



# What Is it Like to be (an Atlantic) Salmon

Marc Mangel

# *Personal*

## Stuff you could get from my CV

BS (Physics) Illinois (1971), MS (Biophysics) Illinois (1972), PhD UBC (1978)

Center for Naval Analyses 1977-1980; UC Davis 1980-1996, UCSC 1996-

UiB Association since 1994, Adjunct 2010-2021 (forced retirement)

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## Some relevant activities 2010 onwards

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Member, Scientific Review Board, IPHC, 2013-2020

Chair, Board of Directors, FishWise (2013-2020)

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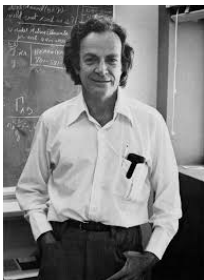
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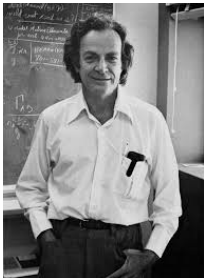
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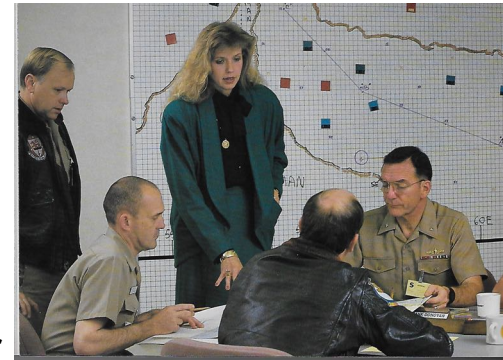
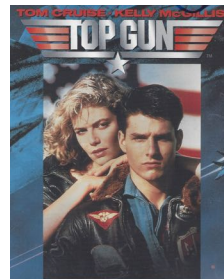
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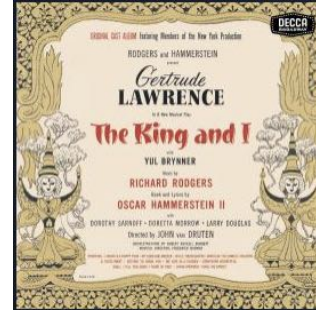


My colleague Christine Fox was the role model for Kelly McGillis's character



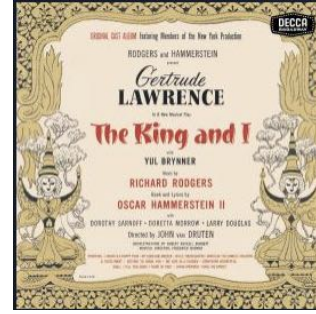
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Thanks to nearly 30 years of playing squash, I have replacements in both shoulders and knees, and one hip (which is why I am not with you)



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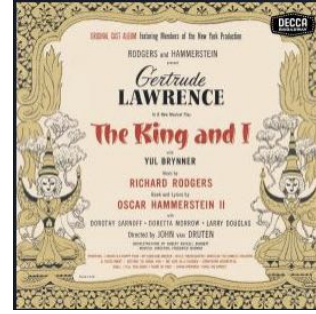
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Two daughters (one in Tacoma, one in the Berkeley area). Four grandkids

Evan (15), Kaila (12) in California; Asher (10), Isaac (9) in Tacoma

Four grand dogs: Radar, Amber (California), Zoka (Tacoma)





# Current research

Consulting gig at Johns Hopkins University  
Applied Physics Laboratory (JHU-APL)  
to bring ideas from population biology to  
understand attack, defense, and  
variability more generally in cyber  
systems. 2018-



Parker  
Solar Probe



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## Decision-Making From the Animal Perspective: Bridging Ecology and Subjective Cognition

*Sergey Budaev<sup>1\*</sup>, Christian Jørgensen<sup>1</sup>, Marc Mangel<sup>1,2</sup>, Sigrunn Eliassen<sup>1</sup> and Jarl Giske<sup>1</sup>*

<sup>1</sup> Department of Biological Sciences, University of Bergen, Bergen, Norway; <sup>2</sup> Department of Applied Mathematics, University of California, Santa Cruz, CA, United States

After this paper is done, I will  
focus on how to make our tools  
less computationally intensive  
and explore applications to a  
wider range of organisms



## What Is it Like to be (an Atlantic) Salmon

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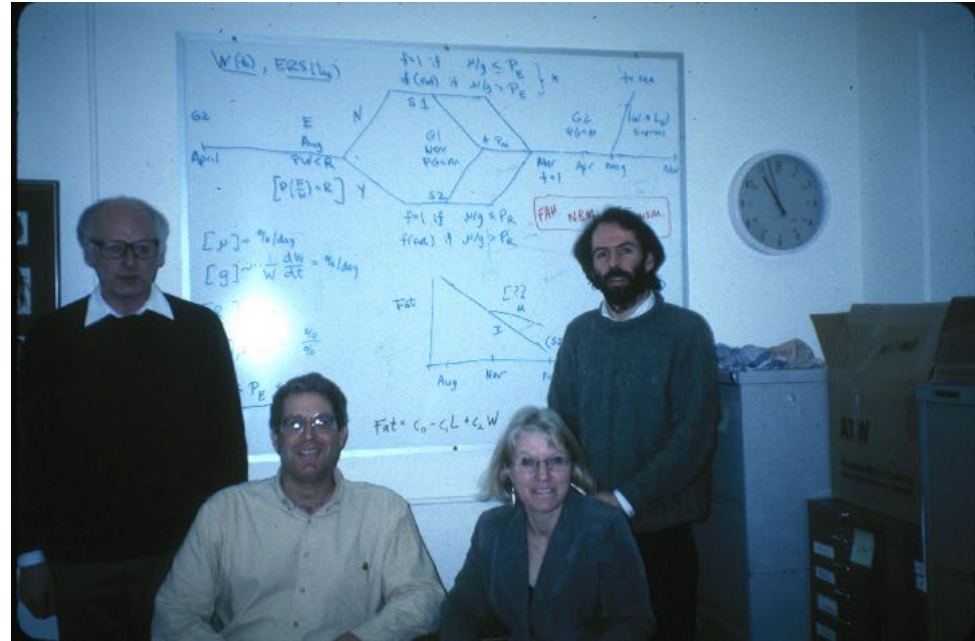


John Thorpe, Neil Metcalfe, Felicity Huntingford



# What Is it Like to be (an Atlantic) Salmon

Marc Mangel



John Thorpe, Neil Metcalfe, Felicity Huntingford

# Learning from the Master

Thorpe, J.E., Mangel, M., Metcalfe, N.B. and F.A. Huntingford. 1998. Modelling the proximate basis of salmonid life-history variation, with application to Atlantic salmon, *Salmo salar* L. *Evolutionary Ecology* 12:581-600.





# Modelling the life-history variation of Arctic charr

Rikardsen AH, Thorpe JE, Dempson JB. Modelling the life-history variation of Arctic charr. *Ecology of Freshwater Fish* 2004; 13: 305–311. © Blackwell Munksgaard, 2004

Abstract – A model based on proximate considerations of life histories of Atlantic salmon, *Salmo salar*, was examined for its applicability to fit the

**A. H. Rikardsen<sup>1</sup>,  
J. E. Thorpe<sup>2</sup>, J. B. Dempson<sup>3</sup>**

<sup>1</sup>Norwegian Institute for Nature Research, Tromsø, Norway, <sup>2</sup>Institute of Biomedical and Life Sciences, University of Glasgow, Glasgow, UK, <sup>3</sup>Fisheries and Oceans Canada, St John's, NF, Canada



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*Transactions of the American Fisheries Society* 138:532–548, 2009  
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DOI: 10.1577/T08-164.1

## Steelhead Life History on California's Central Coast: Insights from a State-Dependent Model

WILLIAM H. SATTERTHWAITE\*

Center for Stock Assessment Research, Department of Applied Mathematics and Statistics,  
University of California Santa Cruz, Santa Cruz, California 95064, USA

MICHAEL P. BEAKES

Center for Stock Assessment Research, Department of Applied Mathematics and Statistics, University of  
California Santa Cruz, Santa Cruz, California 95064, USA; and National Marine Fisheries Service,  
110 Shaffer Road, Santa Cruz, California 95060, USA

ERIN M. COLLINS

California Department of Fish and Game, 8175 Alpine Avenue, Suite F, Sacramento, California 95826, USA

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JOSEPH E. MERZ

Cramer Fish Sciences, 126 East Street, Auburn, California 95603, USA; and Institute of Marine Sciences,  
University of California Santa Cruz, Santa Cruz, California 95064, USA

ROBERT G. TITUS

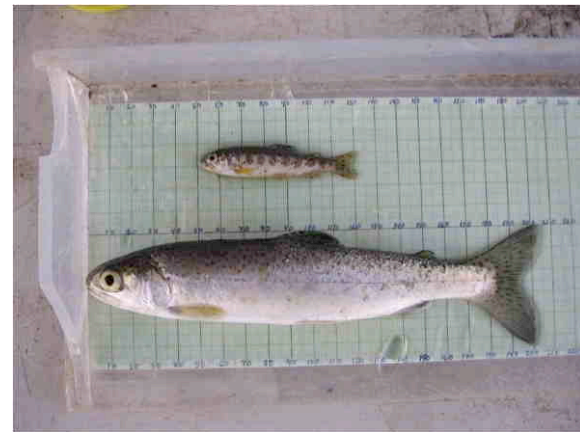
California Department of Fish and Game, 8175 Alpine Avenue, Suite F, Sacramento, California 95826, USA

SUSAN M. SOGARD

National Marine Fisheries Service, 110 Shaffer Road, Santa Cruz, California 95060, USA

MARC MANGEL

Center for Stock Assessment Research, Department of Applied Mathematics and Statistics,  
University of California Santa Cruz, Santa Cruz, California 95064, USA



Two fish from the American River of  
The same age, captured on the same day  
In the same location





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Volume 122

January 1993

Number 1

*Transactions of the American Fisheries Society* 122:1–33, 1993  
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## Phylogeny of the Pacific Trouts and Salmon (*Oncorhynchus*) and Genera of the Family Salmonidae

R. F. STEARLEY<sup>1</sup> AND G. R. SMITH

Museum of Paleontology and Museum of Zoology  
University of Michigan, Ann Arbor, Michigan 48109, USA

**Abstract.**—Seven genera—*Brachymystax*, *Acantholingua*, *Salmothymus*, *Hucho*, *Salvelinus*, *Salmo*, and *Oncorhynchus*—make up the living Salmoninae. Relationships of 33 extant and 4 fossil salmonid species and subspecies were studied on the basis of 119 characters analyzed by parsimony algorithms. Twelve equally parsimonious trees each requiring 253 steps were calculated. Monophyly of recognized genera is consistent with all 12 estimates. The earliest branch of the family Salmonidae is the subfamily Coregoninae. Its sister group is the clade including the Thymallinae and Salmoninae. Within the Salmoninae, *Eosalmo*, from the Eocene of British Columbia, is the sister group of all living genera, as previously shown by Mark Wilson. The living Asian species

Steelhead are *Oncorhynchus*  
not *Salmo*



Source: *The Philosophical Review*, Oct., 1974, Vol. 83, No. 4 (Oct., 1974), pp. 435-450

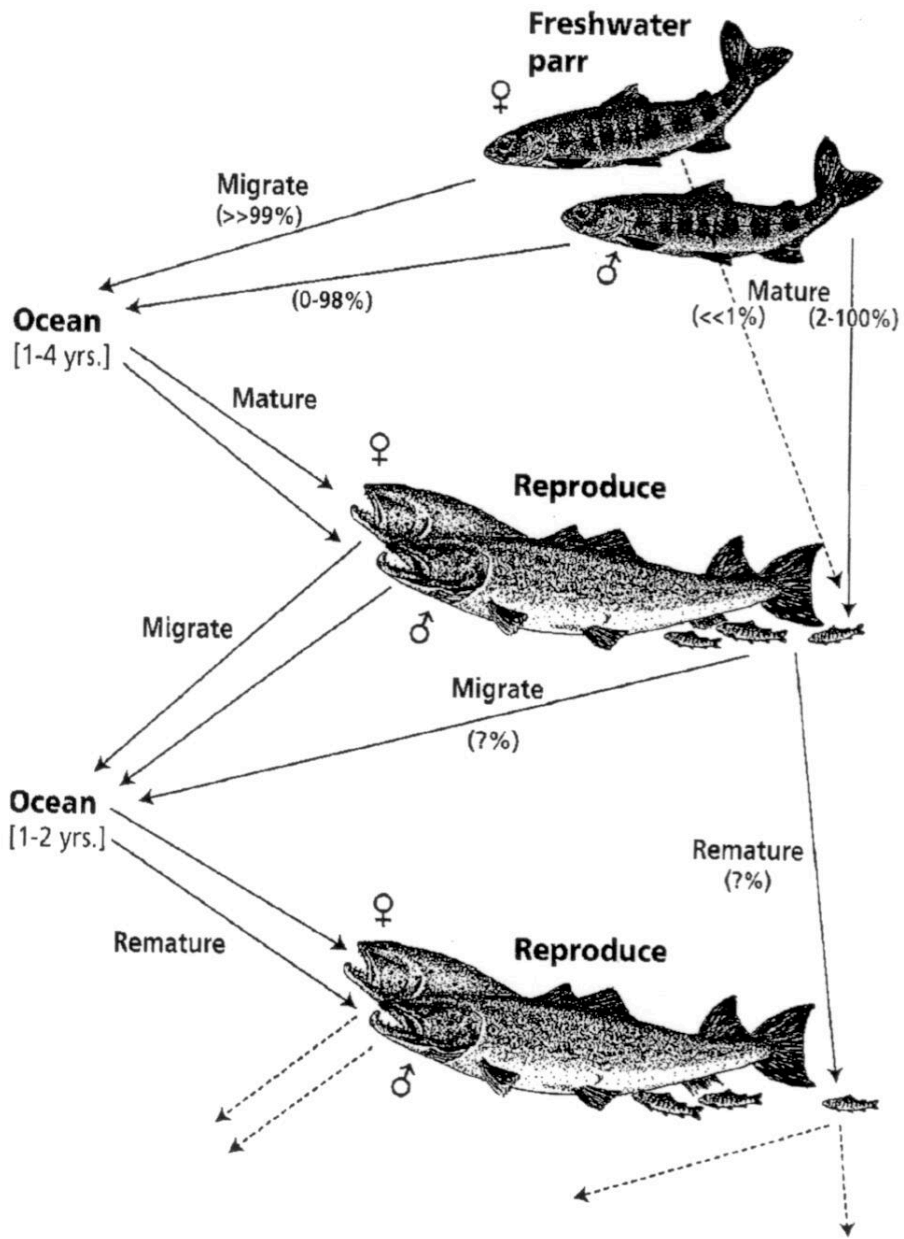
Published by: Duke University Press on behalf of Philosophical Review

Stable URL: <https://www.jstor.org/stable/2183914>

## WHAT IS IT LIKE TO BE A BAT?

CONSCIOUSNESS is what makes the mind-body problem really intractable. Perhaps that is why current discussions of the problem give it little attention or get it obviously wrong. The recent wave of reductionist euphoria has produced several analyses of mental phenomena and mental concepts designed to explain the possibility of some variety of materialism, psychophysical identification, or reduction.<sup>1</sup> But the problems dealt with are those common to this type of reduction and other types, and what makes the mind-body problem unique, and unlike the water-H<sub>2</sub>O problem or the Turing machine-IBM machine problem or the lightning-electrical discharge problem or the gene-DNA problem or the oak tree-hydrocarbon problem, is ignored.

parentheses.



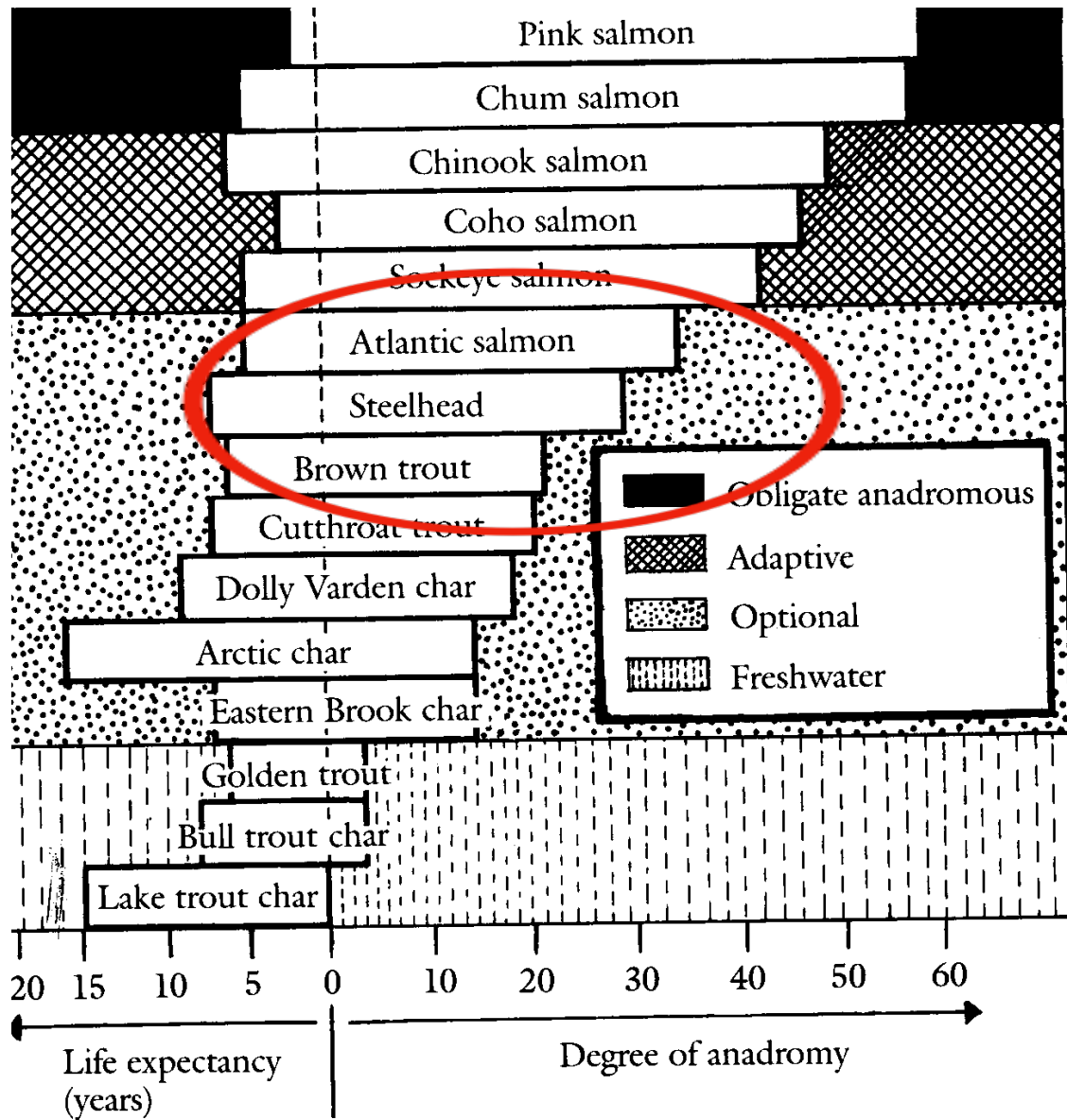
Atlantic Salmon is an iteroparous and anadromous *Salmo*

Fleming. 1998. CJFAS 55 (Suppl 1): 59

Ray Troll

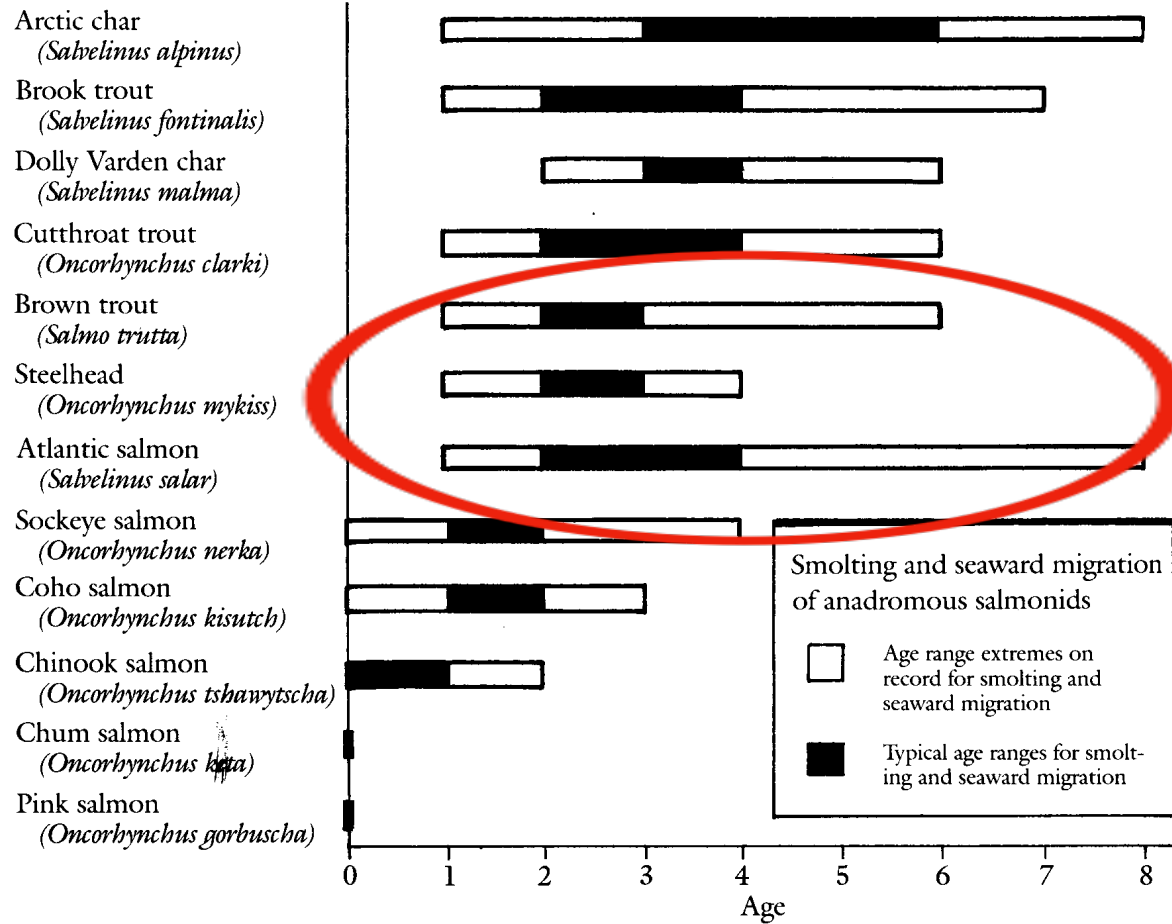


THE SALMON FAMILY TREE



ZIEGENFUS

# Another view



How do we understand and predict

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- Early maturation ('precocious parr')

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- Early maturation ('precocious parr')
- Links between environment and return (that is, when will the fish mature?)



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Salmonid life histories are

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### Salmonid life histories are

- Embedded in an annual cycle

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- Early maturation ('precocious parr')
- Links between environment and return (that is, when will the fish mature?)

### Salmonid life histories are

- Embedded in an annual cycle
- Regulated by inhibition of maturation

# The photoperiodic control of life history processes

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Nothing in biology makes sense except in the light of evolution (**ultimate**)

Theodosius Dobzhansky (1973)

# The photoperiodic control of life history processes

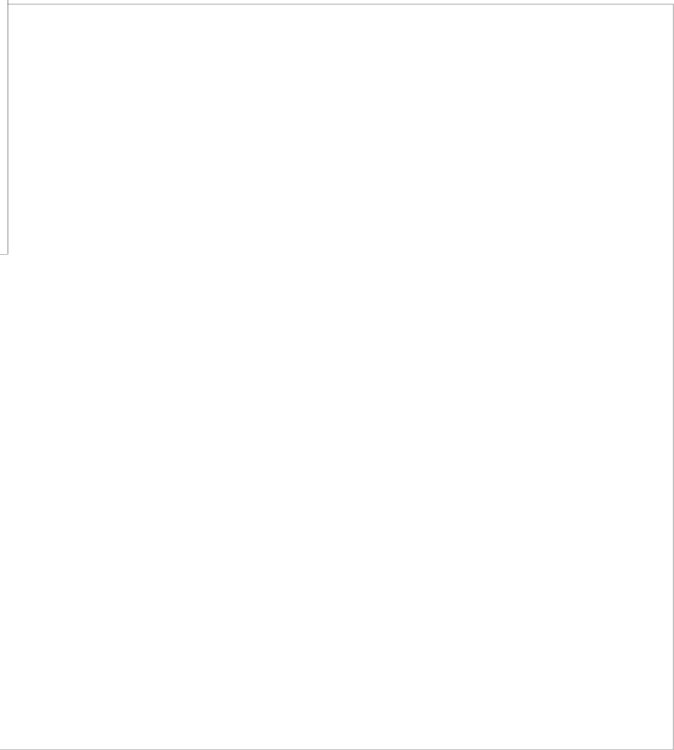
Nothing in biology makes sense except in the light of evolution (**ultimate**)

Theodosius Dobzhansky (1973)

Nothing in evolution makes sense except in the light of cell biology (**proximate**)

John Gerhart and Marc Kirschner, Cells, Embryos and Evolution (1997)

The Fresh Water Phase  
for Atlantic Salmon  
(Relevant for Early  
Maturation -- and thus  
relevant to iteroparity)



November: Fertilization  
Initiate Maturation

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for Atlantic Salmon  
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November: Fertilization  
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April: Birth  
Is state sufficiently  
great to complete maturation?

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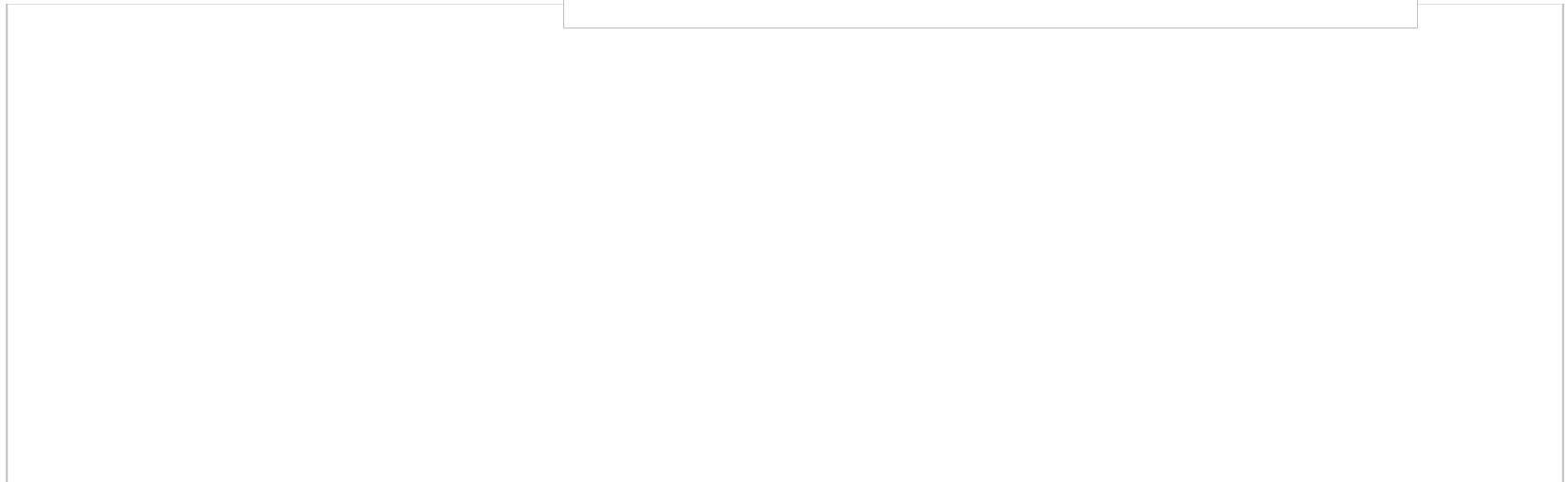
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Is state sufficiently  
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Yes

Continue maturation  
Reproduce in  
November

Mature parr



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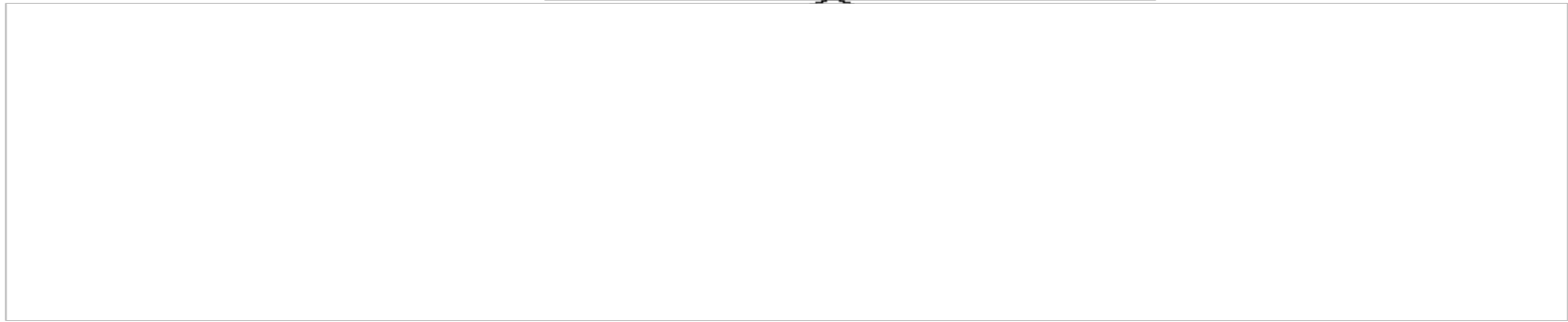
Yes

Continue maturation  
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November

No

Inhibit maturation

Mature parr



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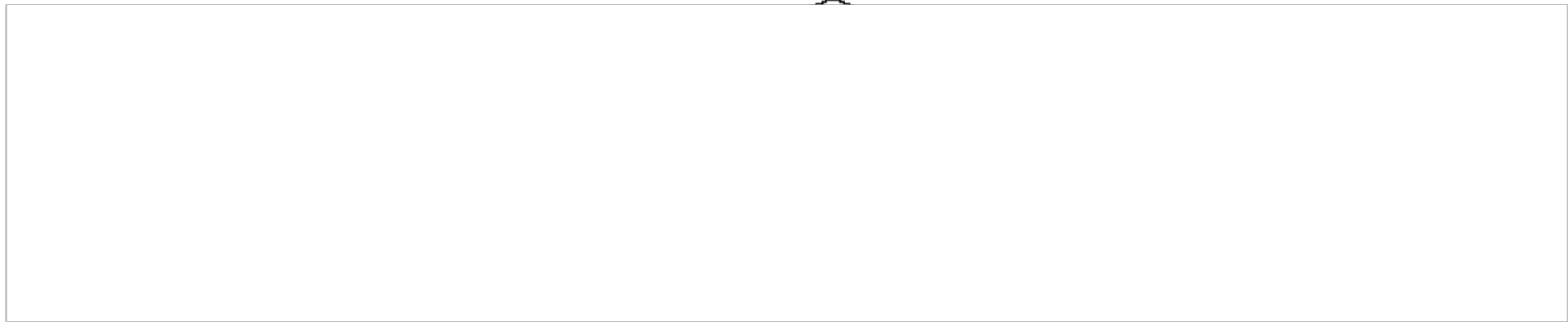
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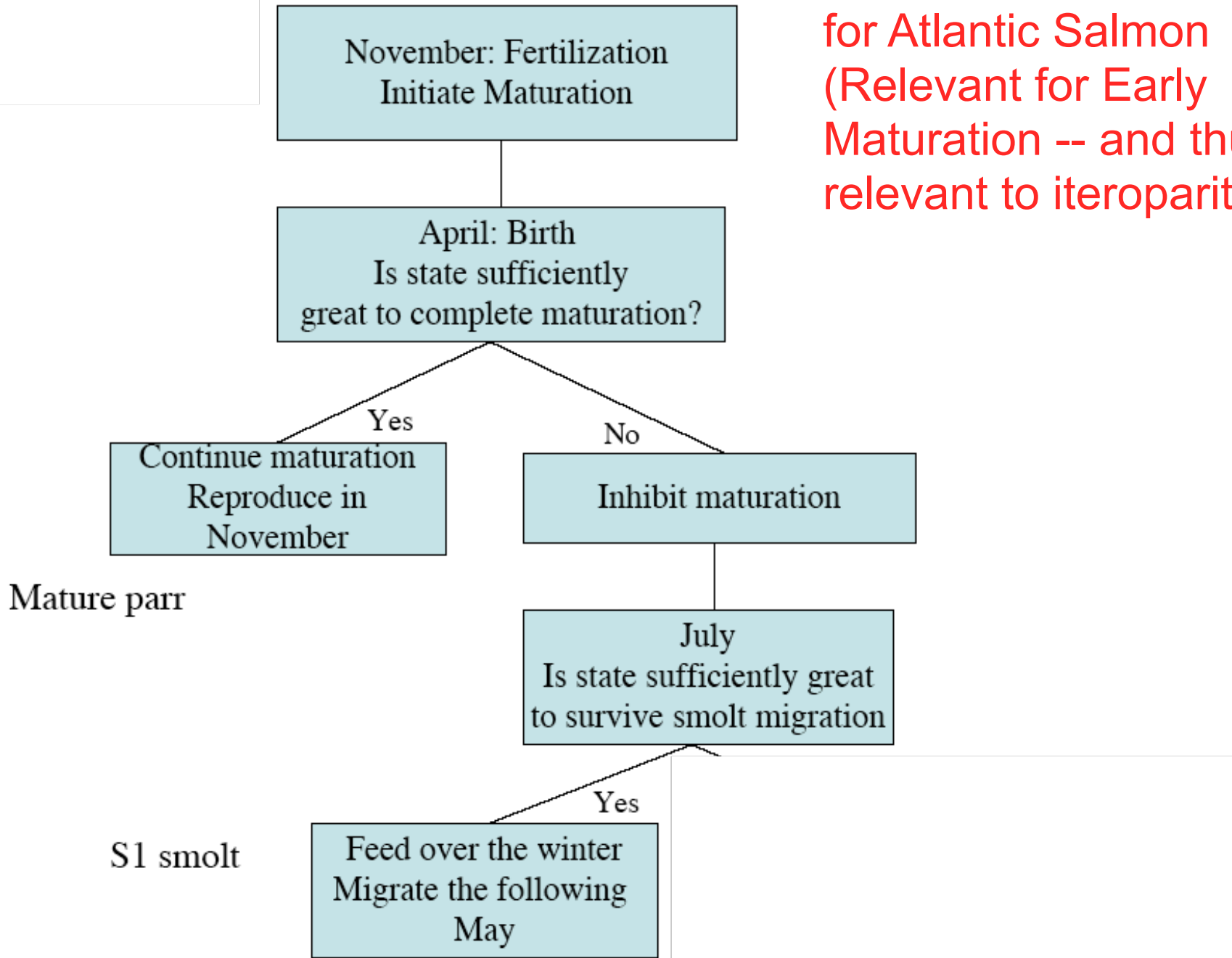
No  
Inhibit maturation

July  
Is state sufficiently great  
to survive smolt migration

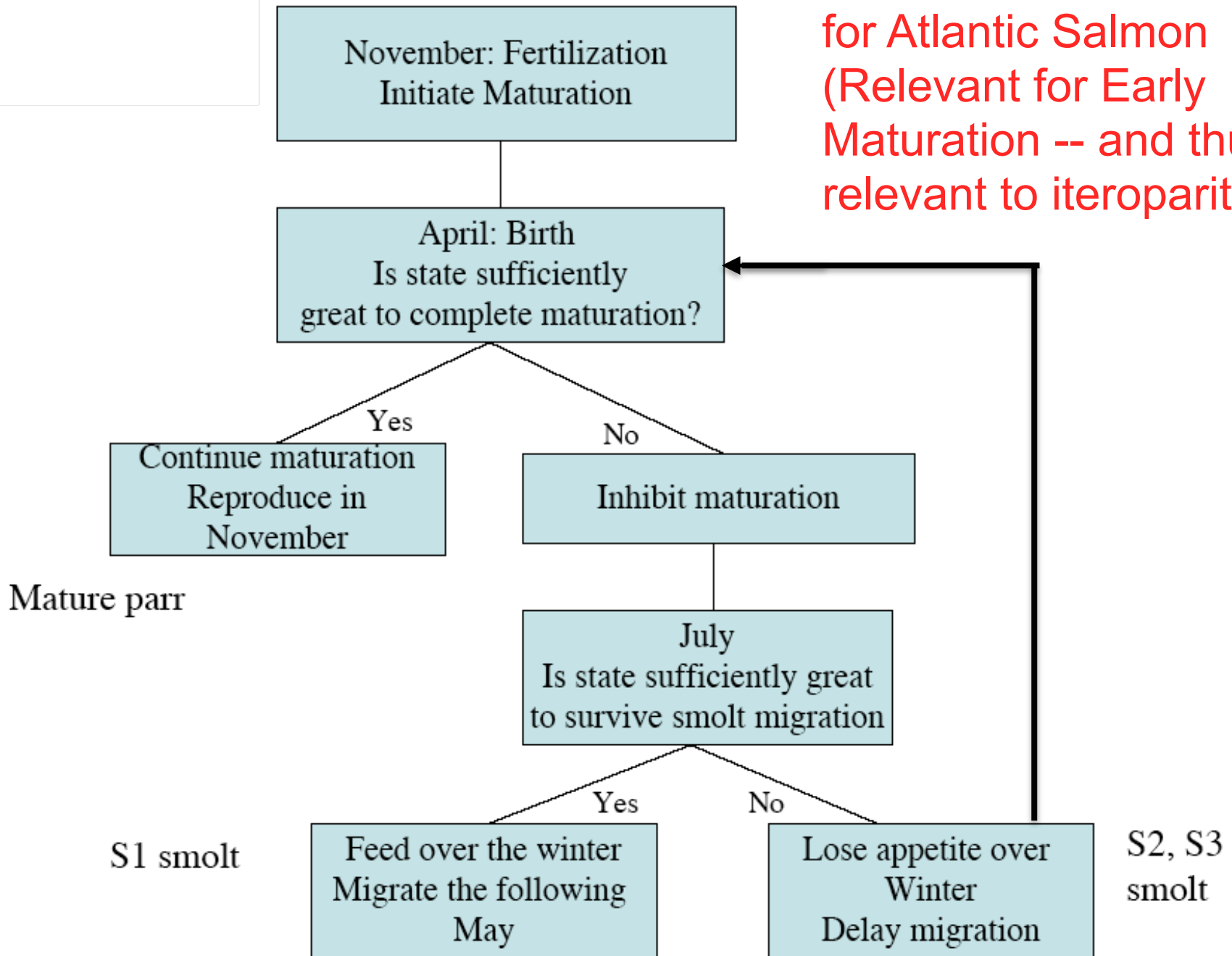
Mature parr



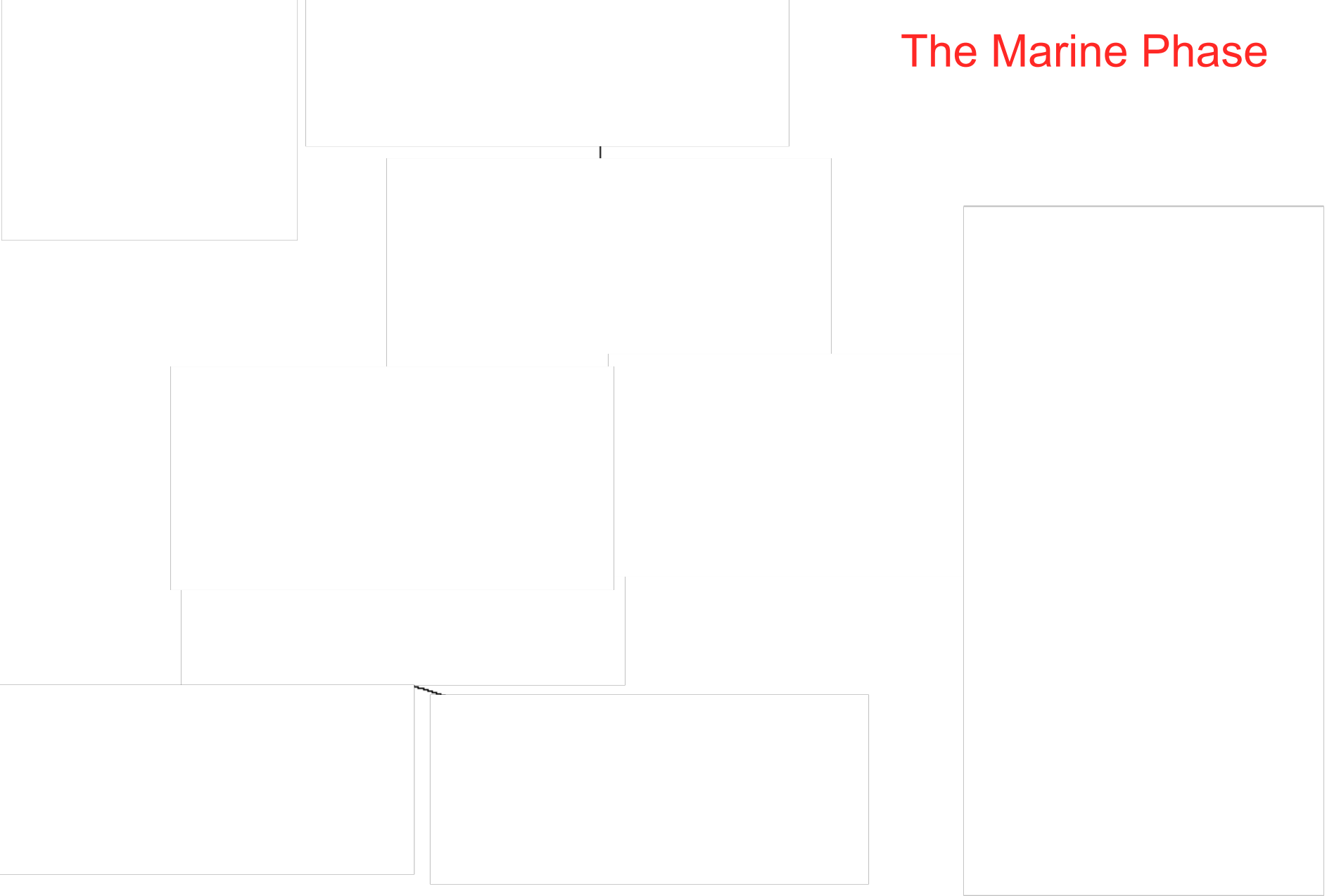
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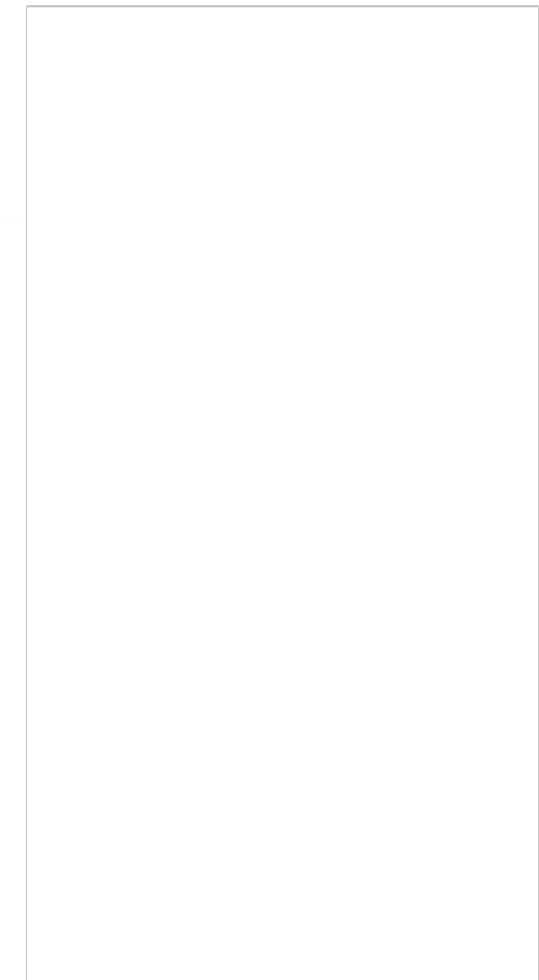
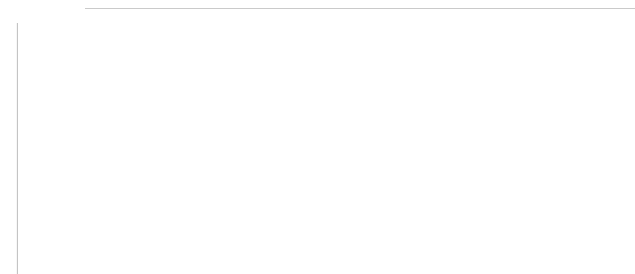
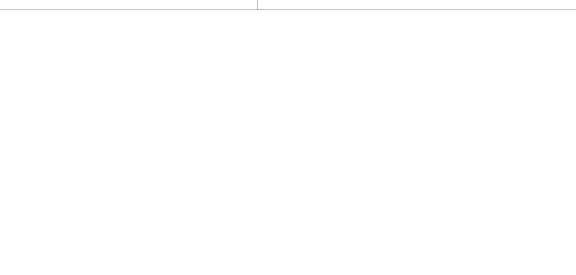
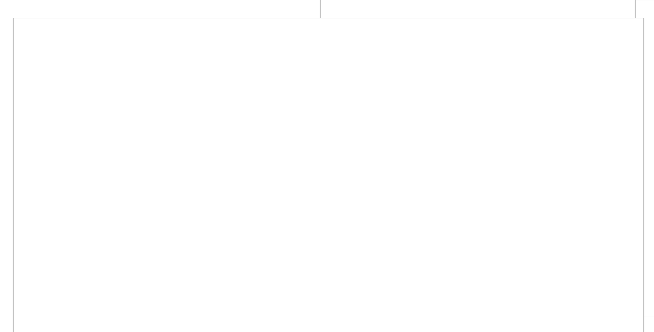
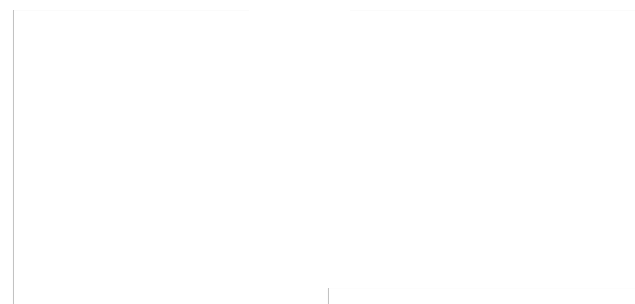
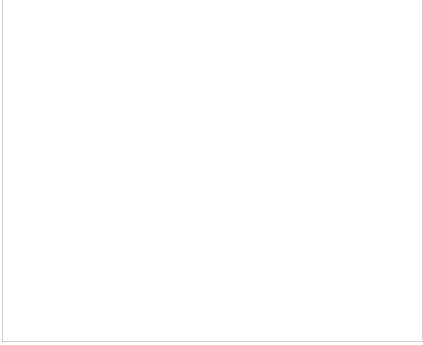


# The Marine Phase



May: Migrate to the sea  
Maturation inhibited

## The Marine Phase

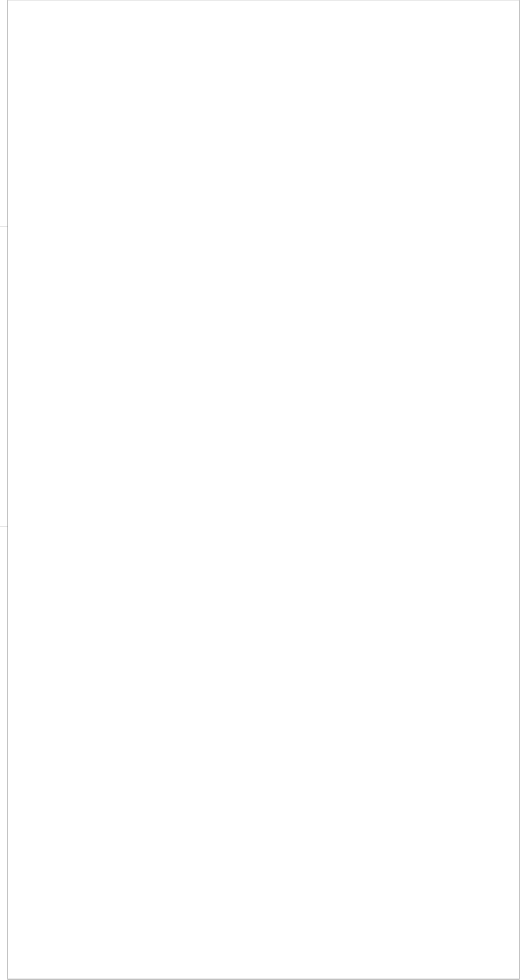
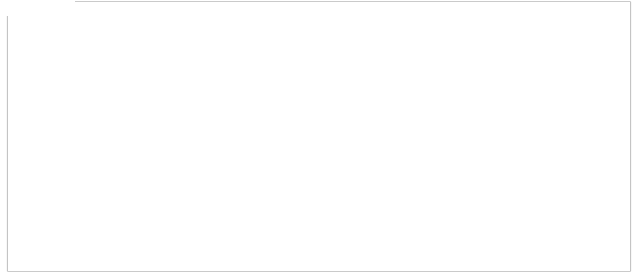
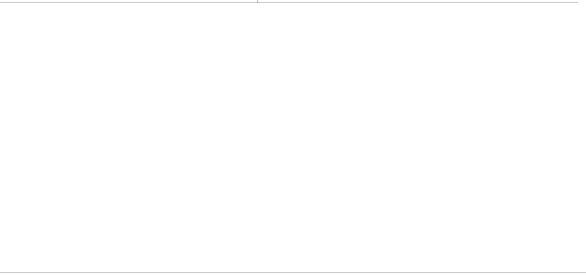
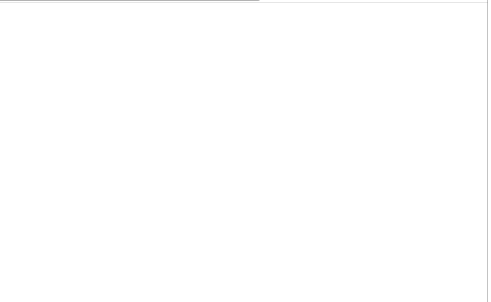




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May: Migrate to the sea  
Maturation inhibited

November  
Is state sufficiently high to  
support maturation?

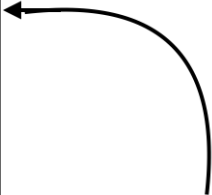


# The Marine Phase

May: Migrate to the sea  
Maturation inhibited

November  
Is state sufficiently high to  
support maturation?

No  
MSW fish  
Continue to inhibit  
Ask next November



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Maturation inhibited

November  
Is state sufficiently high to support maturation?

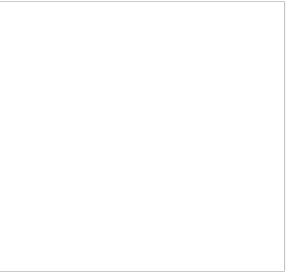
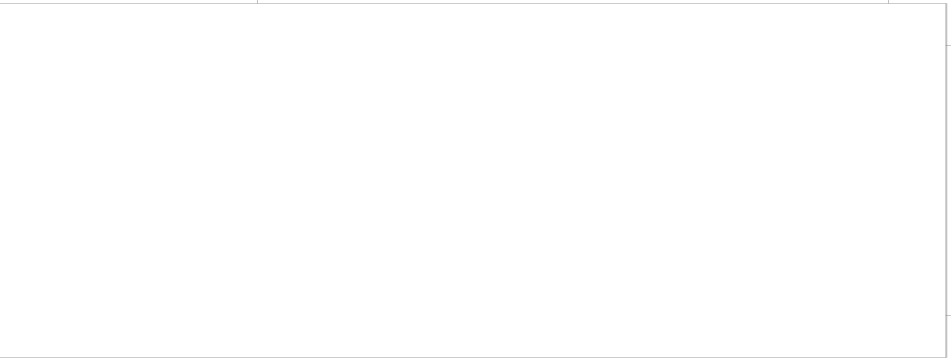
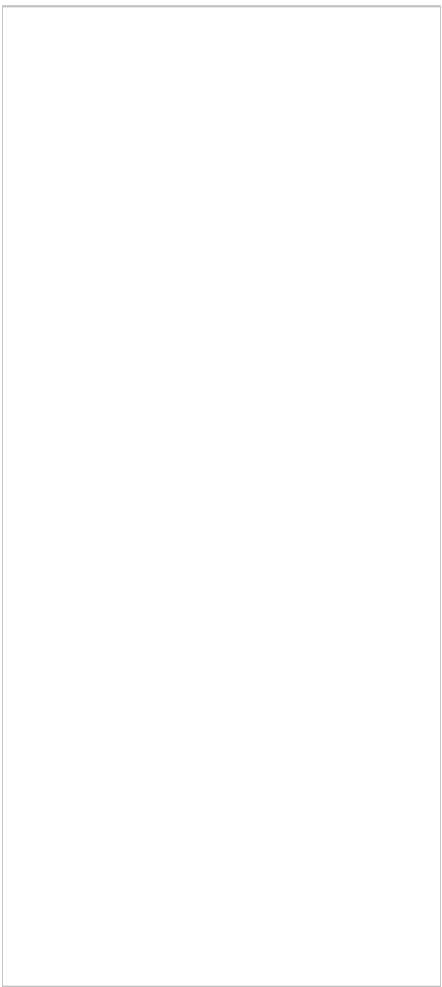
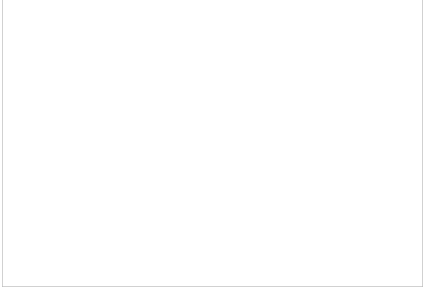
MSW fish

Yes

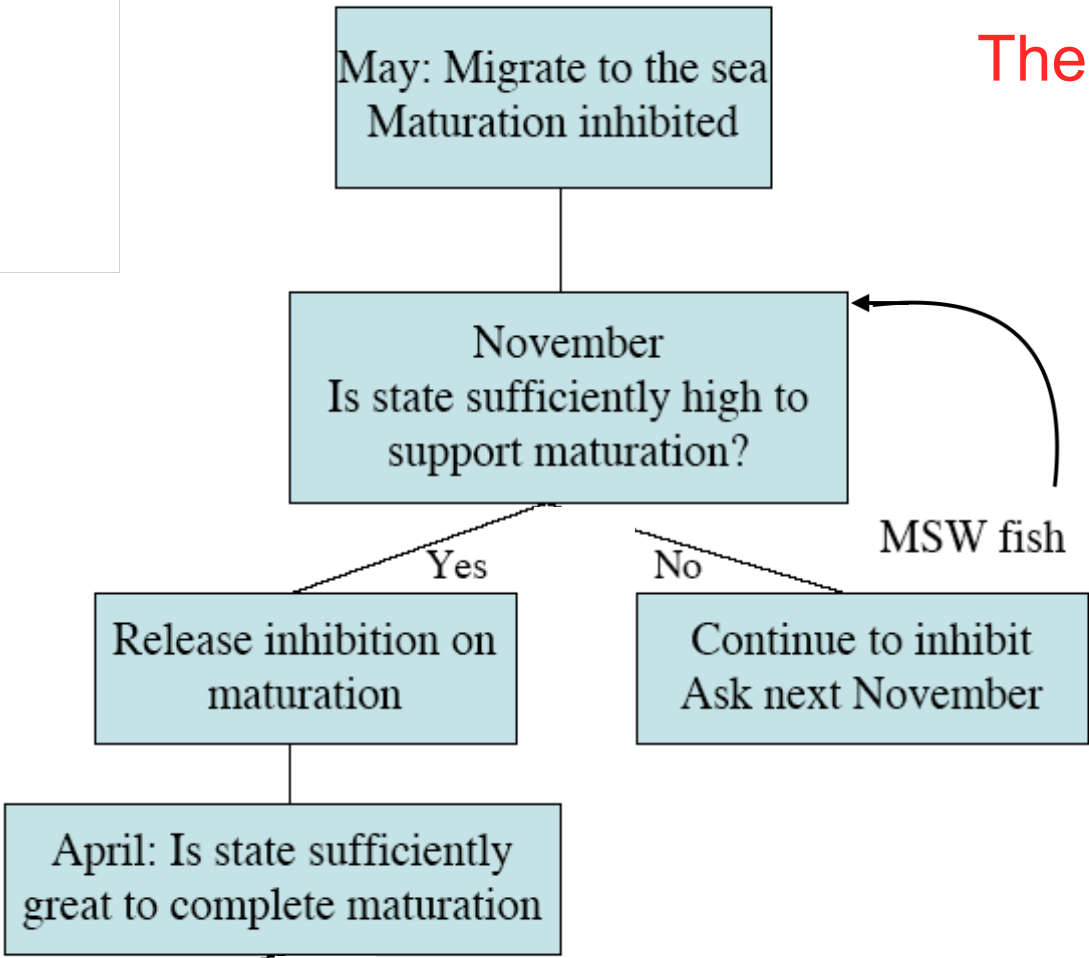
No

Release inhibition on maturation

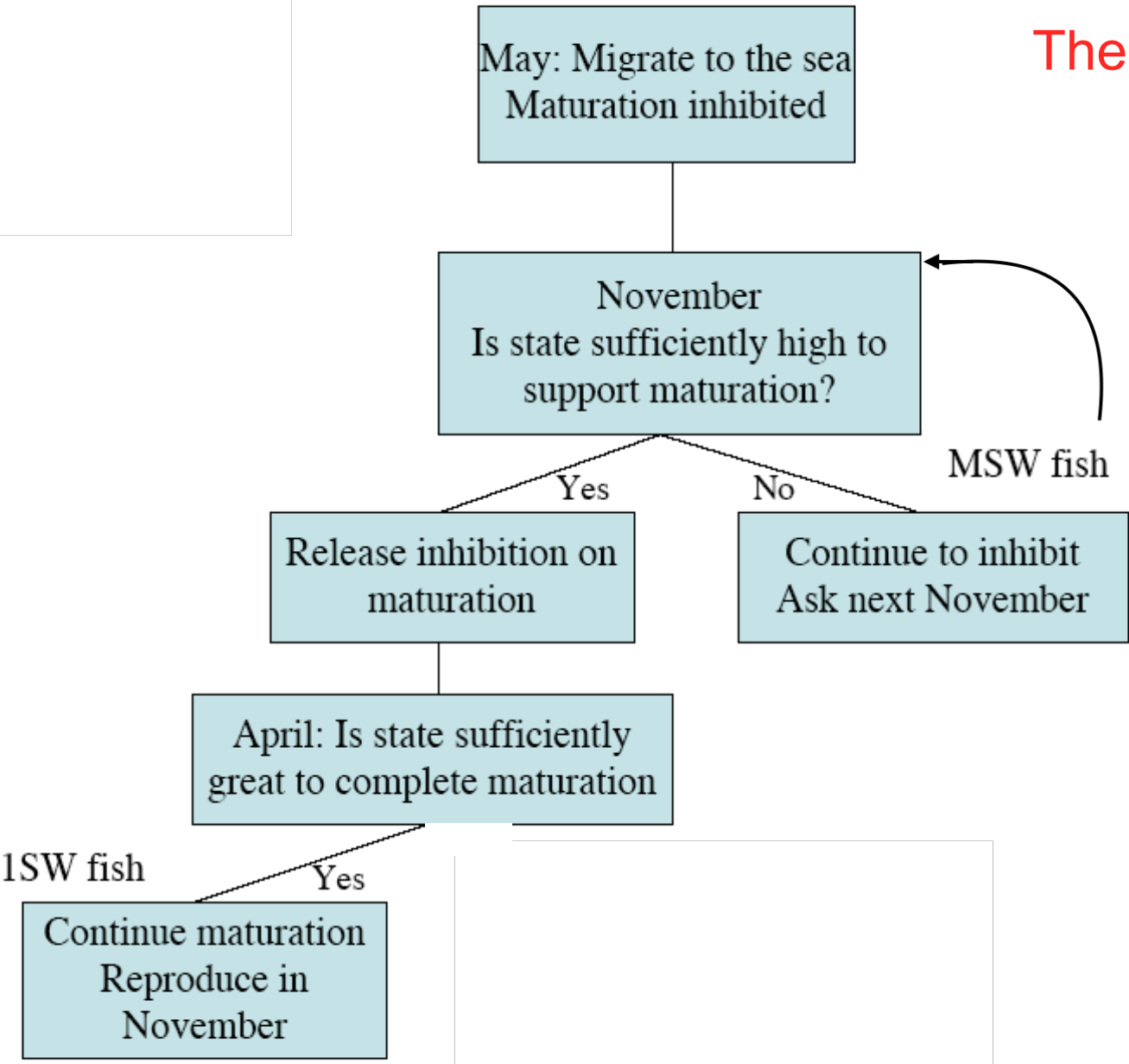
Continue to inhibit  
Ask next November



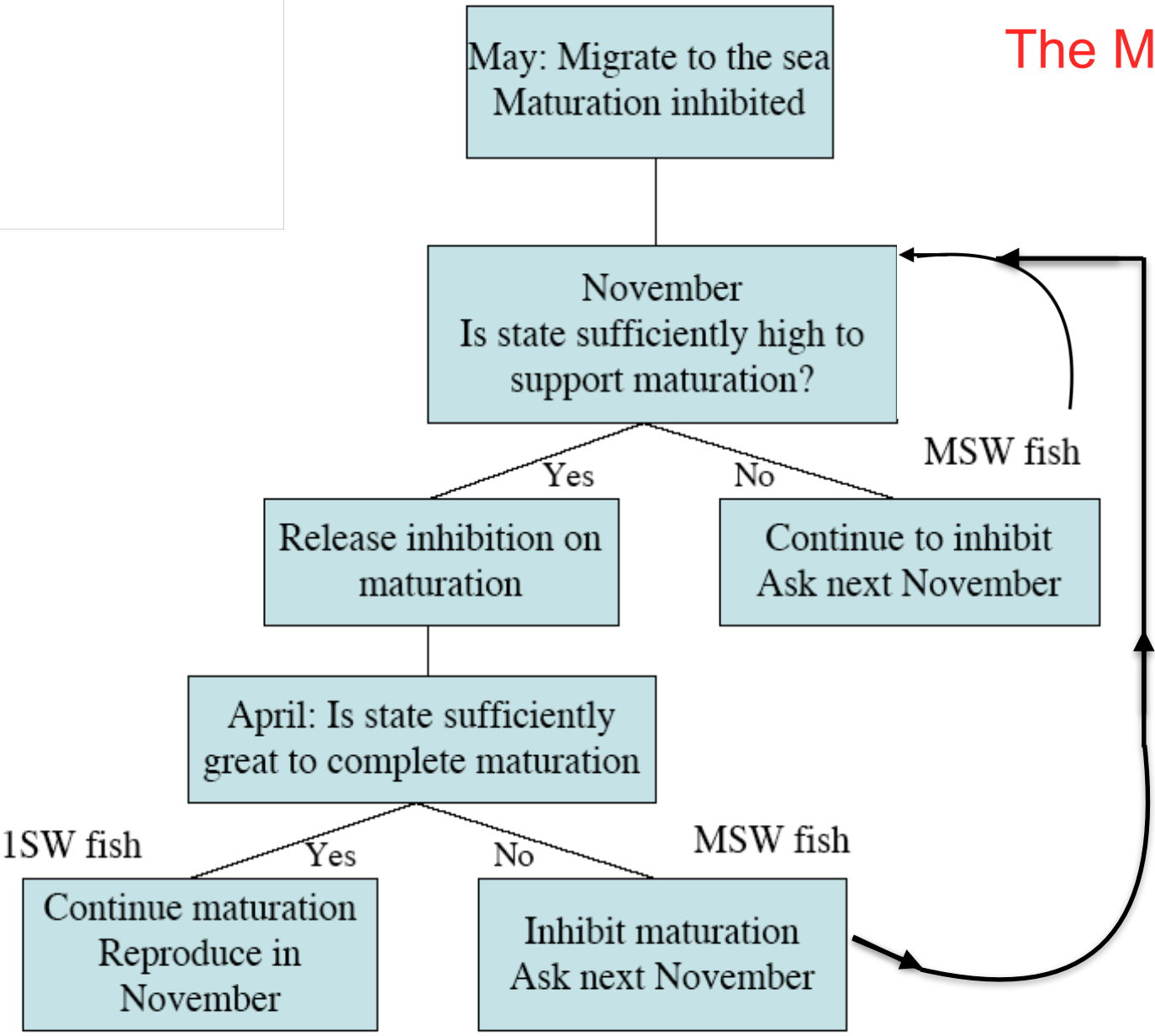
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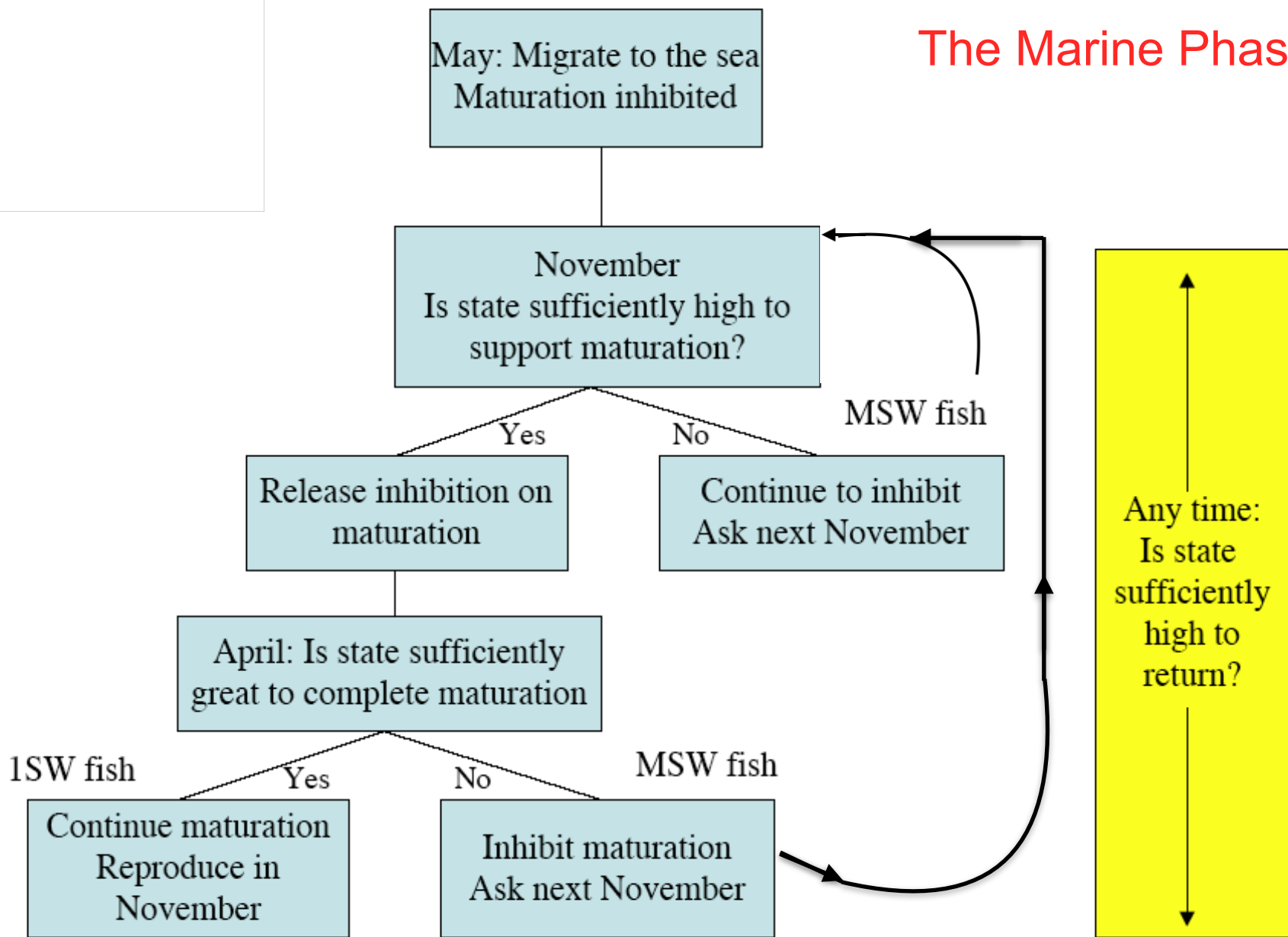
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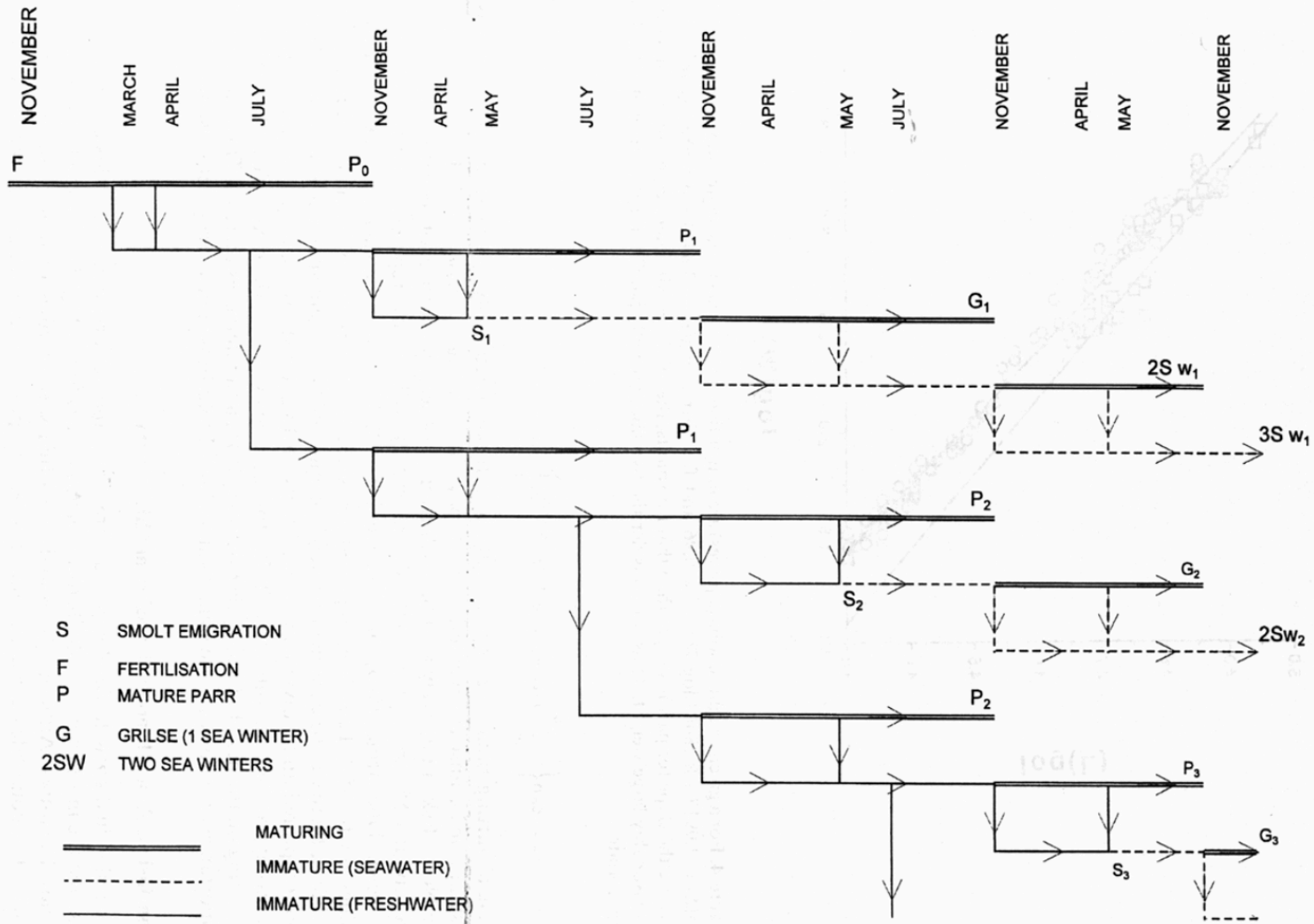


# The Marine Phase



*In both freshwater and marine, the timing of the windows is a result of natural selection*

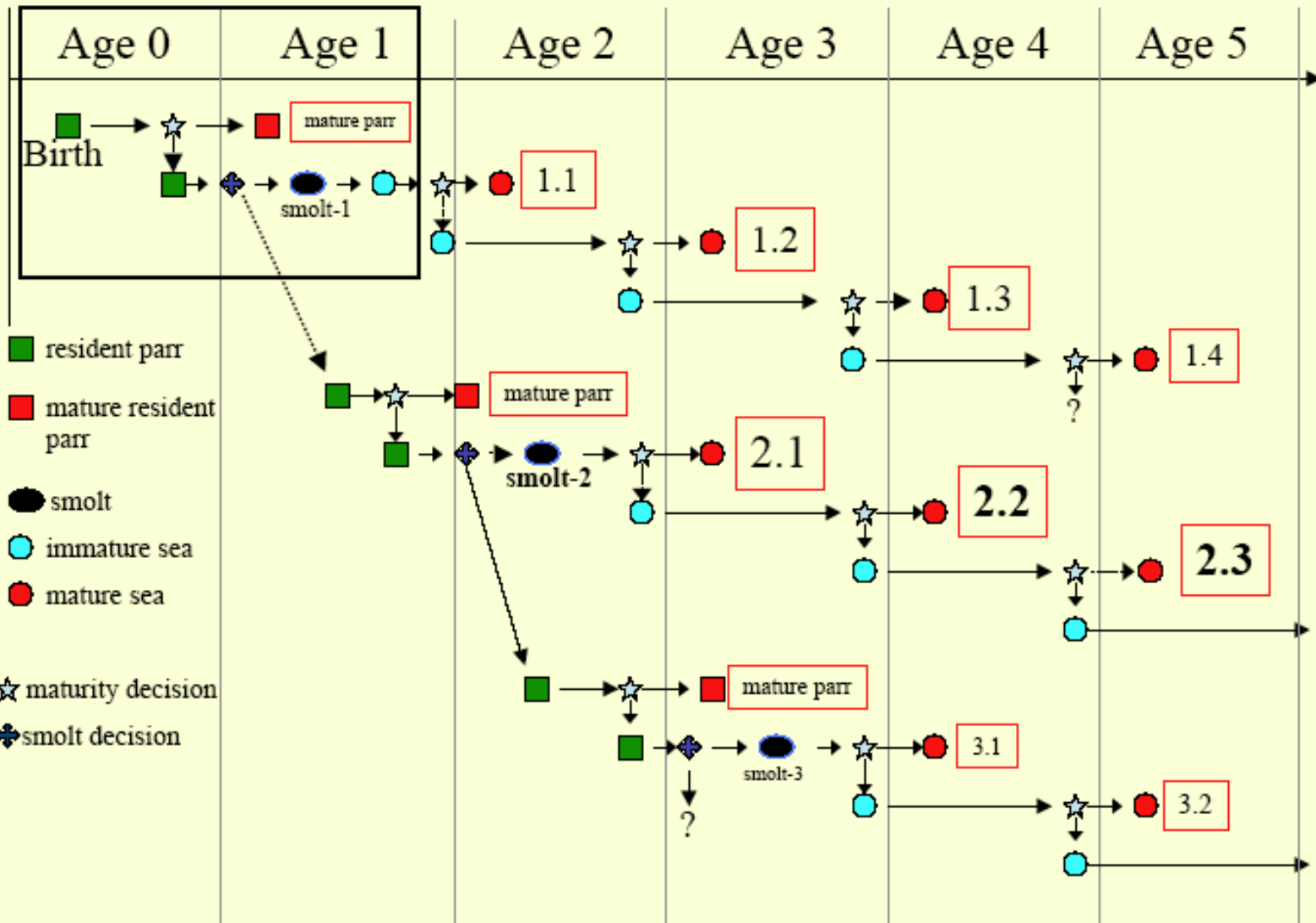
# Leads to The Salmonid Life History Decision Tree



Thorpe et al 1998

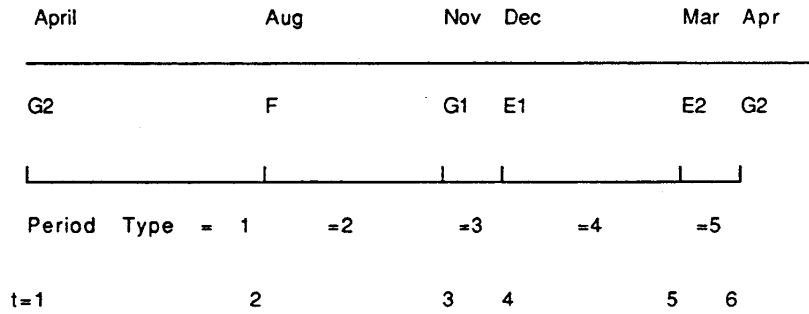


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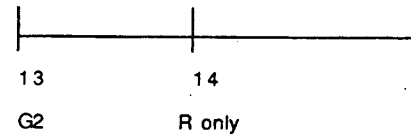
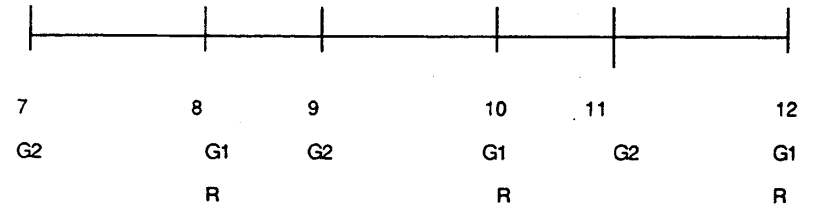
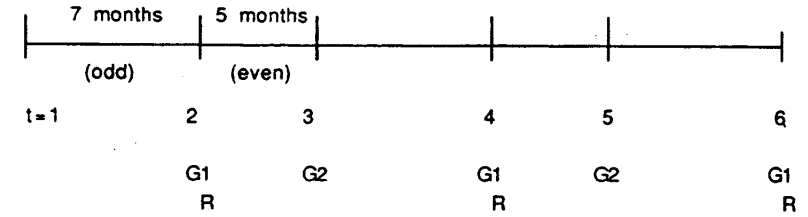


Thanks to David Swank

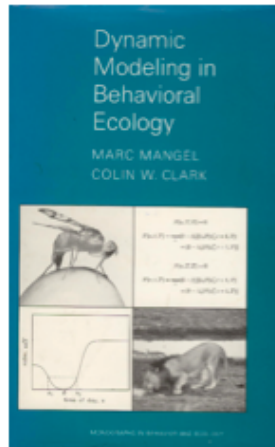
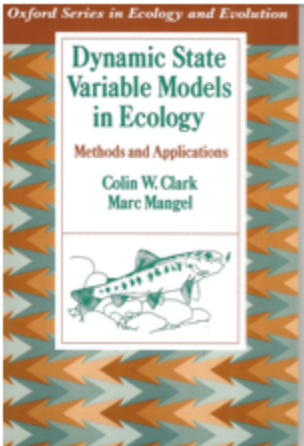
# A Quantitative Framework via State Dependent Life History Theory Implemented by Stochastic Dynamic Programming



Fresh water phase



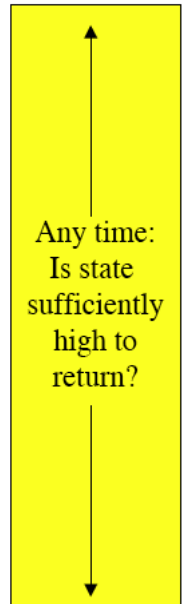
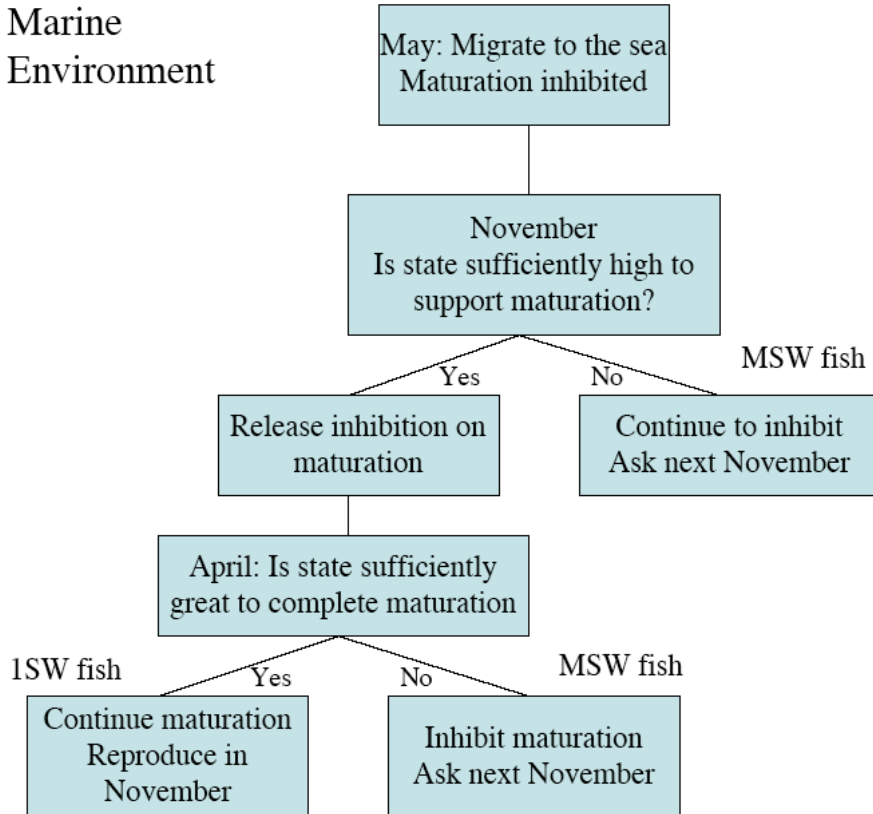
Marine phase



Mangel. Deep Sea Research, II (Topical Studies in Oceanography) 41:75-106

# What Is It Like to be (an Atlantic) Salmon also means....

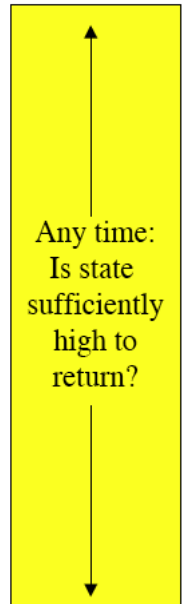
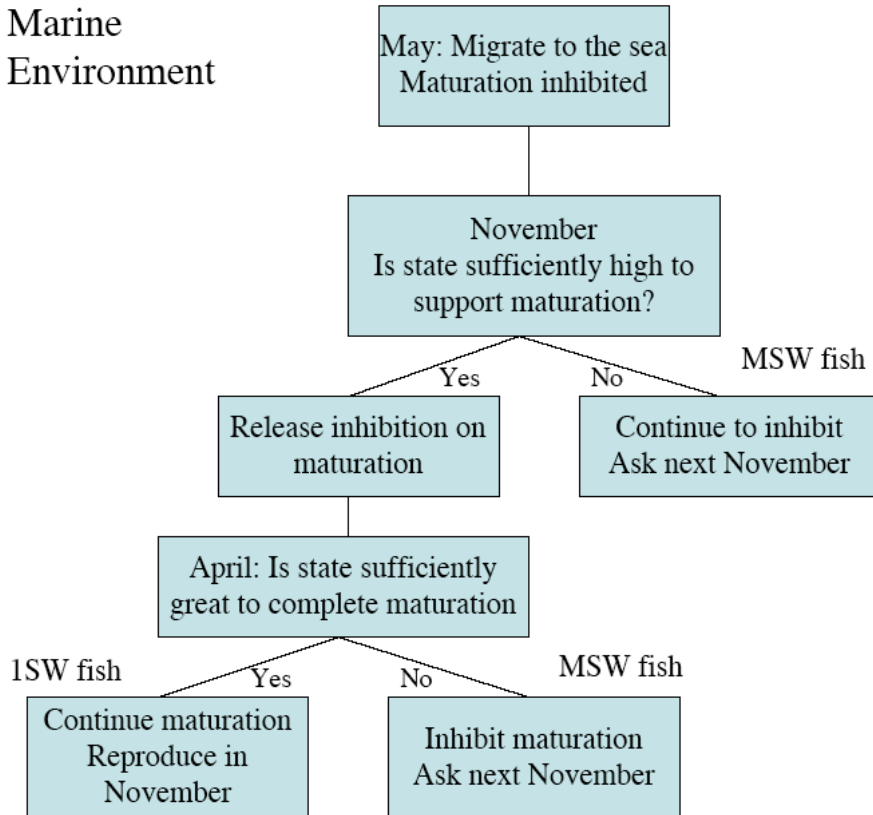
Marine  
Environment



# What Is It Like to be (an Atlantic) Salmon also means....

- How does iteroparity fit into this picture in a quantitative way?

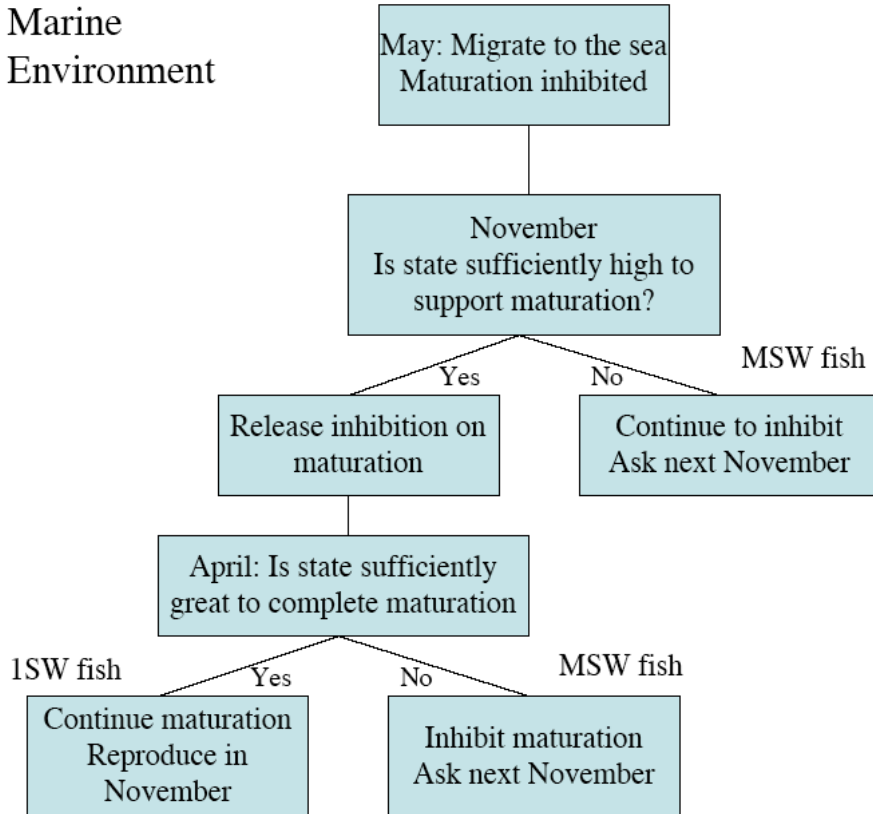
Marine Environment



# What Is It Like to be (an Atlantic) Salmon also means....

- How does iteroparity fit into this picture in a quantitative way?
- Why do ocean-going *Salmo* lack diversity?

Marine Environment

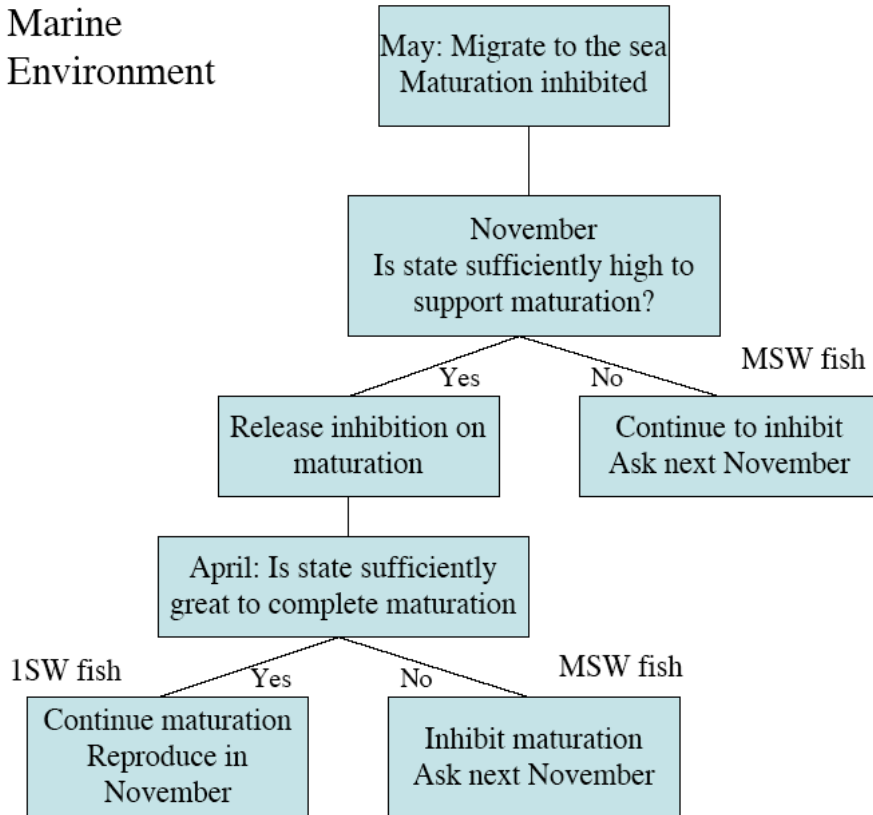


Any time:  
Is state sufficiently high to return?

# What Is It Like to be (an Atlantic) Salmon also means....

- How does iteroparity fit into this picture in a quantitative way?
- Why do ocean-going *Salmo* lack diversity?
- Why is *Salmo salar* not *Salmo trutta* or sardine or cod?

Marine Environment

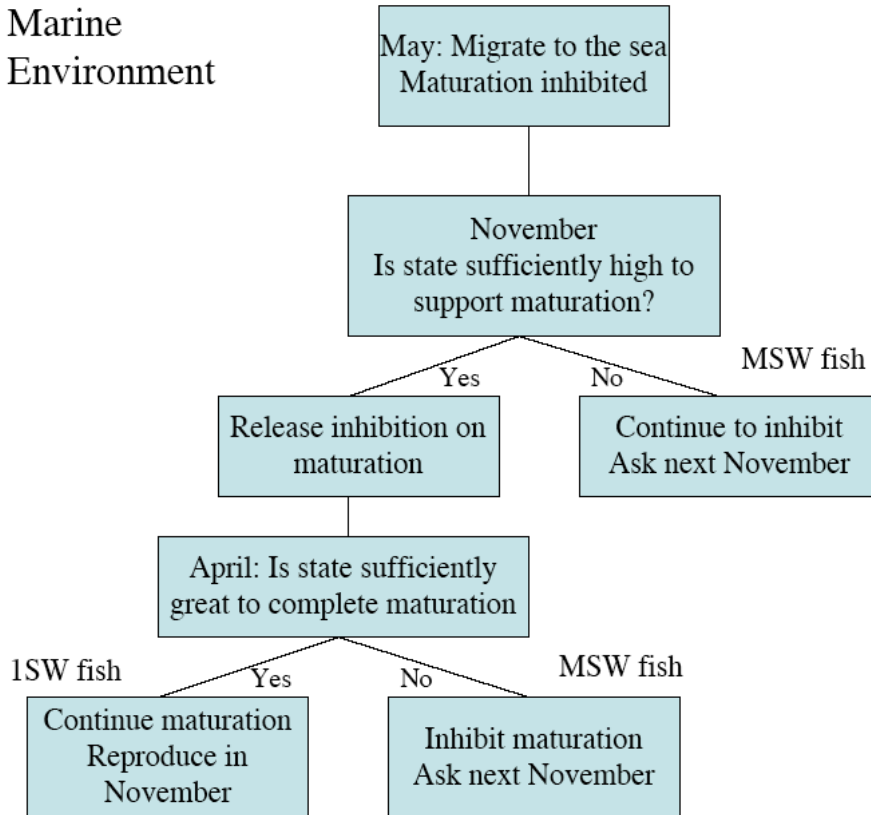


Any time:  
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# What Is It Like to be (an Atlantic) Salmon also means....

- How does iteroparity fit into this picture in a quantitative way?
- Why do ocean-going *Salmo* lack diversity?
- Why is *Salmo salar* not *Salmo trutta* or sardine or cod?
- What is the deal with steelhead/rainbow trout

Marine Environment



Any time:  
Is state sufficiently high to return?