Science, Service, Stewardship

Does Size Matter?

Effect of catching and releasing various sizes of fish on stock sustainability

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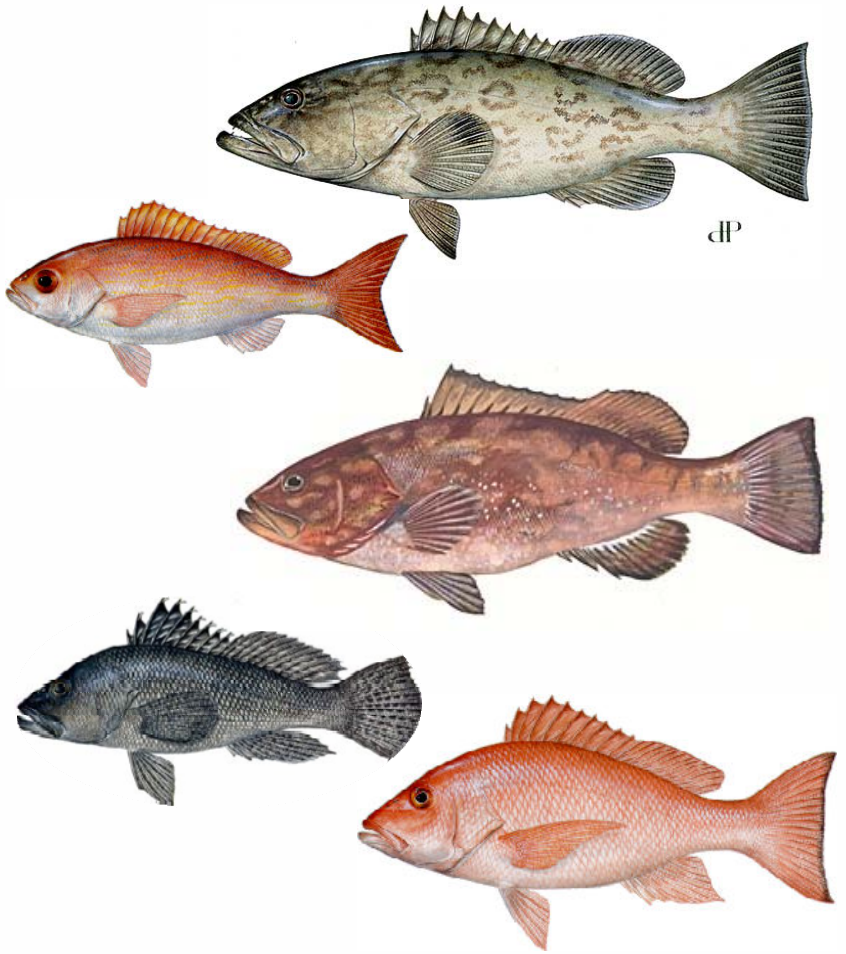
Topics…

- Fish size
  - Reproductive value
  - Release mortality
    - Depth
- Implications for stock sustainability
- Management implications
- Research recommendations



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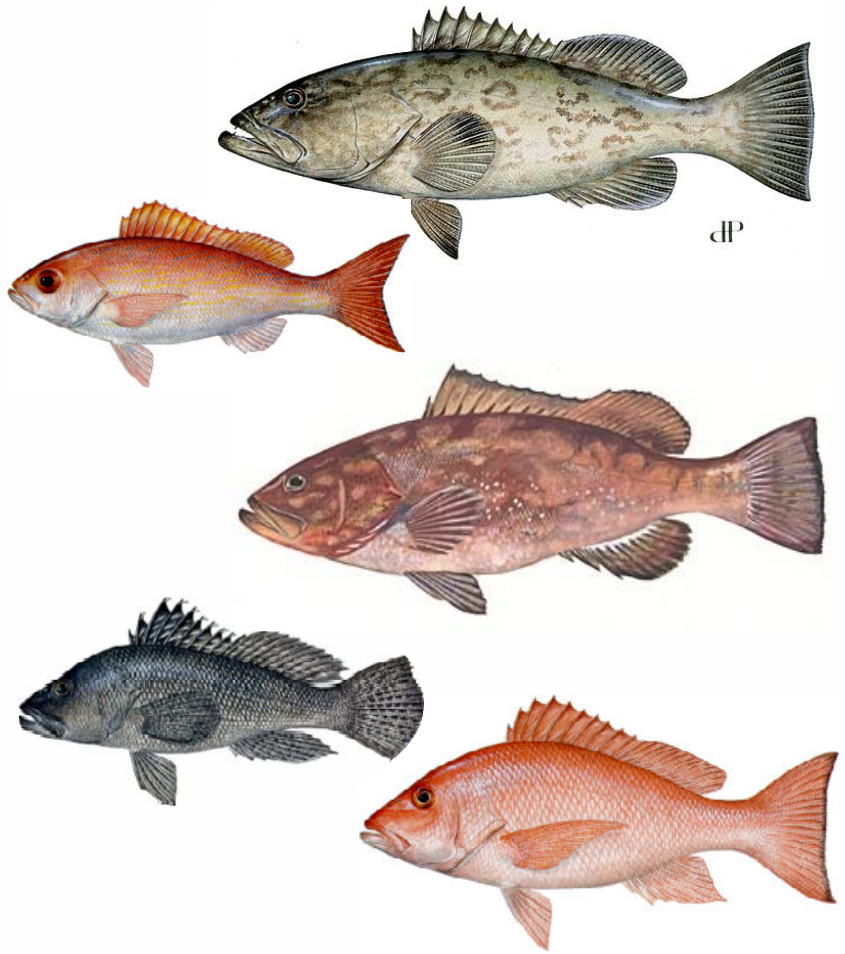
Size and reproductive value

Reef fish in the SE US:

- Reproduce by spawning; external fertilization
- Spawn multiple times a year (batch spawners)

Annual fecundity =
(# eggs per spawn) x (# of spawns per year)



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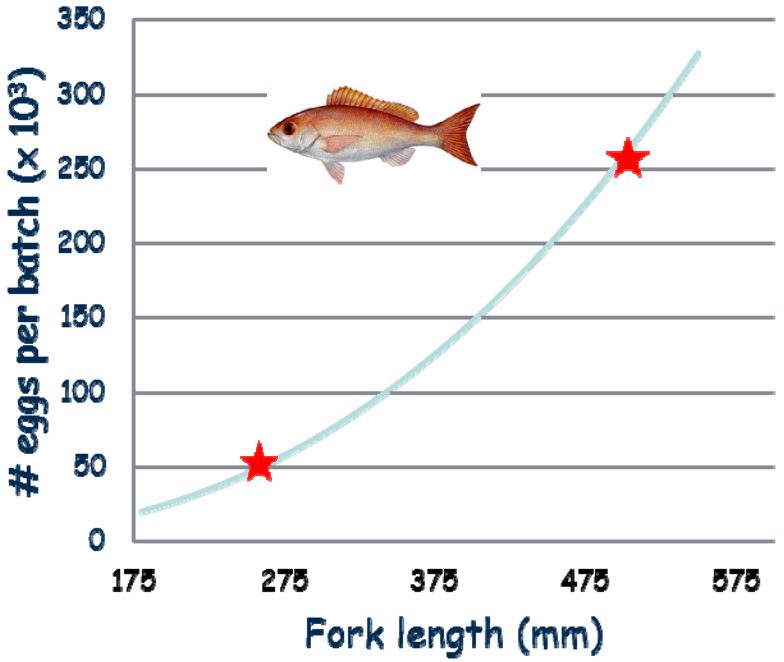
Does size matter?

- Yes
  - Non-linear relationship between fish size and # of eggs produced per batch
- $E = aw^b$
- For a small increase in fish size, there is a disproportionate increase in # eggs per spawn



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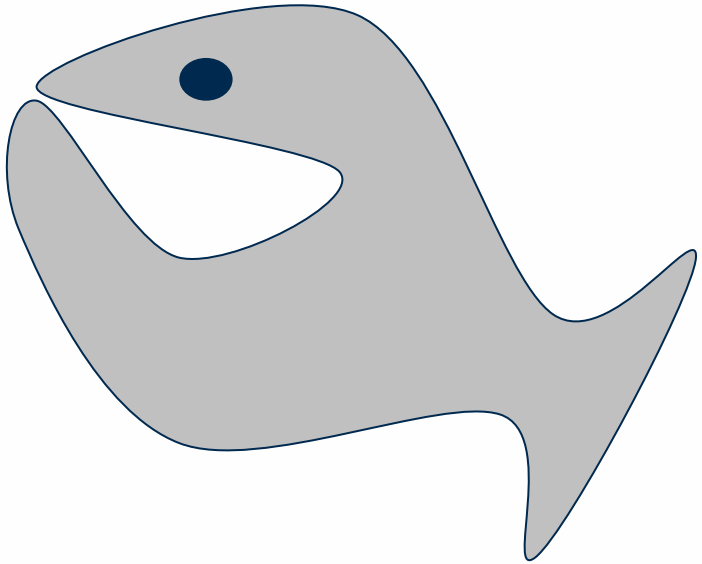
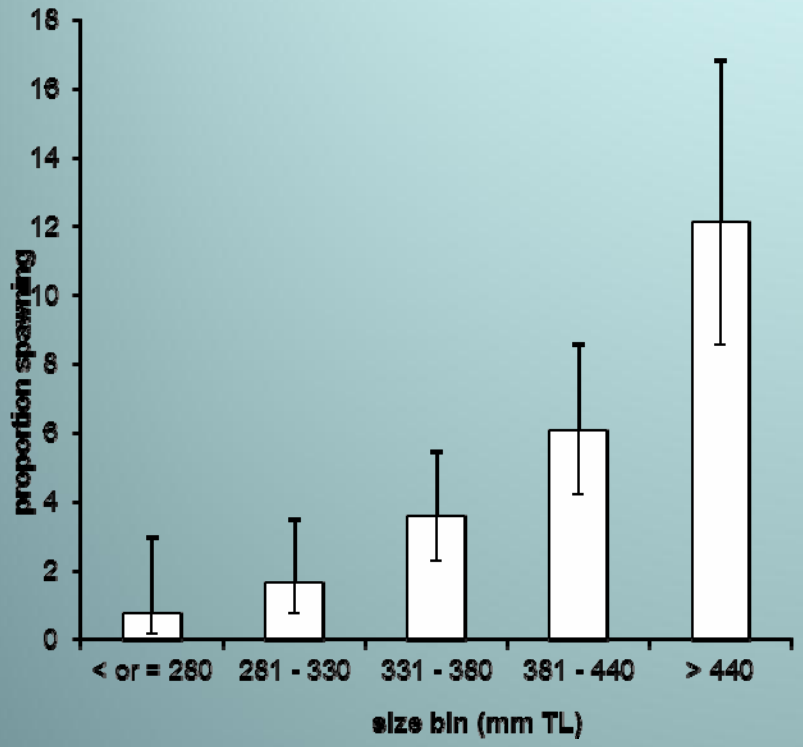
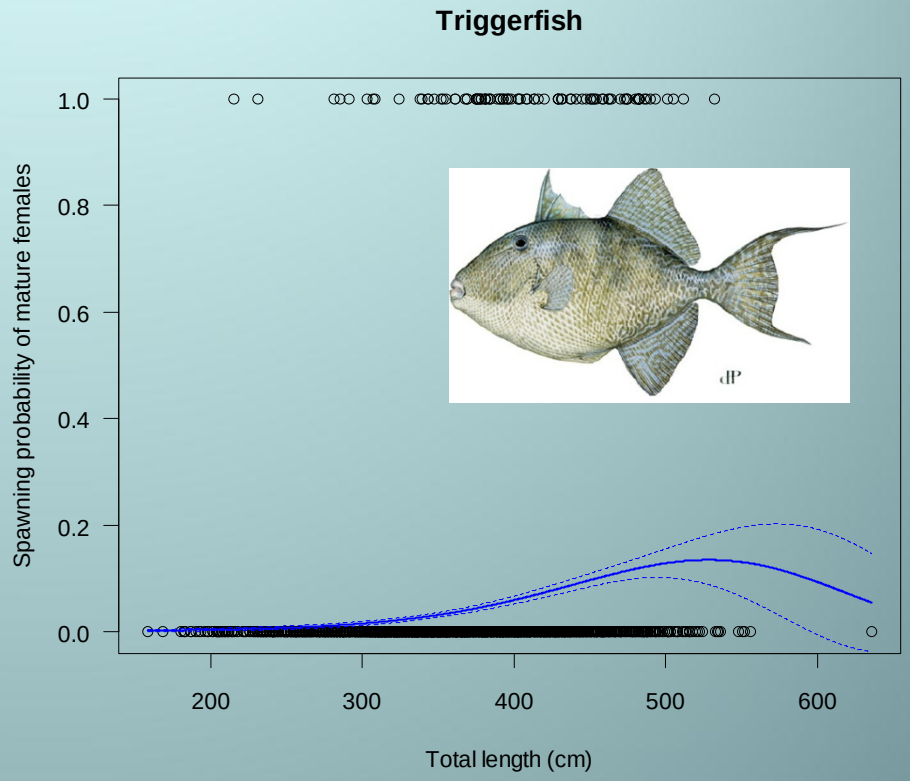
Does size matter?

- Unclear - relationship unknown for many species in southeast



Does spawning frequency vary with fish size?





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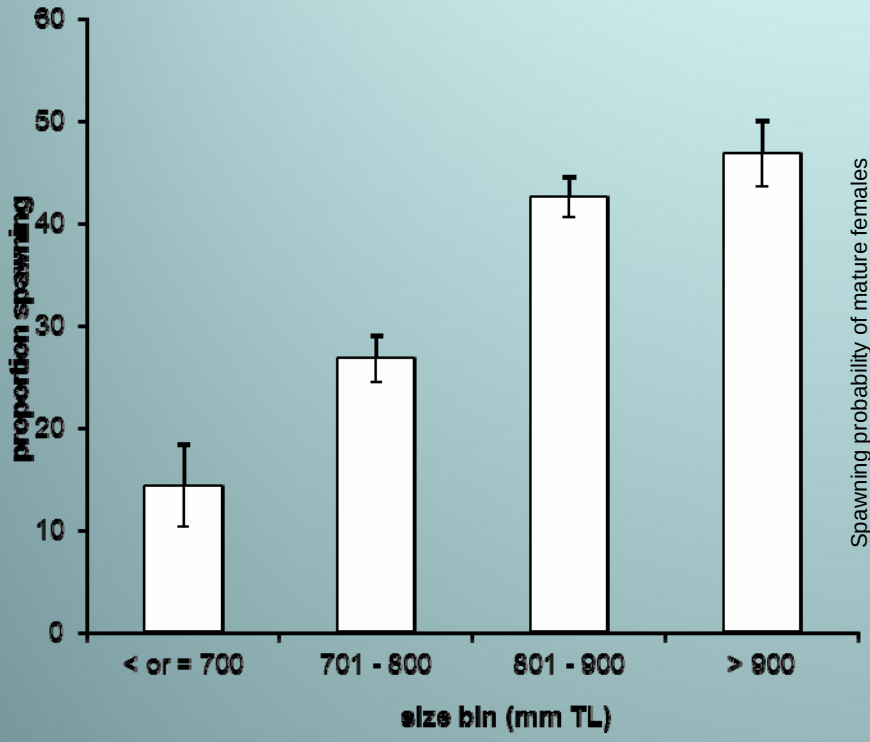

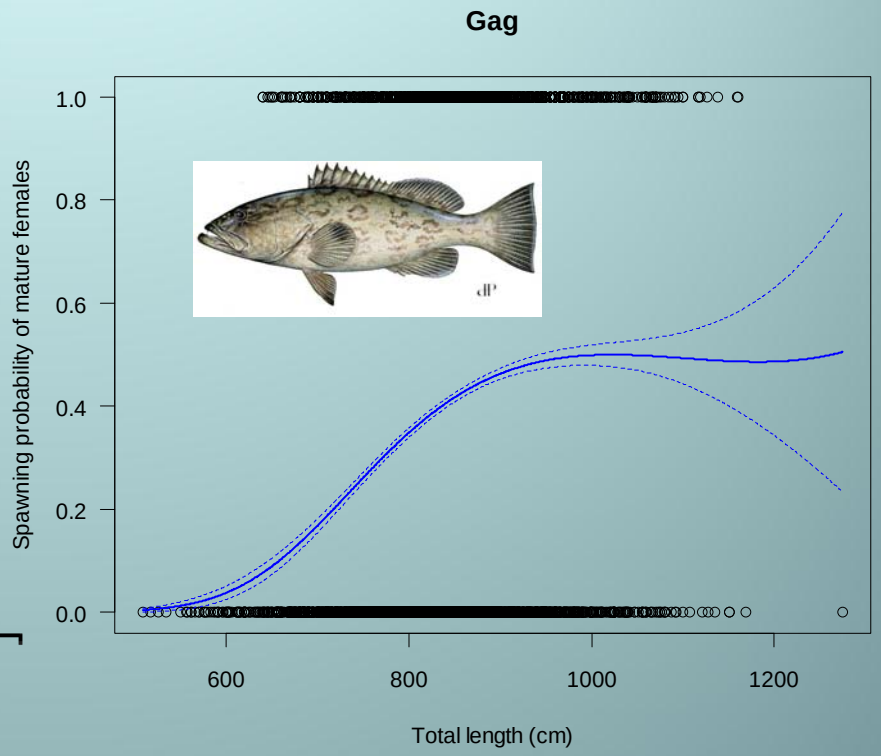

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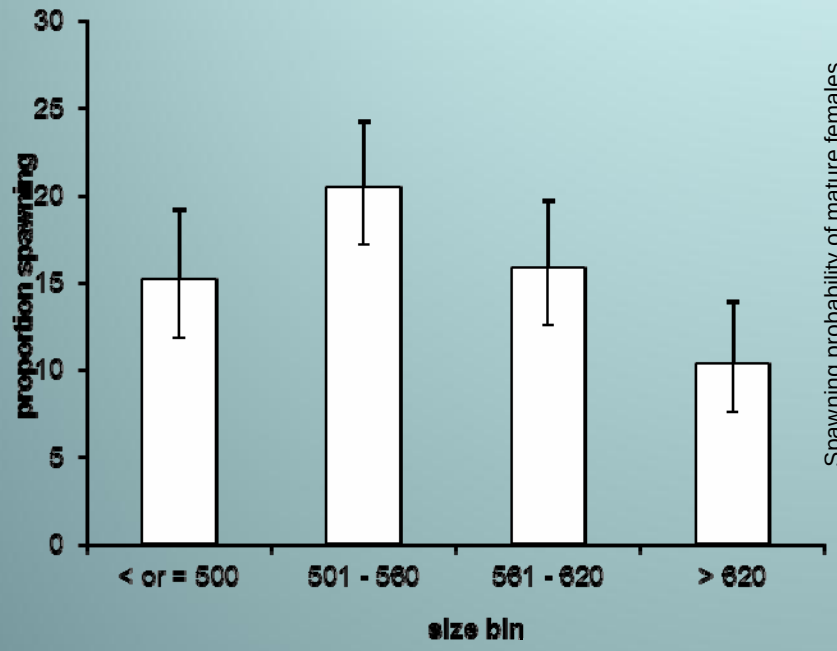

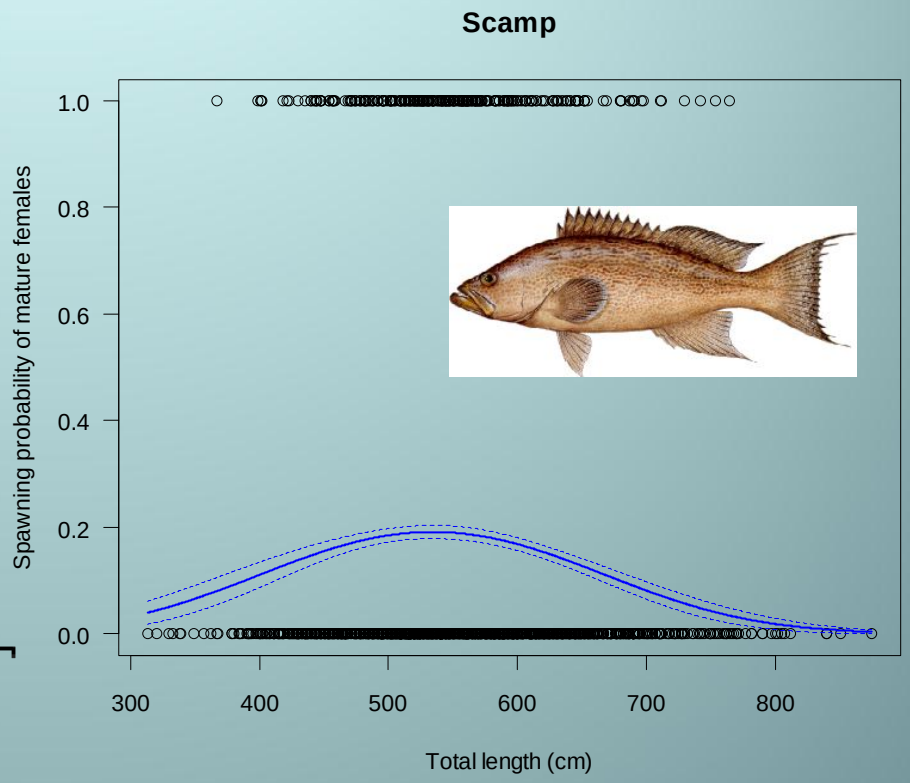

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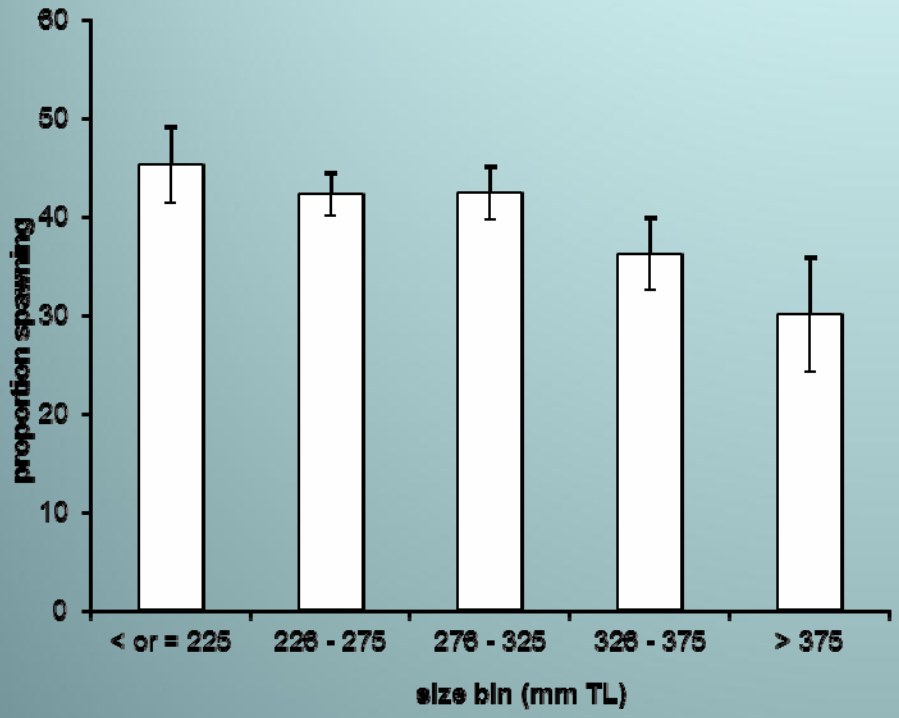

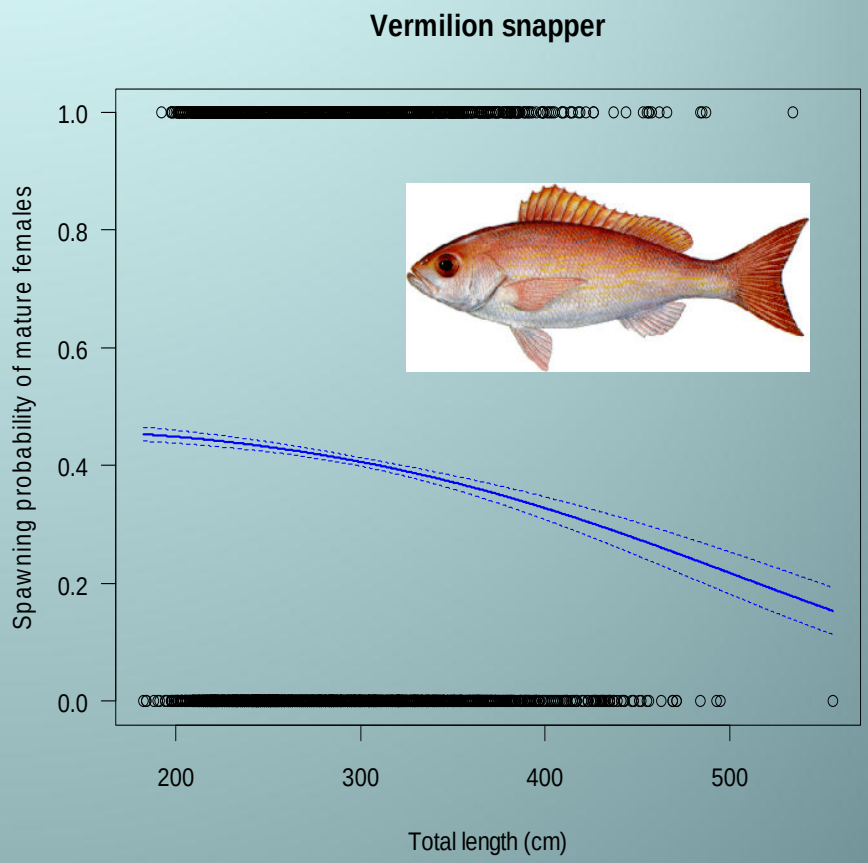

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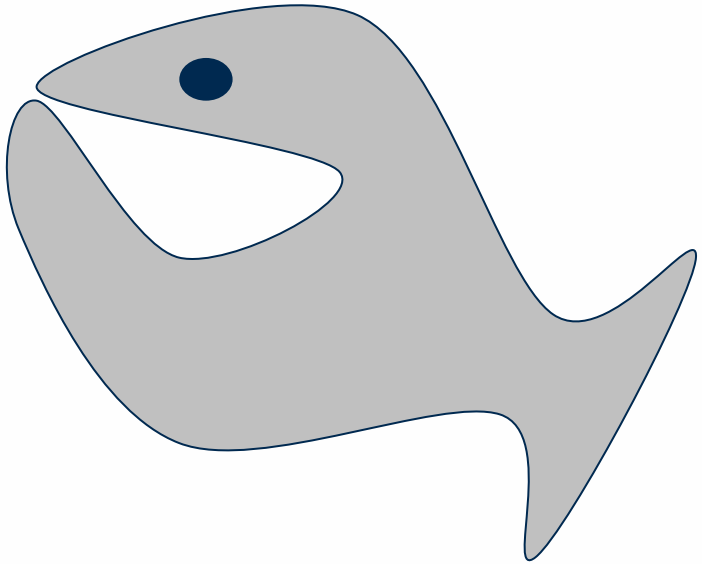
Annual fecundity =
(# eggs per spawn) x (# of spawns per year)

Does size matter?

- Relationship varies by species
- Increases with age / size for most species (Fitzhugh et al. in review)
  - Gag, red and YT snapper, triggerfish
- Decreases for vermilion snapper
- Unknown for many species
- Usually assumed to be constant in stock assessments
- Adds error to assessments



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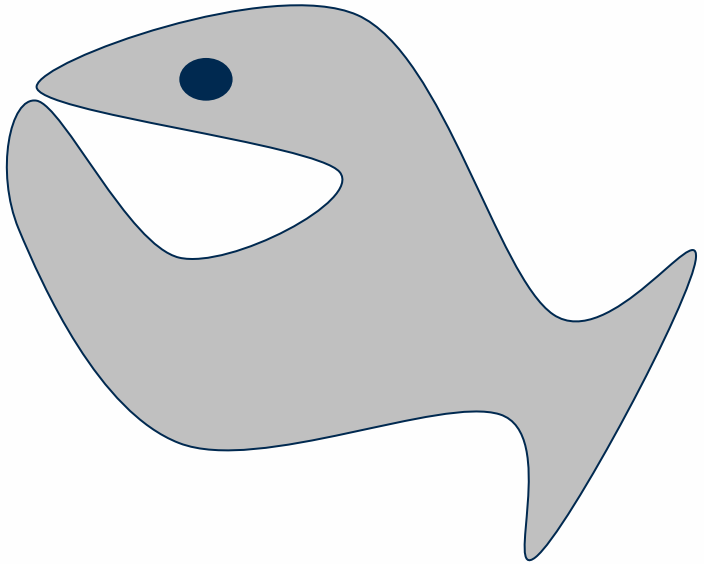
Size and reproductive value

- Annual fecundity = (eggs per spawn) x (# of spawns)
- General conclusion: annual fecundity (reproductive capacity) increases disproportionately with fish size



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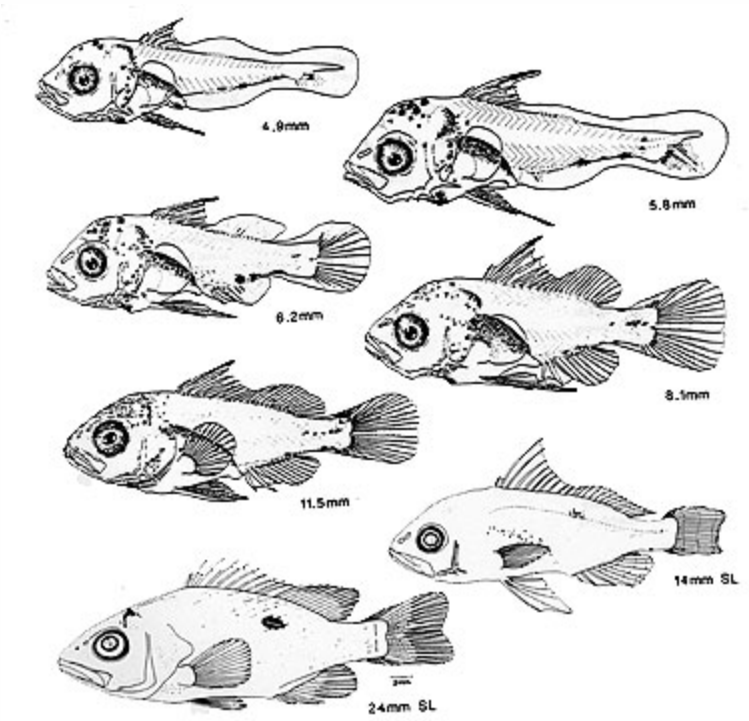
Size and reproductive value

- Some evidence that older (larger) fish produce better eggs and larvae
  - Rockfish (Berkeley et al. 2004)
  - Atlantic cod (Trippel 1998)
  - SE species?
- Implication: older / larger fish produce more survivors



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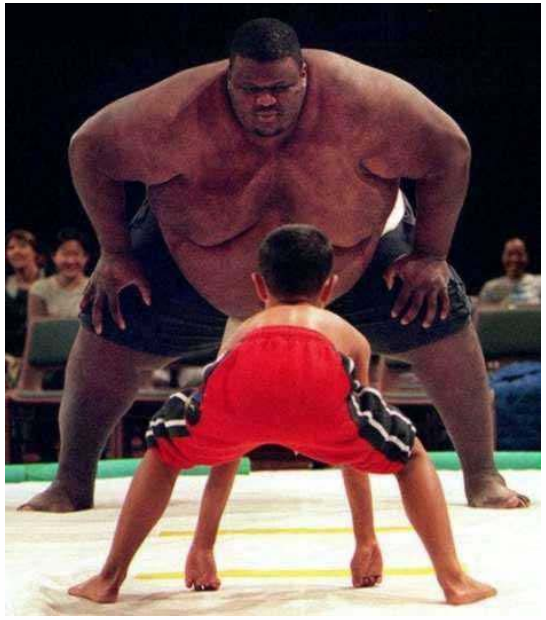
Size and reproductive value

- Bigger = much better
- More eggs produced x better offspring survival = significant increases in reproductive value with size
- Probably true for ~ all reef fish species in the southeast



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Does release mortality vary with fish size?

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- **Review of 274 studies and 14 mortality factors**

Hook location*	Modified hook
Fish size	Hook removal/cut line*
Bait/artificial*	Venting**
Hook size	Active/passive fishing
Treble/single hook	Play/handling time**
Circle/J- hook**	Capture depth*
Barbed/barbless hook***	Water temperature*

* highly significant p<0.01
** significant p<0.05
*** marginally significant p<0.1

Bartholomew and Bohnsack 2005

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Size and release mortality

- Evidence for both increasing and decreasing release mortality with size, depending on species and study
- Most studies indicated no effect of size

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Size and release mortality

- Limited information from SE US
  - Black sea bass and vermilion snapper
    - No effect of size (Collins et al. 1999)
  - Red grouper and red snapper
    - Slight (non-significant) trend of increasing mortality with increasing size (Burns et al. 2002)
    - Barotrauma-related swim bladder injury increases with size for both species (Burns et al. 2008)
    - Greater recapture rates for larger individuals (Burns pers. comm.)
  - (Dolphin) predation may be higher on smaller fish (Burns, pers. comm.)

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Size and release mortality

Limited indication of effects of size on release mortality for SE US reef fish

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Size and release mortality

Limited indication of effects of size on release mortality for SE US reef fish

More research needed

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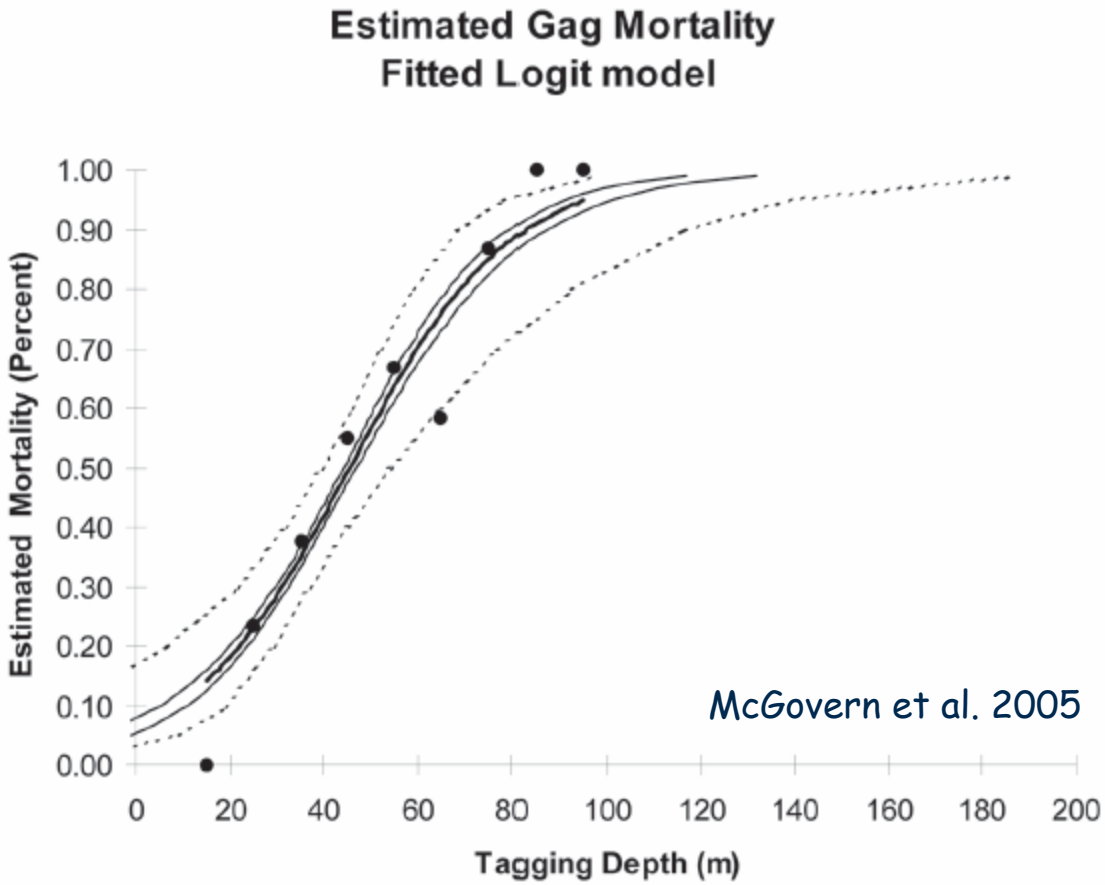
Depth

- Extent of barotrauma-related injuries (and therefore release mortality) increases with depth
- For some species, positive relationship between size and depth
  - Gag, black sea bass, red snapper, gray snapper
- In these cases, larger fish likely suffer greater release mortality



McGovern et al. 2005

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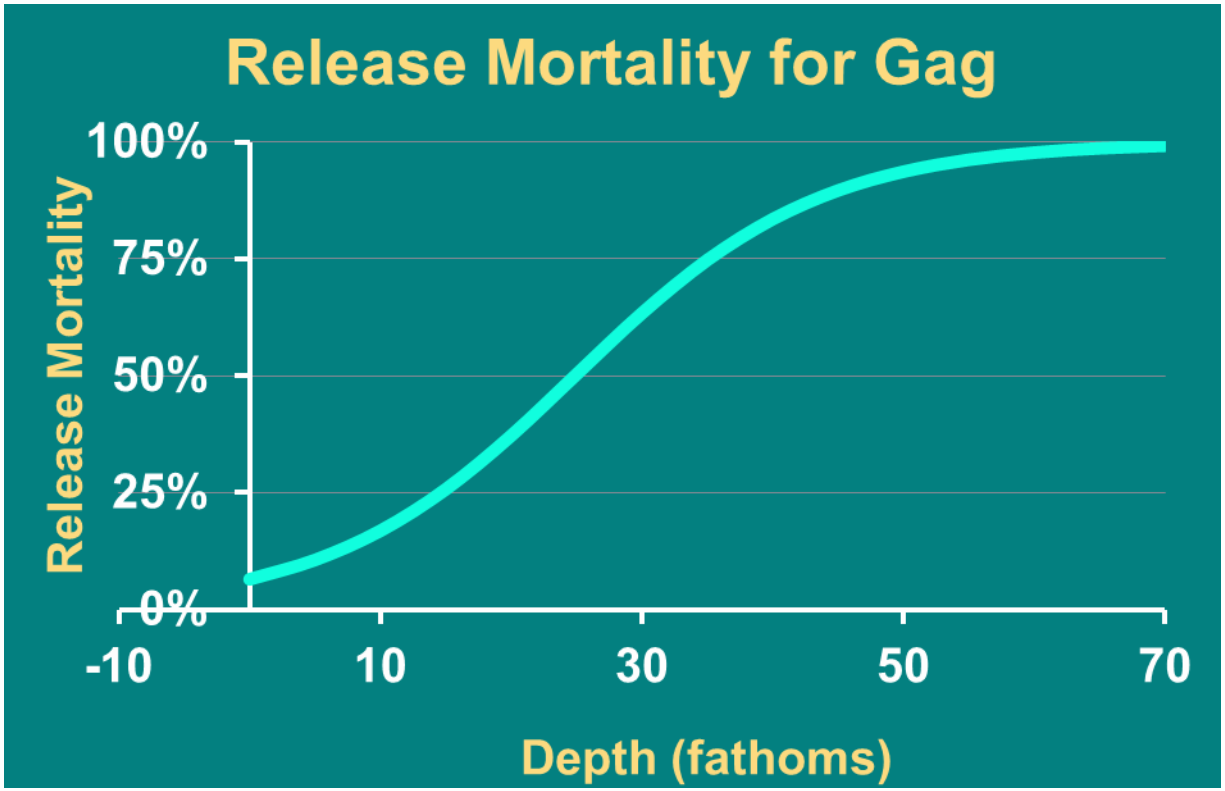

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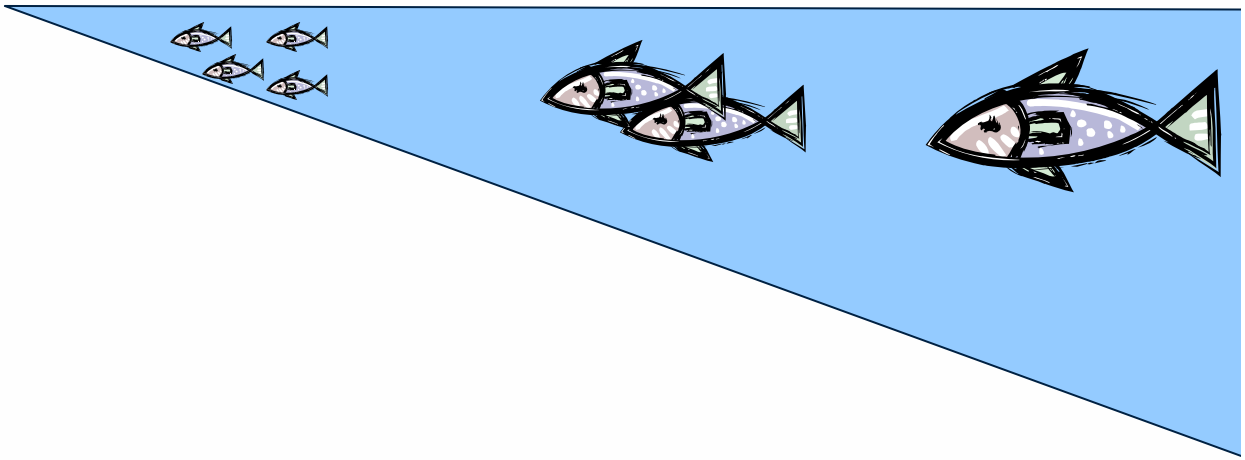

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Summary

- Large fish contribute disproportionately to reproductive output of population
- Limited indication of size-related release mortality, aside from that related to depth of capture
- Depth of capture critical determinant of release mortality

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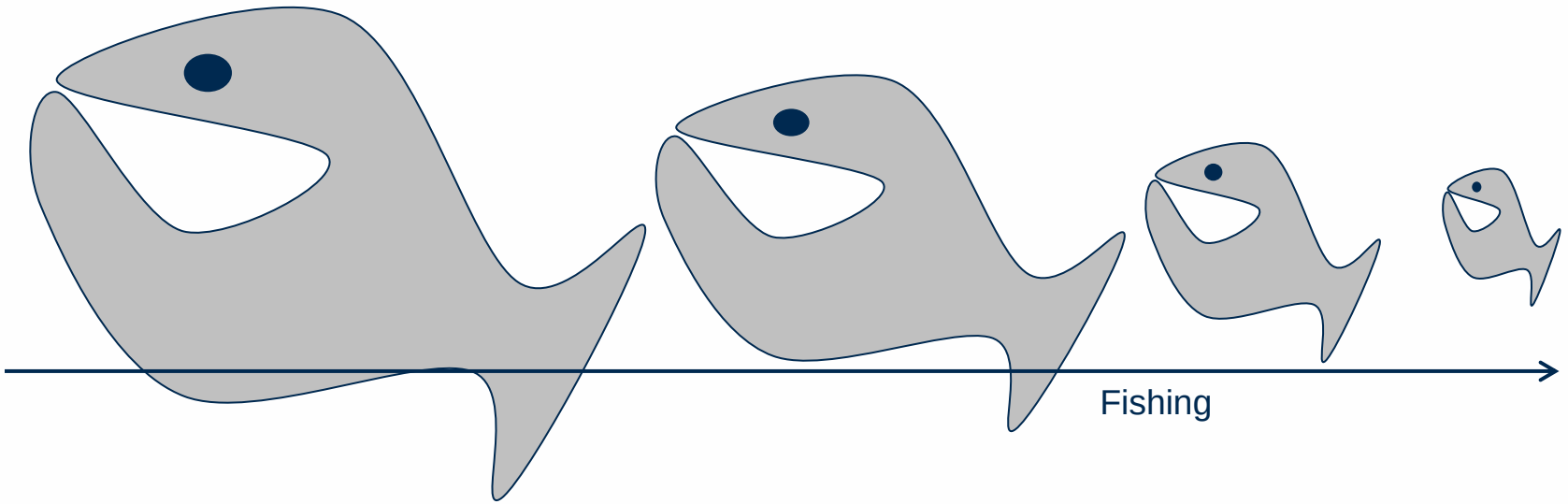
Stock sustainability

Fisheries tend to target the largest fish, leading to size/age truncation



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Stock sustainability

1957

Early 1980s

2007

McClenachan, L. 2008. Documenting Loss of Large Trophy Fish from the Florida Keys with Historical Photographs. Conservation Biology.

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Stock sustainability

- Consistent, repeated removal of largest fish over time removes "fast-growth" genotypes from the population
- Result = slower growth rates and decreased stock productivity (Dieckmann 2009, many others)

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Stock sustainability

- For sex-changing species (e.g., many groupers), removal of largest fish can result in skewed sex ratios
  - Many groupers change from female to male with age; largest fish are predominantly male
  - Percentage of male (vs female) gag grouper in South Atlantic waters decreased from 20% to 6% between ~ 1980 and 1995 (McGovern et al. 1998)
- Result = impaired reproductive output?

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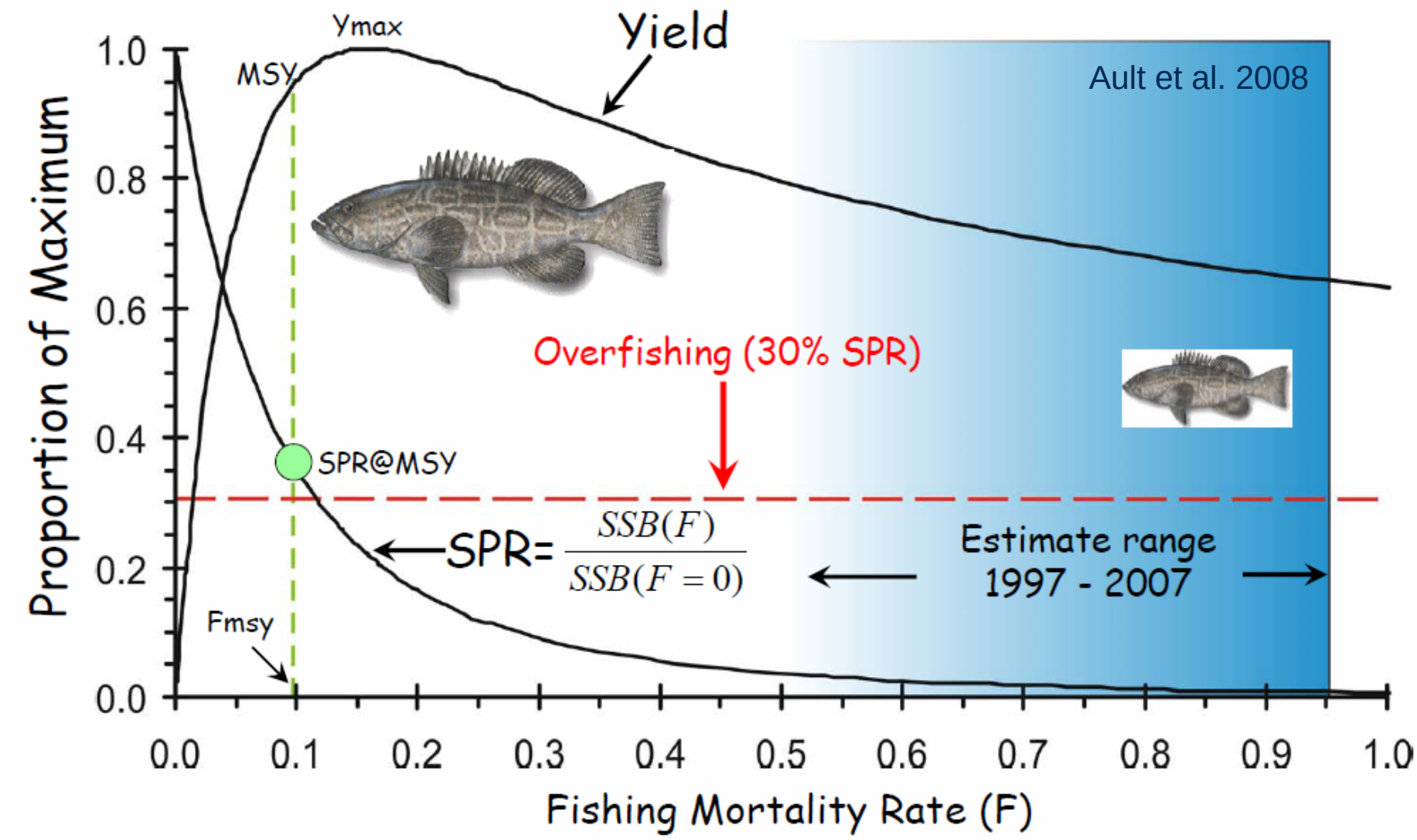
Stock sustainability

- Size / age truncation leads to considerable reductions in Spawning Potential Ratio (SPR)
  - Current spawning stock biomass / Virgin spawning stock biomass
  - SPR ~ 30-40% = overfishing benchmark
    - SPR < 30-40% = overfishing


Ymax
Yield
MSY
Ault et al. 2008
Overfishing (30% SPR)
SPR@MSY
SPR= $\frac{SSB(F)}{SSB(F=0)}$
Estimate range
1997 - 2007
Fmsy
Proportion of Maximum
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Fishing Mortality Rate (F)

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Stock sustainability

Maintaining large individuals in the population encourages stock sustainability

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Management implications

- In relatively shallow waters, high likelihood of survival of released fish
  - Management measures such as bag and size limits can support the maintenance of large fish in the population and stock sustainability
- In relatively deep waters, low likelihood of survival of released fish
  - For depleted or heavily exploited stocks, spatial closures (voluntary or regulatory) may be necessary?

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Management implications

Ex: speckled hind and Warsaw grouper

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Management implications

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  - Management measures such as bag and size limits can support the maintenance of large fish in the population and stock sustainability
- In relatively deep waters, low likelihood of survival of released fish
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Management implications

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  - Management measures such as bag and size limits can support the maintenance of large fish in the population and stock sustainability
- In relatively deep waters, low likelihood of survival of released fish
  - For depleted or heavily exploited stocks, spatial closures (voluntary or regulatory) may be necessary? OR…
  - Recompression?

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Research needs

- Improved species-specific information on release mortality
  - Size
  - Barotrauma
  - Predation
- Studies of the effects of recompression on release mortality
- Other?

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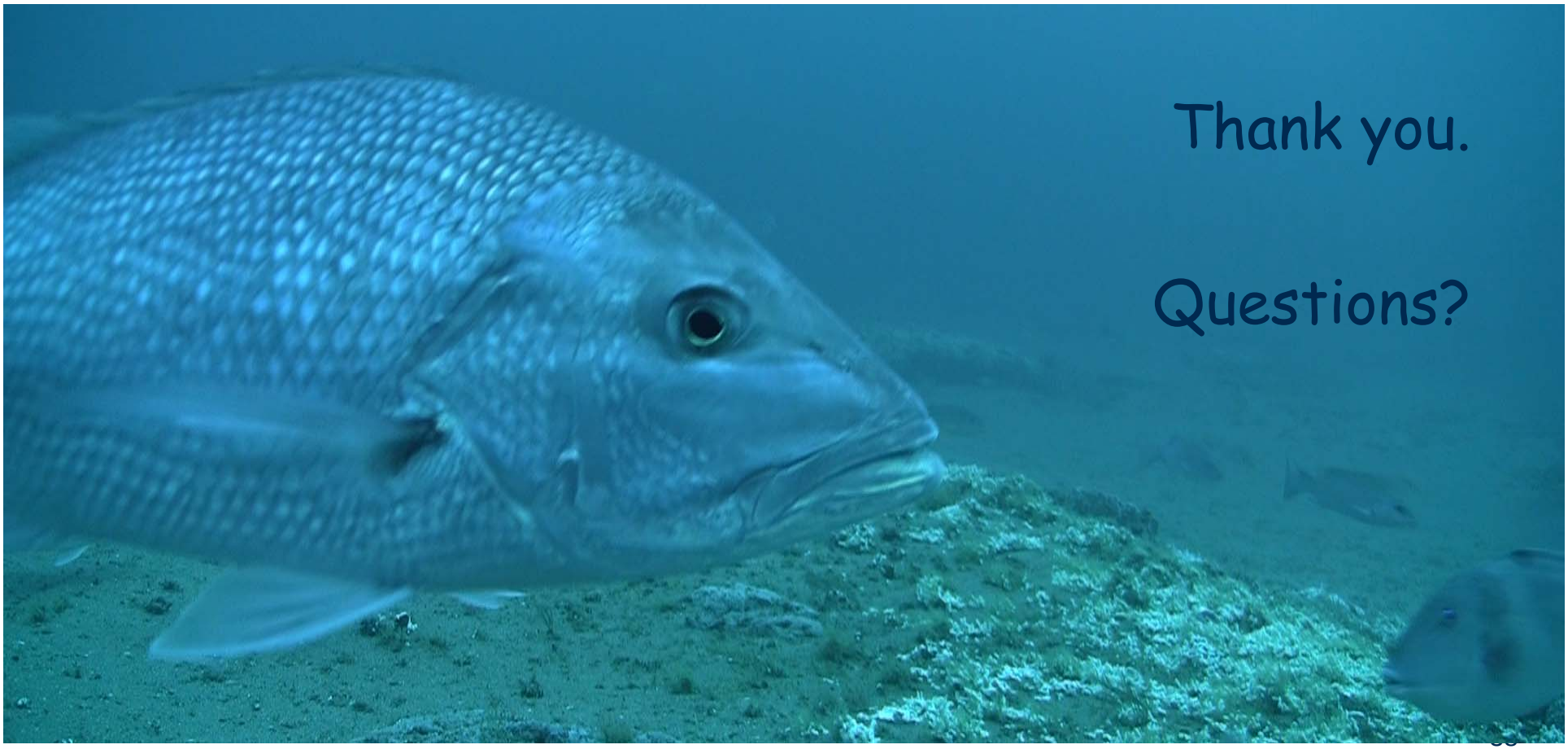


Thank you.
Questions?

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Trippel, EA. 1998. Egg Size and Viability and Seasonal Offspring Production of Young Atlantic Cod. TAFS 127(3): 339-359.

Lambert et al. 2005?

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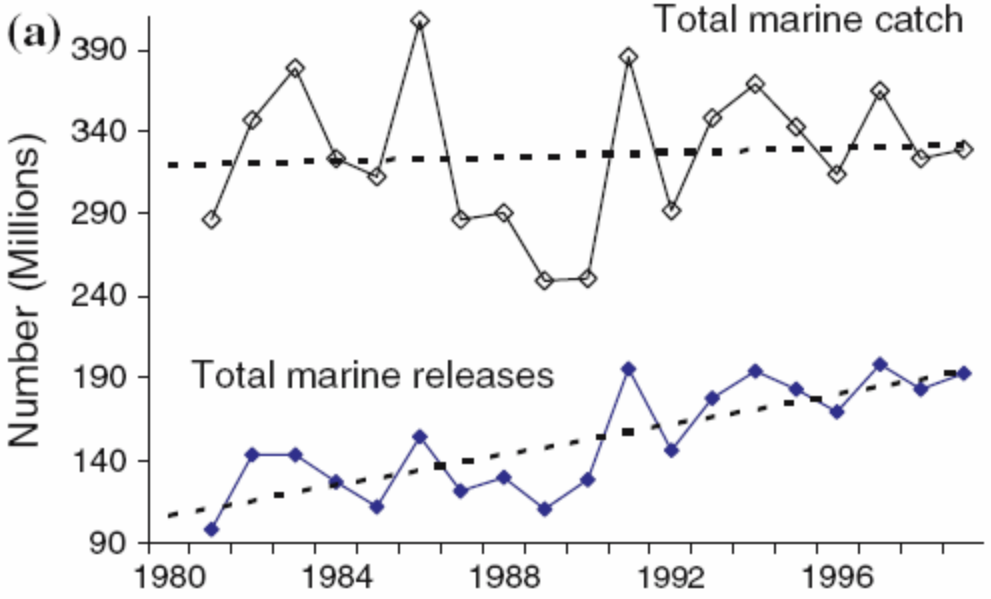
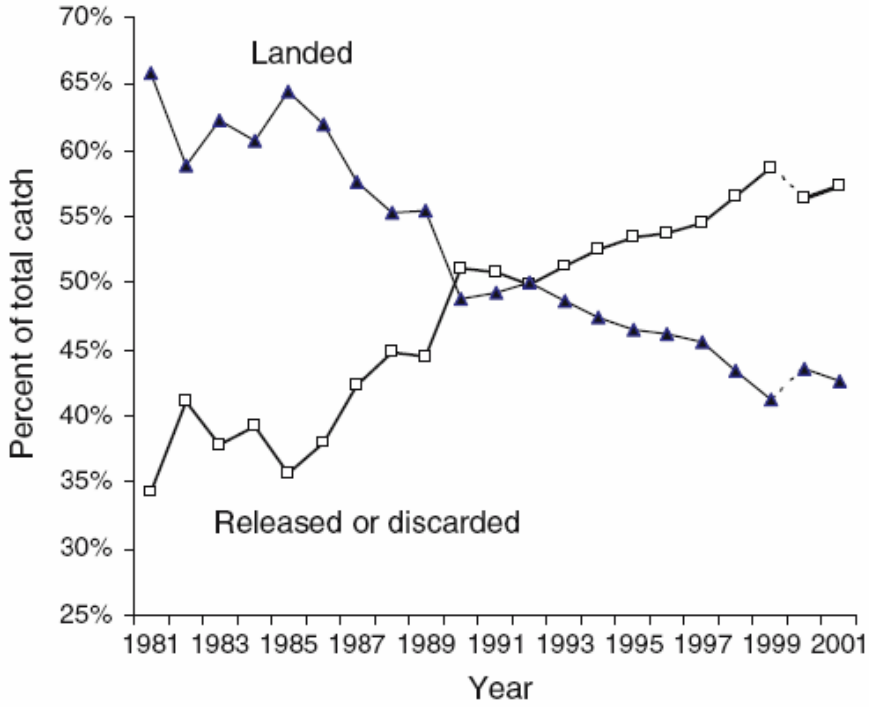
Releasing fish has become common





Bartholomew and Bohnsack 2005