The lost generation:

Spring spawning and connectivity in the Georges Bank sea scallop population

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Fisheries and Oceans Canada Pêches et Océans Canada

DALHOUSIE UNIVERSITY Inspiring Minds

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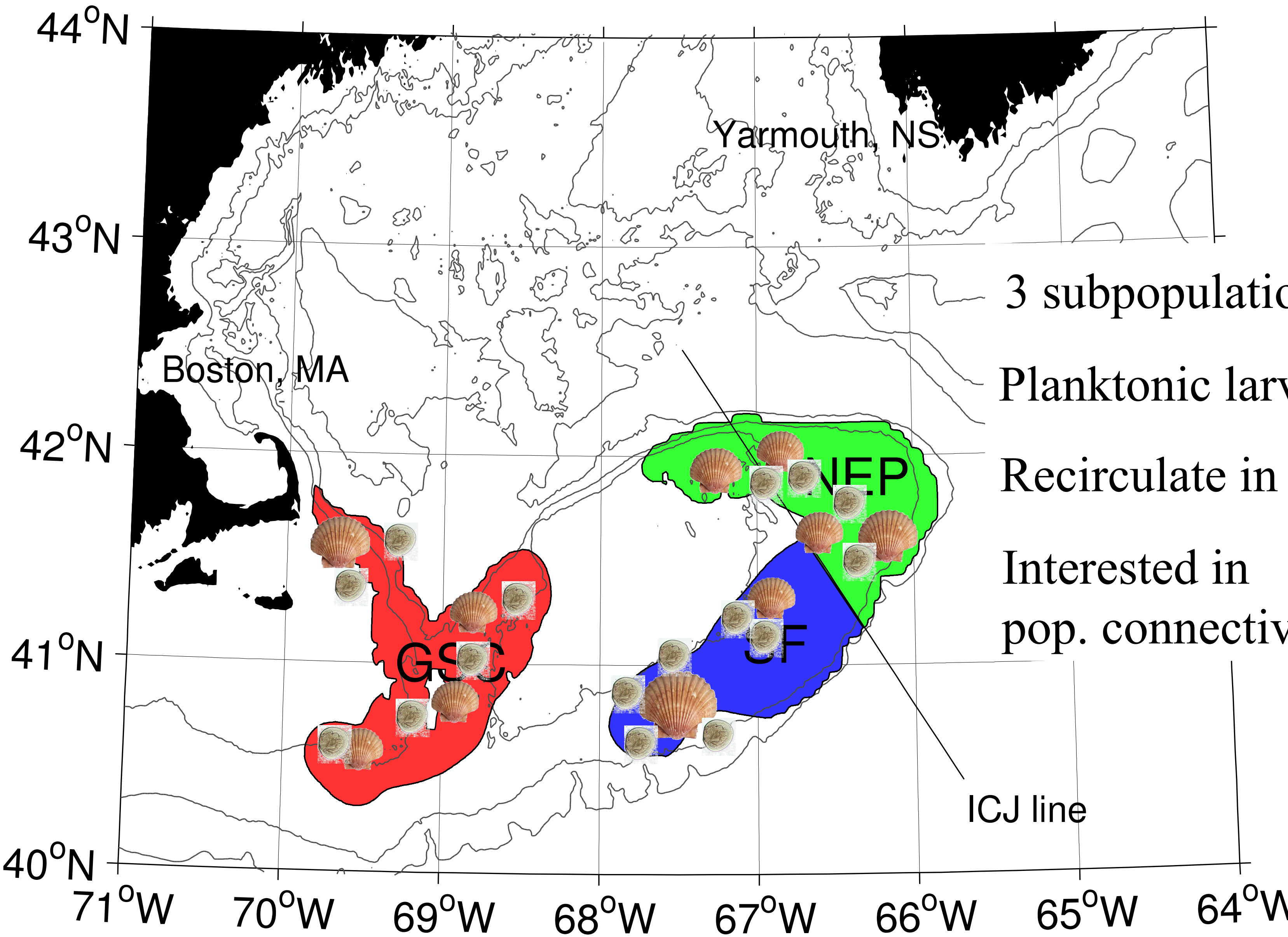
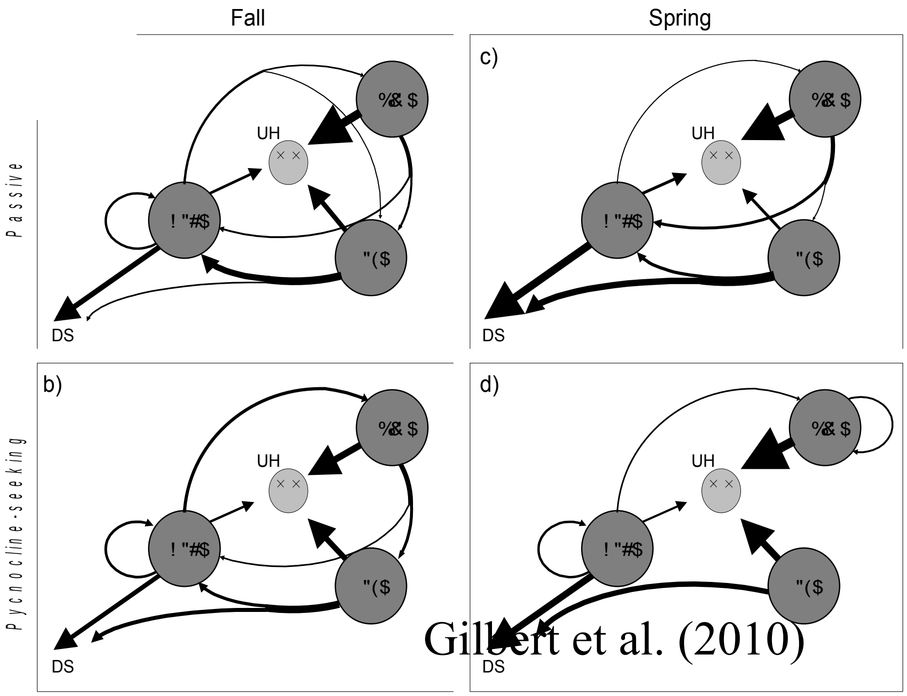
Scallops on Georges Bank: connected subpopulations



- 3 subpopulations
- Planktonic larvae
- Recirculate in gyre
- Interested in pop. connectivity

What We Know About the Fall Spawn



Gilbert et al. (2010)

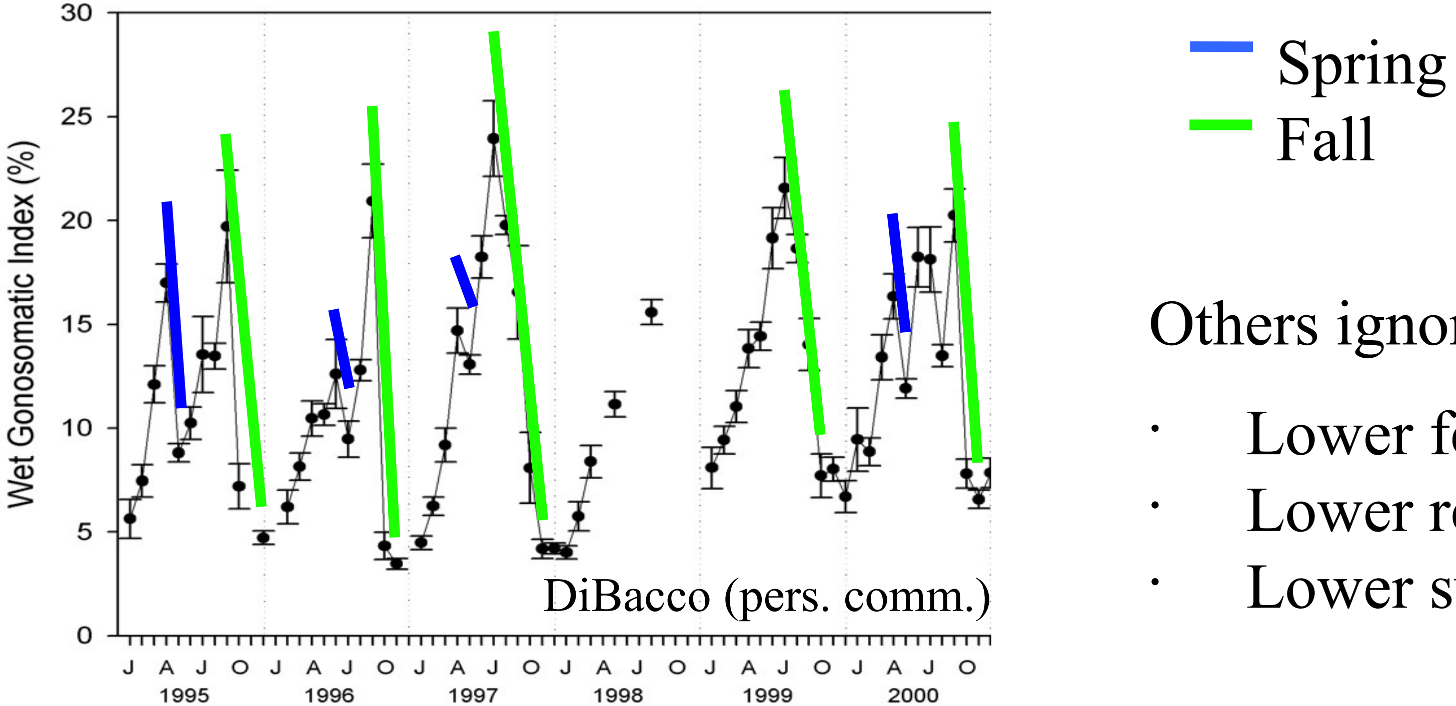
Significant retention, exchange *(Tremblay et al., 1994)*

Inter-annual variation in physics matters *(Tian et al., 2009)*
Factor of 5

Vertical Distribution matters *(Gilbert et al., 2010)*
Factors of 1-5

But What About Spring?

Scallops also spawn in spring (DiBacco, 1995)



Others ignored spring:

- Lower fecundity
- Lower retention
- Lower survivorship

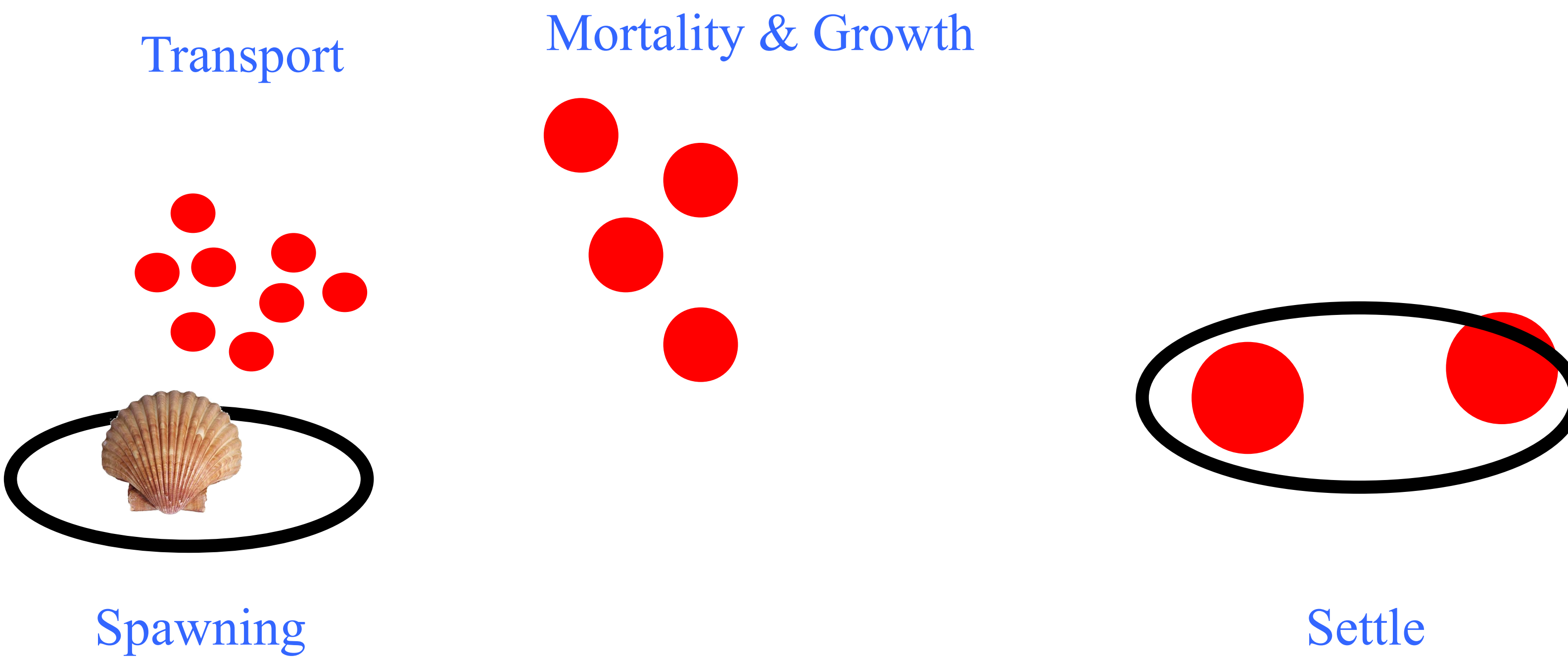
Gilbert et al. (2010): Significant retention in spring

Objective:
Quantify contribution of spring spawn to population connectivity

Model overview

3D particle-tracking model (Gilbert et al., 2010)

Coupled with an IBM



Analysis

1. "Settlement Distribution"

Where do larvae begin settlement?

2. "Larval Connectivity Matrix"

$\square(i,j)$ = # from bed j settling in bed i

$$\begin{bmatrix} \square(GSC,GSC) & \square(GSC,NEP) & \square(GSC,SF) \\ \square(NEP,GSC) & \square(NEP,NEP) & \square(NEP,SF) \\ \square(SF,GSC) & \square(SF,NEP) & \square(SF,SF) \\ \square(UH,GSC) & \square(UH,NEP) & \square(UH,SF) \end{bmatrix}$$

GSC, NEP, SF spawning beds
UH – unsuitable habitat

Fecundity

DFO – Years 1984-2004 – 3 Size-classes

(DiBacco, pers. comm.)		**Fec. (eggs x 106)**	
		Spring	Fall
Siz e	Small (50-95 mm)	21	36
	Medium (95-120 mm)	33	68
	Large (120-170 mm)	61	132

Fecundity is size-specific

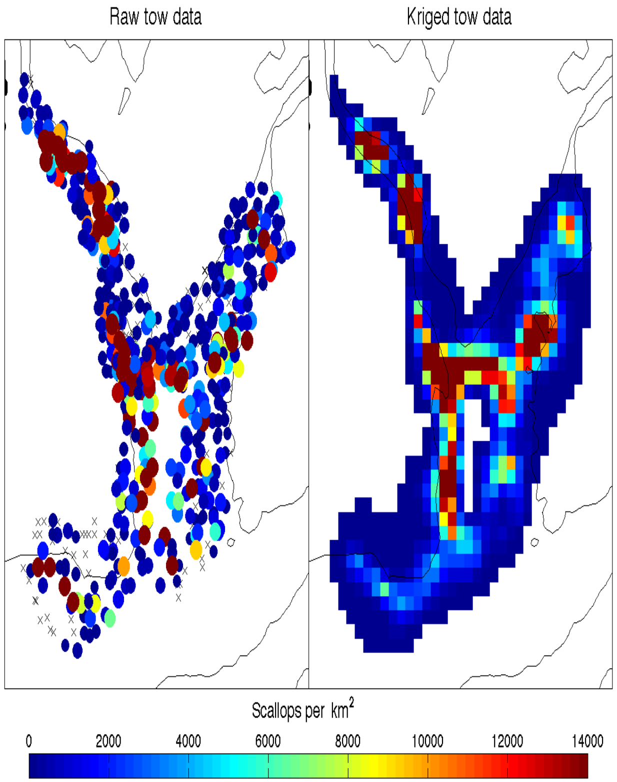
Fall matches previous estimates

Spring is ~1/3 of reproductive output

Estimating Abundance & Distribution

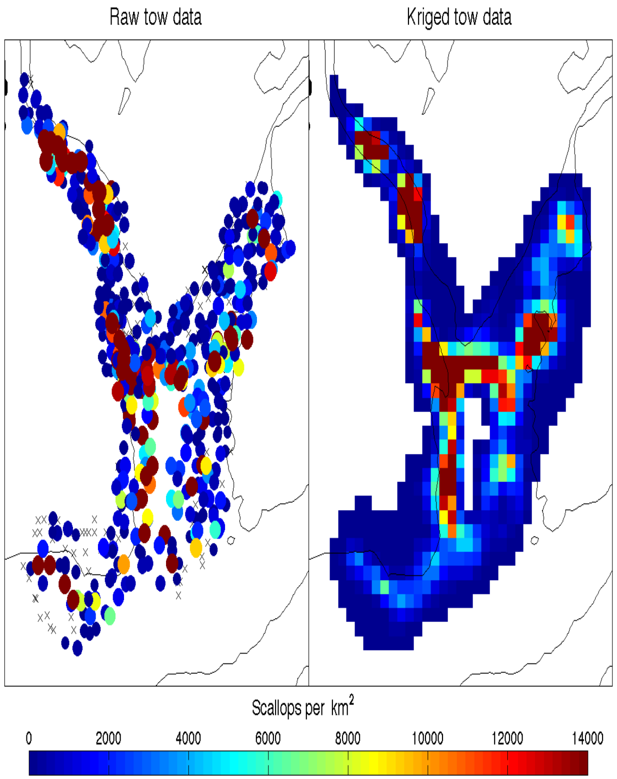
DFO & NOAA – Years 1996-2004 – 3 Size-classes

Tow data



krige

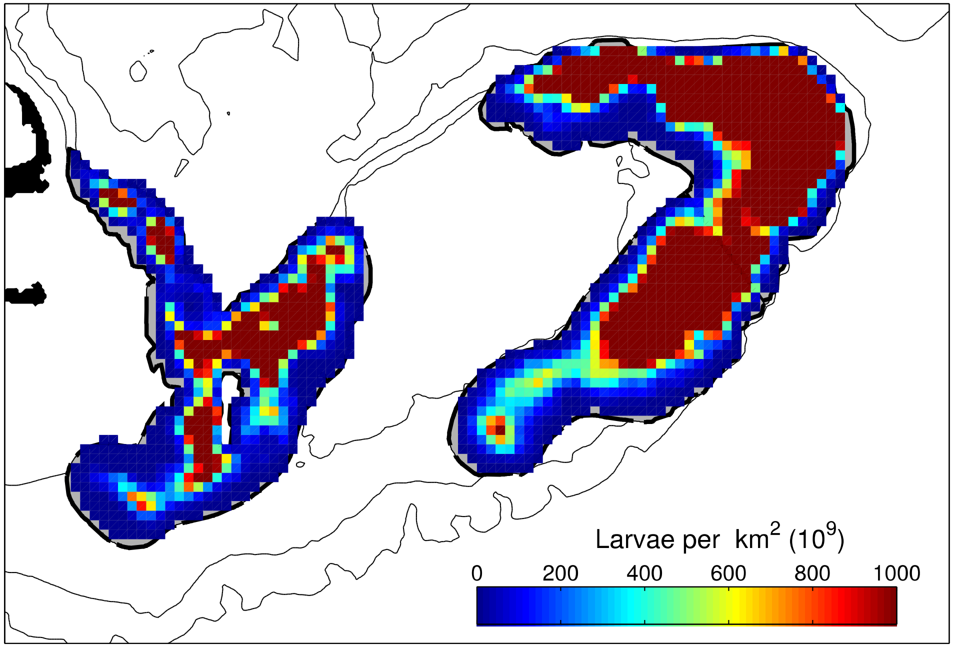
Female Abundance



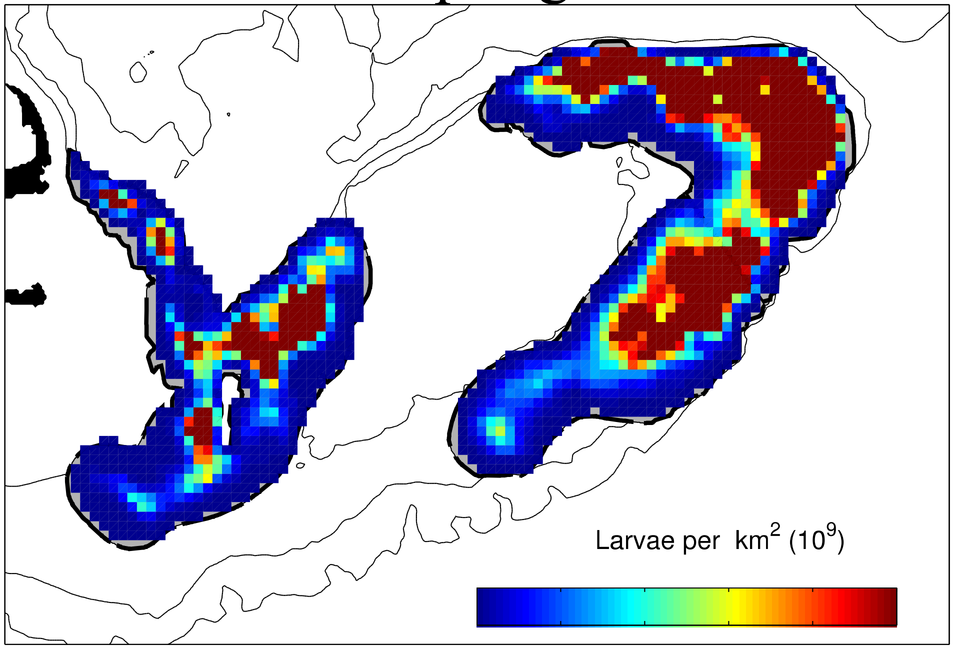
Spawning Field

spawning field = $\sum$ fecundity(size) * females(size)

Fall



Spring



spatial variation within subpopulations

same distribution in both seasons

spring 1/3 of spawning, fall ~2/3

Transport & Connectivity in Fall

Simulated larval dispersal in fall

Mortality rate: constant, 20% d-1

Larvae (1010)		**Spawn**		
		GSC	NEP	SF
Settle	GSC			[illegible]
	NEP			[illegible]
	SF	[illegible]	[illegible]	[illegible]
	UH	22	406	202

Transport & Connectivity in Spring

Simulated larval dispersal in spring

Mortality rate: constant, 20% d-1

Larvae (1010)		**Spawn**		
		GSC	NEP	SF
Settle	GSC	[illegible]	[illegible]	[illegible]
	NEP	[illegible]	[illegible]	[illegible]
	SF	[illegible]	[illegible]	[illegible]
	UH	1	26	8

Long PLD reduces survivorship (1/18)

Spring negligible for const. m.

Transport & Connectivity in Spring

Re-ran spring simulation

Mortality rate: Q10 = 2

Larvae (1010)		Spawn		
		GSC	NEP	SF
Settle	GSC	[illegible]	[illegible]	[illegible]
	NEP	[illegible]	[illegible]	[illegible]
	SF	[illegible]	[illegible]	[illegible]
	UH	23	345	78

Spring connectivity maybe not negligible...

Spring vs Fall

What portion of larval connectivity is from spring?

Spring (%)		Spawn		
		GSC	NEP	SF
Settle	GSC	45	0	6
	NEP	19	65	-
	SF	7	4	0
	UH	36	41	38

Retained in metapopulation: Fall: 5 Trillion
Spring: 1.4 Trillion

20% of larvae settling in metapopulation are spring-spawned

Summary

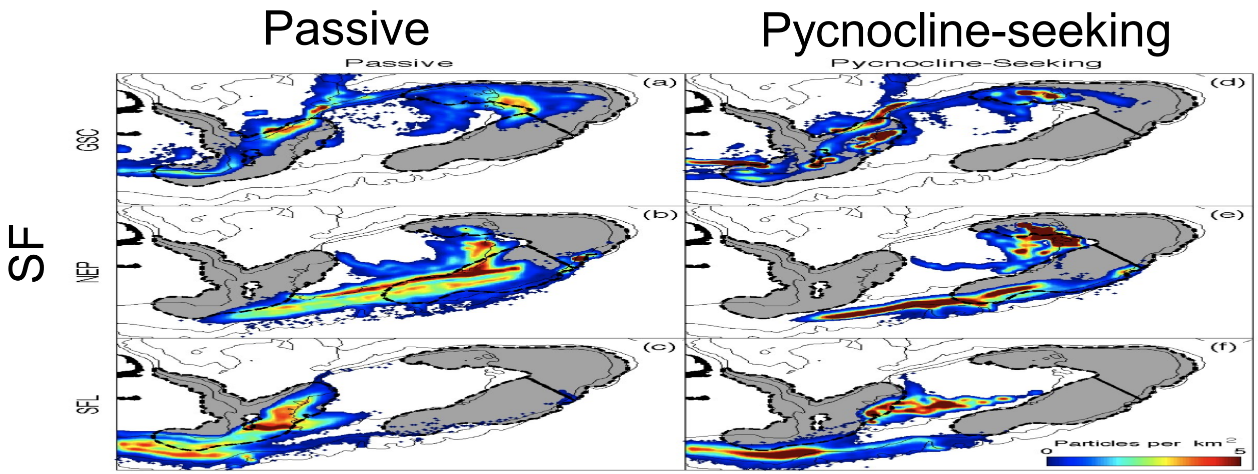
1. Reduced fecundity 2. Reduced retention 3. Reduced survivorship

- Spring fecundity estimates are conservative

Summary

1. Reduced fecundity   2. Reduced retention   3. Reduced survivorship

- Spring retention may be underestimated
- Vertical distribution matters, but unknown!



Summary

1. Reduced fecundity   2. Reduced retention   3. Reduced survivorship

- Mortality critical, but unknown!

Depends on several factors:

1. Predation
2. Abiotic
3. Food

Spring on GB:

1. More zooplankton
2. Cool, well-mixed
3. More phytoplankton

Conclusion

Formal model forced us to examine assumptions closely

Spring spawn may contribute significantly to population (despite good, but non-quantitative arguments)

Need more study on:

1. Seasonal fecundity
2. larval depth-distribution in spring
3. Seasonal larval mortality rates

PLEASE?