on zooplankton during its entire life (5–10), but initially rotifers may be of some importance (3).

Vendace is of great importance for commercial fishing in Vänern and Mälaren.

Vendace (cisco) from ca. 5 to 15 cm (ages 0+ to 2–3+) caught in L. Vänern at the beginning of August 2001. The older fish are of harvestable size for the fishery for roe later in autumn.

Ambio ... Royal Swedish Academy of Sciences 2001
... www.ambio.kva.se

Verh. Internat. Verein. Limnol. | 24 | 2465–2469 | Stuttgart, September 1991

At what life stage is year-class strength of coregonids (*Coregonus lavaretus* L.) in Lake Constance determined?

Reiner Eckmann and Martin Pusch

BULLETIN OF MARINE SCIENCE, 74(3): 671–683, 2004

MOTE SYMPOSIUM INVITED PAPER

LAKE SUPERIOR ECOSYSTEM, 1929–1998: SIMULATING ALTERNATIVE HYPOTHESES FOR RECRUITMENT FAILURE OF LAKE HERRING (*COREGONUS* ...)

Sean P. C...

Journal of Fish Biology (1997) **51** (Supplement A), 303–316

Patterns in vendace recruitment in Lake Pyhäjärvi, south-west Finland

H. Helminen*, J. Sarvala† and J. Karjalainen‡

*Southwest Finland Regional Environment Centre, Inkilänkatu 4, FIN-20300 Turku, Finland; †Department of Biology, University of Turku, FIN-20014 Turku, Finland and ‡Karelian Institute, University of Joensuu, P.O. Box 111, FIN-80101 Joensuu, Finland

...ative impacts ...nes, and fishing mortality ...our alternative hypotheses as potential ...herring: strong and

...itment of Canadian Arctic Cisco (*Coregonus autumnalis*) into Alaskan Waters

Robert G. Fechhelm

LGL Ecological Research Associates, Inc., 1410 Cavitt Street, Bryan, TX 77801, USA

and David B. Fissel

Arctic Sciences Ltd., 100 Ilsley Avenue, Unit AA, Dartmouth, N.S. B3B 1L3

Fechhelm, R. G., and D. B. Fissel ...

J. Great Lakes Res. 30 (Supplement 1):423–433
Internat. Assoc. Great Lakes Res., 2004

...nt of Canadian arctic cisco (Coregonus autum- 906–910.

JOURNAL FISHERIES RESEARCH BOARD OF CANADA, VOL. 28, NO. 6, 1971

Temper... Requirements for Growth and Survival of ... Ciscos (*Coregonus artedii*)

J. H... ...ARD R. JONES, AND ROLL F. SYRETT

...ater Quality Office ...Minnesota, USA

...ature requirements ...s. Bd. Canada

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Contents lists available at ScienceDirect

Fisheries Research

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

Year-class strength, physical fitness and recruitment cycles in McCo...vendace (*Coregonus albula*)

Thomas Axenrot[a,*], Erik Degerman[b]

[a] Institute of Freshwater Research, Department of Aquatic Resources, Swedish University of Agric... Drottningholm, Sweden
[b] Institute of Freshwater Research, Department of Aquatic Resources, Swedish University of Agric... Sweden

ARTICLE INFO

...e history: ...ble online 14 April 2015

...r cycles ...ength

Advanc. Limnol. **64**, p. 57–70
Biology and Management of Coregonid Fishes – 2011

...shing or the environment – what regulates ...cruitment of an exploited marginal vendace ...oregonus albula* (L.)) population?

...aela A. J. Bergenius[1,*], Anna Gårdmark[1], Didzis ...
...i Kaljuste[1], Teija Aho[1]

...5 figures and 2 ...

North American Journal of Fisheries Management 32:499–514, 2012
© American Fisheries Society 2012
ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1080/02755947.2012.680005

ARTICLE

The Spatial Scale for Cisco Recruitment Dynamics in Lake Superior during 1978–2007

...b J. Rook*

Schweiz. Z. Hydrol. 49/3, 1987

...Auburn, California 95602, USA

0036-7842.87/030353-1051.50 + 0.20/0

Climate change alters the egg development dynamics in cold-water adapted coregonids

Juha Karjalainen · Tapio Keskinen · Merja Pulkkanen · Timo J. Marjomäki

Biotic and Abiotic Factors Related to Lake Herring Recruitment in the Wisconsin Waters of Lake Superior, 1984–1998

...hael H. Hoff*

...gical Survey
Science Center
Biological Station
Shore Drive East
Wisconsin 54806

THE EFFECT OF LAKE SUPERIOR SURFACE WATER TEMPERATURE ON LAKE HERRING (*COREGONUS ARTEDI*) LENGTH AND YEAR-CLASS STRENGTH

Taylor & Francis
Taylor & Francis Group

Evaluating Potential Sources of Mortality for Larval Bloater (*Coregonus hoyi*): Starvation and Vulnerability to Predation

...A. Rice[1]
...Wisconsin, Madison, WI 53706, USA
...owder
...iversity, Raleigh, NC 27695-7617, USA
...kowski
...iversity of Wisconsin, Milwaukee, WI 53201, USA

...s of mortality for larval bloater ... Aquat. Sci. 44: 467–472.

North American Journal of Fisheries Management 33:1243–1257, 2013
© American Fisheries Society 2013
ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1080/02755947.2013.837122

ARTICLE

Biotic and Abiotic Factors Influencing Cisco Recruitment Dynamics in Lake Superior during 1978–2007

Benjamin J. Rook*
College of Natural Resources, University of Wisconsin–Stevens Point, 2100 Main Street, Stevens Point, Wisconsin 54481, USA

Michael J. Hansen
U.S. Geological Survey, Great Lakes Science Center, Hammond Bay Biological Station, 11188 Ray Road, Millersburg, Michigan 49759, USA

Owen T. Gorman
U.S. Geological Survey, Great Lakes Science Center, Lake Superior Biological Station, 2800 Lake Shore Drive East, Ashland, Wisconsin 54806, USA

Recruitment variability in vendace, Coregonus albula (L.), and its consequences for vendace harvesting

Timo Marjomäki

AQUATIC ECOSYSTEM HEALTH & MANAGEMENT

Has climate variability driven the trends and dynamics in recruitment of pelagic fish species in Swedish Lakes Vänern and Vättern in recent decades?

Alfred Sandström,* Henrik Ragnarsson-Stabo, Thomas Axenrot, and Eva Bergstrand

SLU, Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Freshwater Research, Stångholmsvägen 2, Drottningholm SE-17893, Sweden
**Corresponding author: alfred.sandstrom@slu.se*

A comparative study on the temperature dependence of embryogenesis in three coregonids (*Coregonus* spp.) from Lake Constance

B...

Transactions of the American Fisheries Society 133:1235–1246, 2004

JOURNAL FISHERIES RESEARCH BOARD OF CANADA, VOL. 28, NO. 6, 1971

Temperature Requirements for Growth and Survival of Larval Ciscos (*Coregonus artedii*)

J. Howard McCormick, Bernard R. Jones, and Roll F. Syrett

Environmental Protection Agency, Water Quality Office
National Water Quality Laboratory, Duluth, Minnesota, USA

McCormick, J. H., B. R. Jones, and R. F. Syrett, 1971. ...
for growth and survival of larval ...
28: 924–927.

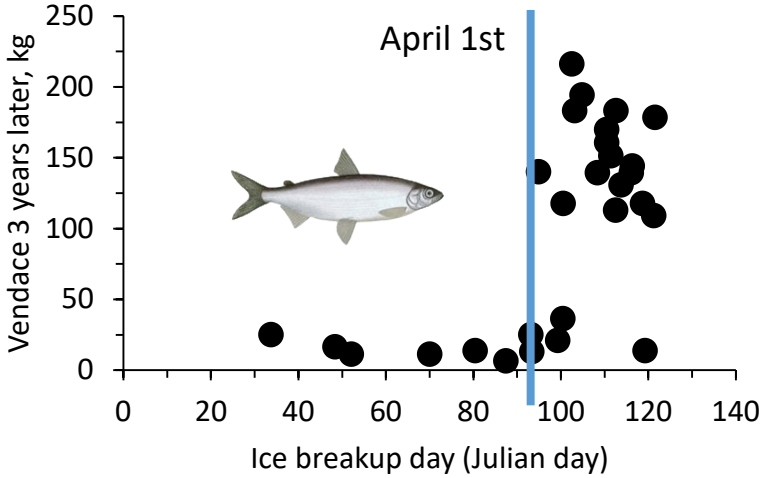
Overwinter Survival of Juvenile Lake Herring in Relation to Body Size, Physiological Condition, Energy Stores, and Food Ration

Kevin L. Pangle[1] and Trent M. Sutton*
Purdue University, Department of Forestry and Natural Resources, 195 Marsteller Street, West Lafayette, Indiana 47907-1159, USA

Ronald E. Kinnunen
Michigan Sea Grant, Michigan State University, 710 Chippewa Square, Suite 202, Marquette, Michigan 49855, USA

Michael H. Hoff[2]
U.S. Geological Survey, Great Lakes Science Center, Lake Superior Biological Station, 2800 Lakeshore Drive East, Ashland, Wisconsin 54806, USA

Lake Superior Ice Cover and Ciscoe Recruitment Relationship



Lake Superior data from USGS Lake Superior nearshore fish surveys, Canadian Ice Service. Lake Mälaren data from Nyberg 2001.

Search

Cisco | Home | Find Friends | Create

Lake Superior Cisco

Timeline | About | Friends

About

- Overview
- Work and Education
- Places You've Lived
- Contact and Basic Info
- **Family and Relationships**
- Details About You
- Life Events

Relationship with Ice Cover

Relationship Status

- Partnership
- Separated
- Divorced
- **It's complicated** ◀

Save Changes | Cancel

Family Members

Bloater

Kiyi

Shortjaw

Blackfin

Friends

Friend Requests 2 | + Find Friends

Following 3

GL Fishers

Mark Vinson

Kiyi

New York Deli's

TNC

Lake Trout

Mysis

Can we develop a model that identifies what factors underlie the variability in survival to age-1?

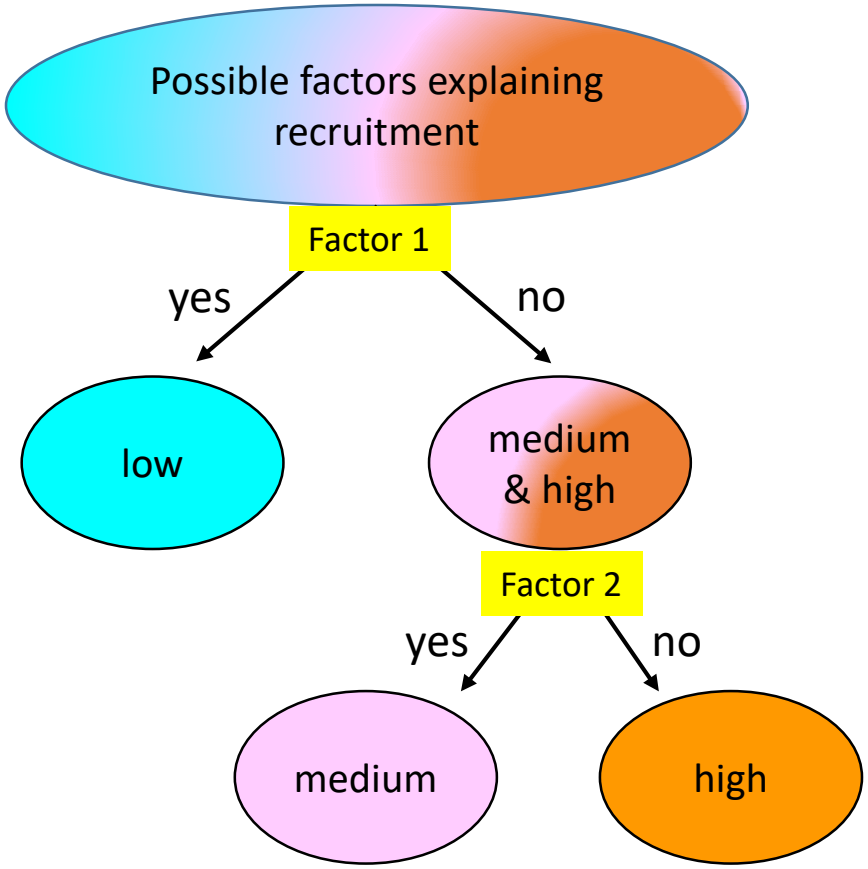
Adult Spawning
- Population size
- Health / fecundity

Egg Incubation
- Ice Cover
- Temperature
- Predation

Larval stage
- Growth
- Predation
- Temperature

Lake Superior Ciscoe age-1 Recruitment Predictive Model

Recruitment group	Years	Index value
None-Low	19	<2 fish / ha
Measurable	12	3-33 fish / ha
High	7	68-750 fish / ha

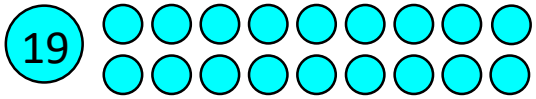


Data from USGS Lake Superior nearshore fish surveys

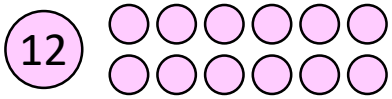
Causal Factors Influencing Cisco Recruitment

Regression tree analysis of the annual recruitment index over 38 years

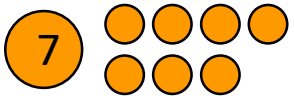
None-Low recruitment



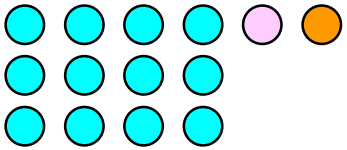
Low-moderate recruitment

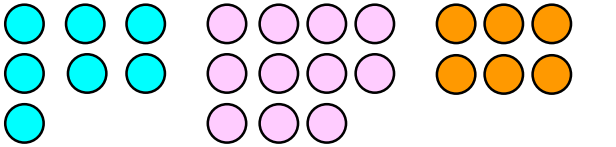


High recruitment

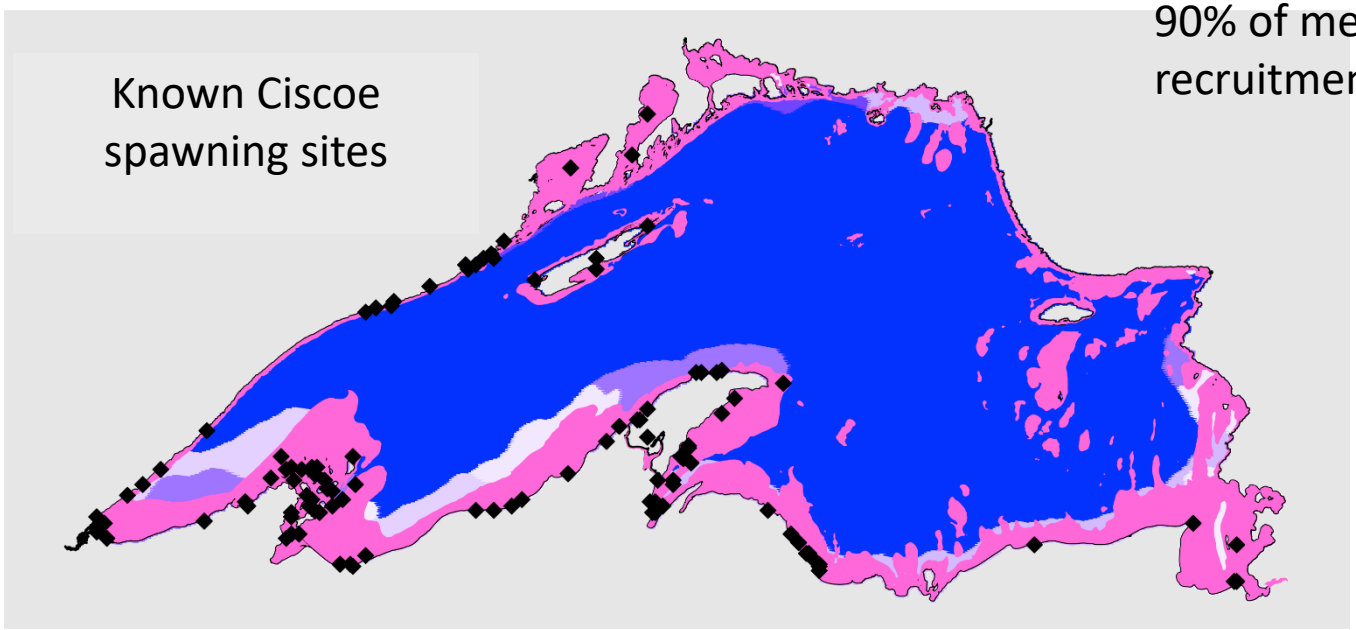


FACTOR 1: Early Ice January ice cover <15% | January ice cover >15%

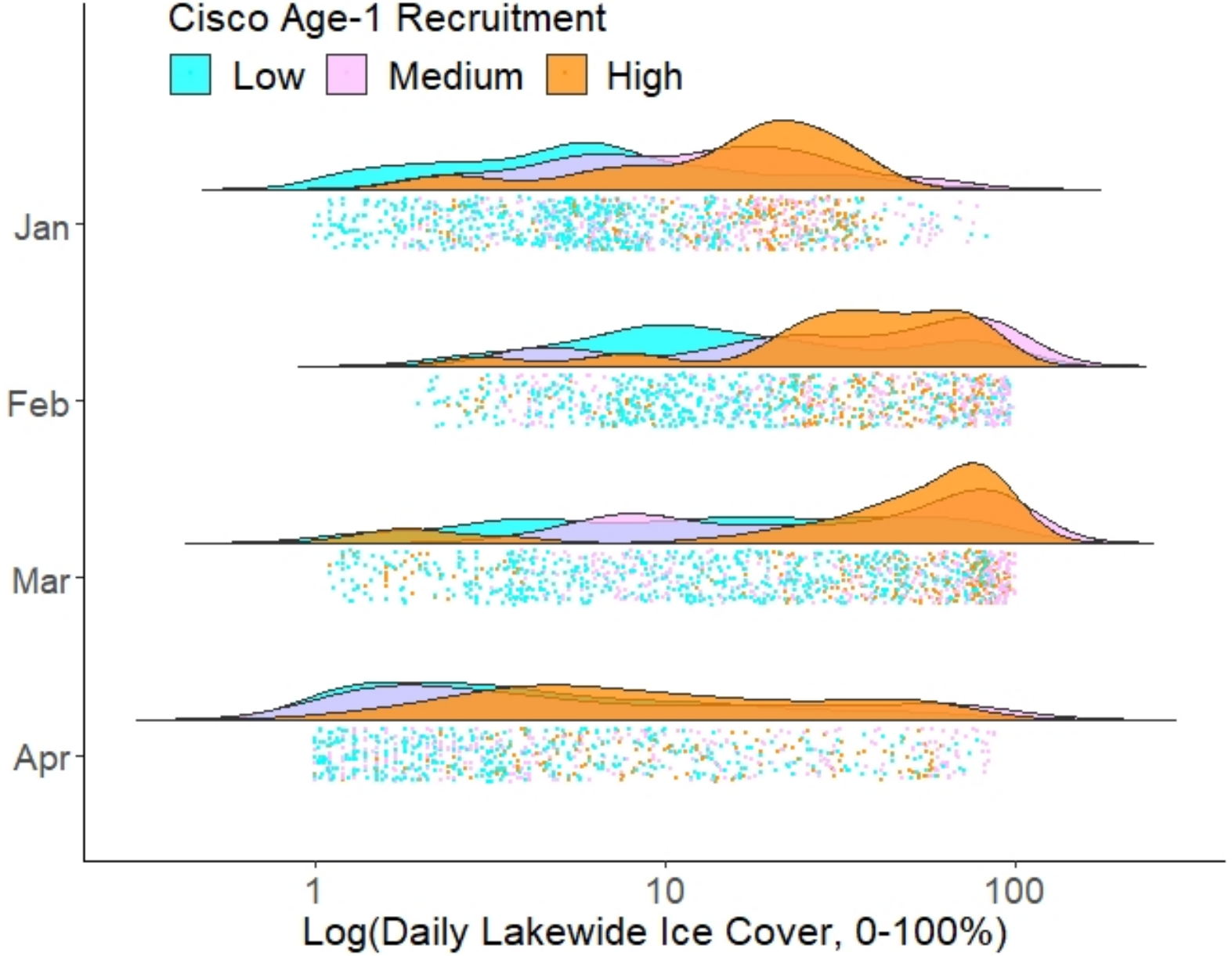




90% of measurable recruitment events

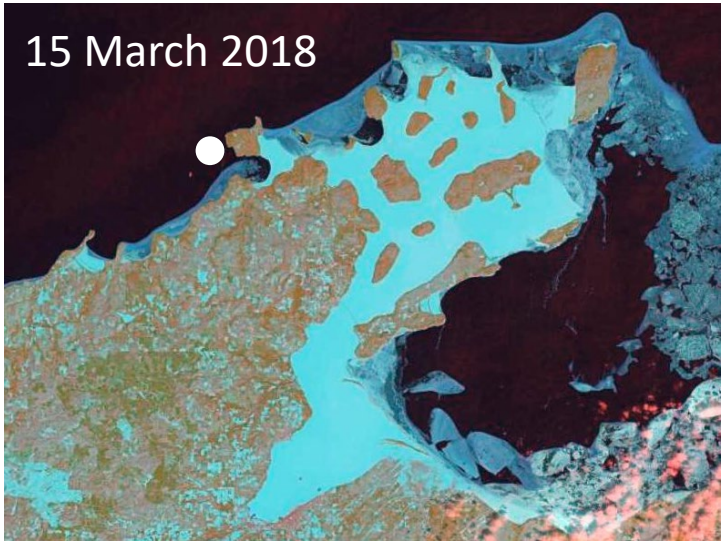


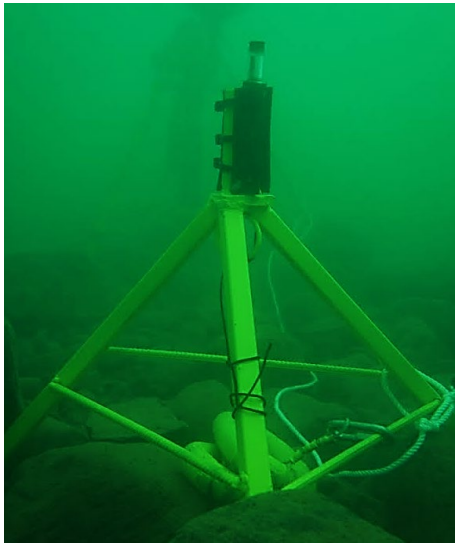
Cisco age-1 Recruitment and Ice Cover

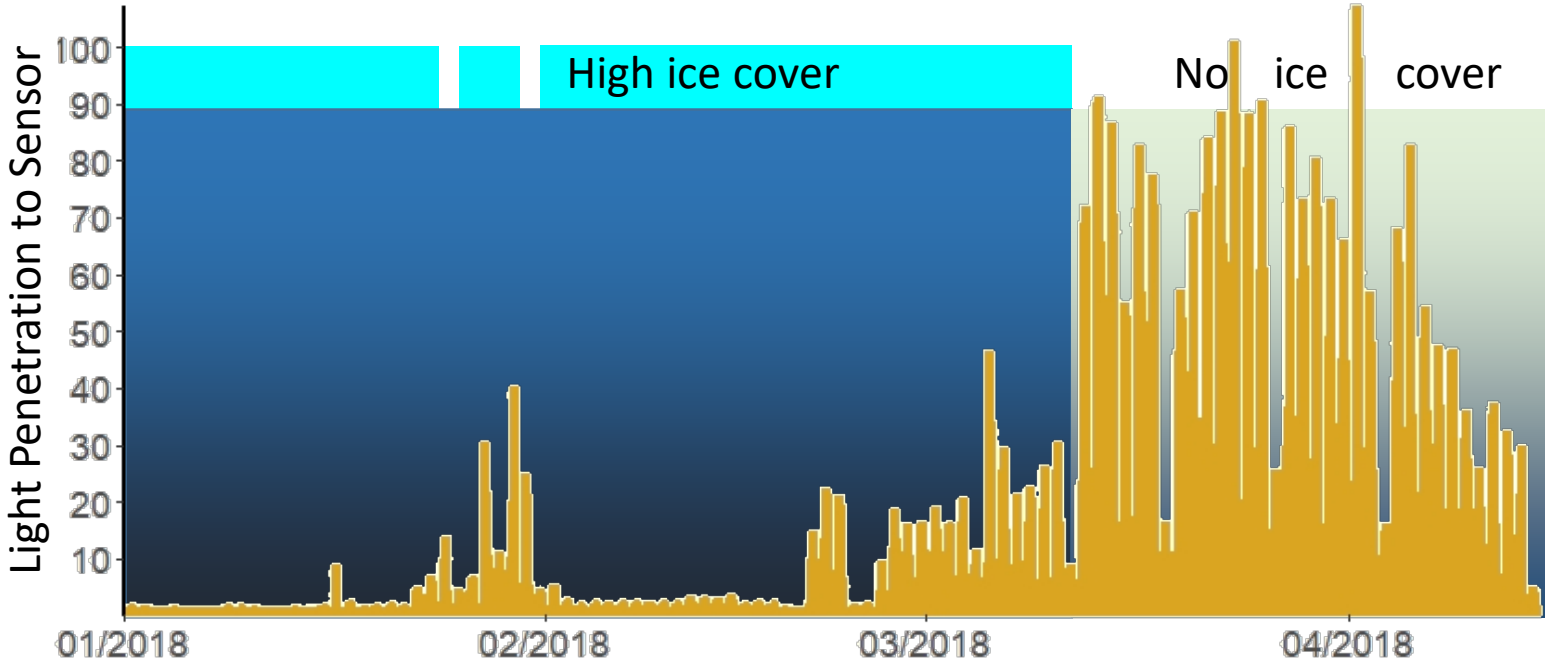


Why would ice be important?

Ice and light



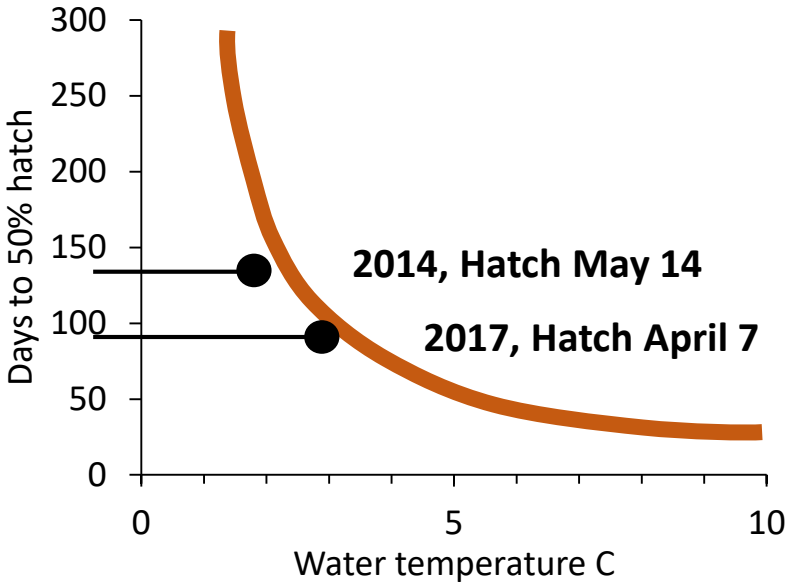




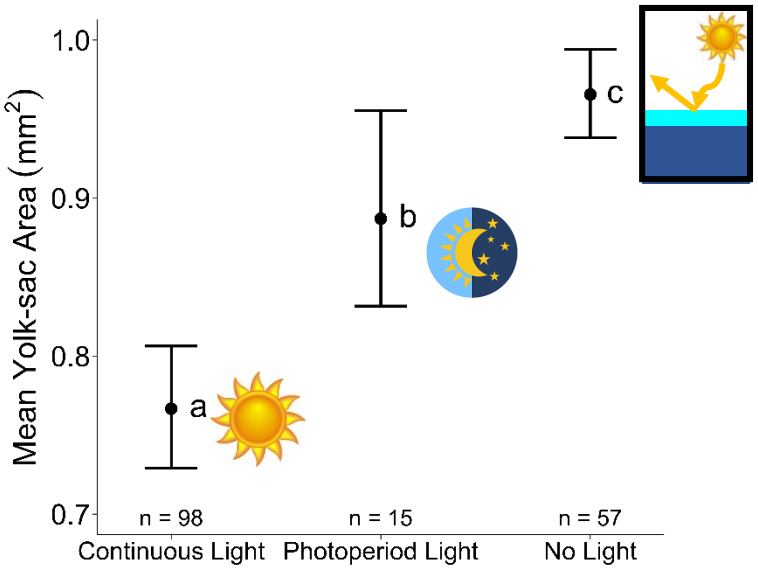
Images from USGS LandSatLook. Light data from Sand Island, Lake Superior, Taylor Stewart University of Vermont

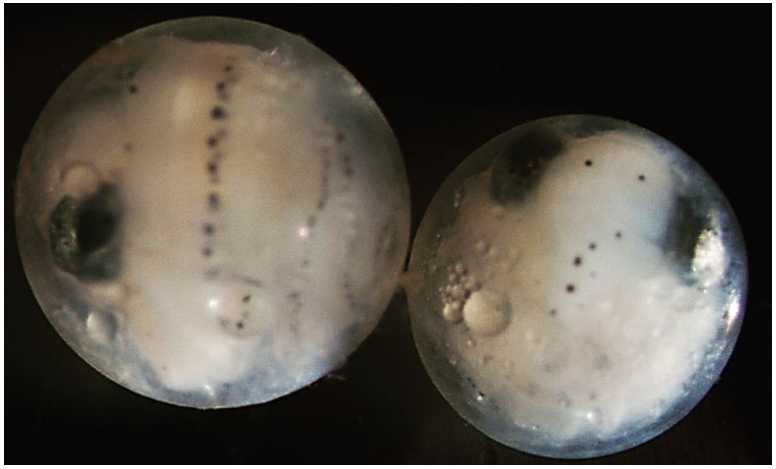
Two Potential Mechanisms Between Ice and Recruitment

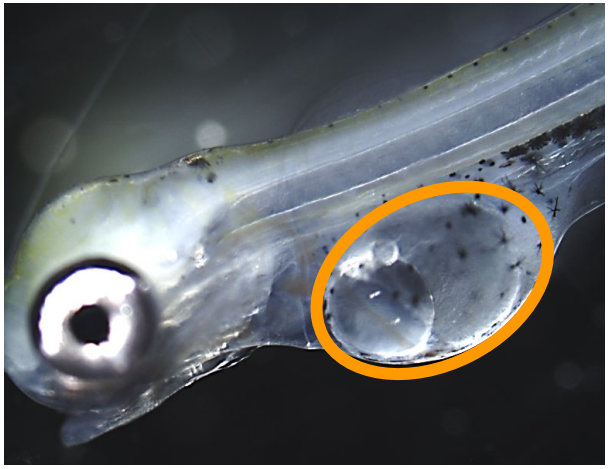
Temperature – development rate



Light – development rate and energy stores

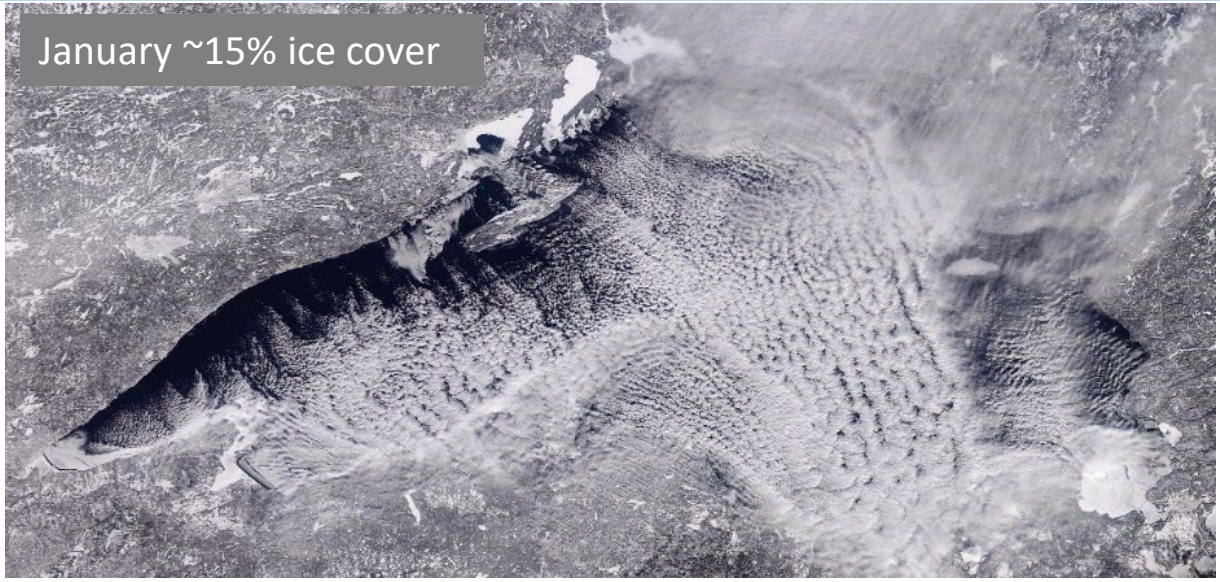


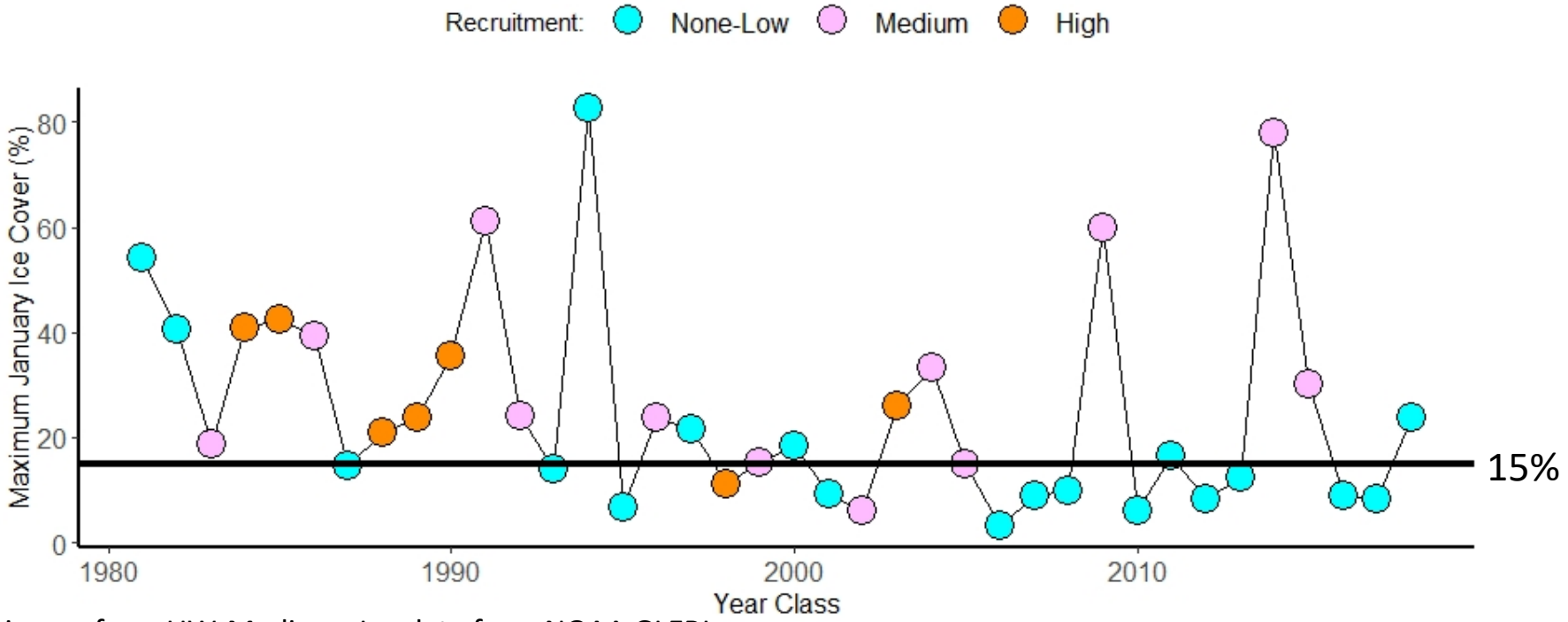




Egg development curve from Colby and Brooke 1973. Yolk-sac area and images from Taylor Stewart, University of Vermont

Trend in January Ice Cover

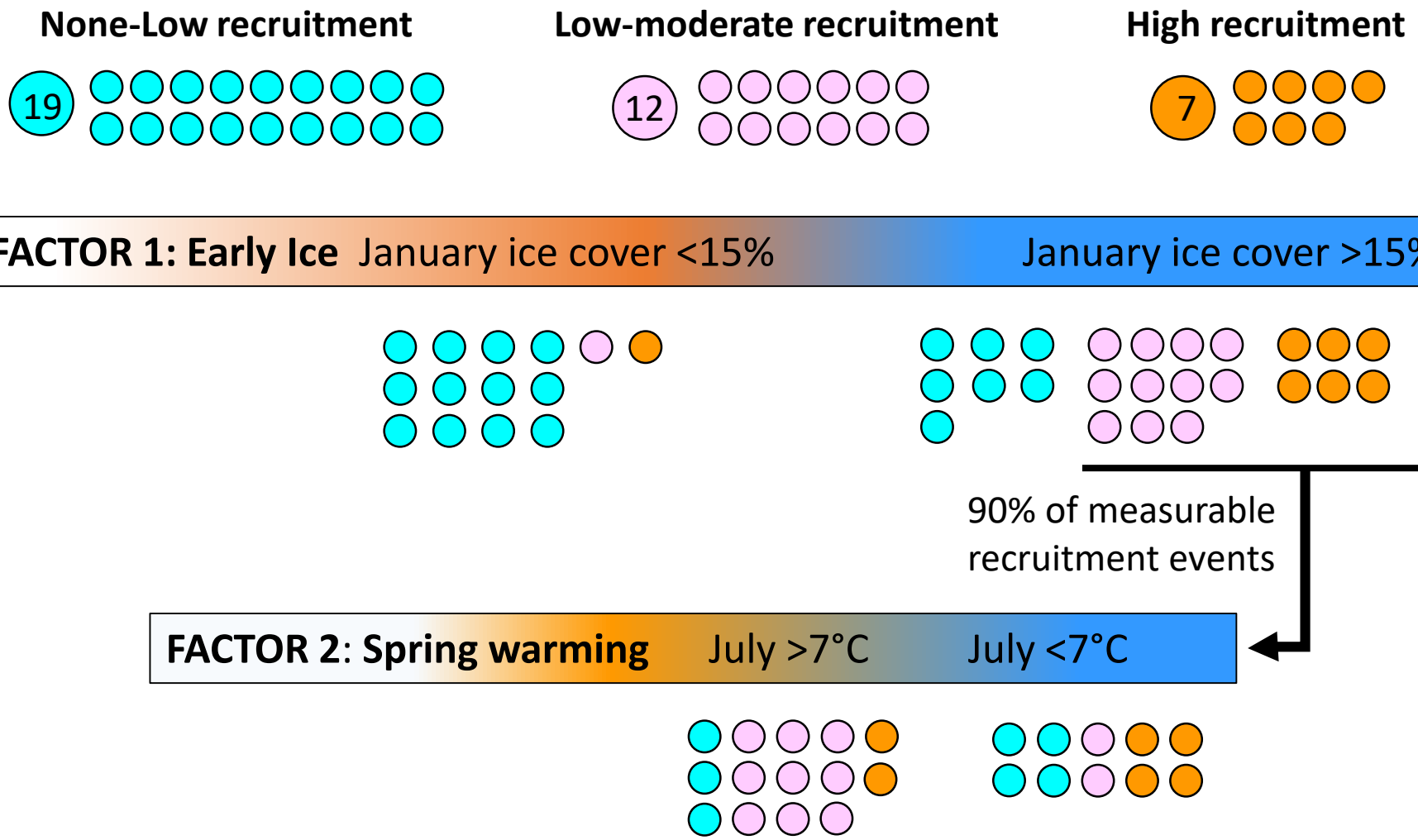




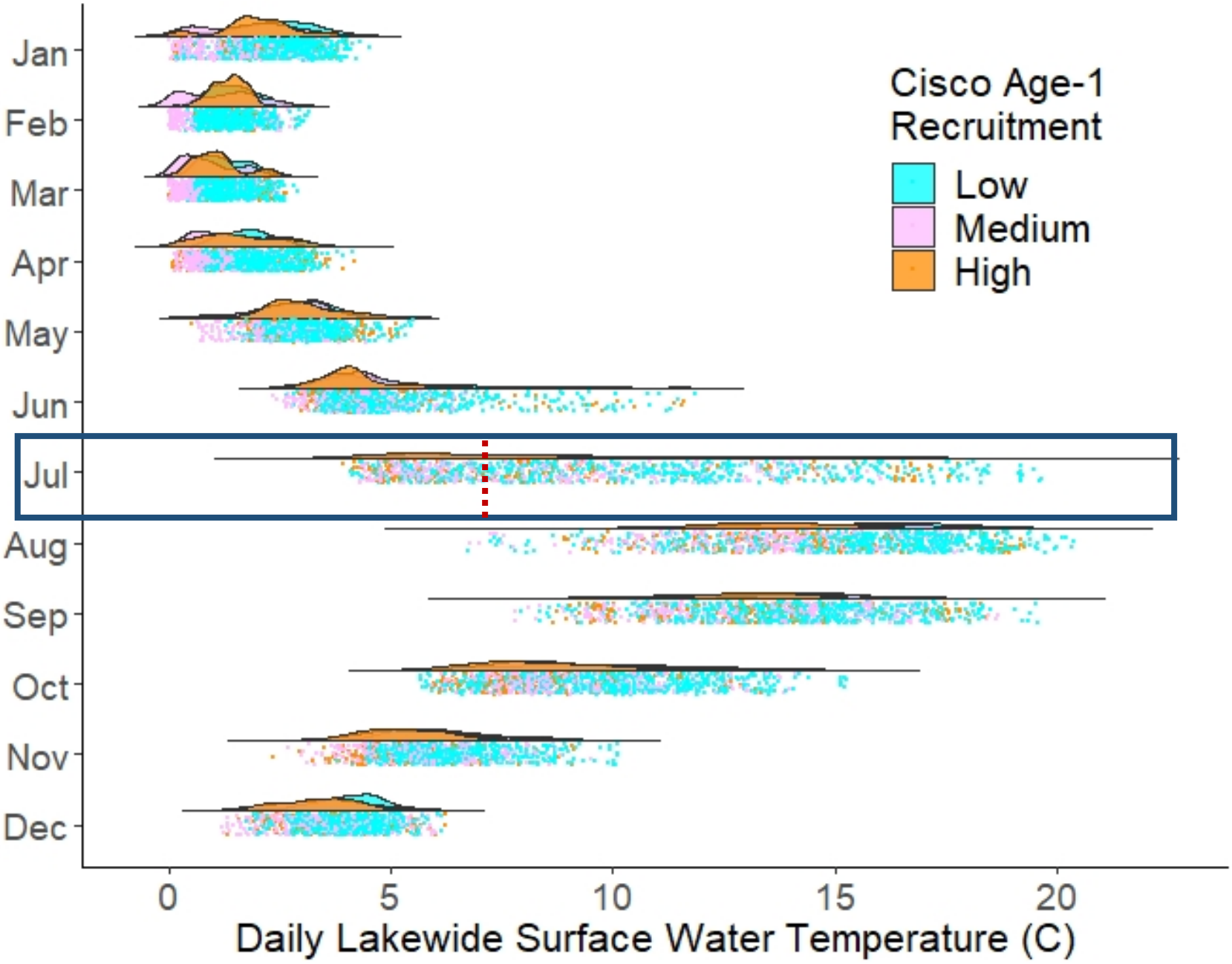
Satellite image from UW-Madison. Ice data from NOAA GLERL

Causal Factors Influencing Cisco Recruitment

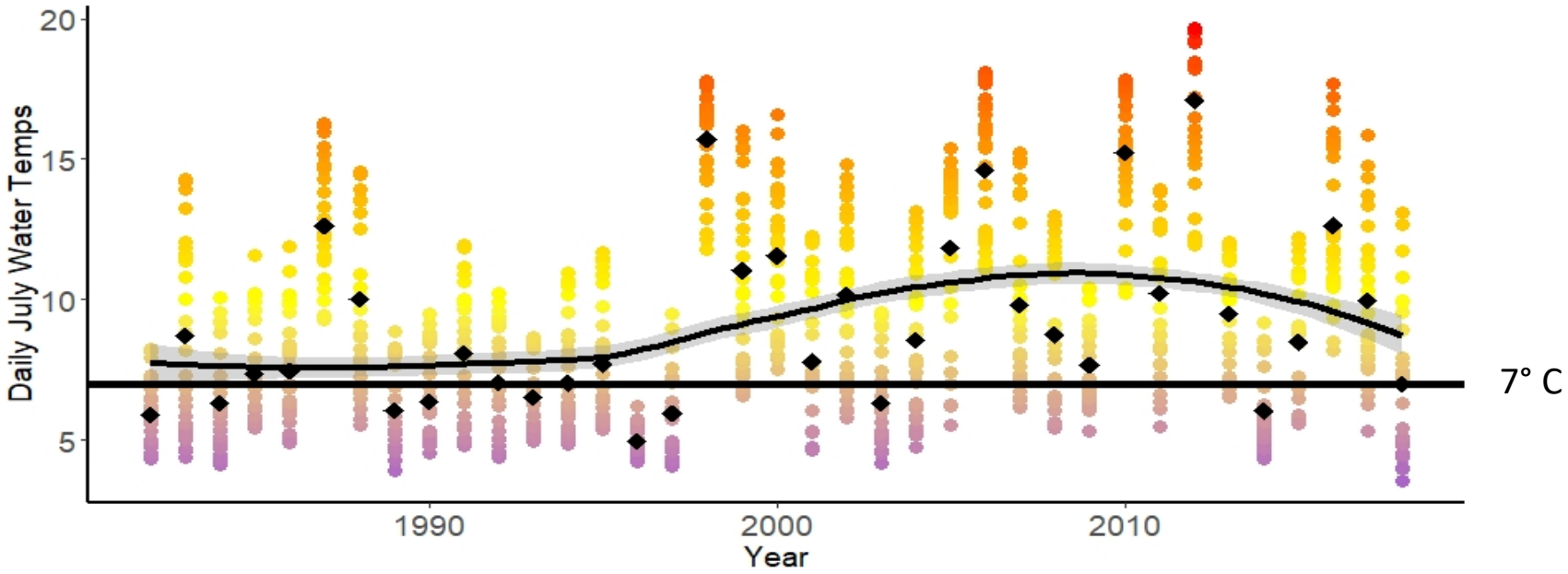
Regression tree analysis of annual recruitment over 37 years



Cisco age-1 Recruitment and Water Temperature



Trend in July Water Temperature



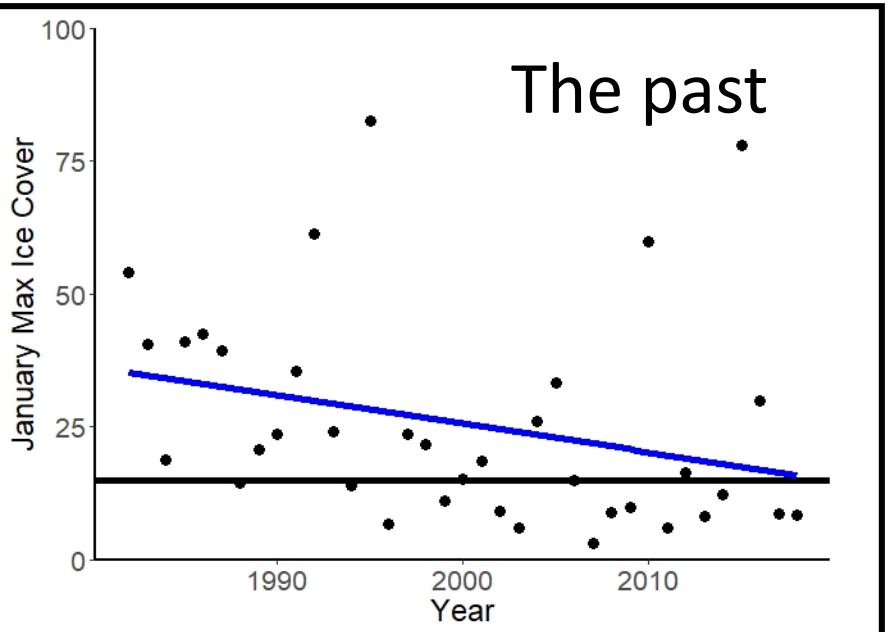
Ice and water temperature data from NOAA GLERL

Forecast

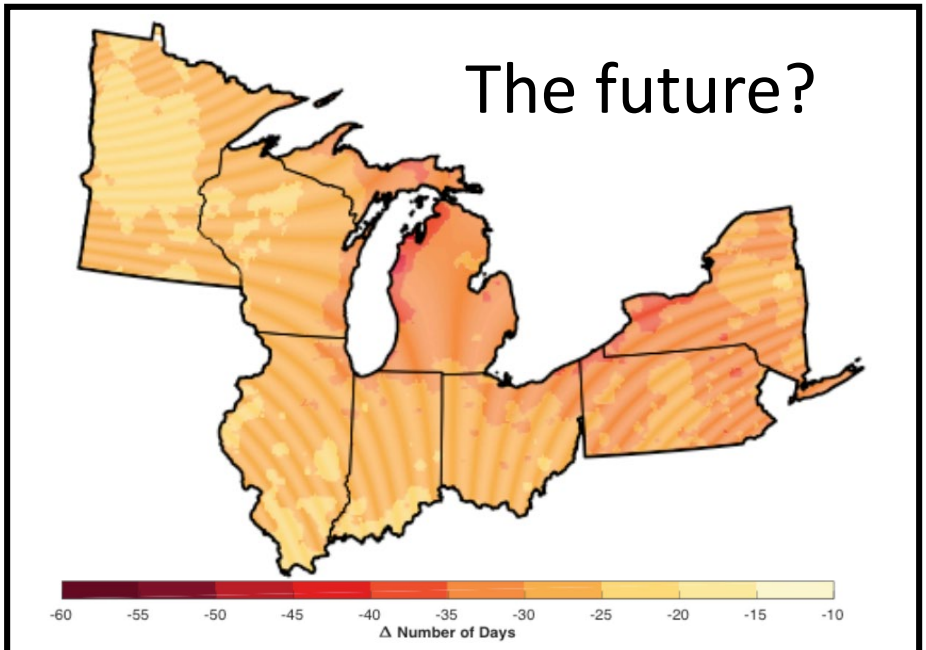
Ciscoe populations will continue to decline without successful recruitment

Current climate trends may increase ice cover variability

Can intermittent polar vortex years sustain ciscoe populations?



Years with >15% January ice decreased over the past 50 years



~30 day reduction in the number of days <32°F over the next 50 years

Cisco recruitment data from USGS nearshore surveys. Ice data from NOAA GLERL. Temperature forecast from Environmental Law and Policy Center