Is flow the cure for the summertime blues?

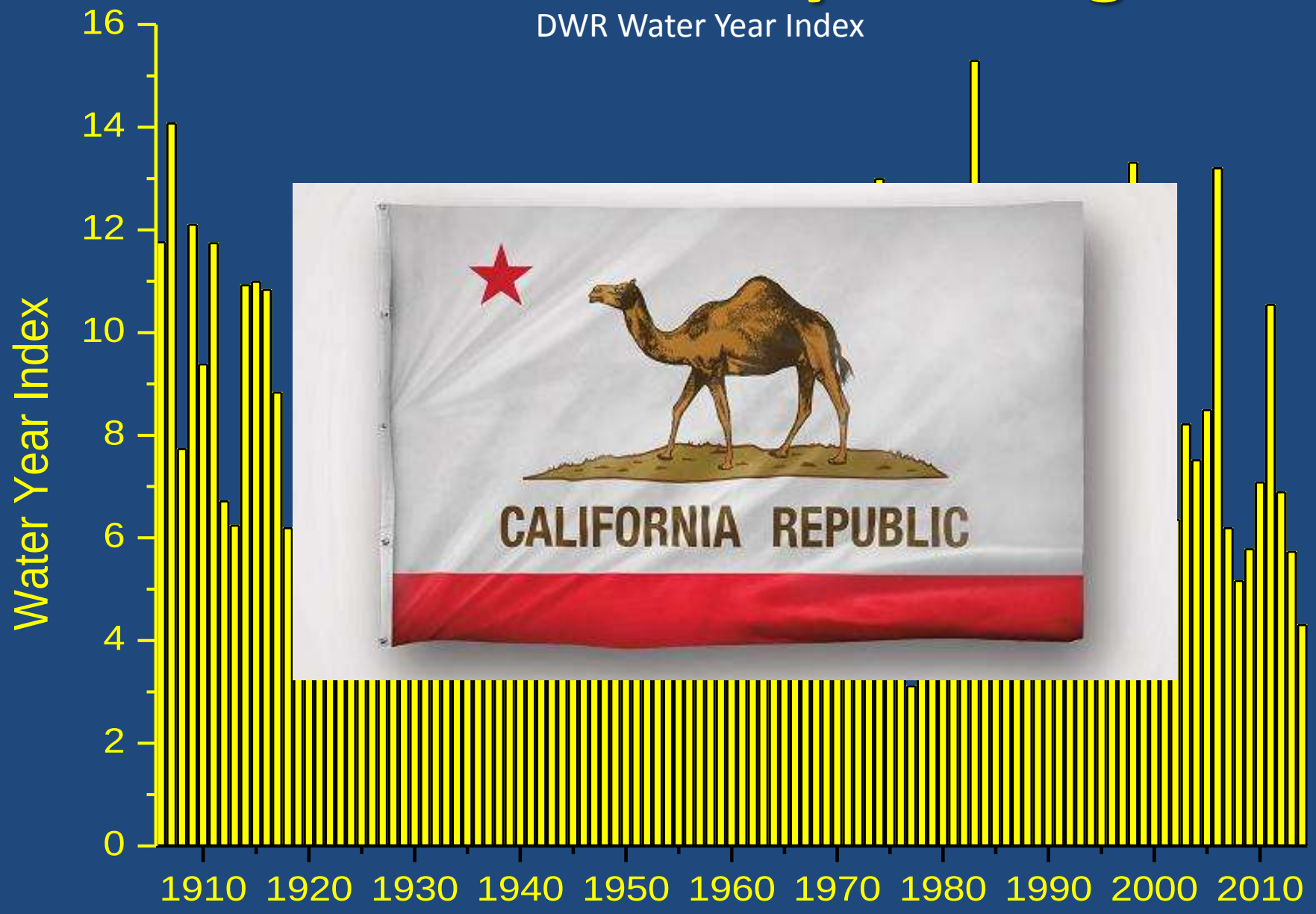
A 12-year record of summer growth for Delta Smelt

Jim Hobbs

UC Davis

2014 Delta Science Conference, October 28, 2014

Climate Variability - Drought



Tier 1 - Landscape Attributes

Erodible Sediment Supply, Proximity to Ocean, Proximity to Discharges, Proximity to Diversions, Bathymetry (Proximity to and Extent of Shallow Areas)

Tier 2 – Environmental Drivers

Air Temperature, Flows, Turbidity, Contaminant Loading, Water Diversions

Weather, Exports, Hydrology, Turbidity, Contaminants

Tier 3 - Habitat Attributes

Food, Predation, Temperature, Entrainment, Toxicity

Food, Predation, Temperature, Transport, Entrainment, Toxicity

Tier 4 - Delta Smelt Responses

Adults → Spawning → **Eggs & Larvae**

Eggs & Larvae → Survival → **Juveniles**

Juveniles → Growth → Survival → **Subadults**

Subadults → Survival → Growth → **Adults**

Tier 5 - Life Stage Transition Seasons

December-May (Winter)

March-June (Spring)

September-December (Fall)

June-September (Summer)

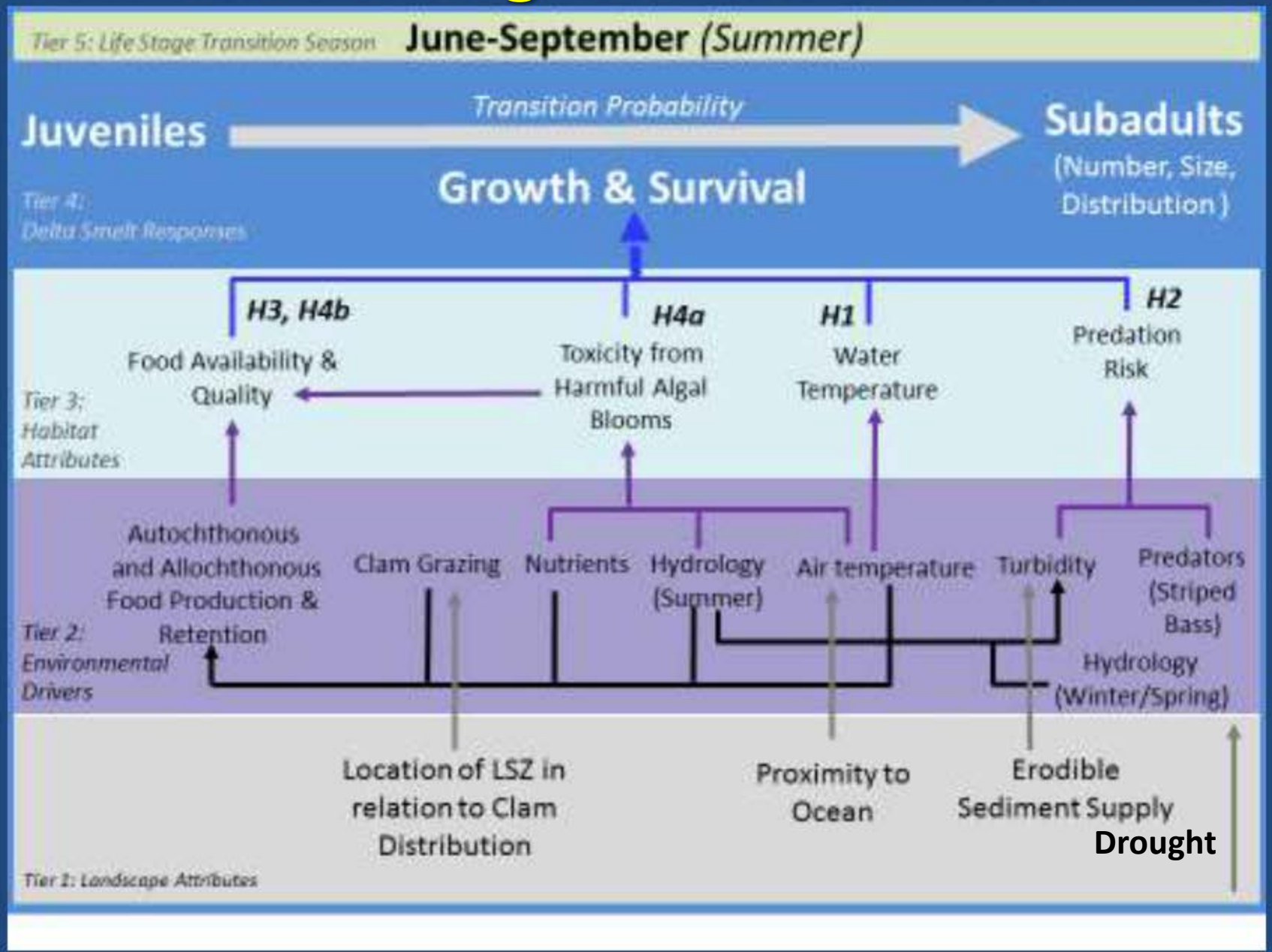
Food, Predation, Size and Location of LSZ, Toxicity

Food, Predation, Temperature Harmful Algal Blooms, Toxicity

Weather, Outflow, Turbidity, Clam Grazing, Nutrients, Contaminants

Weather, Hydrology, Turbidity, Clam Grazing, Nutrients, Contaminants

How does drought affect delta smelt?



Drought effects on delta smelt

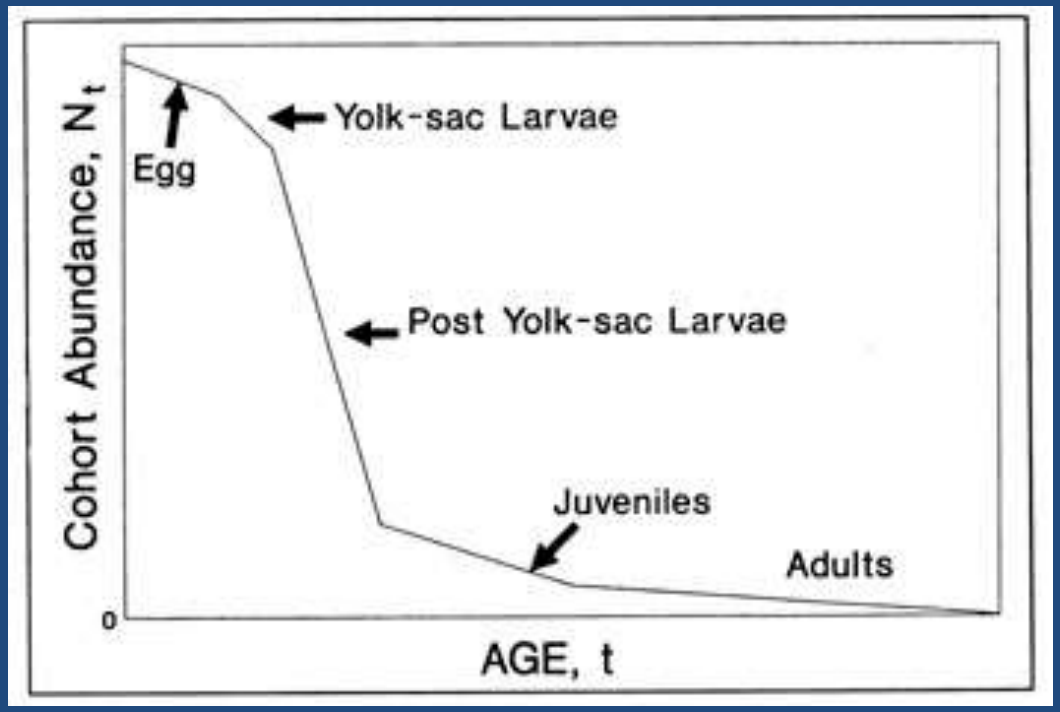
H1: Growth will be lower during drought years for all life-stages

H2: Life History Diversity will be reduced during drought years

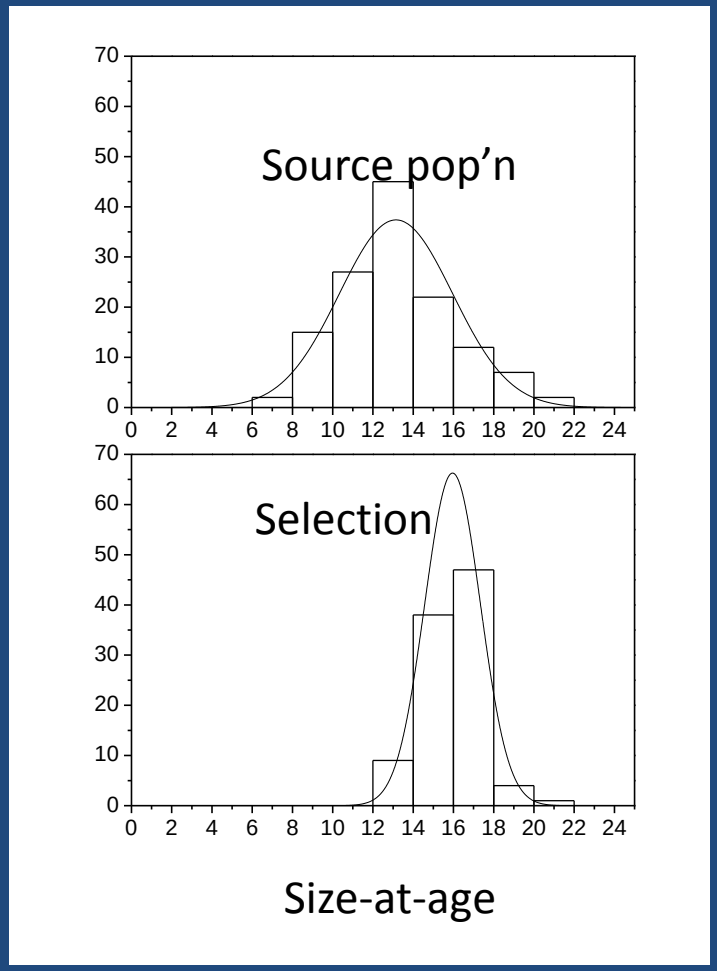
Conceptual Model Tier & Variable	Adults (Dec - May)	Larvae (March - June)	Juveniles (June - September)	Subadults (September - December)
Fish Response				
Fecundity	↓			
Abundance	↓	↓	↓	↓
Genetic Diversity	↓	↓	↓	↓
Life History Diversity	↓		↓	↓
Distribution	↓	↓	↓	↓
Growth	↓	↓	↓	↓
Survival	↓	↓	↓	↓

Why growth is important?

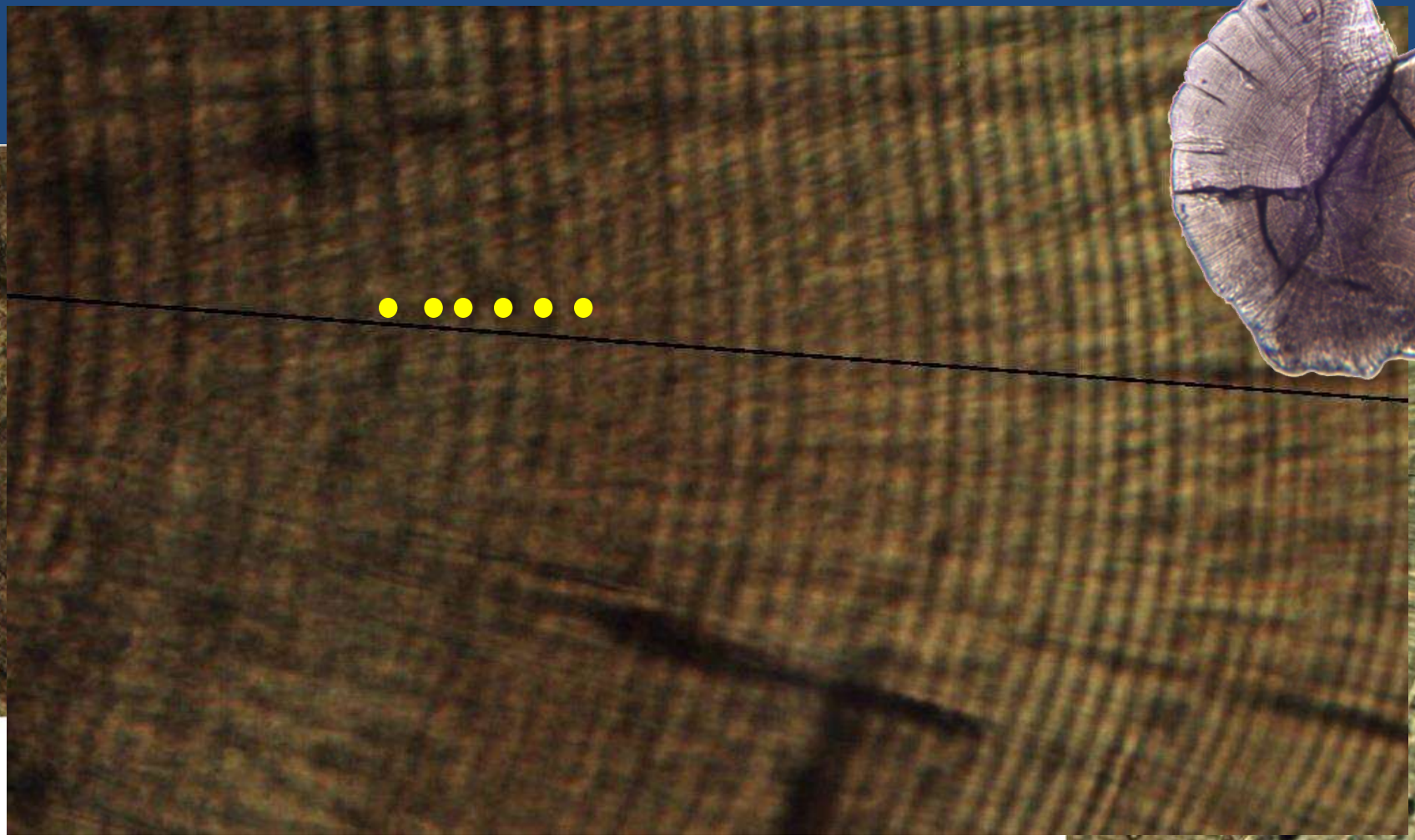
1) Mortality is HIGH in early life stages of fish

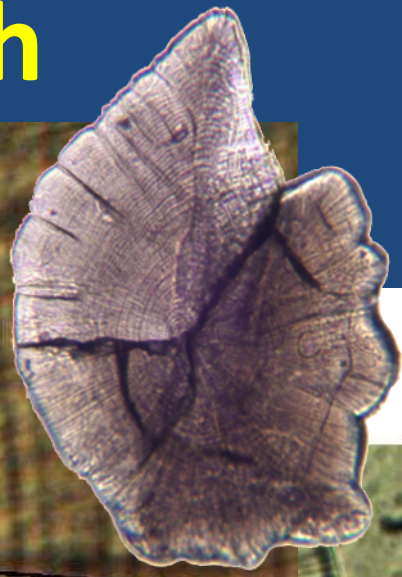


2) Mortality is selective on fish size

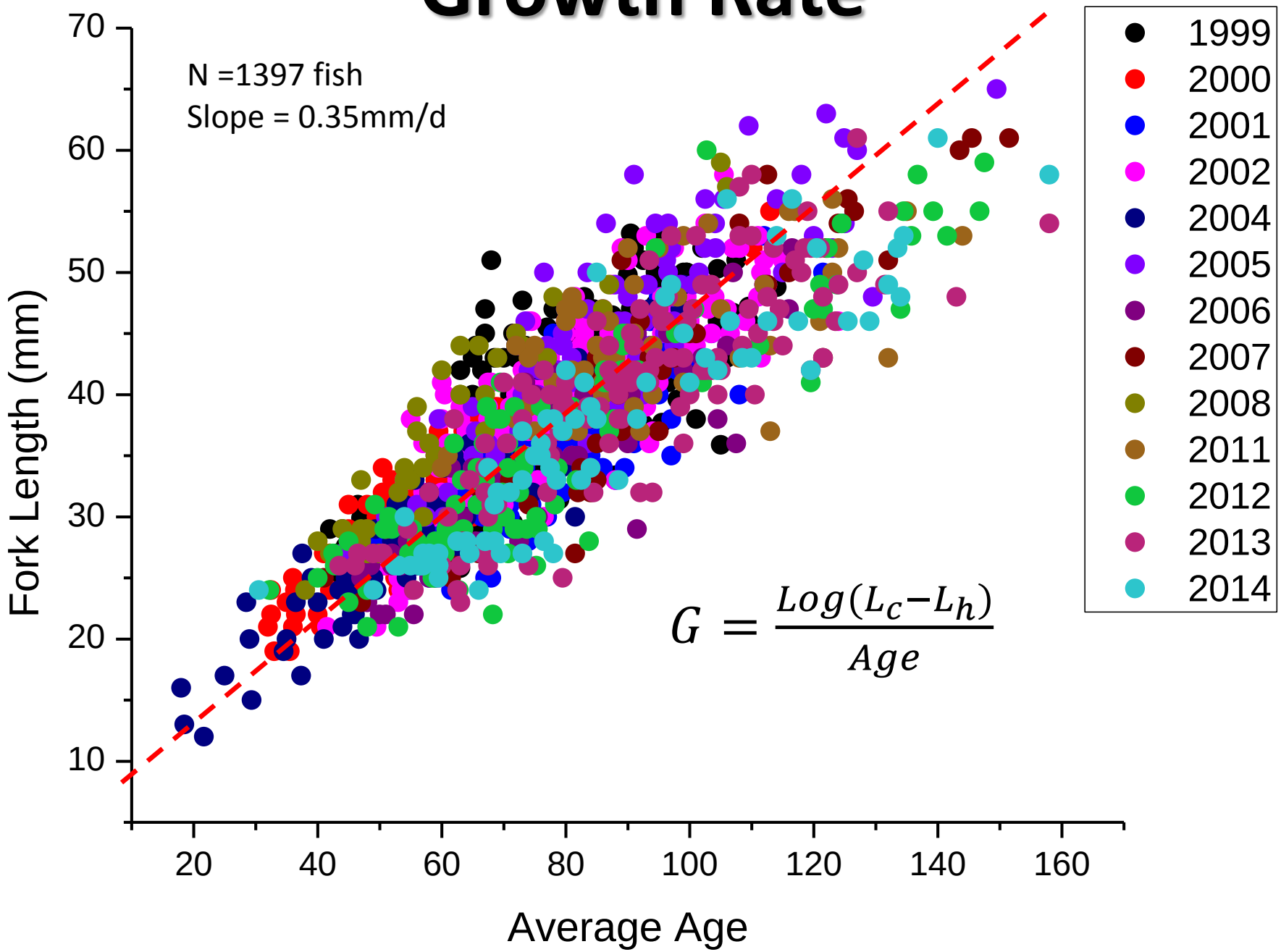


How we measure growth





Growth Rate


N =1397 fish
Slope = 0.35mm/d
Fork Length (mm)
Average Age
70
60
50
40
30
20
10
20
40
60
80
100
120
140
160
1999
2000
2001
2002
2004
2005
2006
2007
2008
2011
2012
2013
2014
$G = \frac{Log(L_c - L_h)}{Age}$

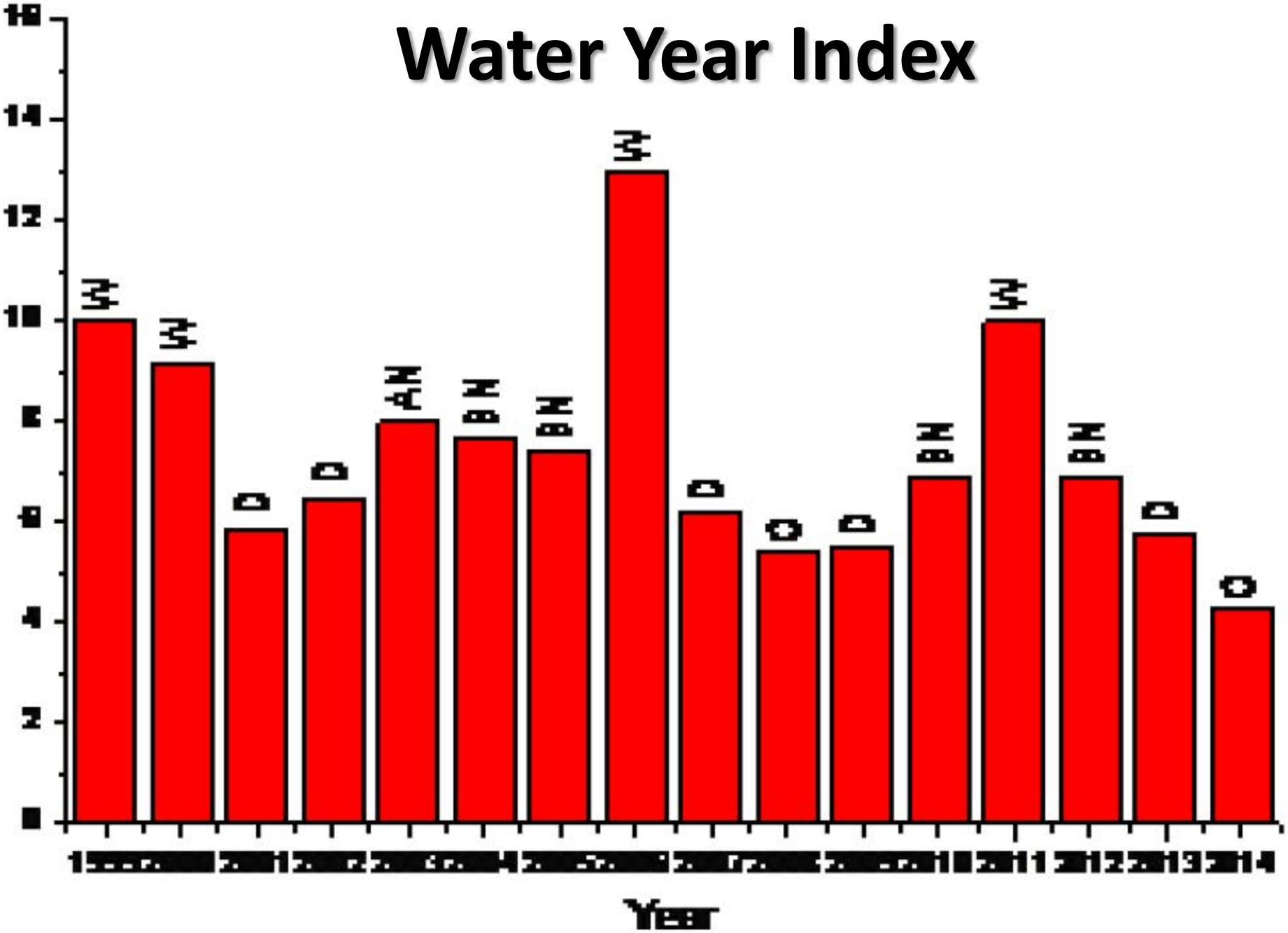
The Study

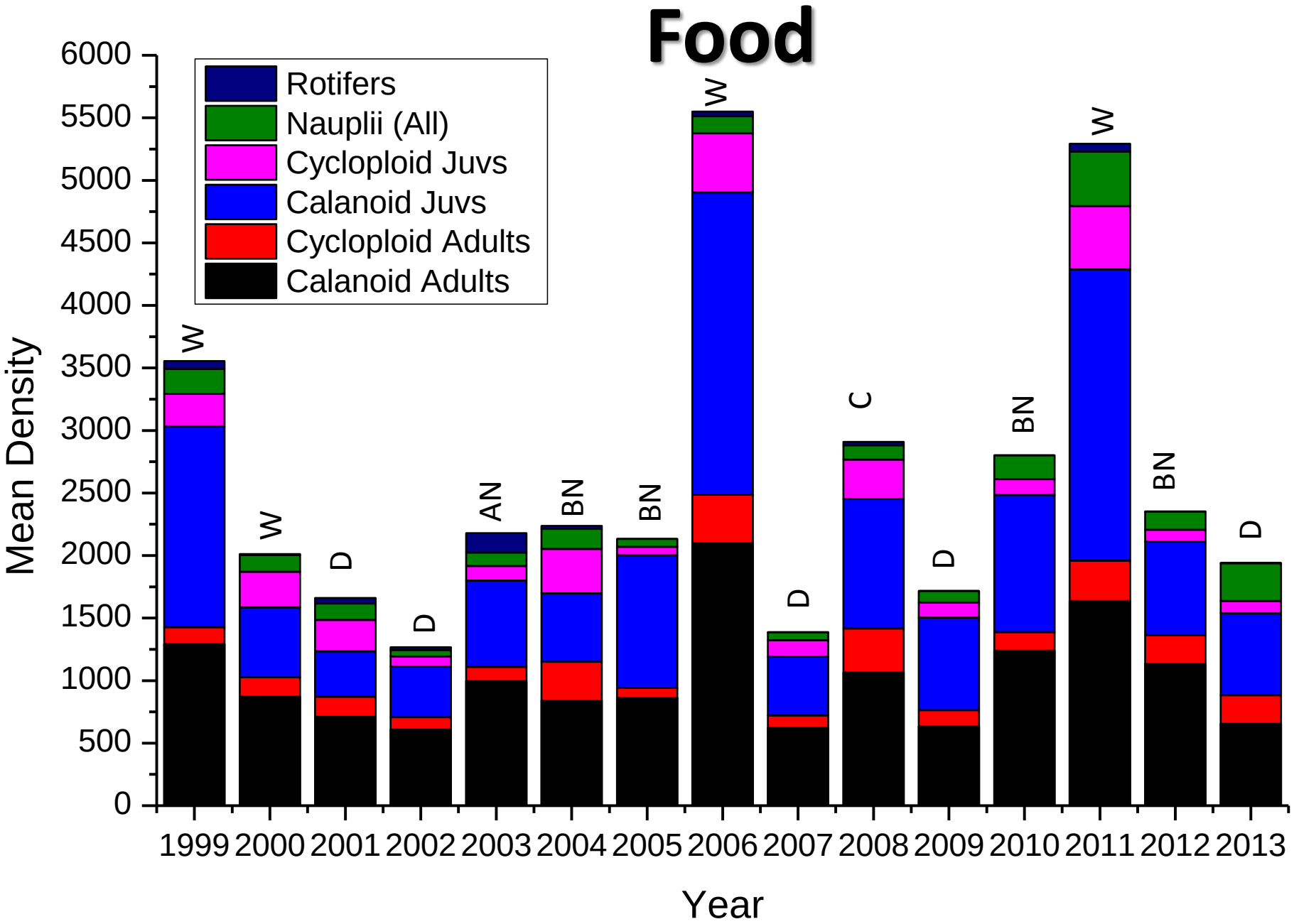
Mean Annual Growth Rate (G)

Summer Townet Survey
1999-2014
w/o 2003,2008-2010

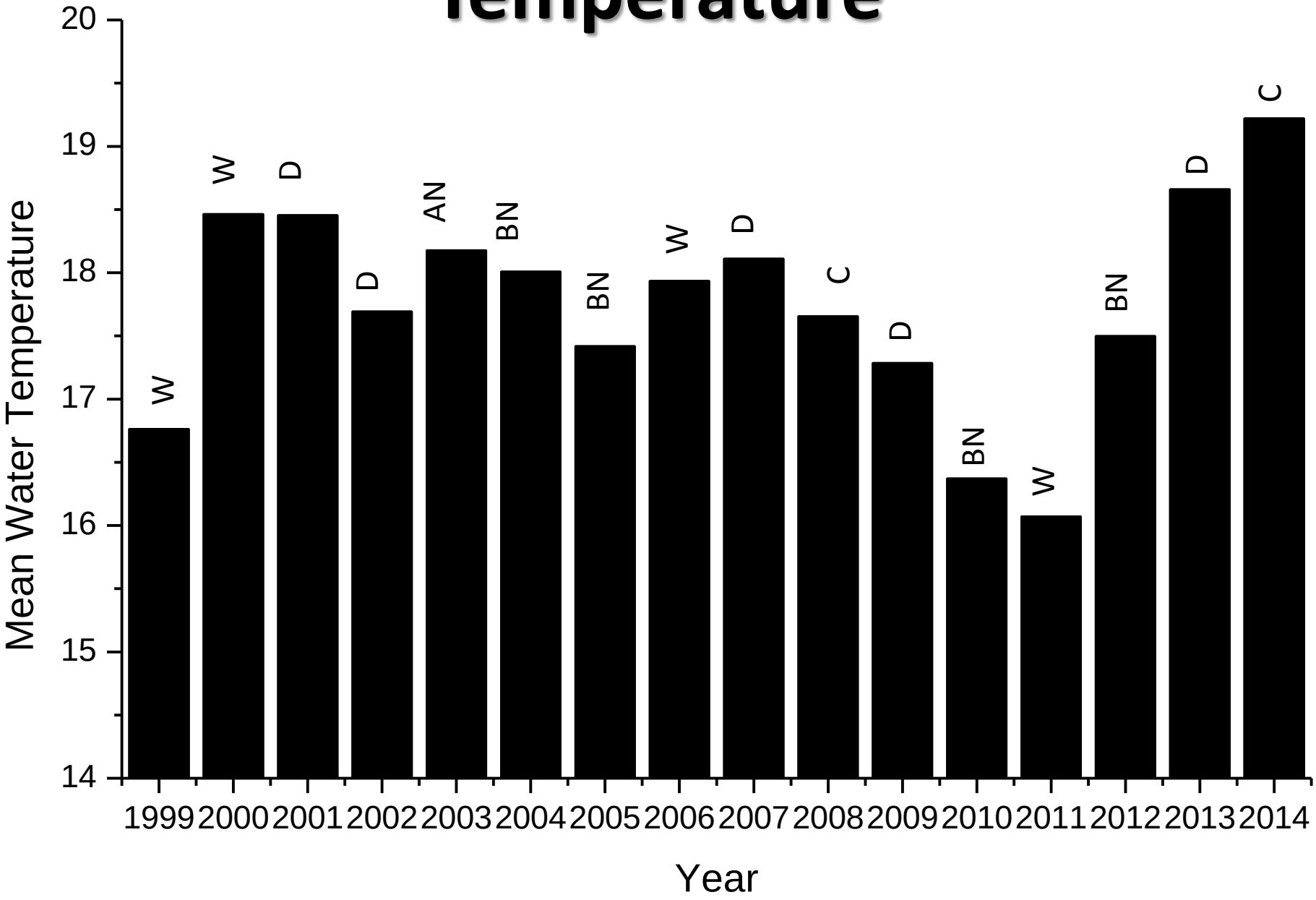
			Drought			
	-		-		+	
→	**Flow**	+	**Food**	+	**Temperature**	
	DWR *annual water year index*		***IEP-EMP*** *mean density copepods Apr-July*		***CDEC*** *- continuous water quality Mean Temp April-July Rio Vista & Mallard Is.*	
	Wet Above normal Below normal Dry Critically dry		Low < 2,600-m^3 Mod High>4,000-m^3		Cool < 17.1 °C Mod High> 18.3 ° C	

Water Year Index

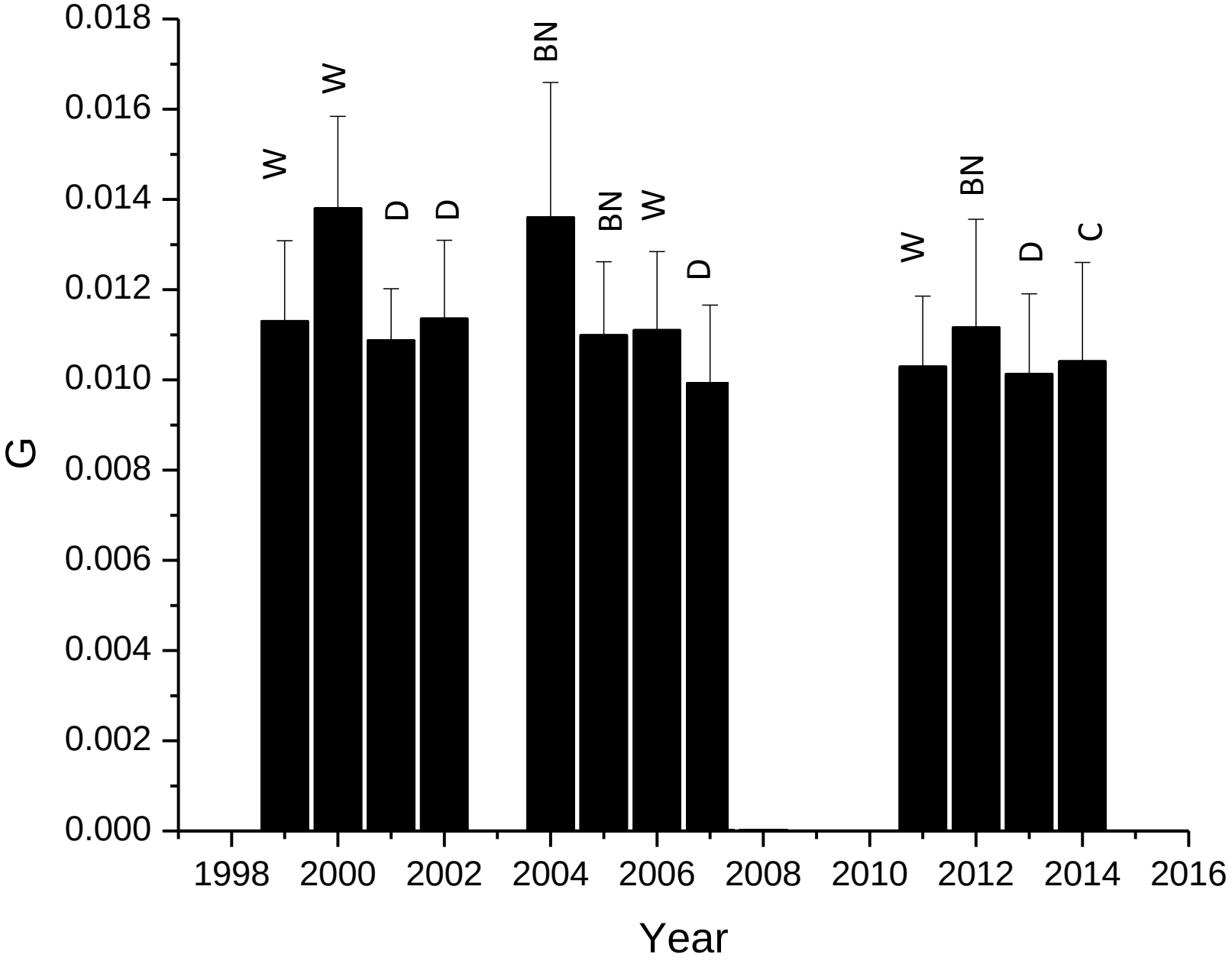



Food
Rotifers
Nauplii (All)
Cycloploid Juvs
Calanoid Juvs
Cycloploid Adults
Calanoid Adults
Mean Density
Year
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
W
W
D
D
AN
BN
BN
W
D
C
D
BN
W
BN
D

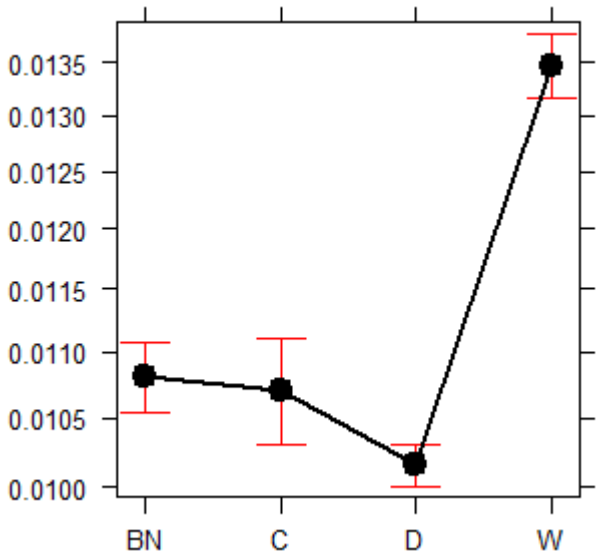
Temperature



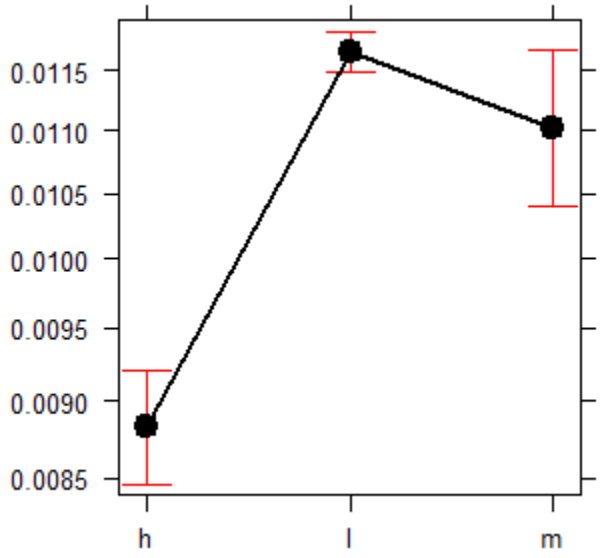
Growth Rate


0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
G
W
W
D
D
BN
BN
W
D
W
BN
D
C
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Year

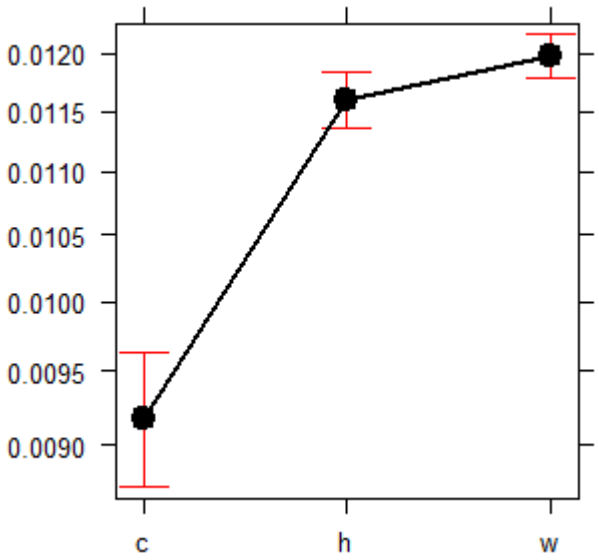
Model Results



Water Year Type

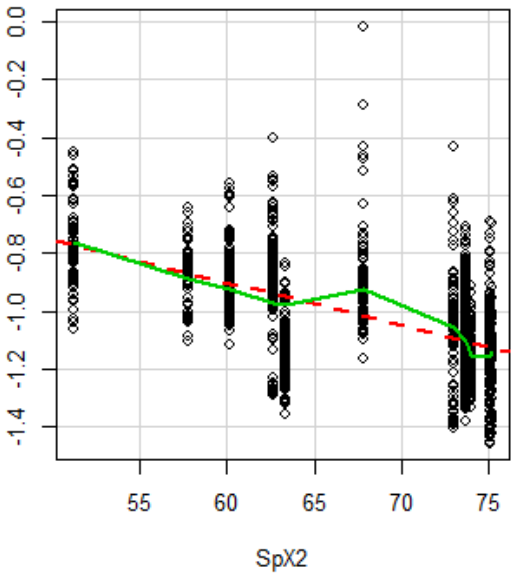


Copepod Density

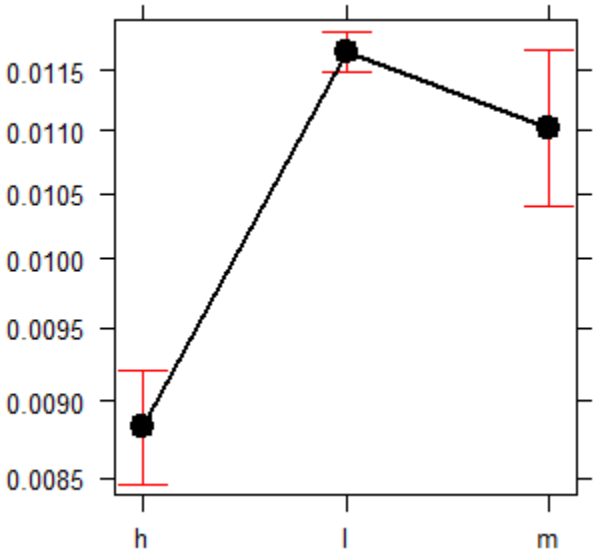


Temperature

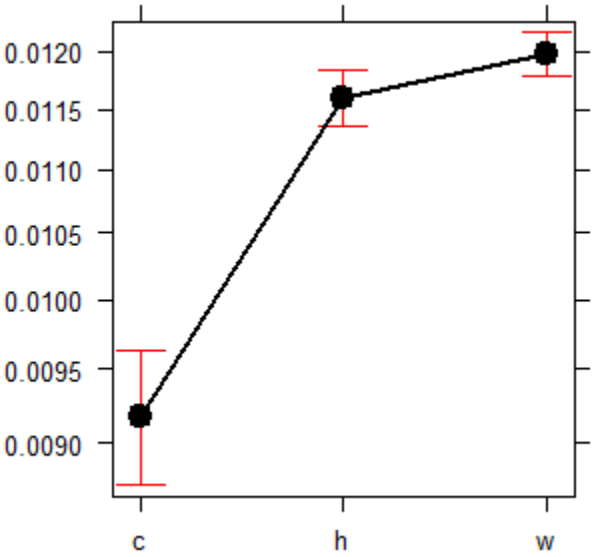
Model Results



Spring X2



Copepod Density



Temperature

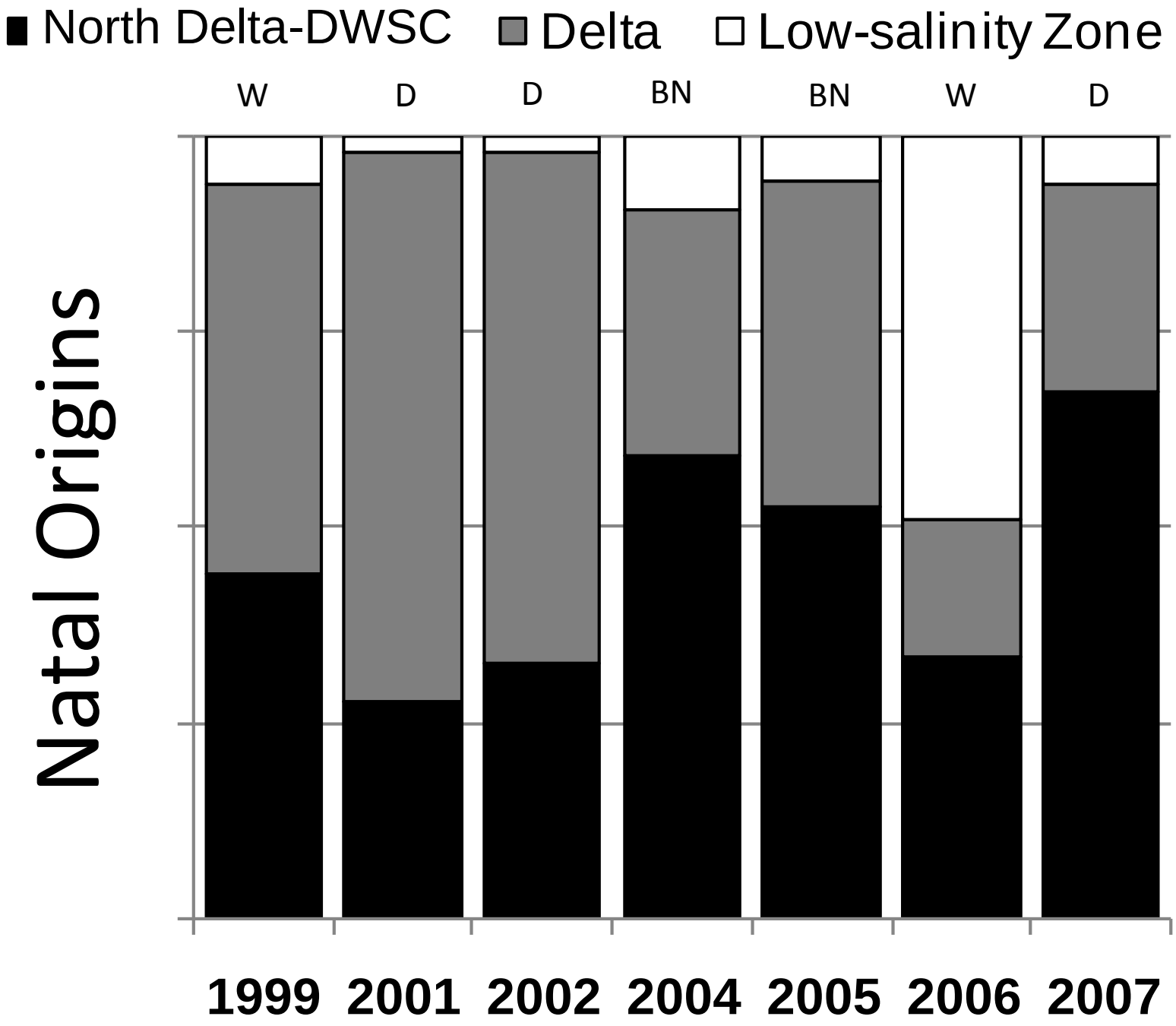
Drought effects on growth

H1: Growth will be lower during drought (dry) for all life-stages

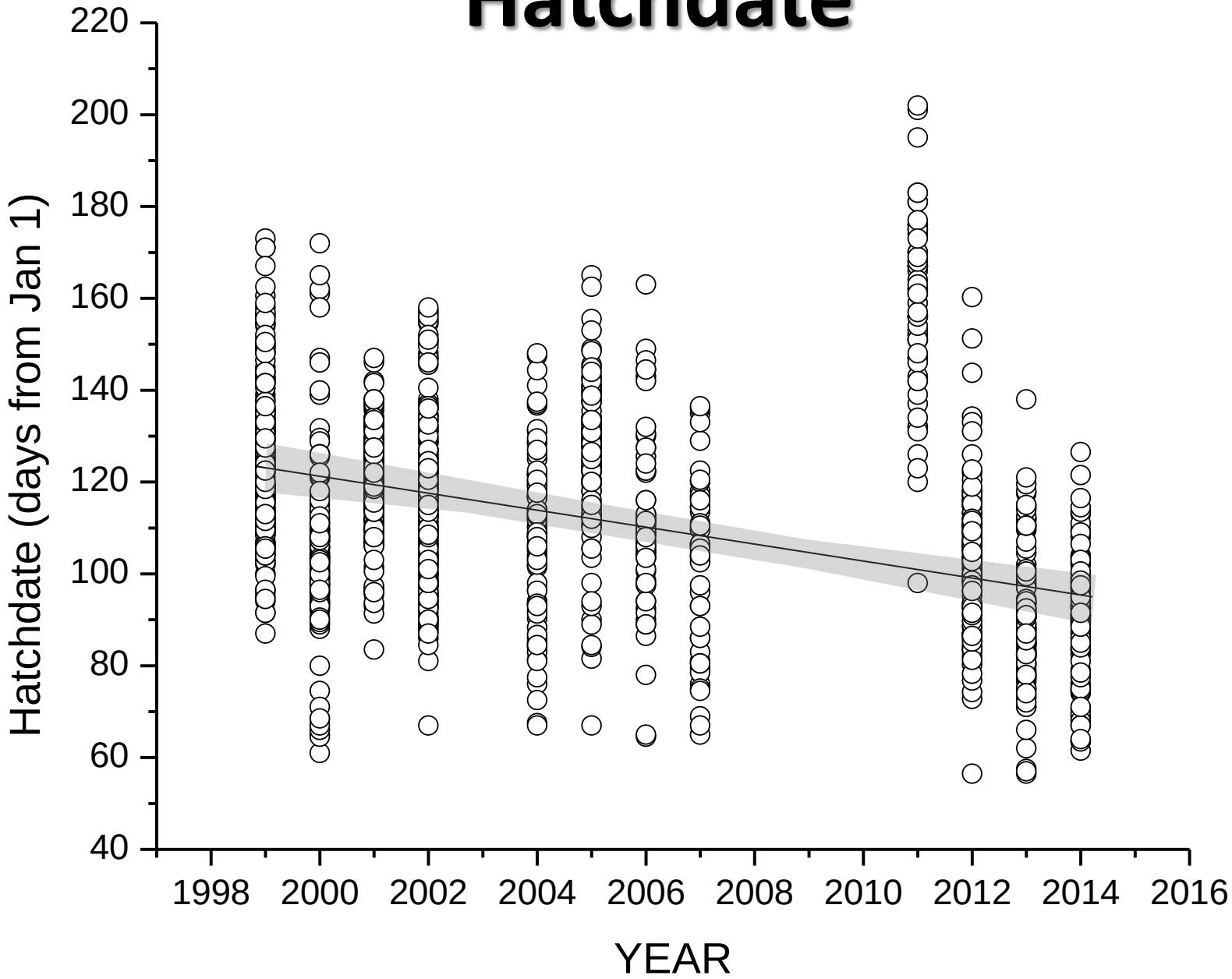
For juveniles during summer growth rate was lower in below normal, dry and critically dry years

H2: Life History Diversity will be reduced during drought years

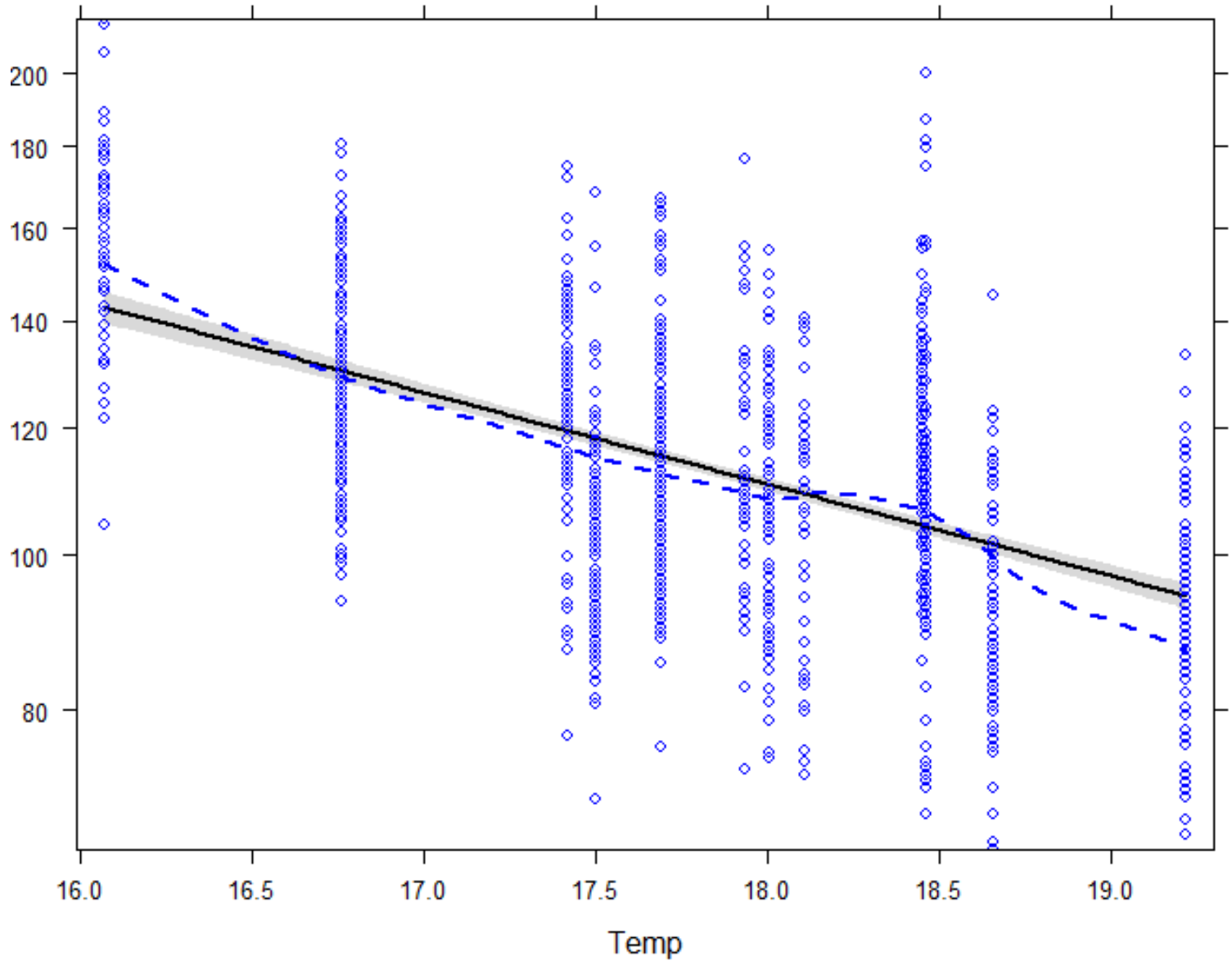
- Natal origins - Migration history
- Hatching Date


North Delta-DWSC
Delta
Low-salinity Zone
W
D
D
BN
BN
W
D
Natal Origins
1999
2001
2002
2004
2005
2006
2007

Hatchdate


Hatchdate (days from Jan 1)
220
200
180
160
140
120
100
80
60
40
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
YEAR

Hatchdates → Temperatures



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Shift in phenotypes- more North Delta born fish early hatching dates

Thank You!

Collaborators: William Bennett
Swee Teh, Ted Sommer, Louise Conrad
The MAST-Drought Team.

Agency: Carol Atkins-CDFW-ERP
Erwin Van Nieuwenhuyse –BOR,

Lab Technicians: Felipe La Luz, Eva Bush
Naoaki Ikemiyagi

Undergraduate Research Assistants:
Anna Schiller, Mackenzie Gilliam,
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