Population Connectivity of Shallow, Deep, & Mesophotic Reef Ecosystems:

Role of Population Dynamics

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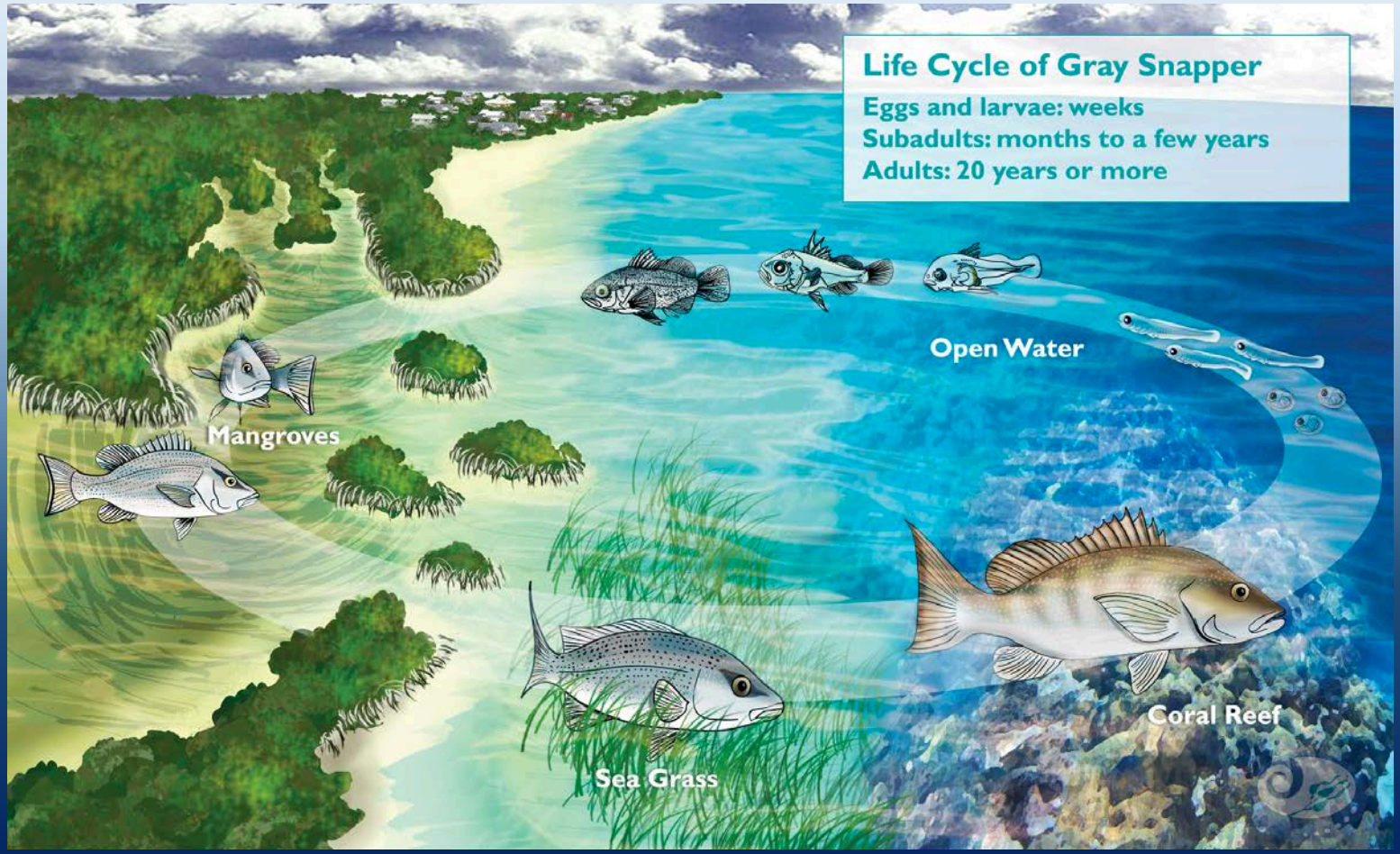
Oregon State University Hatfield

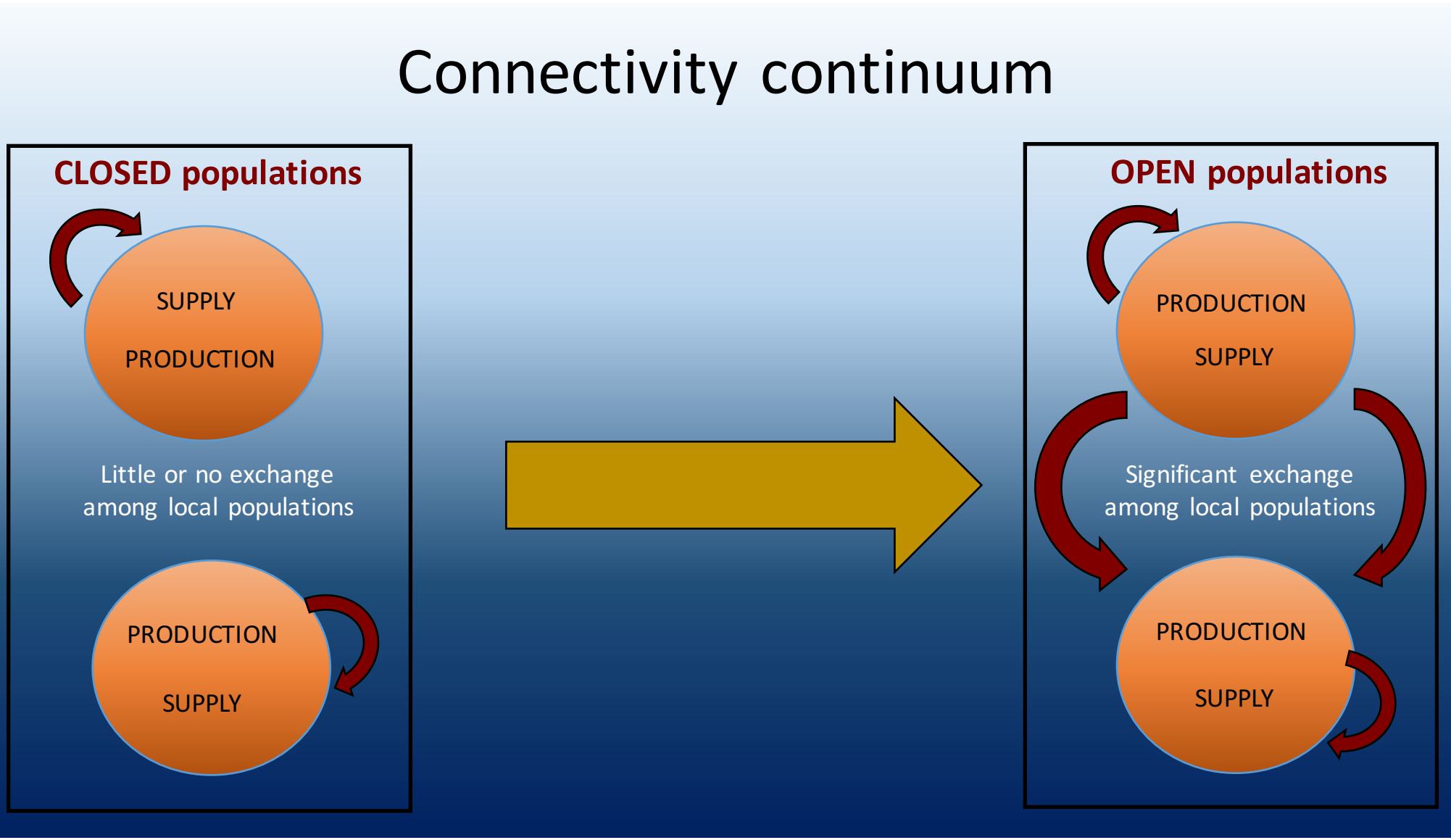
NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

UNIVERSITY OF MIAMI

Most marine organisms have complex life histories



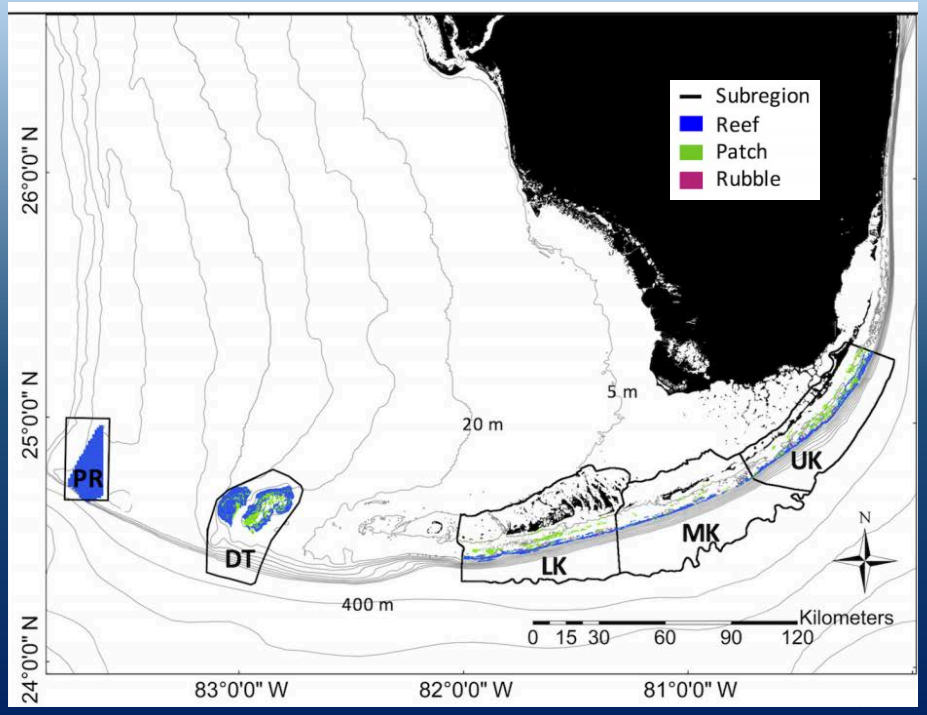
Connectivity continuum

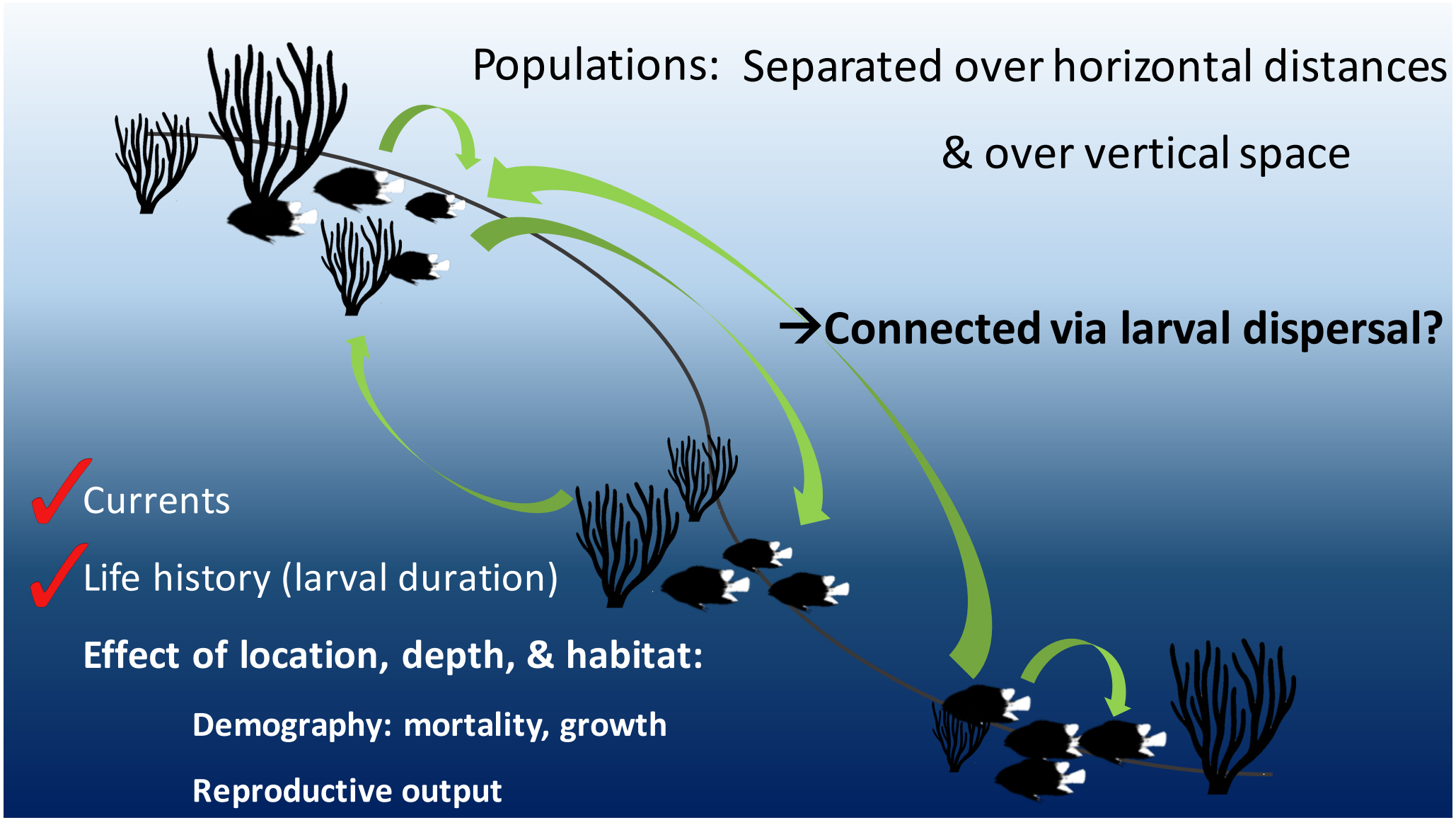


Objective:

Determine potential connectivity of key species between Pulley Ridge & downstream reefs of the Florida Keys

→ **Do PR populations produce larvae that settle to downstream sites?**




Populations: Separated over horizontal distances
& over vertical space
→Connected via larval dispersal?
✓Currents
✓Life history (larval duration)
Effect of location, depth, & habitat:
Demography: mortality, growth
Reproductive output

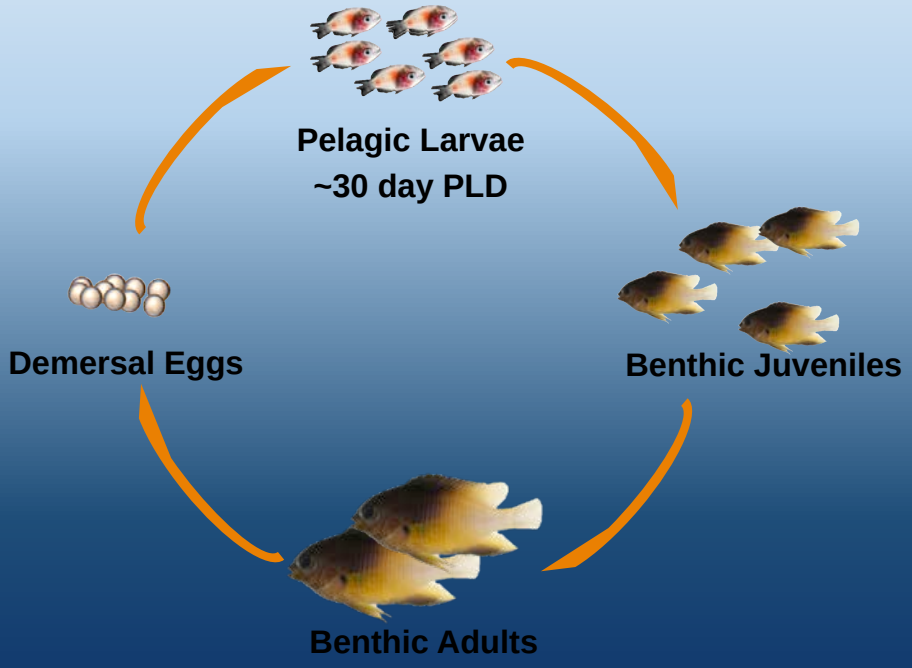

Selection of model fish species to examine
demographics, habitat suitability,
& reproductive output:
the bicolor damselfish

Bicolor damselfish—*Stegastes partitus*

- Bipartite life cycle

  Pelagic larval duration = ~30 d

- Common reef fish
- Planktivorous
- Territorial
- Easy to observe & collect
- Broad depth range (0-150m)

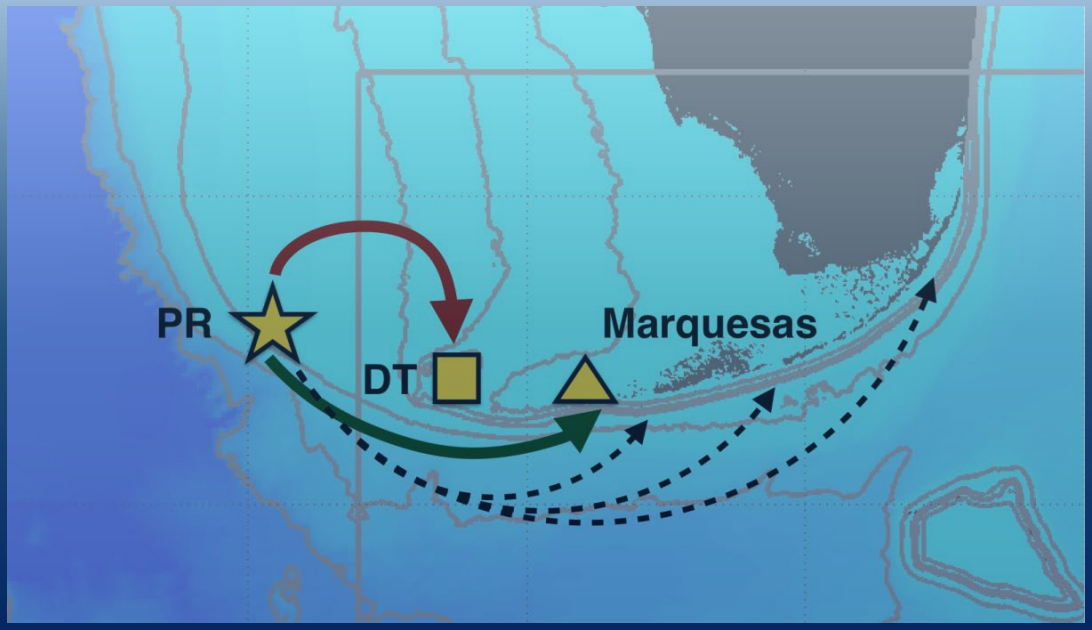


What do we know about POTENTIAL for exchange?

Input currents, larval duration & behavior, & habitat availability into biophysical model:

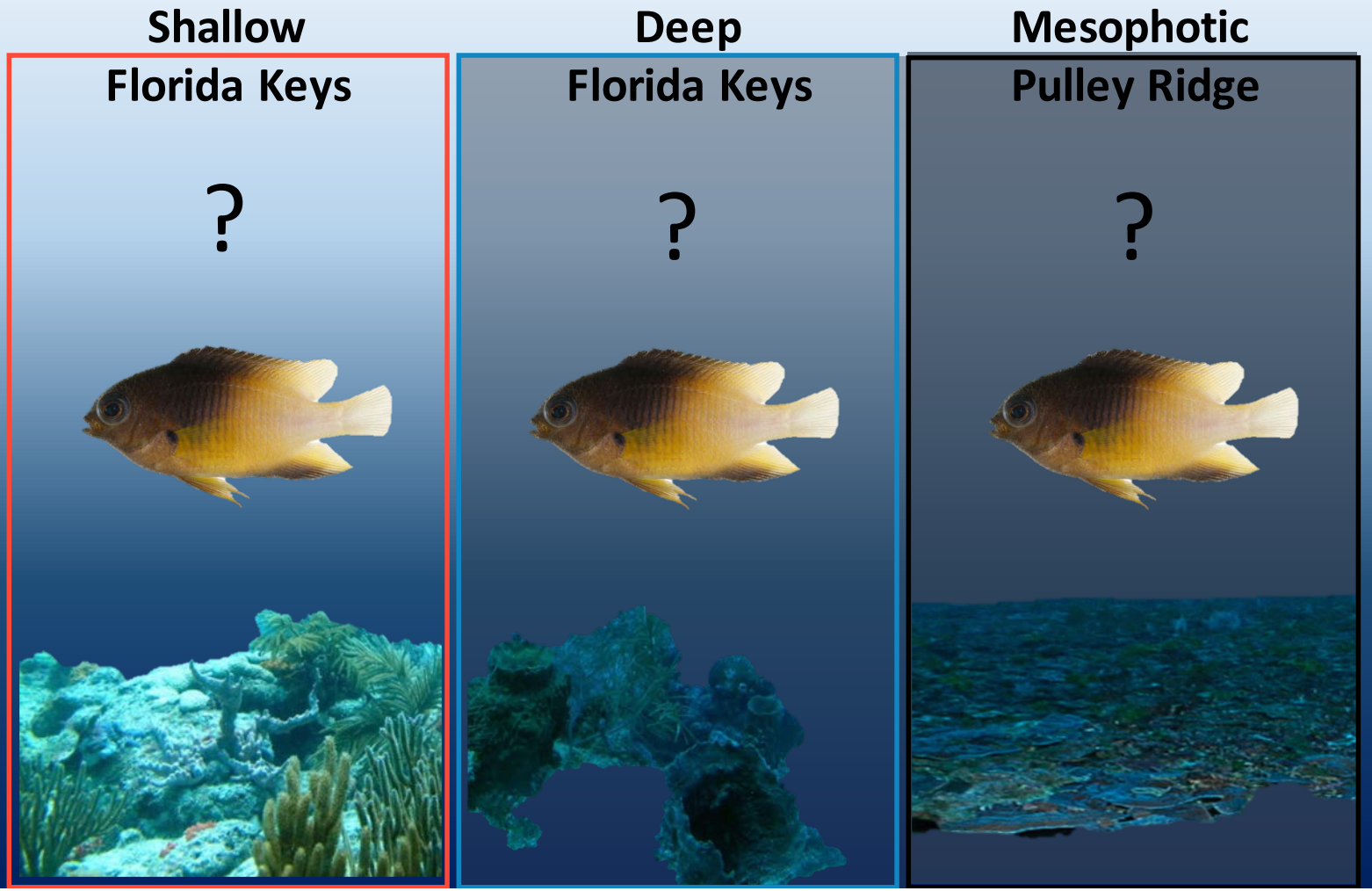
→Predicts that PR populations CAN provide larvae that settle to downstream Keys sites

→Connections are intermittent, via 2 primary pathways (eddy dependent)



Vaz et al. (2016)

But we still do not know if populations differ among habitats



1. Demographics & reproduction across vertical spatial scales

2. Behavior, diet, & fitness across vertical spatial scales

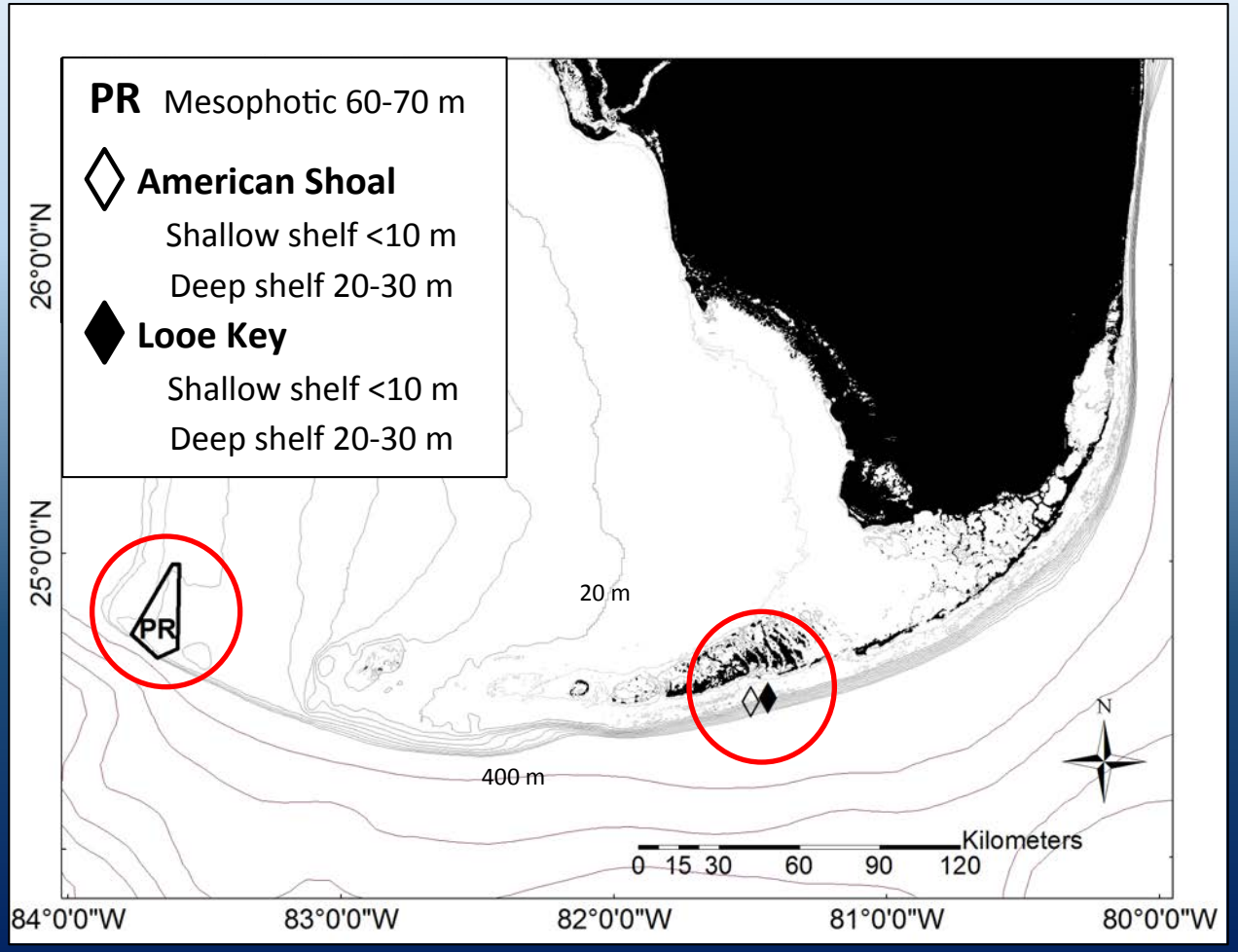
3. Regional reproductive output

1. DEMOGRAPHICS & REPRODUCTION

Depth-driven differences in size, age, growth, & reproduction?

1. DEMOGRAPHICS & REPRODUCTION

Study sites



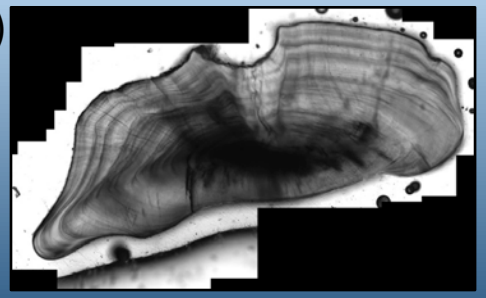
1. DEMOGRAPHICS & REPRODUCTION

Methods

Abundances:

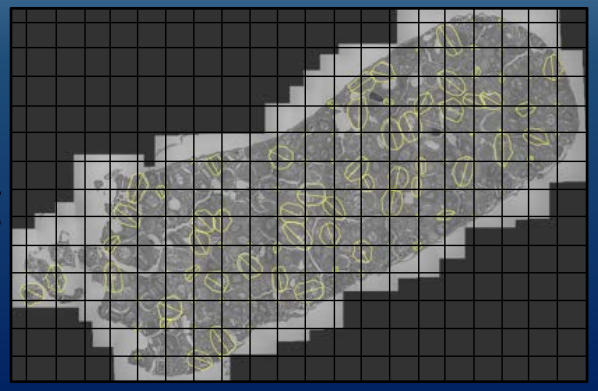
→Fish density transects

Mesophotic ROV (100 m x 5 m)—*Reed et al. 2014*
Shallow & deep shelf visual (25 m x 2 m)
Monthly recruitment surveys (5 m x 1 m)



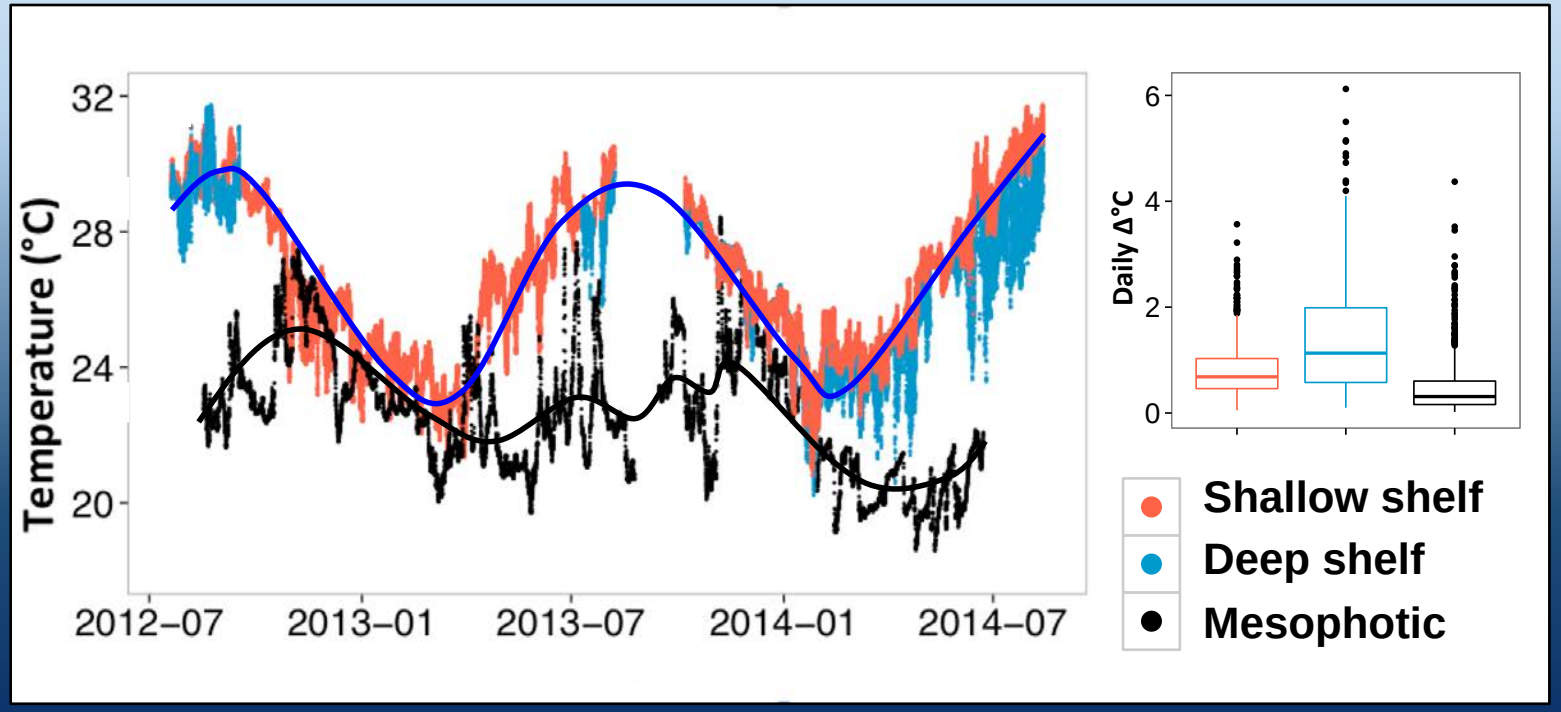
Growth rates:

→Hand-net collections
→Otolith reading
→Ovary sectioning;
oocyte counting & staging



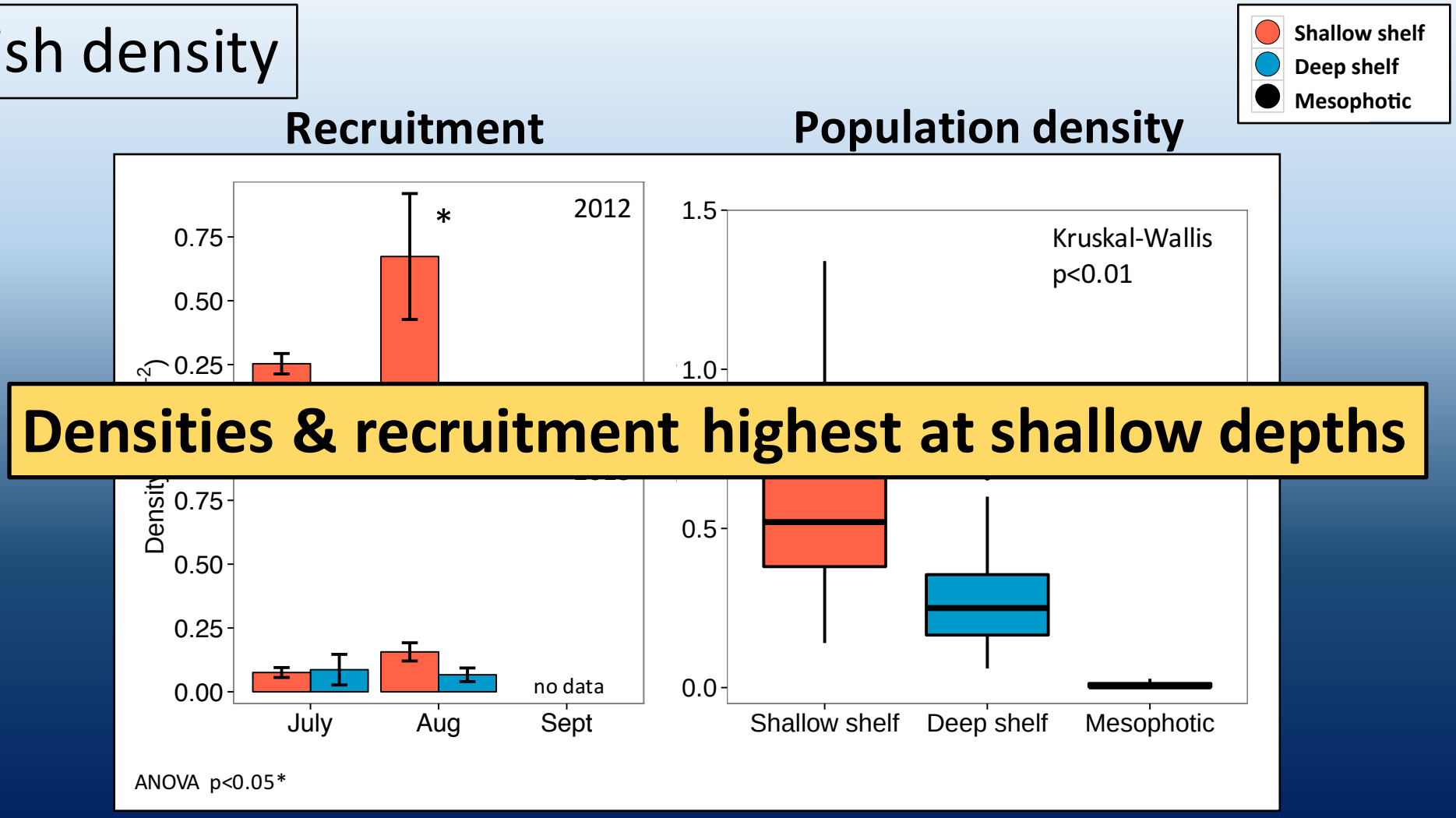
1. DEMOGRAPHICS & REPRODUCTION

Temperature



1. DEMOGRAPHICS & REPRODUCTION

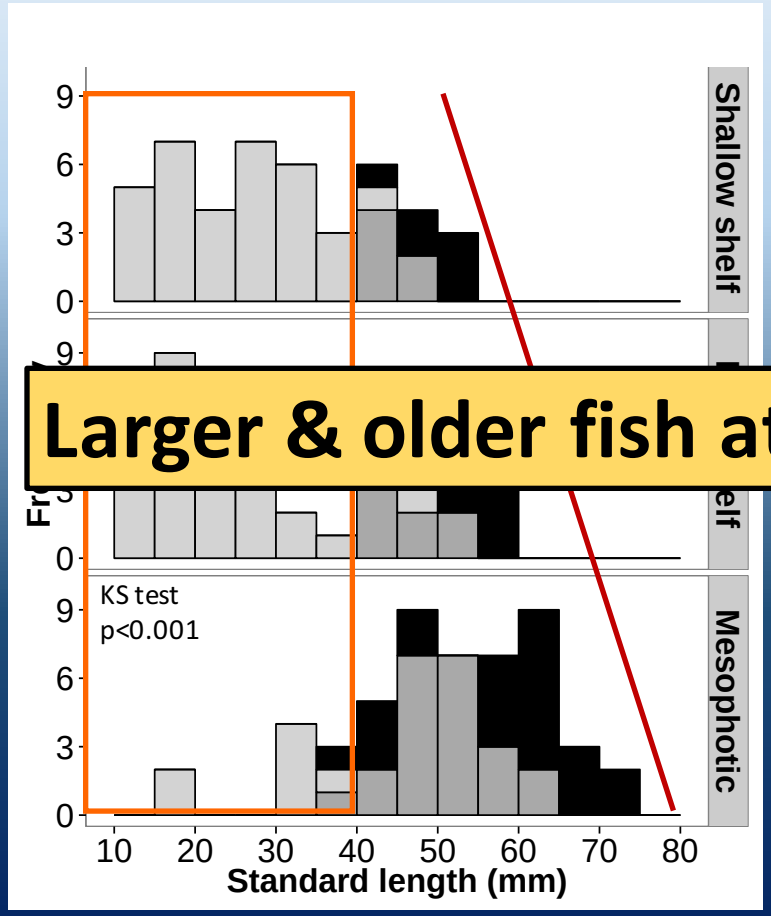
Fish density

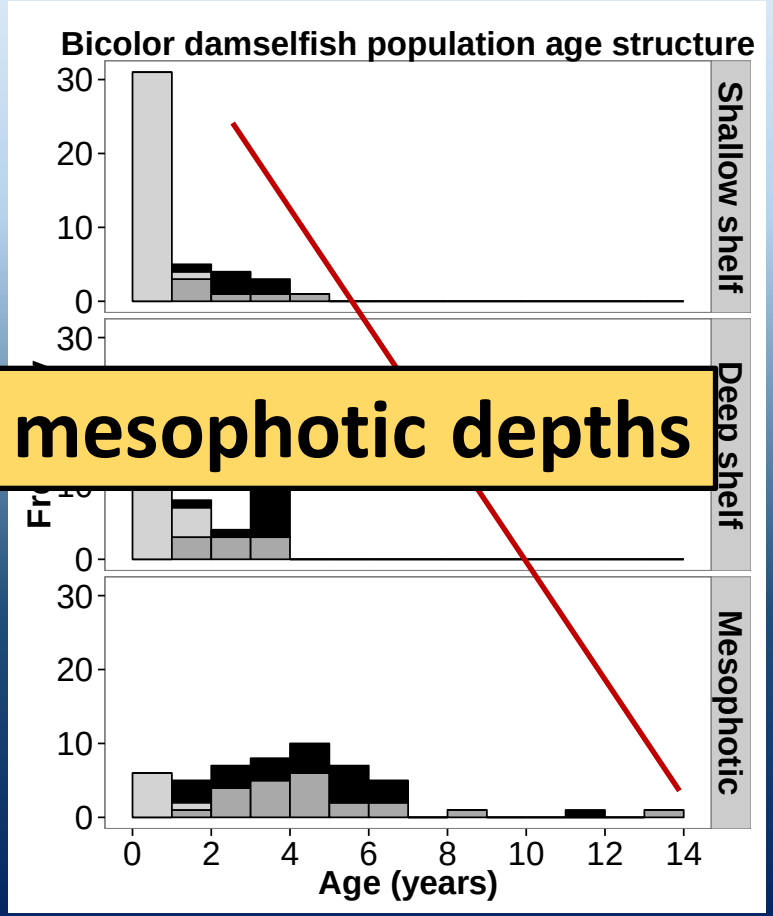


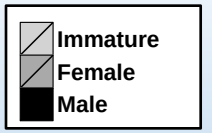
Densities & recruitment highest at shallow depths

1. DEMOGRAPHICS & REPRODUCTION

Population structure







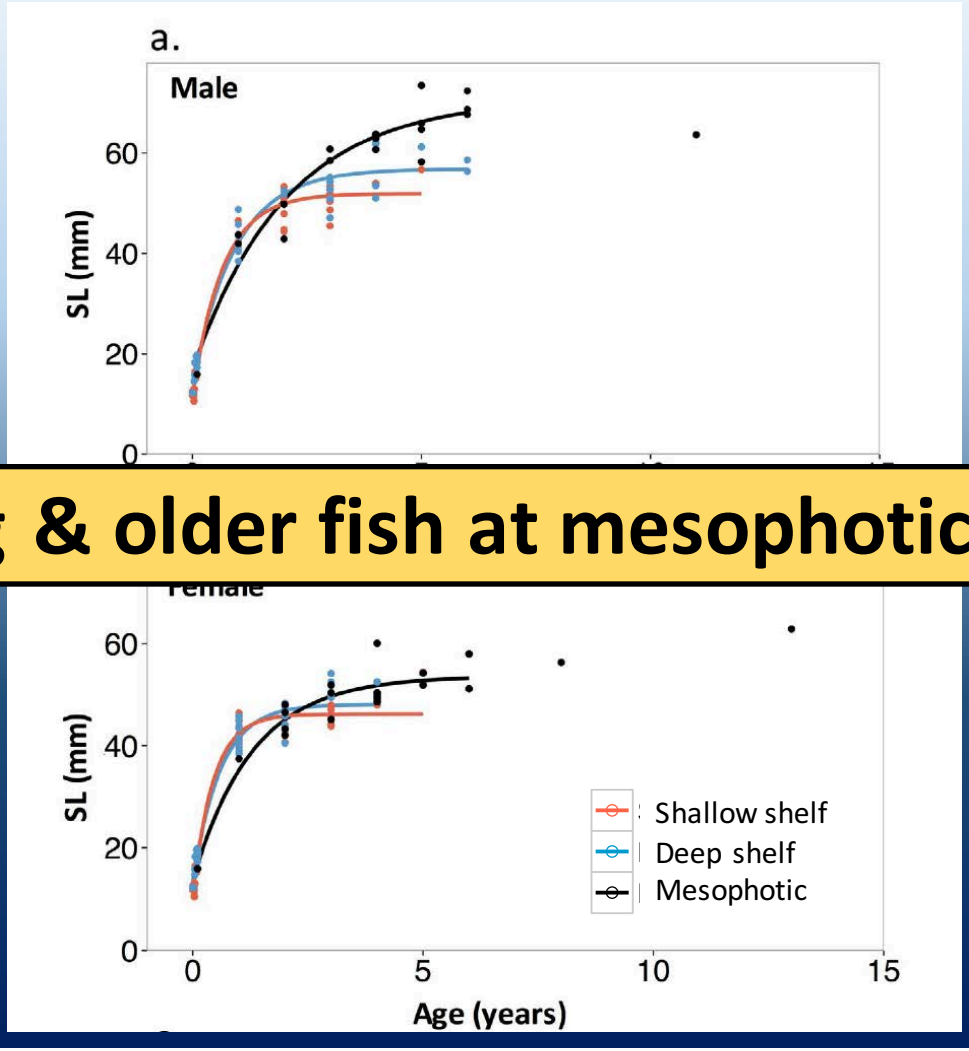
Larger & older fish at mesophotic depths

1. DEMOGRAPHICS & REPRODUCTION

Age & Growth

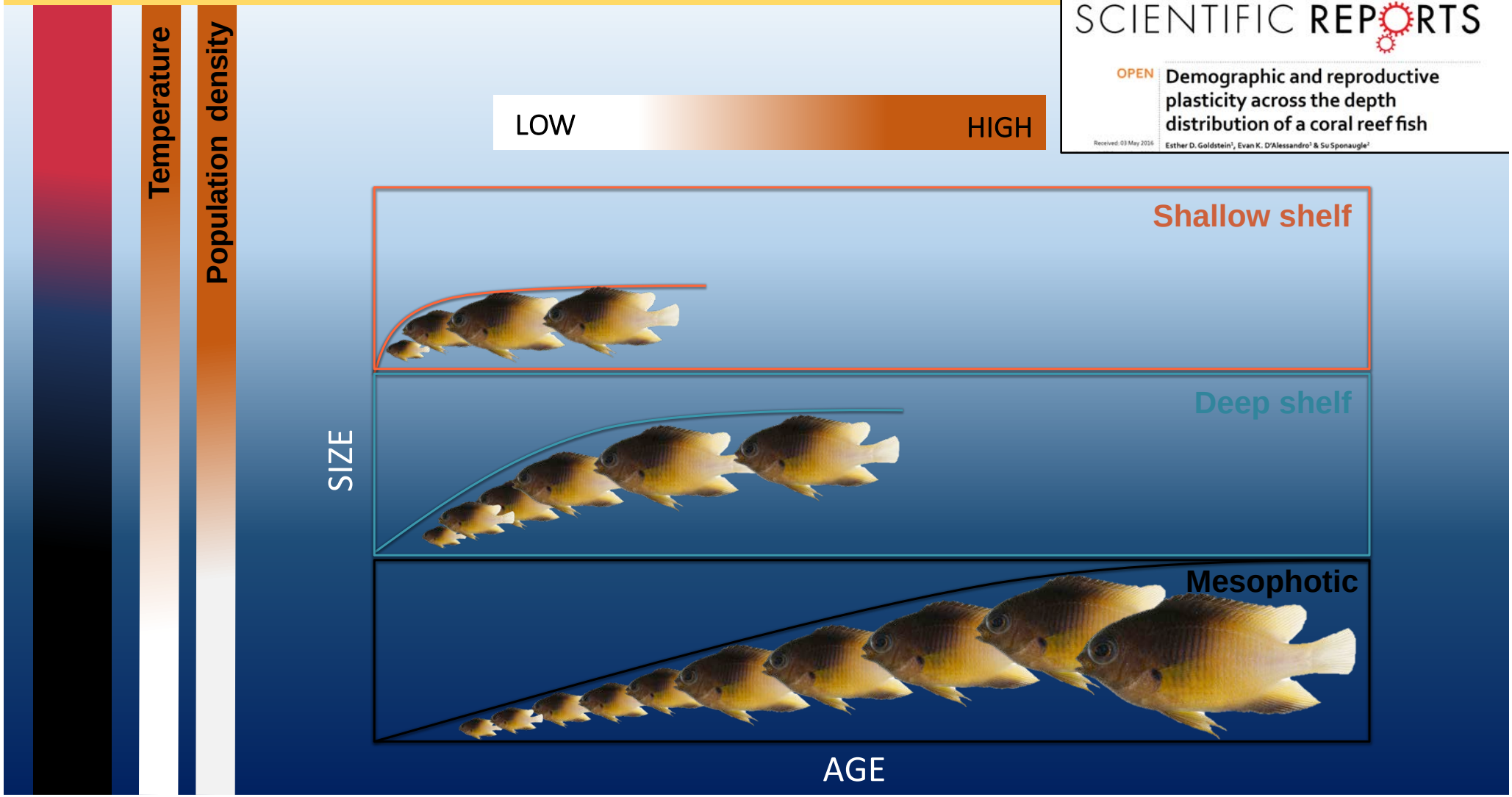
Von Bertalanffy

$L_t = L_\infty[1-e^{-k(t-to)}]$



Slower-growing & older fish at mesophotic depths

1. DEMOGRAPHICS & REPRODUCTION



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SCIENTIFIC REPORTS

OPEN

Demographic and reproductive plasticity across the depth distribution of a coral reef fish

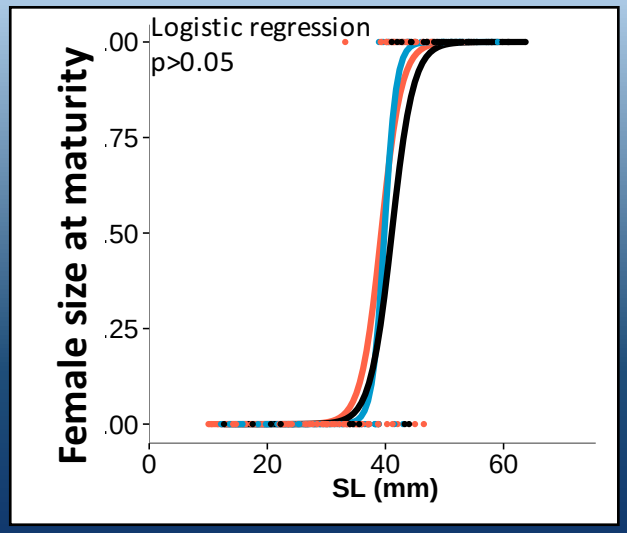
Received: 03 May 2016

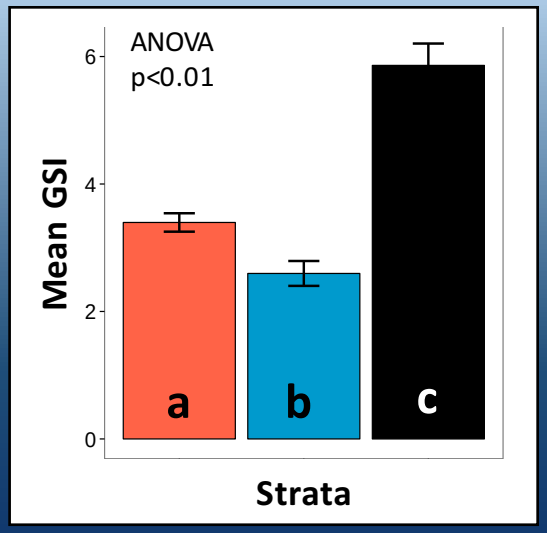
Esther D. Goldstein[1], Evan K. D'Alessandro[2] & Su Sponaugle[2]

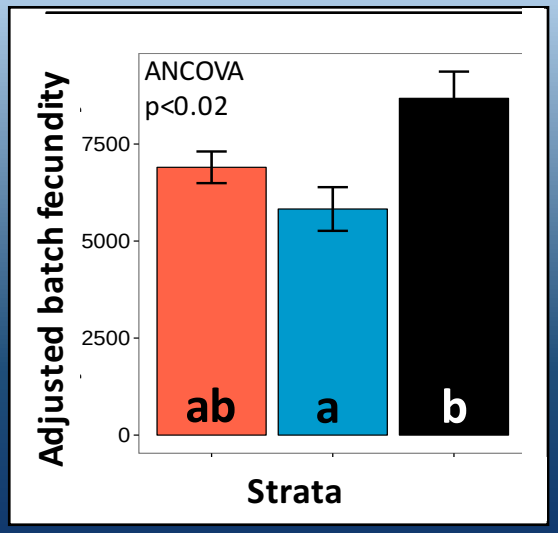
1. DEMOGRAPHICS & REPRODUCTION

Reproductive investment & fecundity?

PR = large at maturity & high reproductive investment





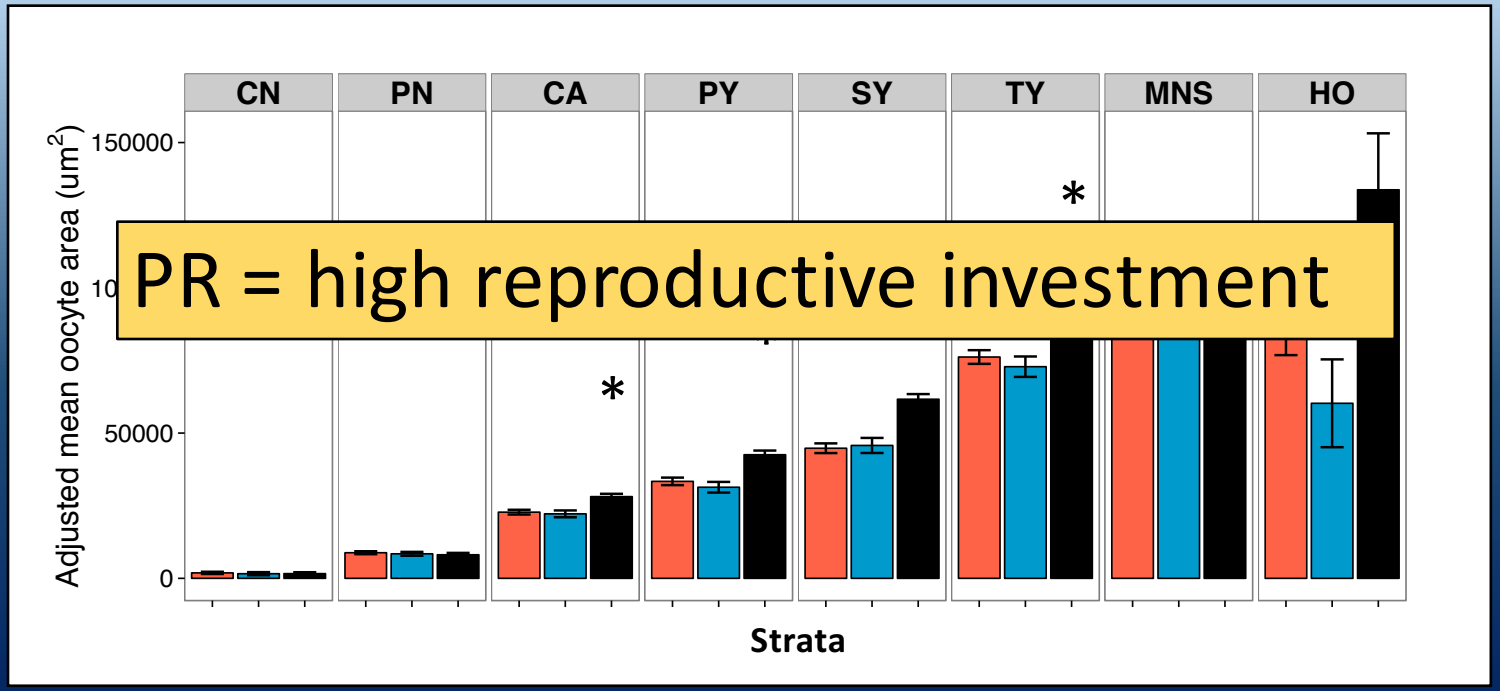


1. DEMOGRAPHICS & REPRODUCTION

Oocyte area

Shallow shelf
Deep shelf
Mesophotic

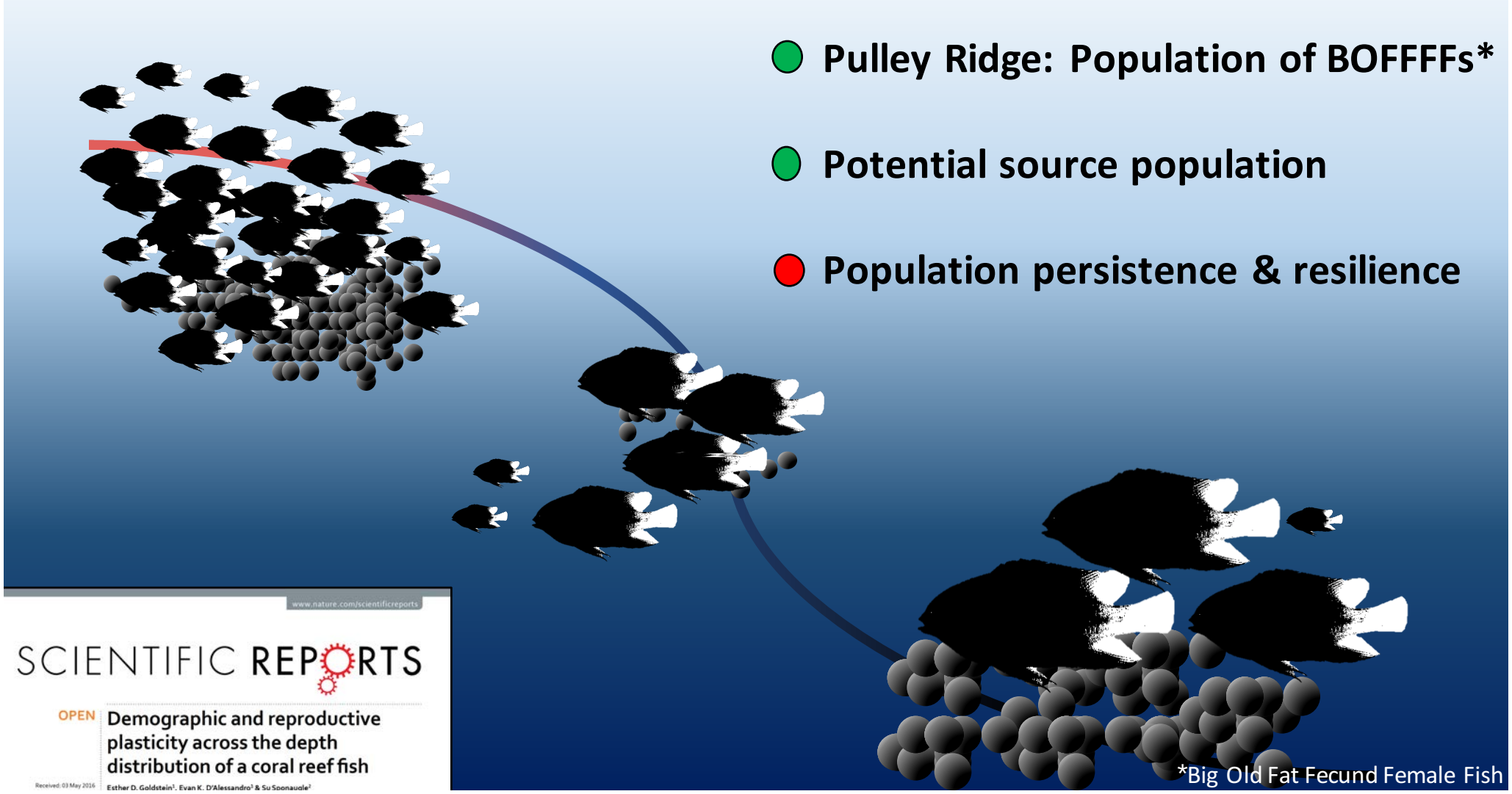
Mesophotic > Shallow shelf = Deep shelf



PR = high reproductive investment

ANCOVA
* p<0.05

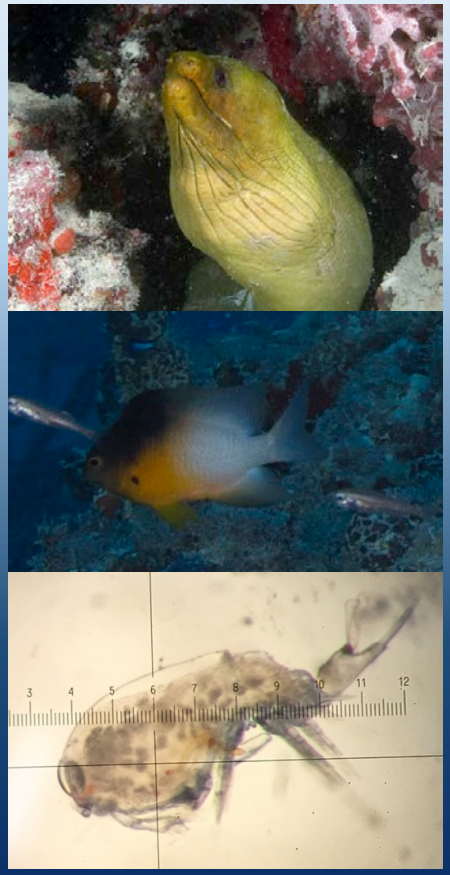
1. DEMOGRAPHICS & REPRODUCTION



2. BEHAVIOR, DIET & FITNESS

Differences in habitat suitability?

- Predators & benthic habitat
- Time & energy allocation
- Diet



2. BEHAVIOR, DIET & FITNESS

Field Sampling

Predator density:

Mesophotic ROV (100 m x 5 m)—*Reed et al. 2014*

Shallow & deep shelf visual (25 m x 2 m)

Benthic habitat:

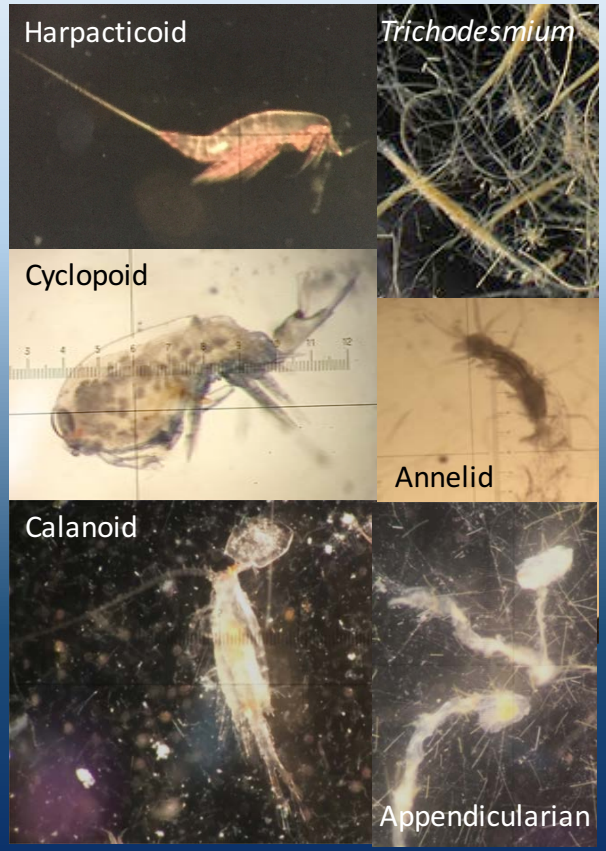
Shallow & deep shelf visual (25 m x 2 m)

- Point intercept habitat
- Maximum vertical relief

Behavior: video quantification

Proportion of time	Counts	Ranked
Shelter	*Plankton bites*	*Vertical swim*
Aggression	*Benthic bites*	
Courtship		
Out of view		

2. BEHAVIOR, DIET & FITNESS



Diet:

→Gut contents

Gut fullness - wet weight

Dry wt. diet categories

Algae Copepod Animal

Trichodesmium UNID

Prey item counts

→Stable isotopes

$\delta^{13}C$ & $\delta^{15}N$ stable isotopes

Fish muscle tissue

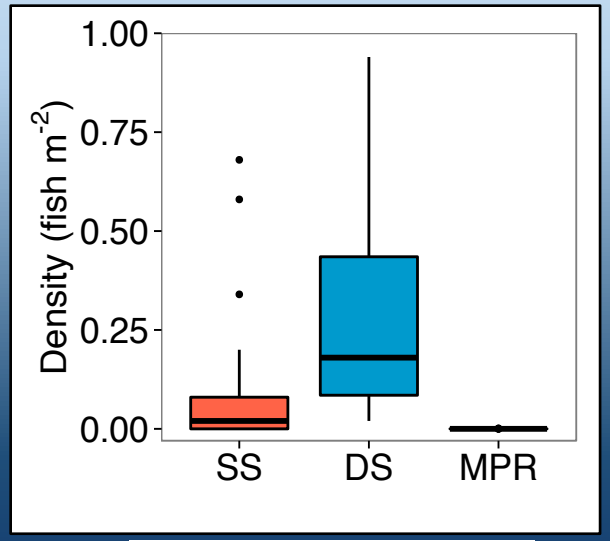
Copepod baselines

Algae source values

2. BEHAVIOR, DIET & FITNESS

Environment

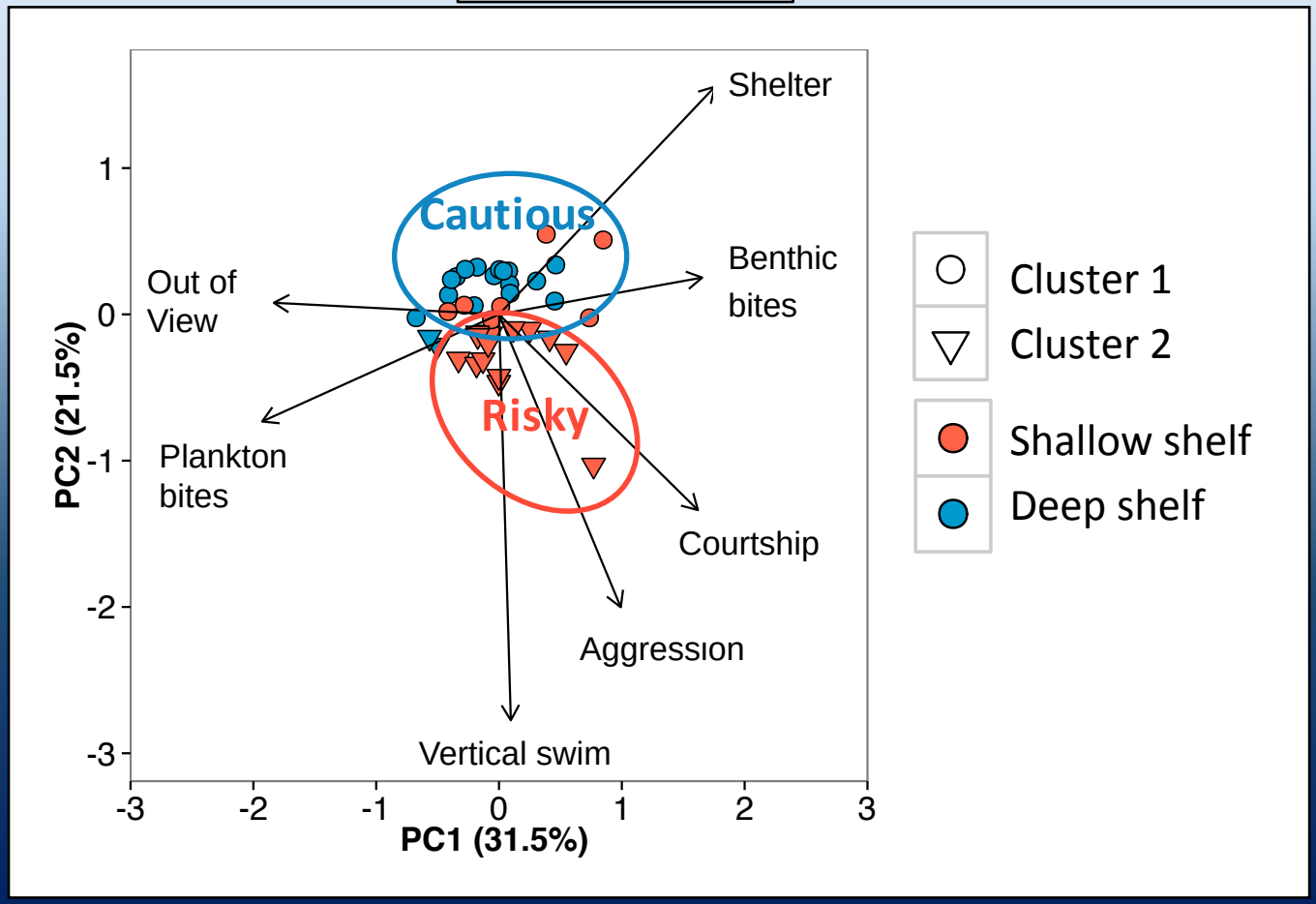
Predator density



MPR < SS < DS

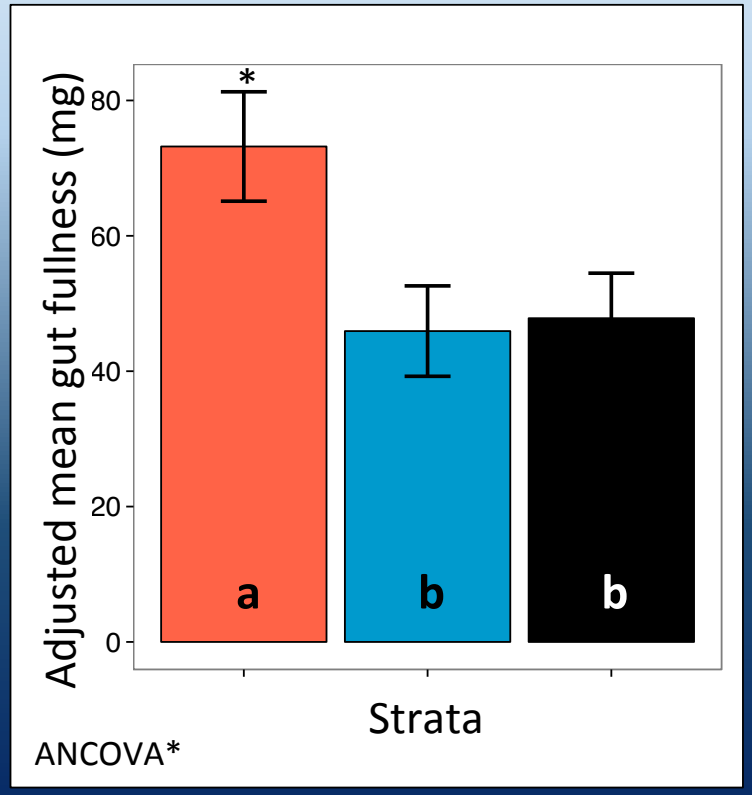
Kruskal-Wallis p<0.001

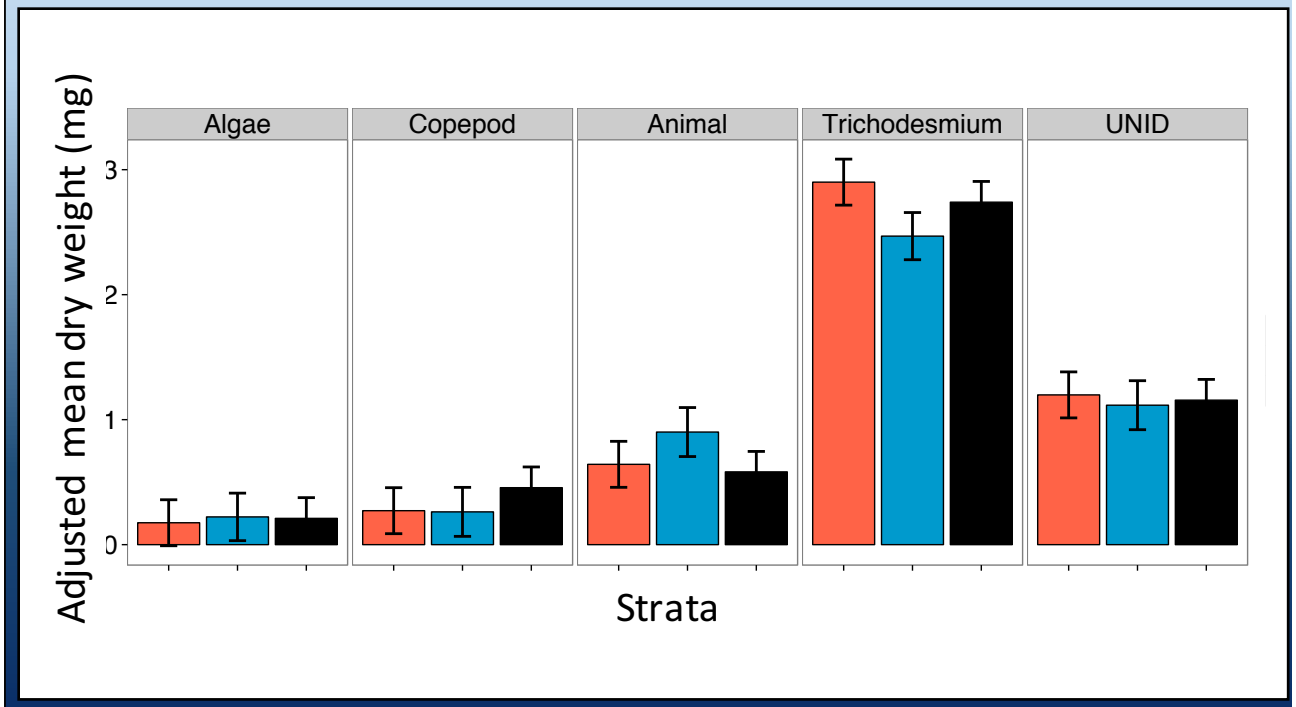
Behavior



2. BEHAVIOR, DIET & FITNESS

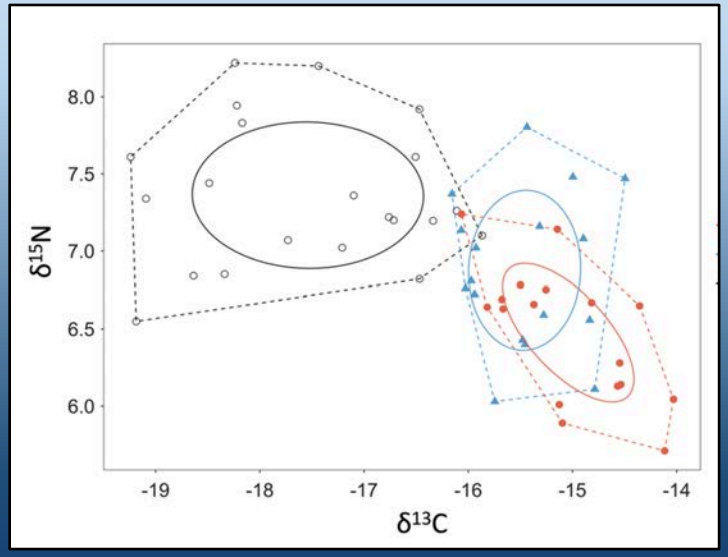
Diet (short term)

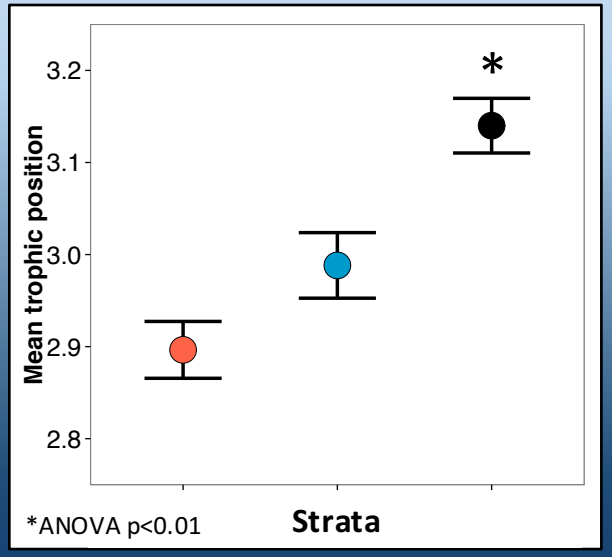


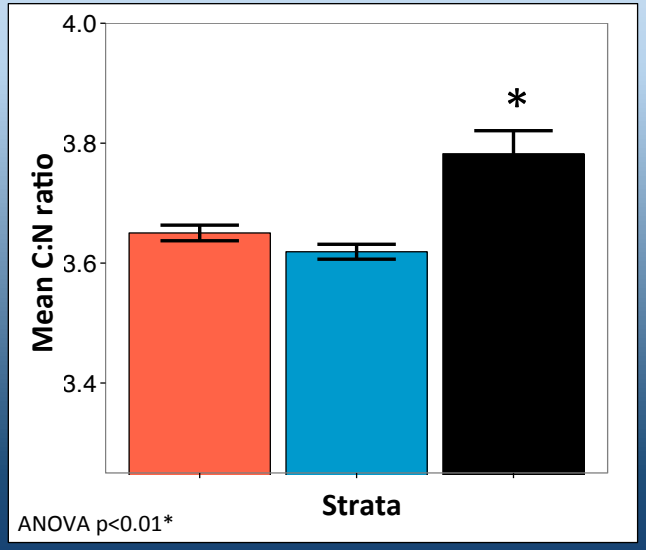


2. BEHAVIOR, DIET & FITNESS

Diet (long term)

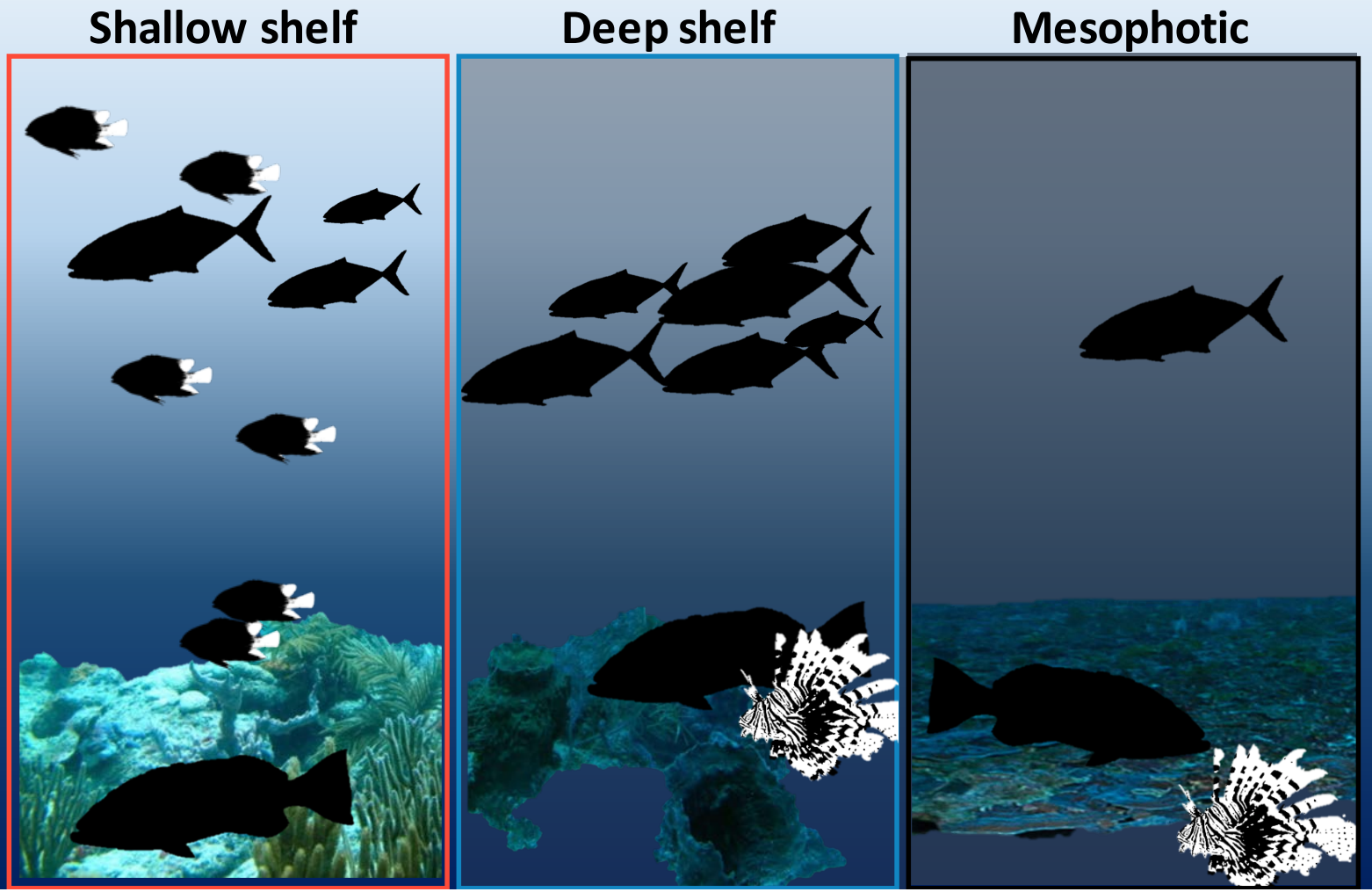




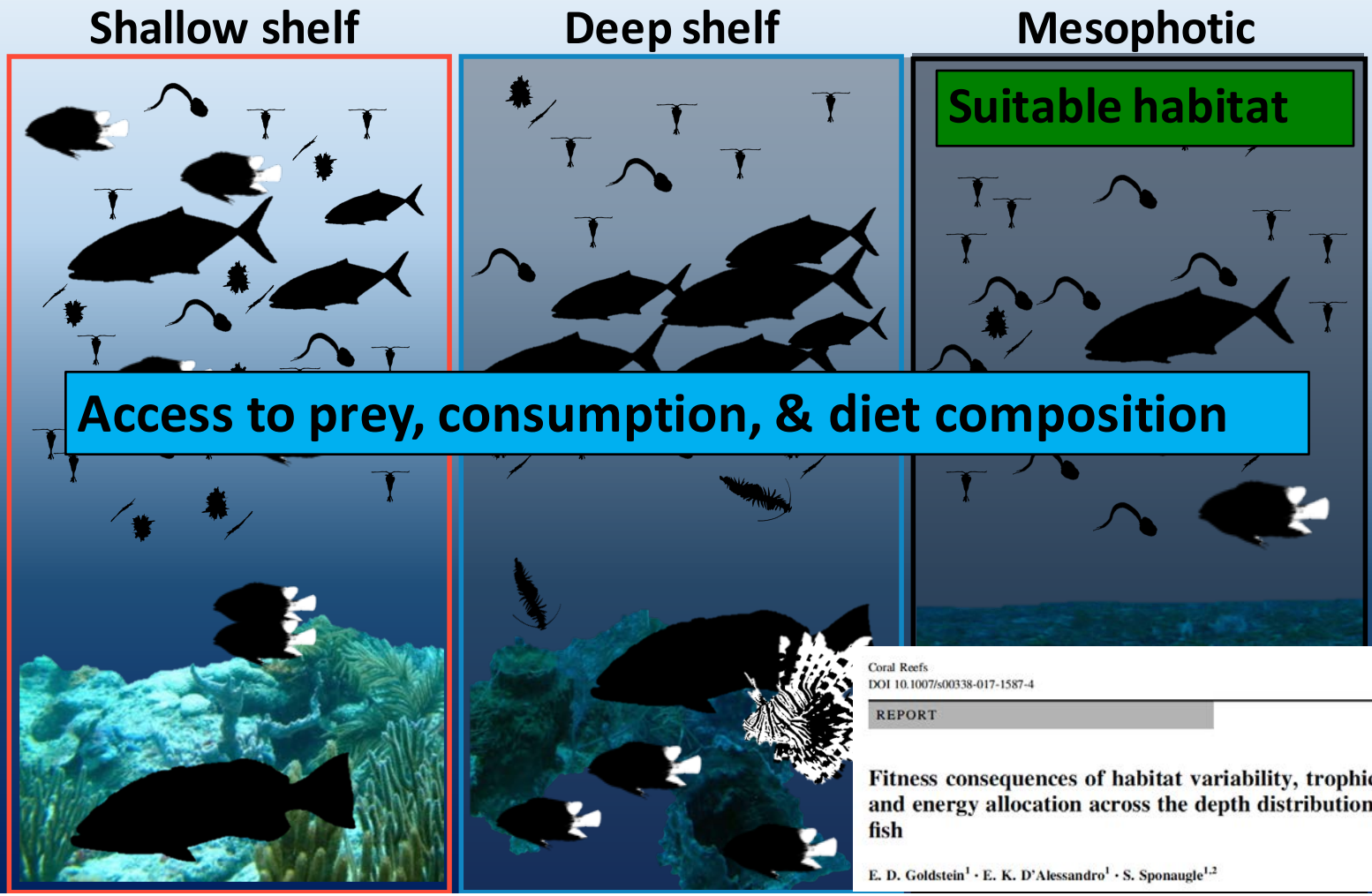


Shallow shelf
Deep shelf
Mesophotic

2. BEHAVIOR, DIET & FITNESS



2. BEHAVIOR, DIET & FITNESS



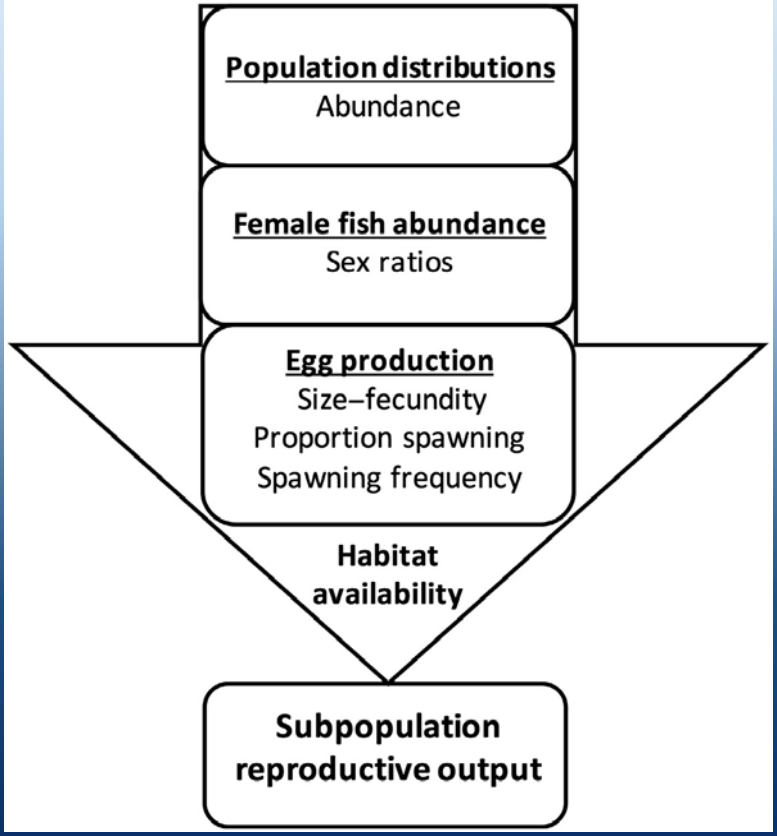
Coral Reefs
DOI 10.1007/s00338-017-1587-4

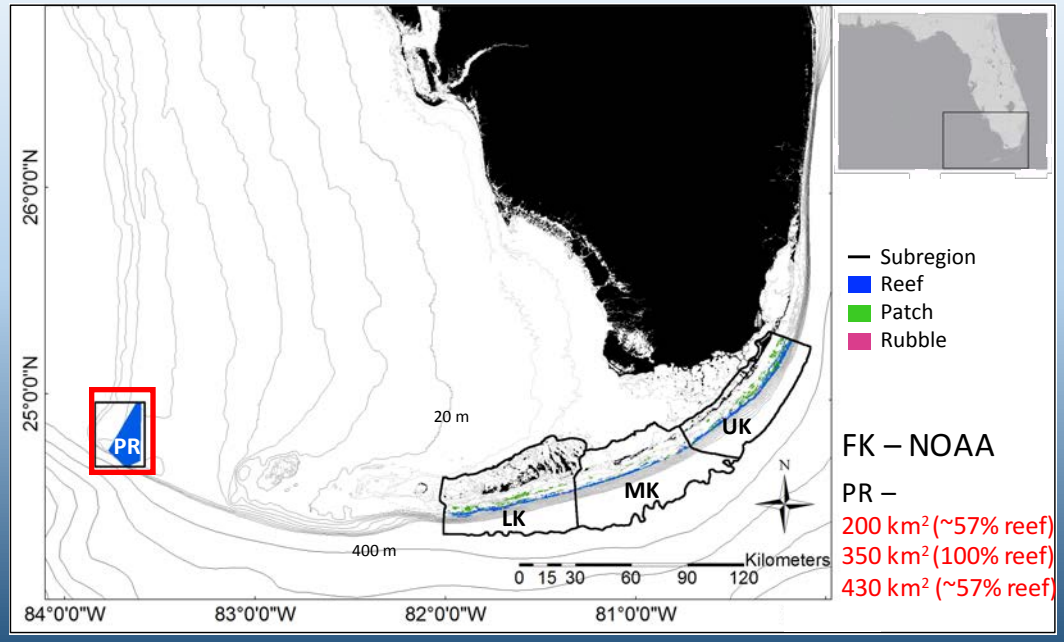
REPORT

Fitness consequences of habitat variability, trophic position, and energy allocation across the depth distribution of a coral-reef fish

E. D. Goldstein[1] · E. K. D'Alessandro[1] · S. Sponaugle[1,2]

3. REGIONAL REPRODUCTIVE OUTPUT





Florida Keys

Visual surveys 2009-2011—*NOAA RVC*

Adults = fish > 50 mm TL

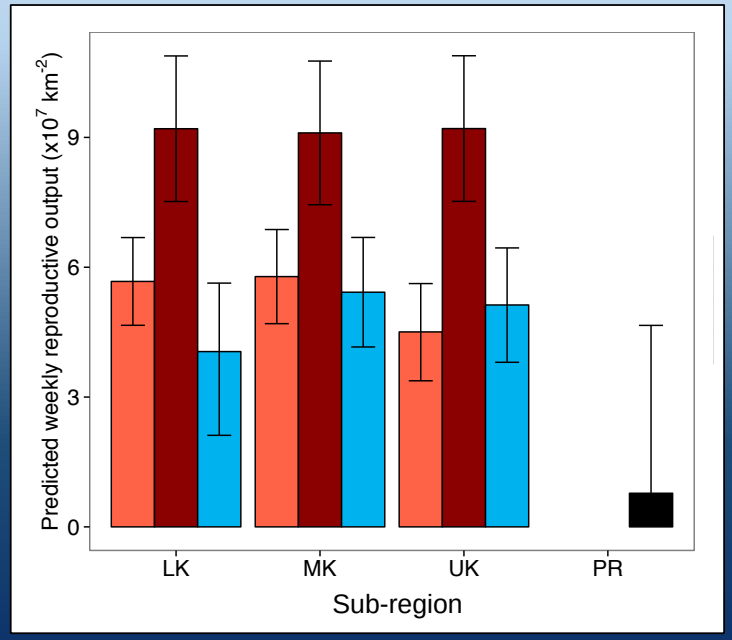
Pulley Ridge

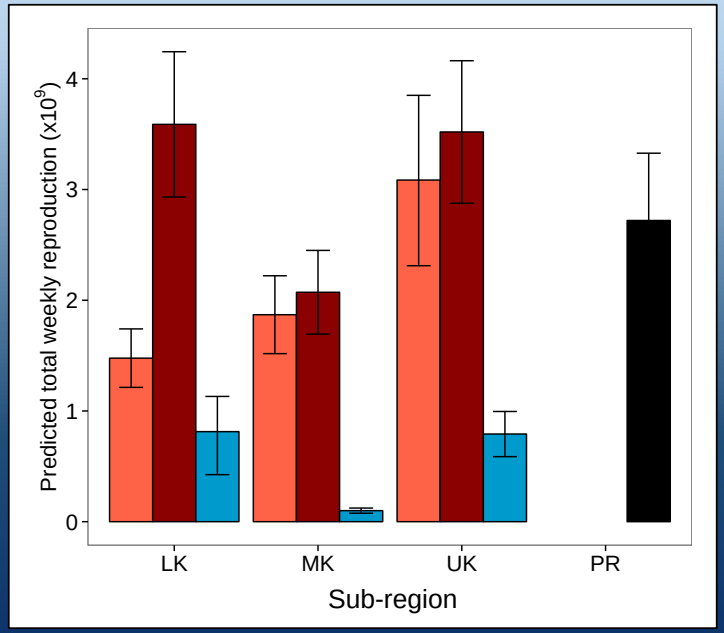
100 m x 5 m ROV surveys 2012-2013

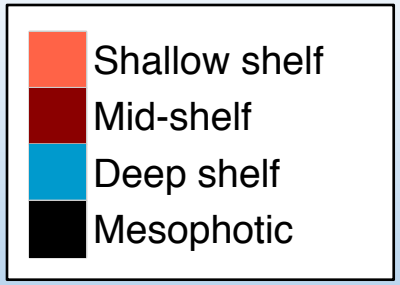
Reed et al. 2014

3. REGIONAL REPRODUCTIVE OUTPUT

Sub-regional reproduction







#eggs X 10^7/km^2

#eggs X 10^9 over total area

3. REGIONAL REPRODUCTIVE OUTPUT

Are PR mesophotic reefs potential larval source populations?

Population distribution

32% Shallow shelf

46% Mid-shelf

8% Deep shelf

14% Mesophotic

- Habitat-specific demographics
- Restricted by amt. avail habitat

9% of regional production

- Quantity vs. quality

1. DEMOGRAPHICS & REPRO	2. BEHAVIOR, DIET & FITNESS	3. REGIONAL REPRO OUTPUT

1. Habitat differences across depths have lifetime impacts on populations demographics & reproduction

2. Access, availability, & consumption of prey affect habitat suitability & energetic investment

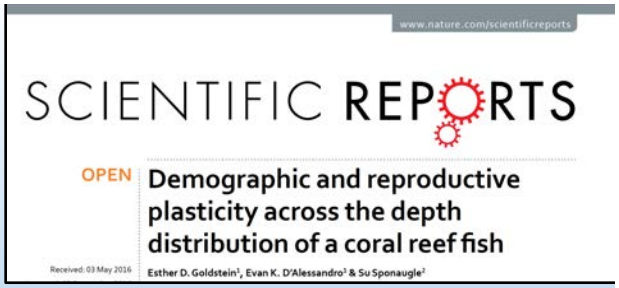
3. Sub-regional larval production is restricted by habitat availability & population demographics

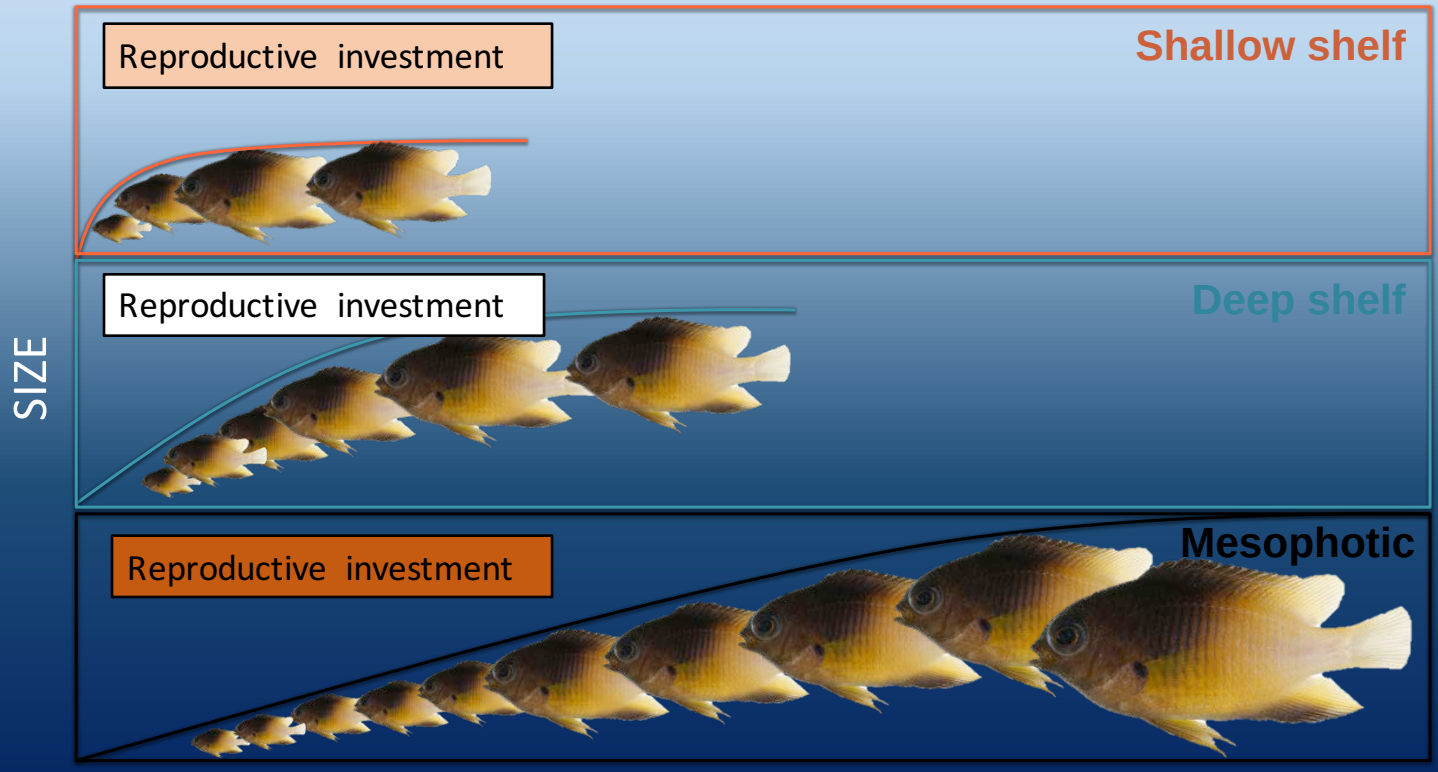
Temperature

Population density

Age, growth & reproductive investment

LOW — HIGH



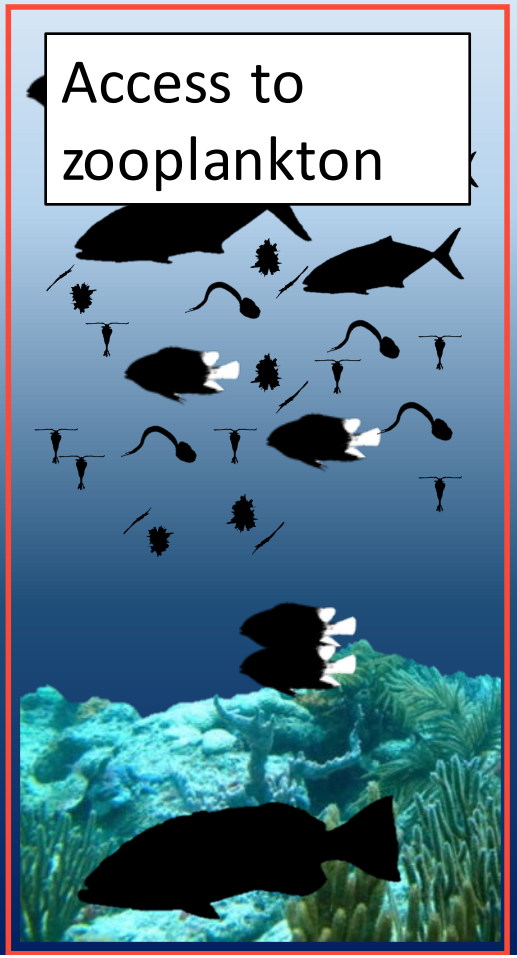


Behavior & diet

Fitness consequences of habitat variability, trophic position, & energy allocation across the depth distribution of a coral reef fish. *Coral Reefs*
Goldstein ED, D'Alessandro EK, Sponaugle S

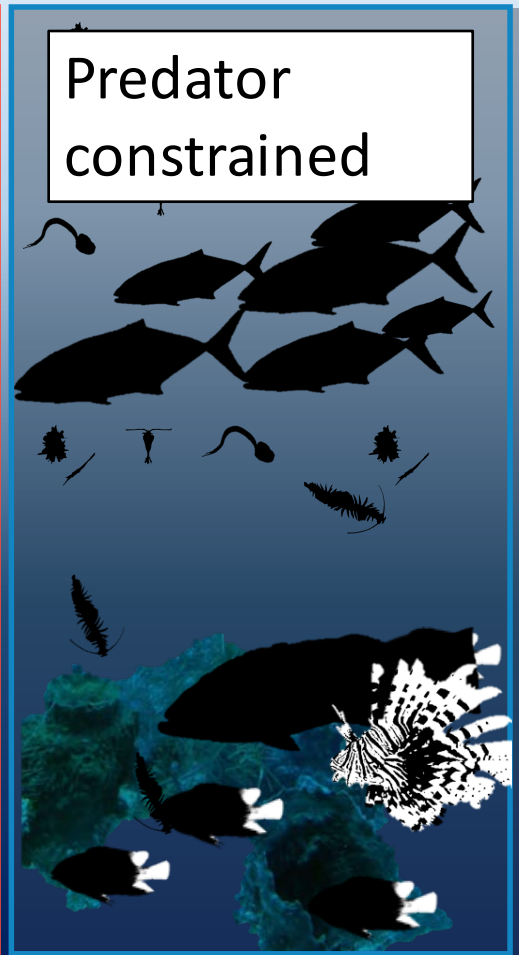
Shallow shelf

Access to zooplankton



Deep shelf

Predator constrained



Mesophotic

Diverse & variable diet

Suitable habitat

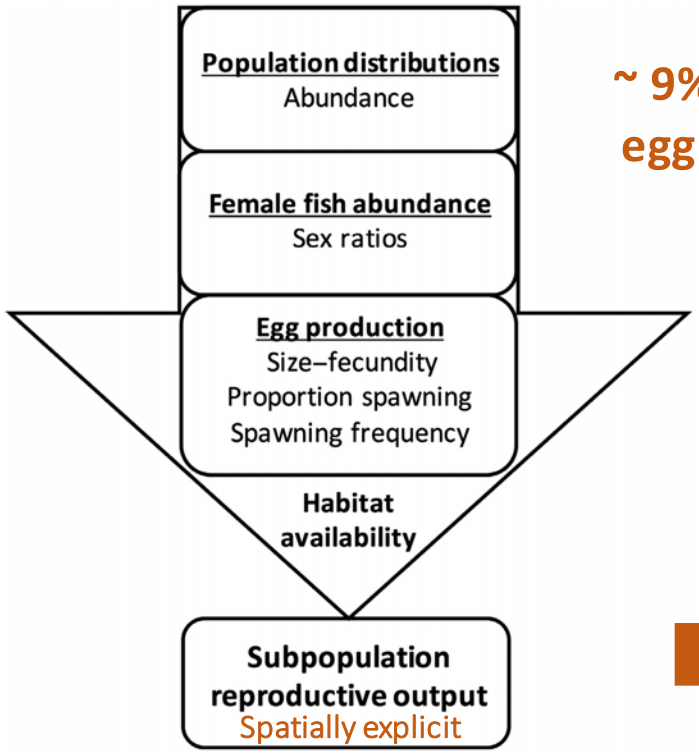
Diet
Size
Longevity
Reproduction

Regional reproductive output

esa ECOSPHERE

Habitat availability and depth-driven population demographics regulate reproductive output of a coral reef fish

E. D. Goldstein,[1,†] E. K. D'Alessandro,[1] J. Reed,[2] and S. Sponaugle[3]



~ 9% of total regional egg production from PR

Parameterize Individual-Based Model particle release

(ongoing collaboration w/Paris Lab)

SUMMARY: Are mesophotic reef refuges or marginal habitats for reef fish?

Individual fish

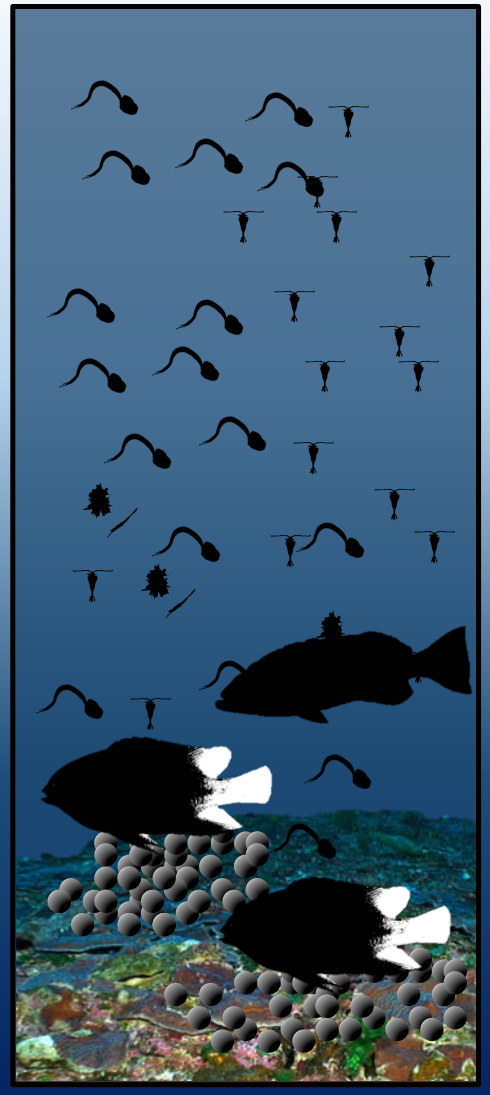
↑ Habitat suitability at periphery of depth distrib

Population

↓ Resilience

Larval source population?

↑ Reproductive investment;
dependent upon availability of habitat



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