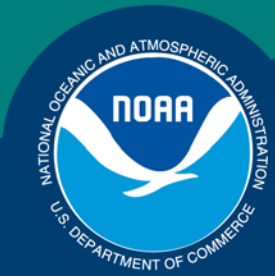


Science, Service, Stewardship



The how and why of hermaphroditism

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Woods Hole Laboratory

²Southeast Fisheries Science Center,
Panama City Laboratory

**NOAA
FISHERIES
SERVICE**

NOAA



Outline



Sex determination in fishes

- beyond gonochorism (the how)

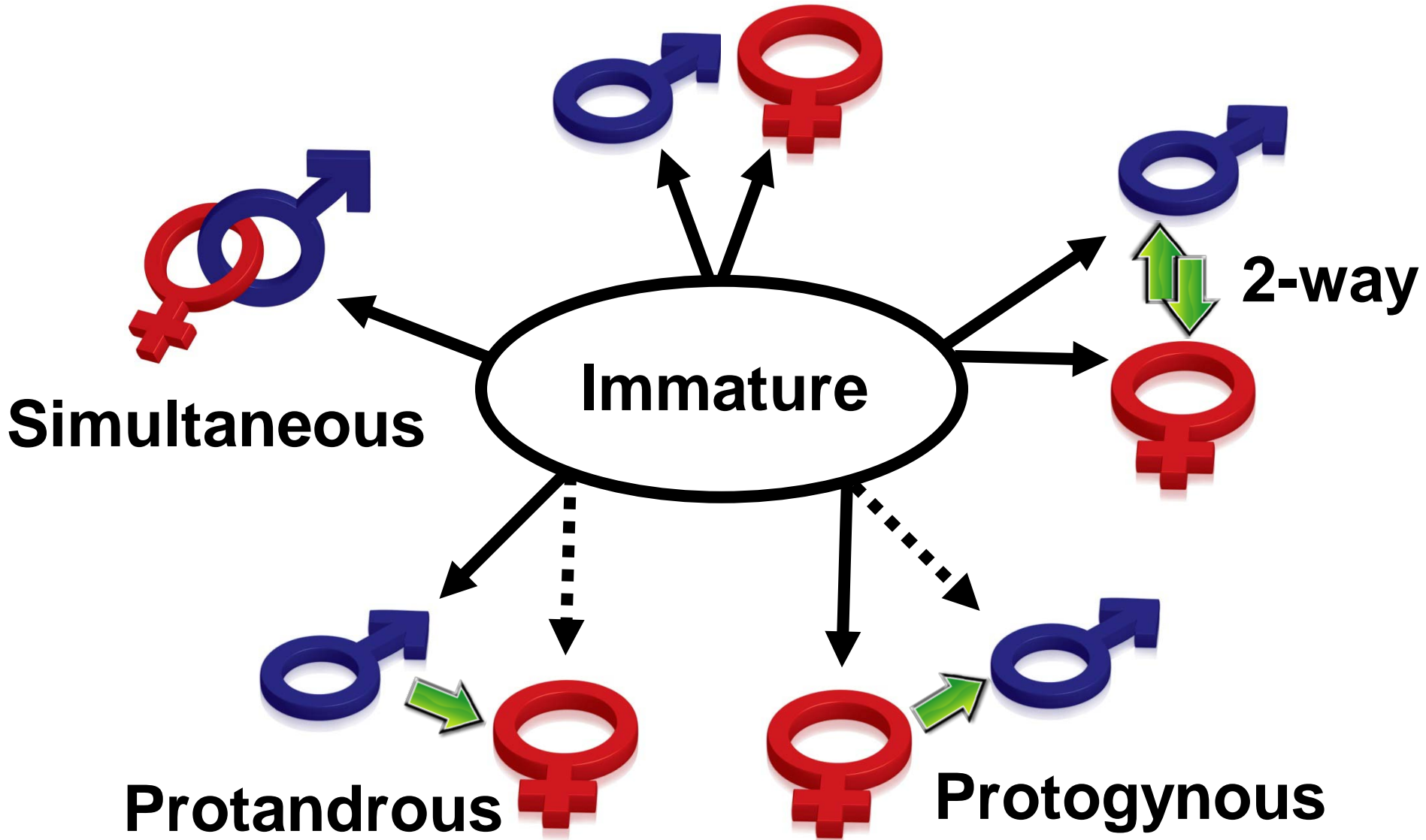
Processes of (sequential) sex change

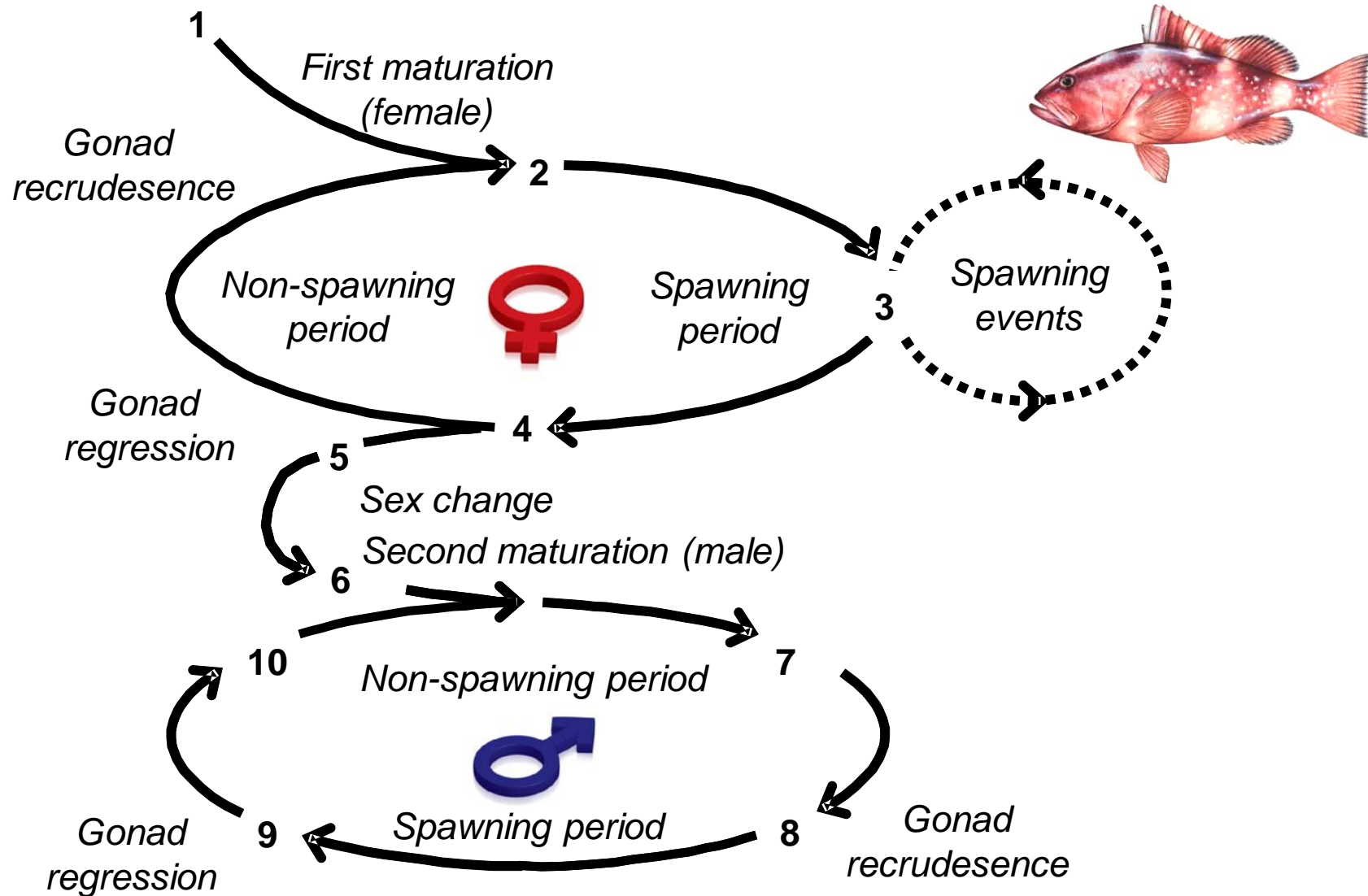
- sex order, timing and rates (the why)

Case studies

- hogfish, gag, black sea bass

Gonochoristic (genetic or environmental sex determination)

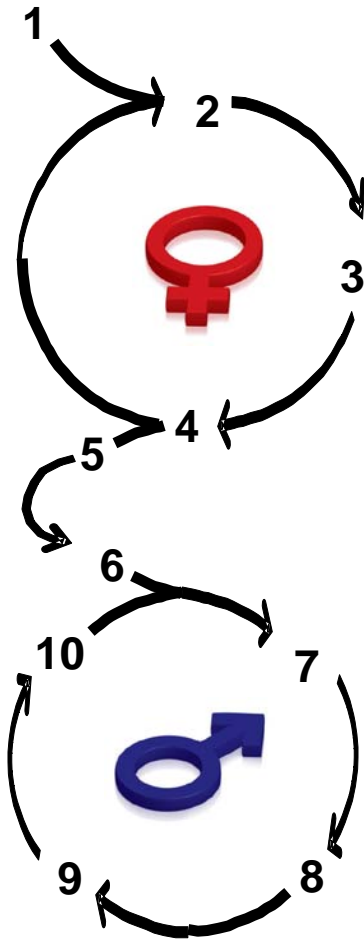




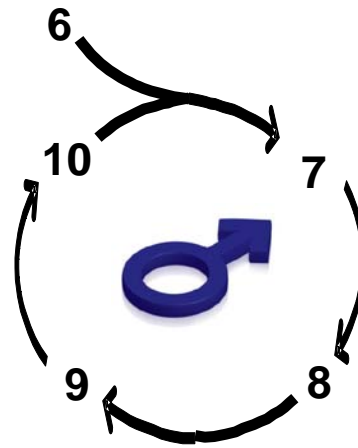
Moe's (1969) reproductive scheme for red grouper

- Monandric (no alternative sexual strategy)
- Post-maturational sex change

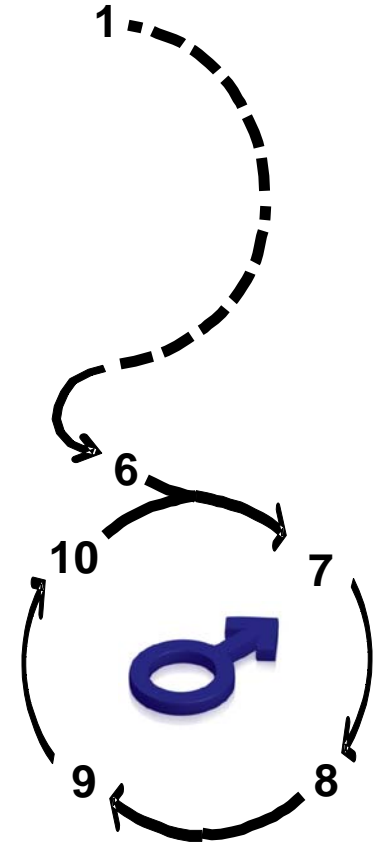
Alternative strategies (mixed strategies)



+



+



Hermaphrodite,
Post-maturational change
(Monandry, pure strategy)

Gonochores
1° male
(Diandry)

Functional
Gonochores
(Pre-maturational
sex change)

Mating systems (Monogamy)

Clownfish are protandric and monogamous



Mating systems (Spawning aggregations)

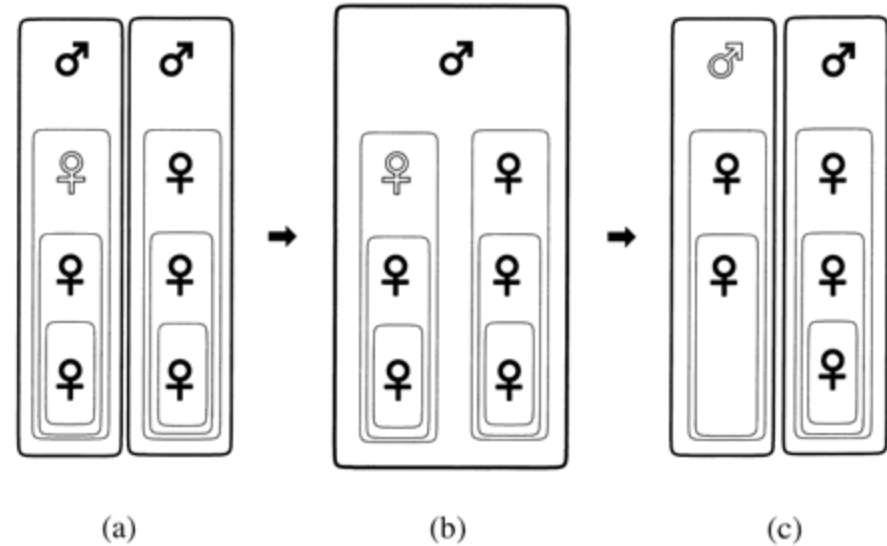
An increased density of fish occurs together with verification of spawning



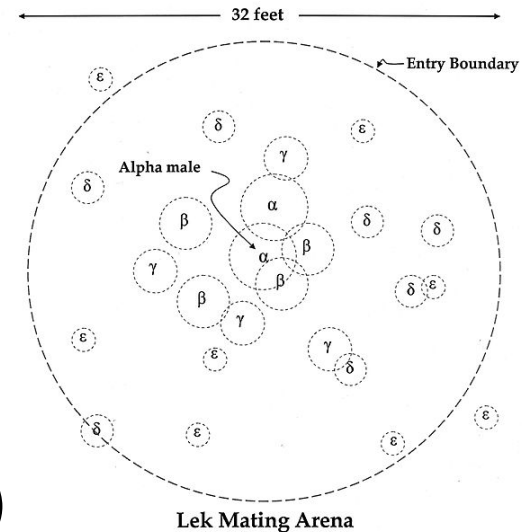
Cubera snappers in a spawning aggregation
(seapics; <http://www.scrfa.org/index.php/home.html>)

Mating systems (Harem v. Lek)

A harem is a defended territory with one male mating with several females.
(common with protogyny)



A lek is a spawning arena of several males.
Females come and go.



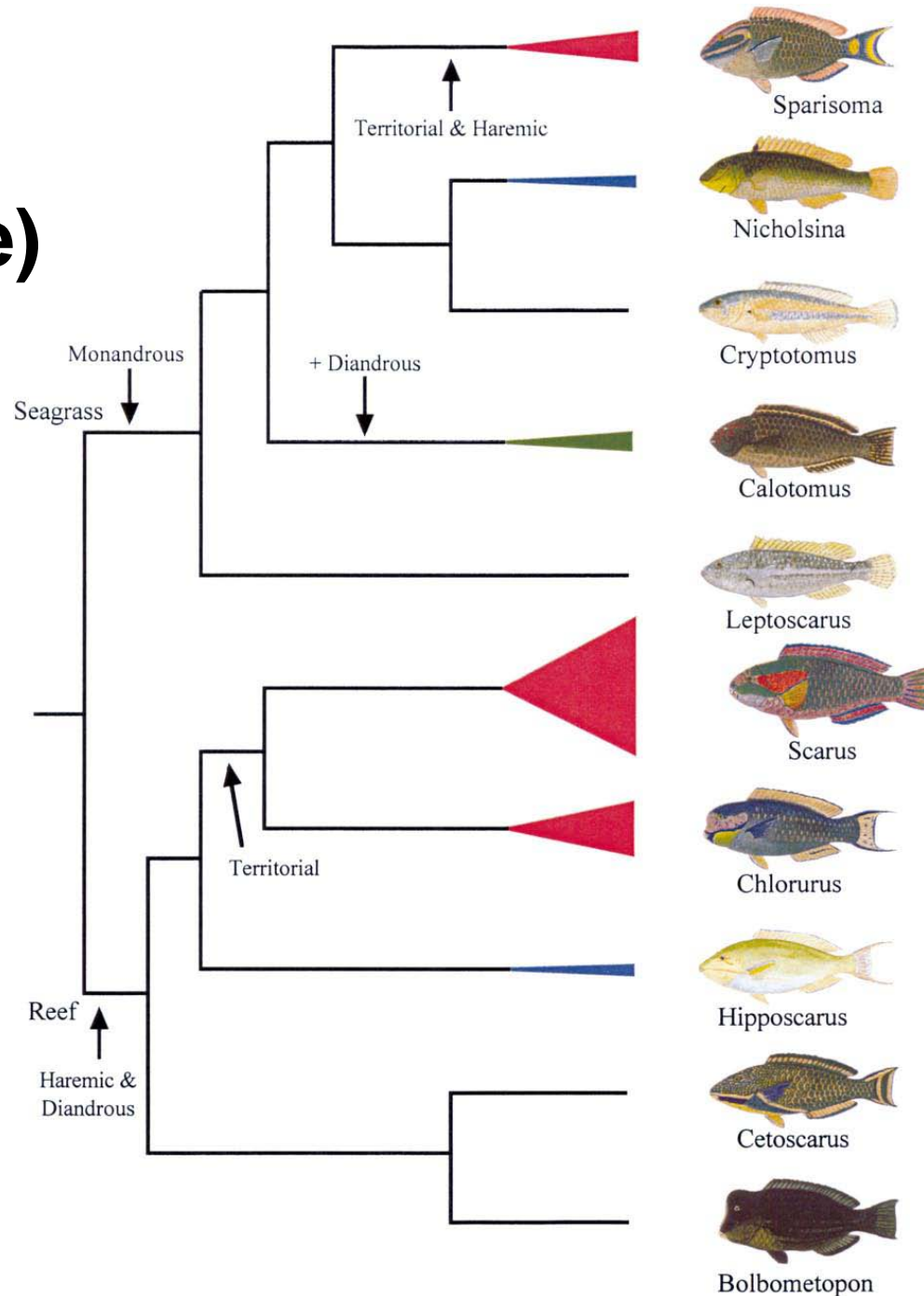
Both are forms of polygamy
(but local sex ratios are reversed)

Diversity

Parrotfishes (Scaridae)

Related to:

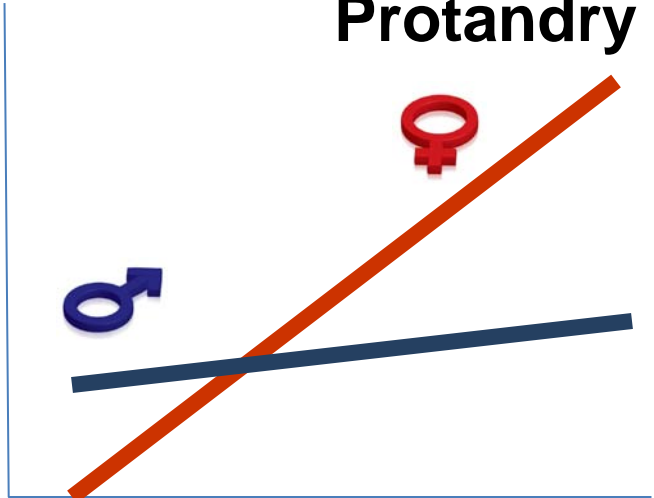
- Sex change strategy
- Mating systems
- Habitat



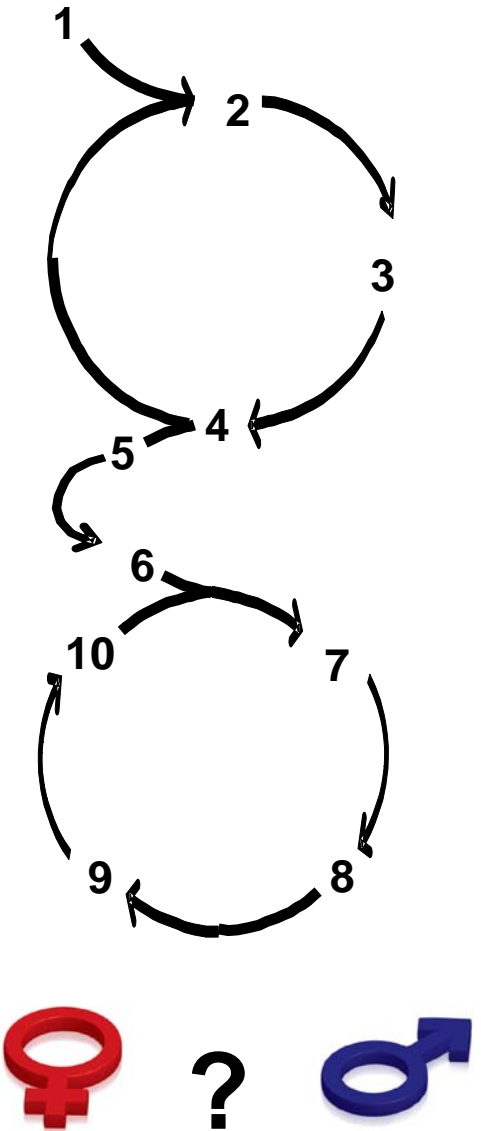
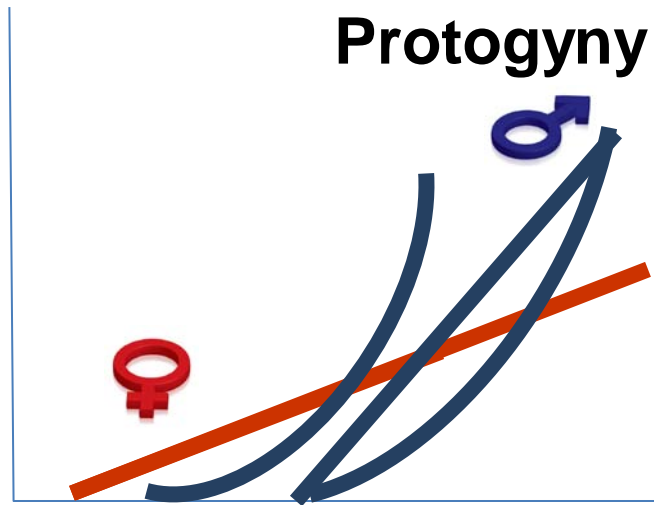
What affects sex order and timing of sex change?

Favors:

Protandry



Protogyny



Species accounts

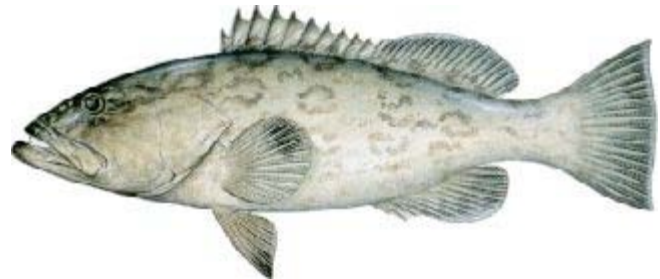
Hogfish

Lachnolaimus maximus
(Labridae)



Gag

Mycteroperca microlepis
(Serranidae)

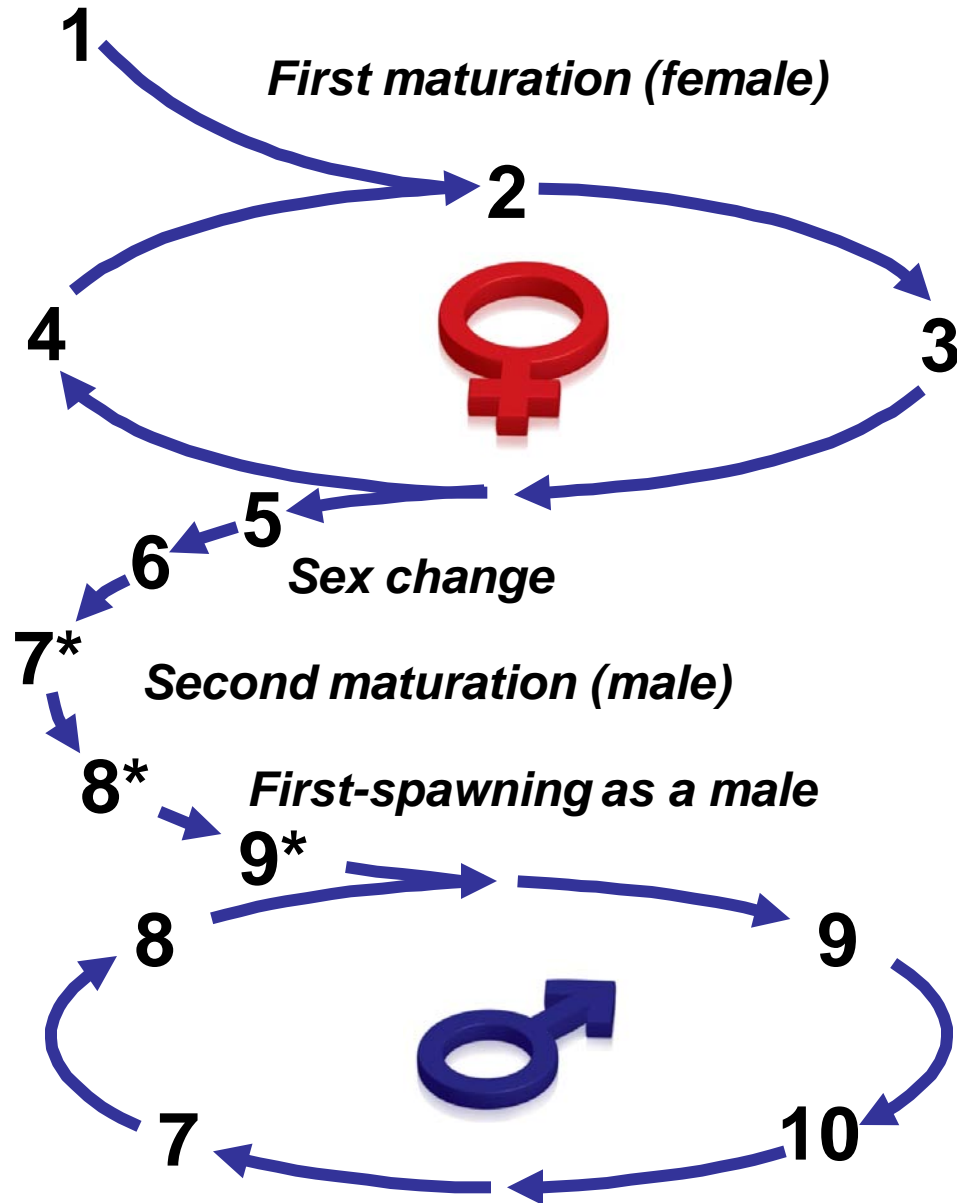


Black sea bass
Centropristis striata
(Serranidae)



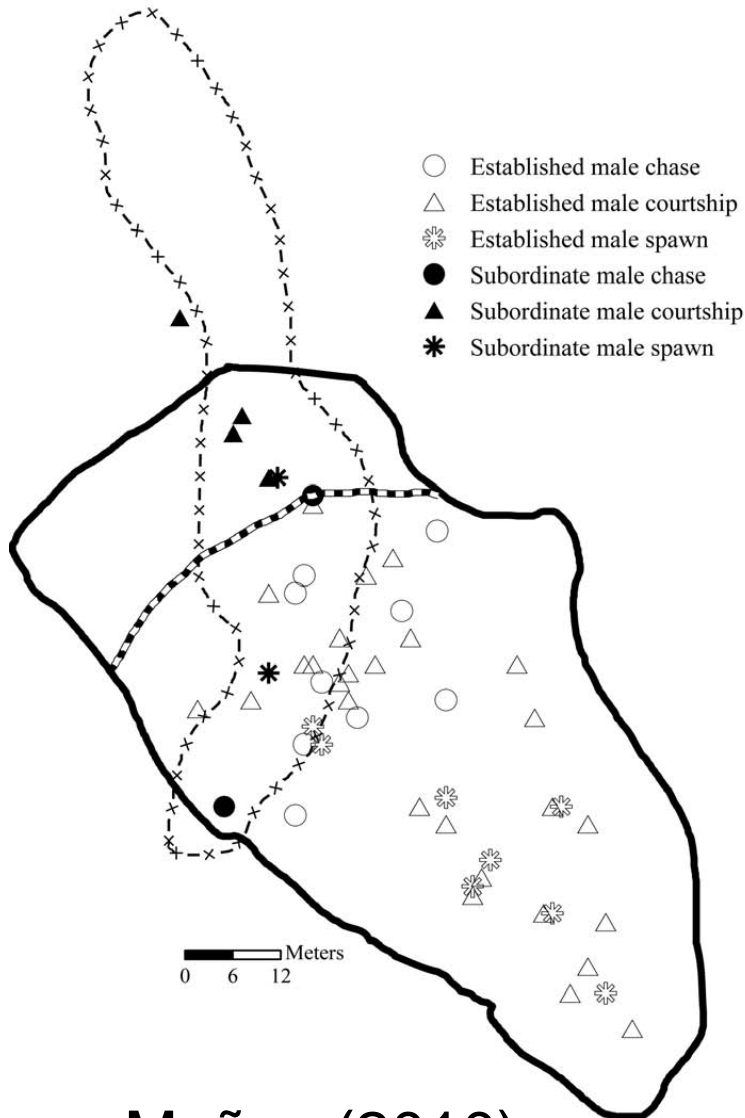
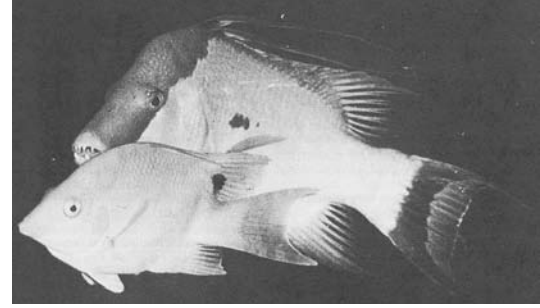
Illustrations: Diane Rome Peebles

Sexual development of hogfish



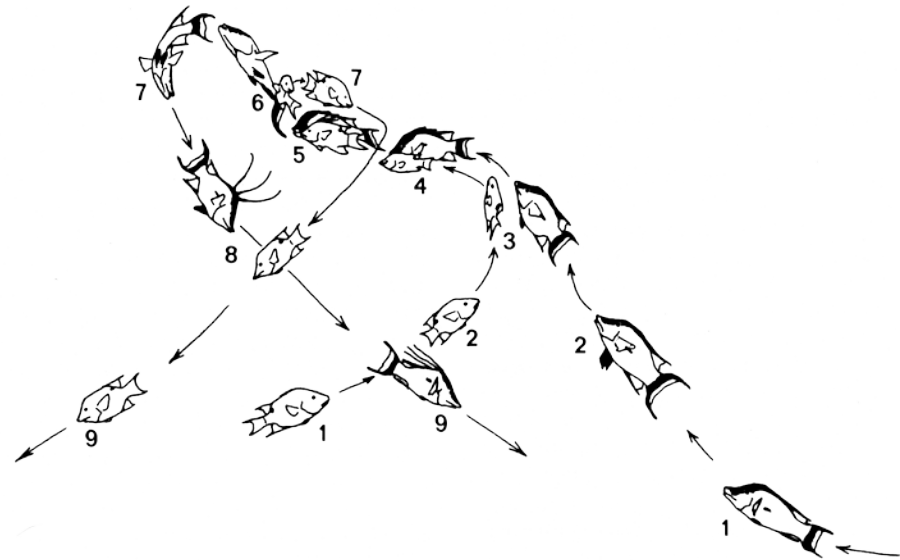
**Protogynous
Monandric
Postmaturational
Dimorphic
Dichromatic
Haremic**

Hogfish males defend a territory...



Muñoz (2010)

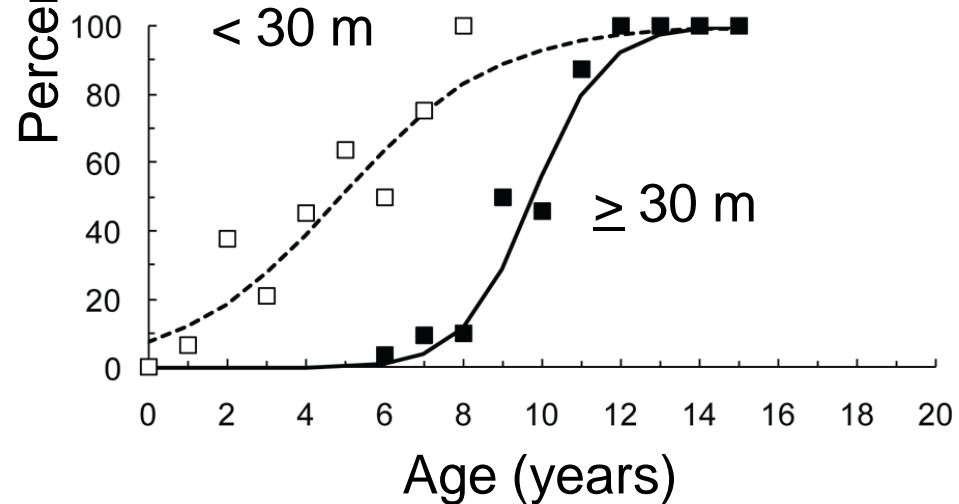
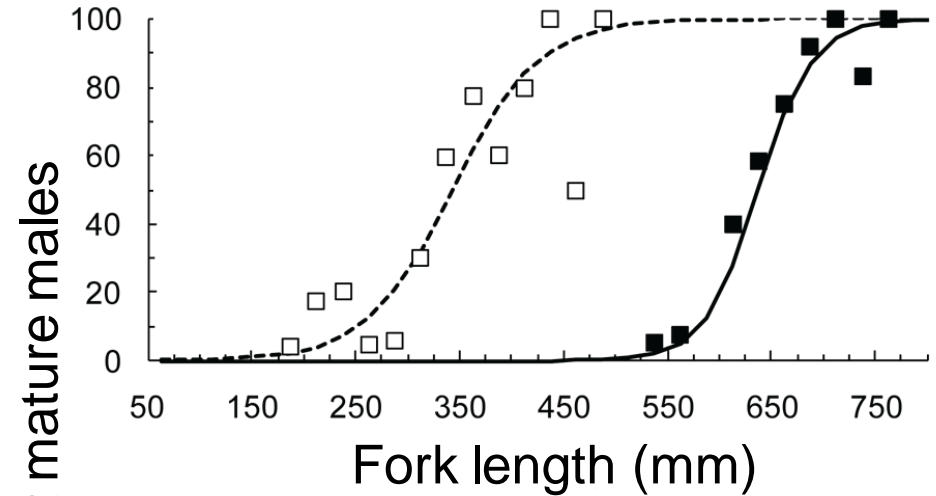
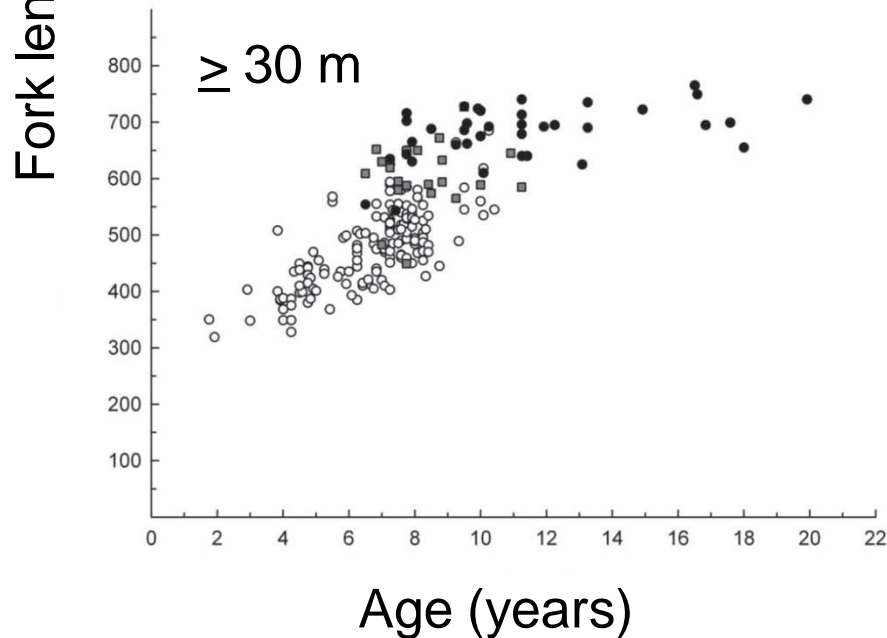
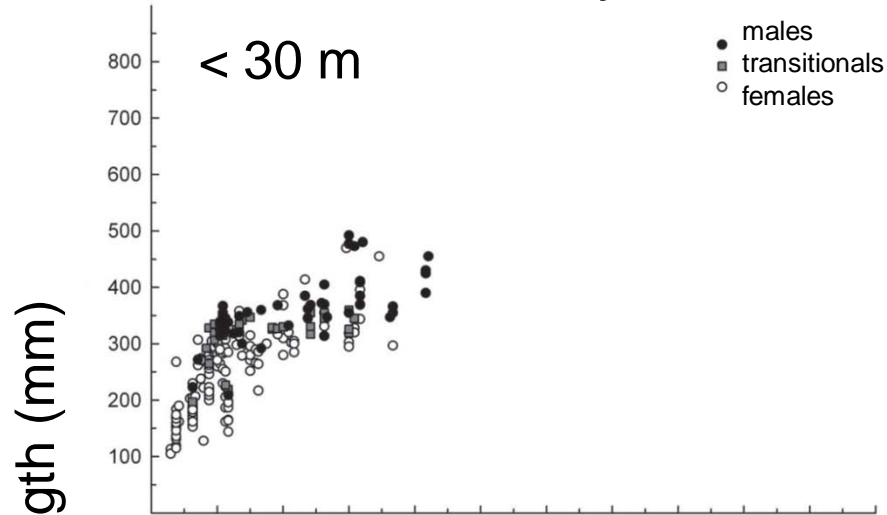
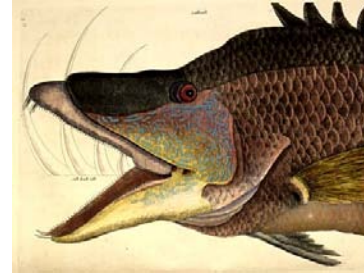
and spawn with several females per day for weeks or even months



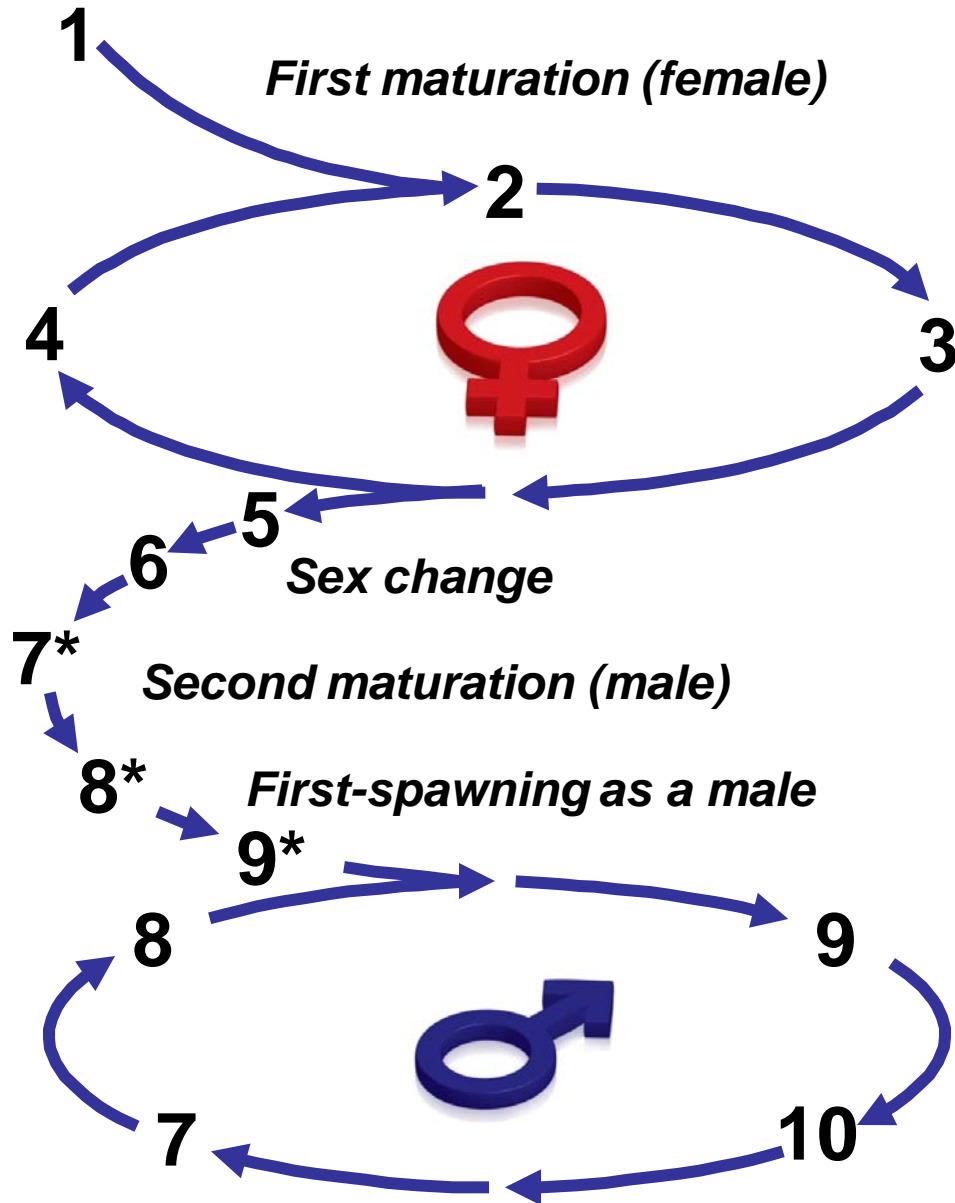
Colin (1982)

Hogfish demographics are spatially dynamic

- Ontogenetic movements
- Differential mortality



Sexual development of gag



**Protogynous
Monandric
Postmaturational
Dichromatic
Lek forming ?**

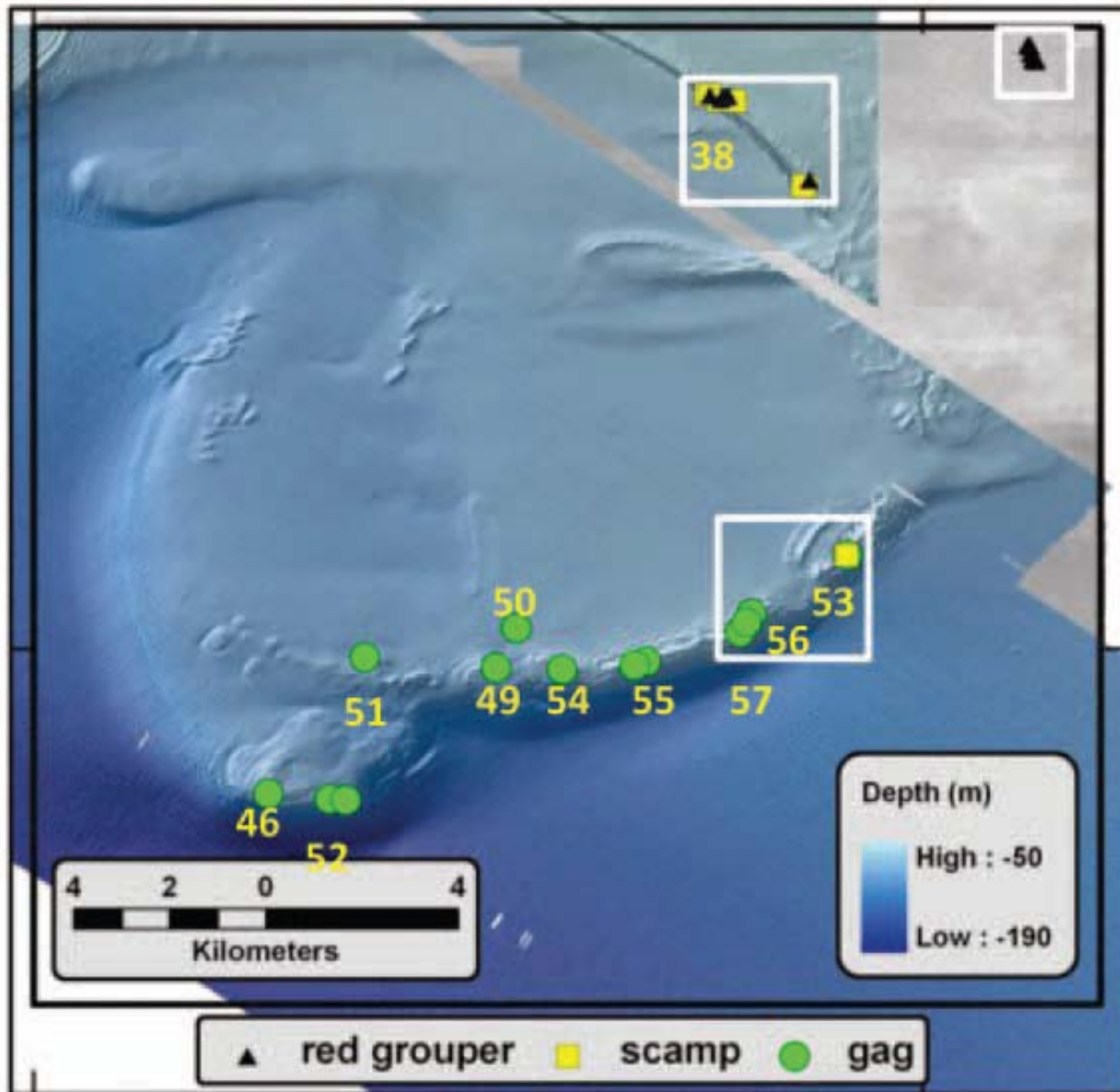
Transitional fish more common after spawning season ends

(Gilmore and Jones 1992;
Koenig et al. 1996)

85°50'W

85°40'W

29°10'N



Gag spawning sites are high relief outer shelf relict reef tracts

The mating system is poorly understood; still small males 'must be' reproductively disadvantaged.

How should we design a program to monitor sex ratios, fish sizes, and reproductive potential?

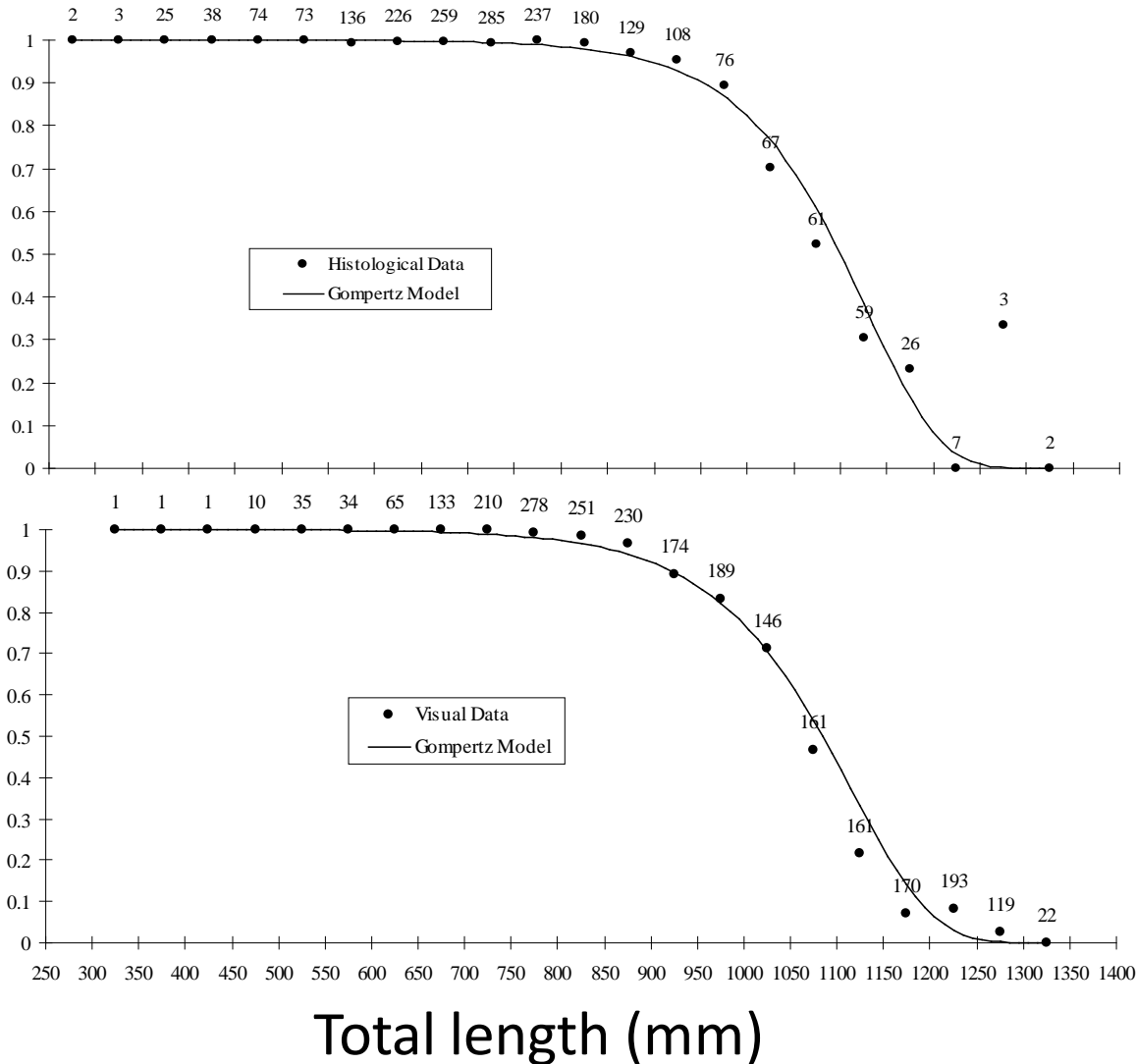
(Fig 3. Coleman et al. 2011)

Proportion female by size:

assessed with gonad histology (top)
assessed by pigmentation (bottom)



Proportion female

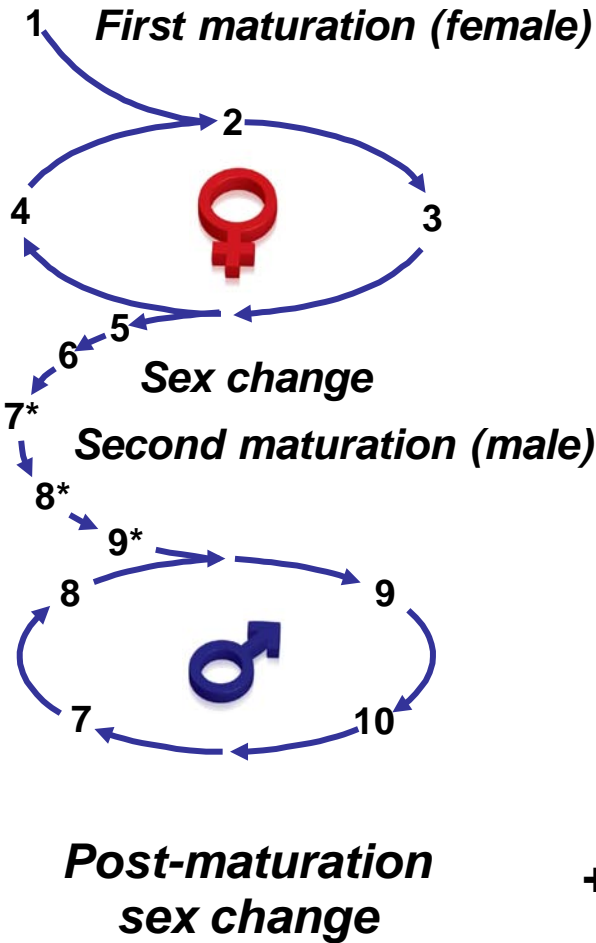


No evidence for change in size/age at transition with changing fishing effort over 30+ years.

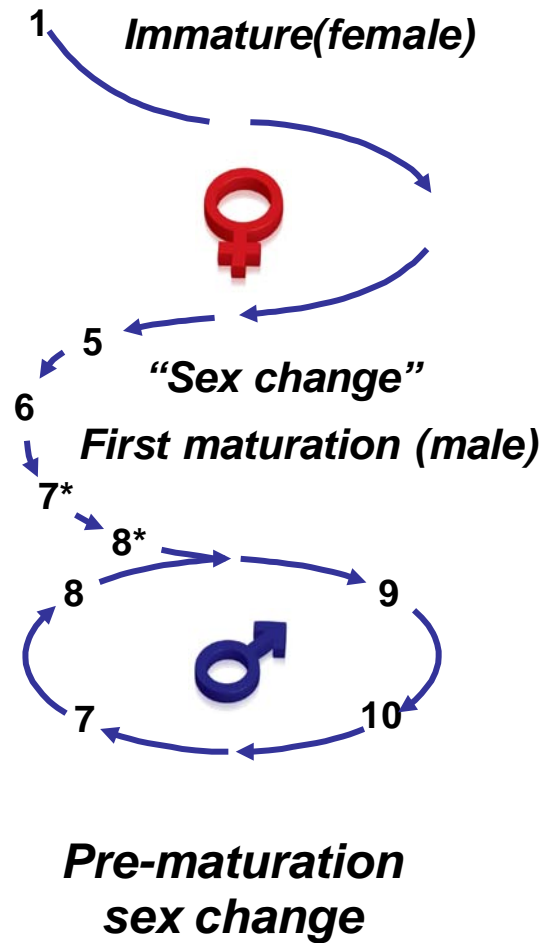
Sex change Age₅₀ = 10.8 years

Sexual development of black sea bass

mixed strategy



+



Protogynous
Monandric
Post- & Pre-maturation
Dimorphic & dichromatic
(but not diagnostic)
Lek forming ?

Transitional fish more
common after spawning
season ends

FEMALE



D

MALE



2010 (May-Oct), MA and RI waters, CRP

Representative macroscopic images

D-Developing,
R-Ripe,
U-Running ripe,
S-Spent,
T-Resting.



R



Three 'functional' classes

- female
- subordinate male (no 2° characteristics)
- dominant male (with 2° characteristics)



U



Regional variations

- Movements
- size, age
- reproductive patterns



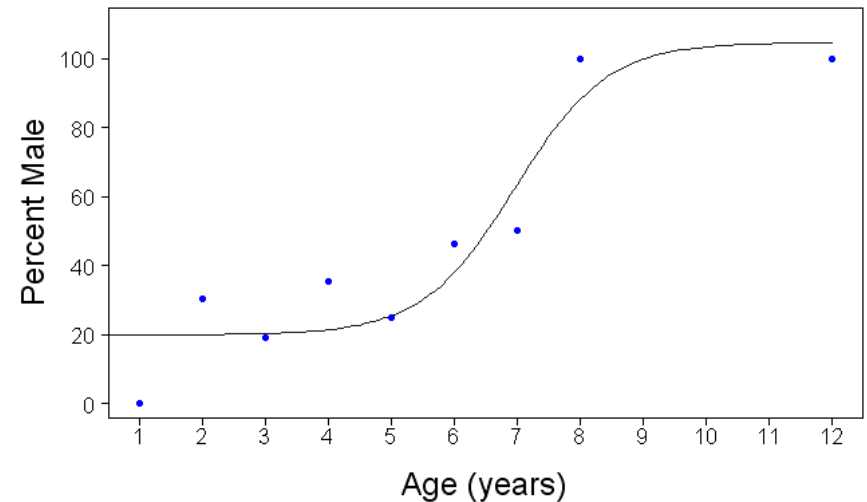
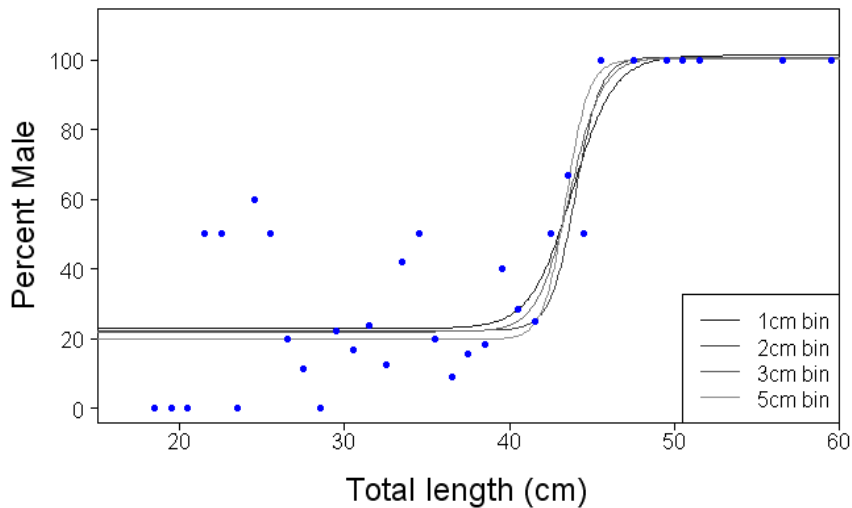
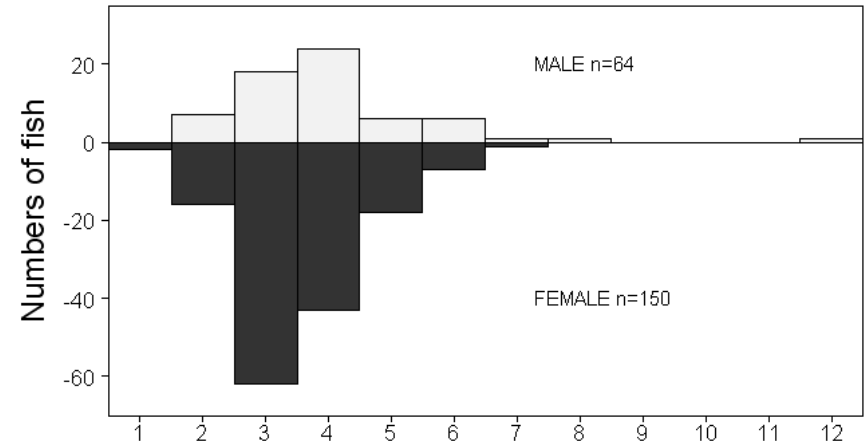
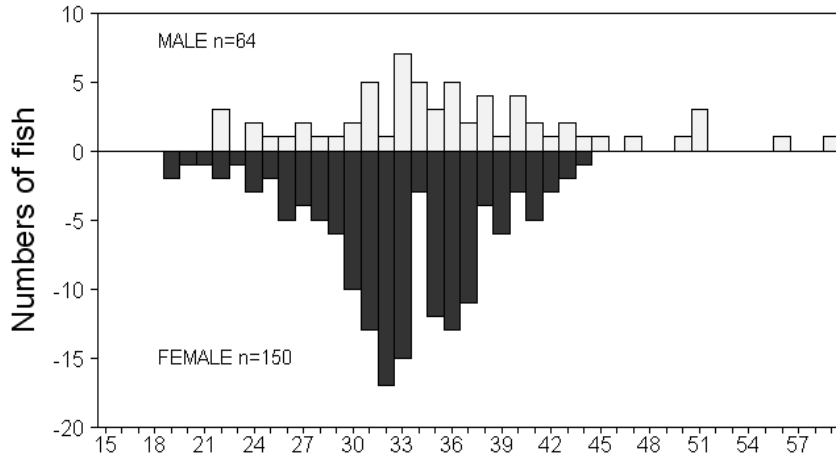
S



T



2010 (May-Oct) MA and RI waters Cooperative Research Program 4-parameter model of sex by size/age





Biological inputs useful for assessing hermaphroditic species

Demographics
(length, sex, maturity, age)

Repro.
potential
(egg, sperm fecundity)

Sexuality
(sex order, timing,
pure/mixed)

Mating system
(sex ratio, mate choice,
2^o characters)





Acknowledgements

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Massachusetts Division of Marine Fisheries

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NE Cooperative Research Program (NFFM7230-1106444)