

Slow management during rapid ecosystem change or How rapid warming drove the collapse of Gulf of Maine cod

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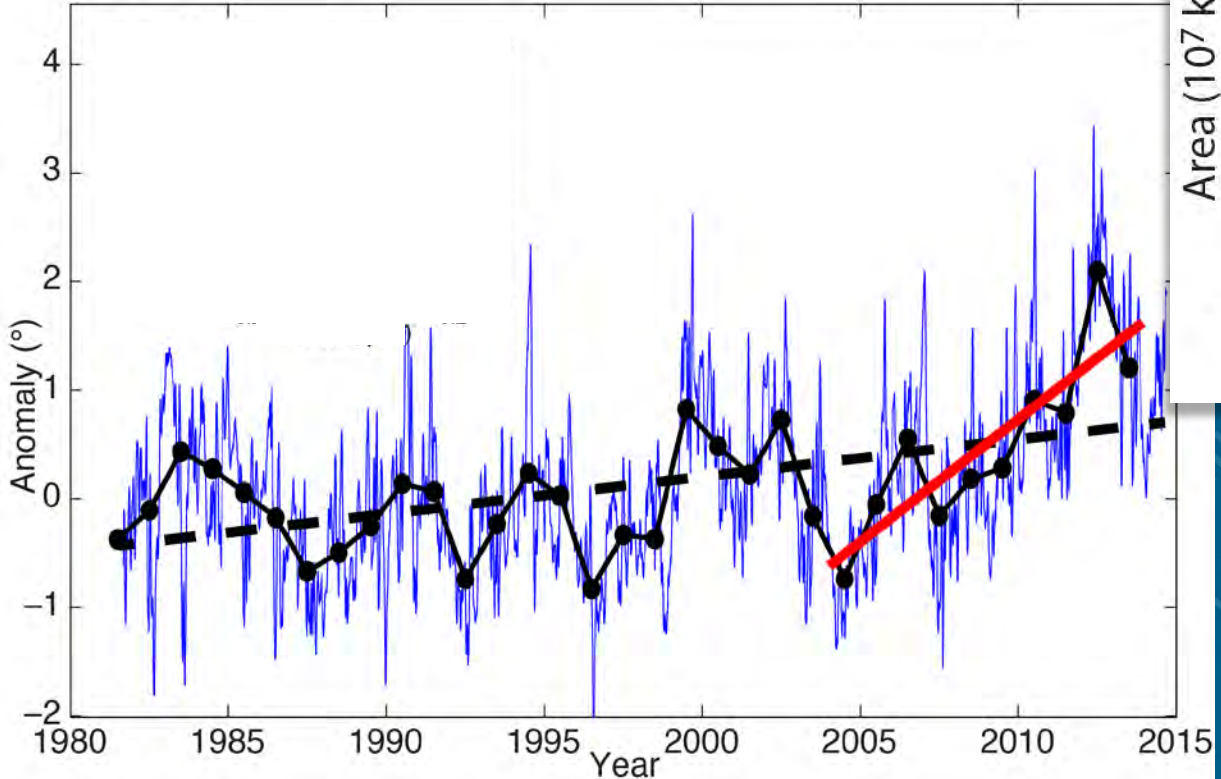
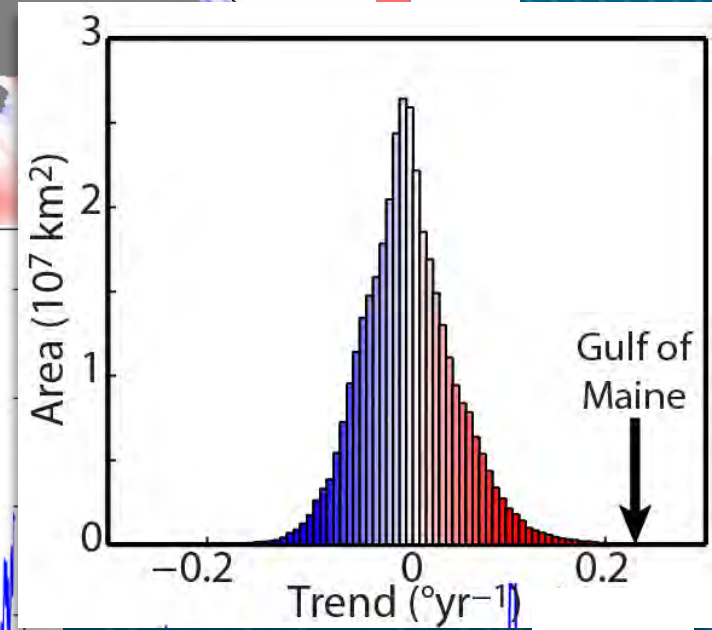
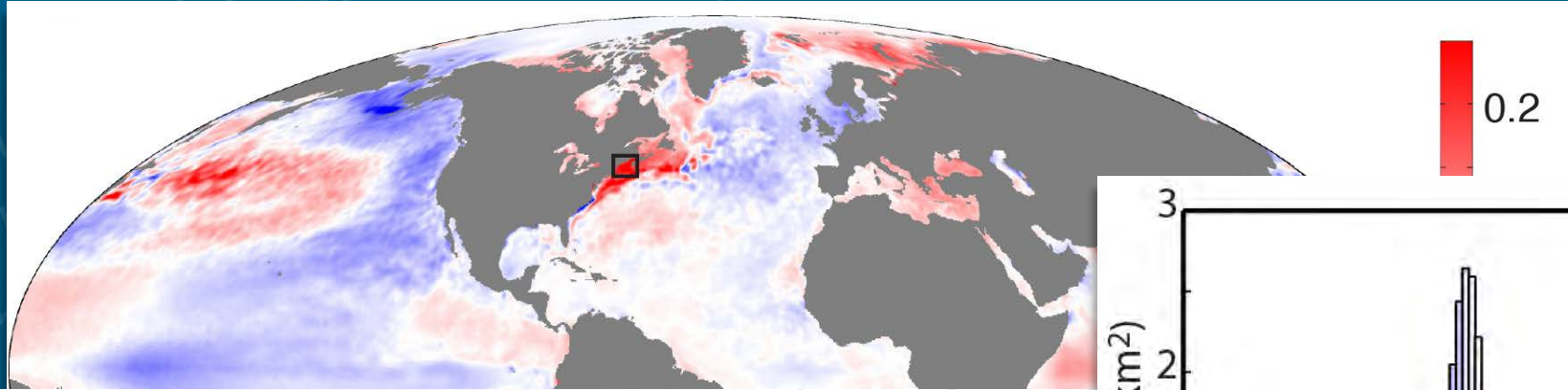


Outline

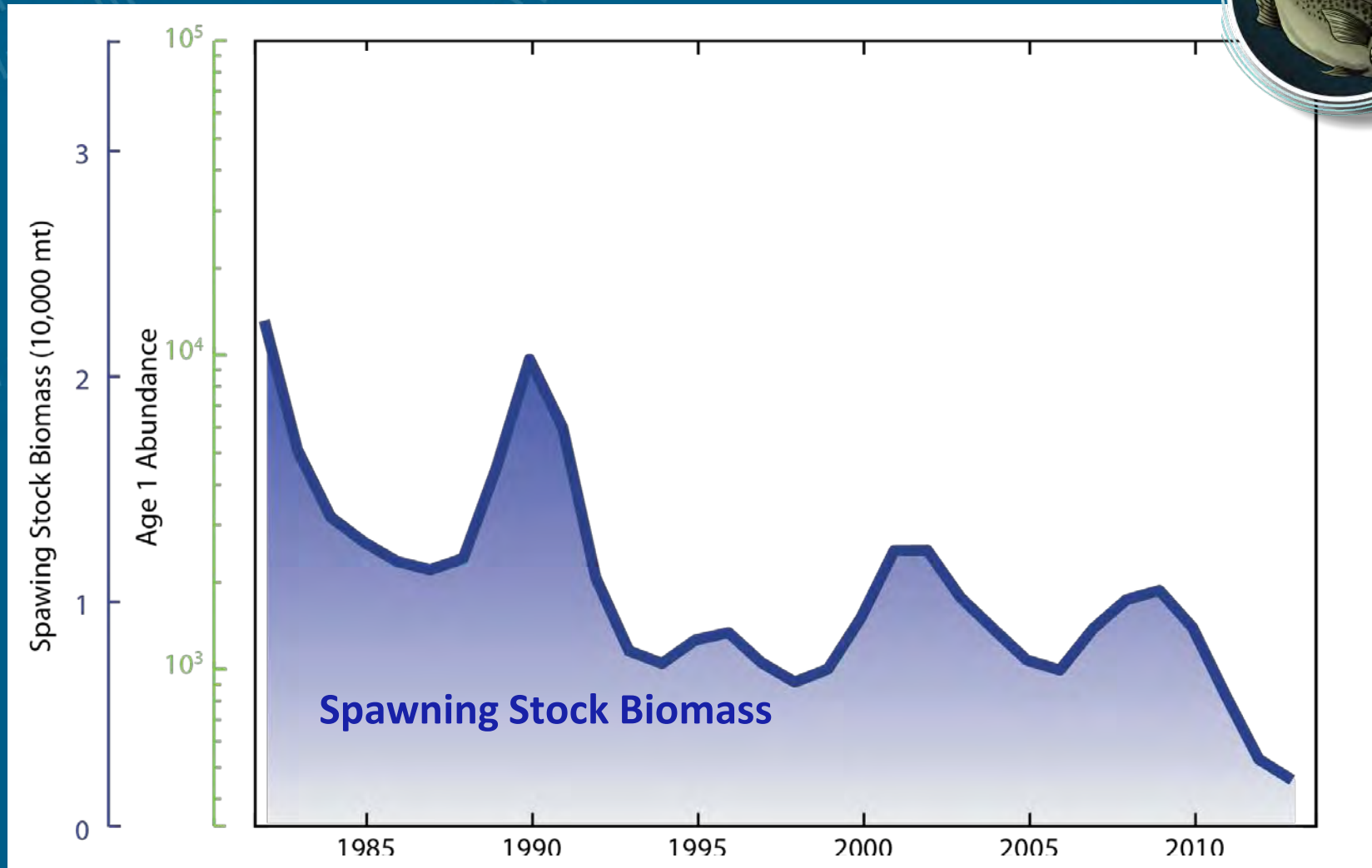
- Rapid warming in the Gulf of Maine
- Warming and cod
 - recruitment
 - natural mortality
 - implications for management
- Lessons
- Synthesis



SST Trends: 2004-2013

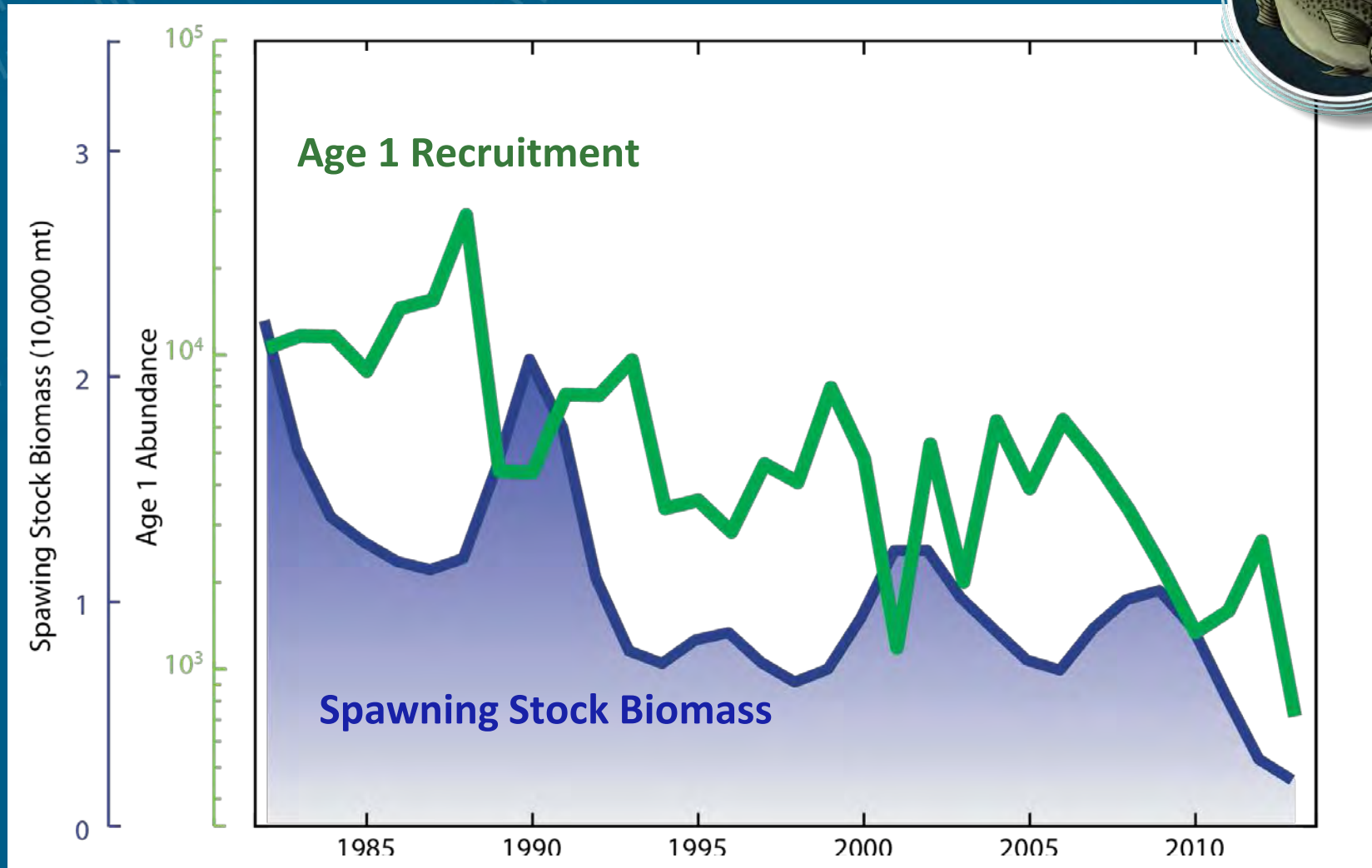


Consequences: Cod



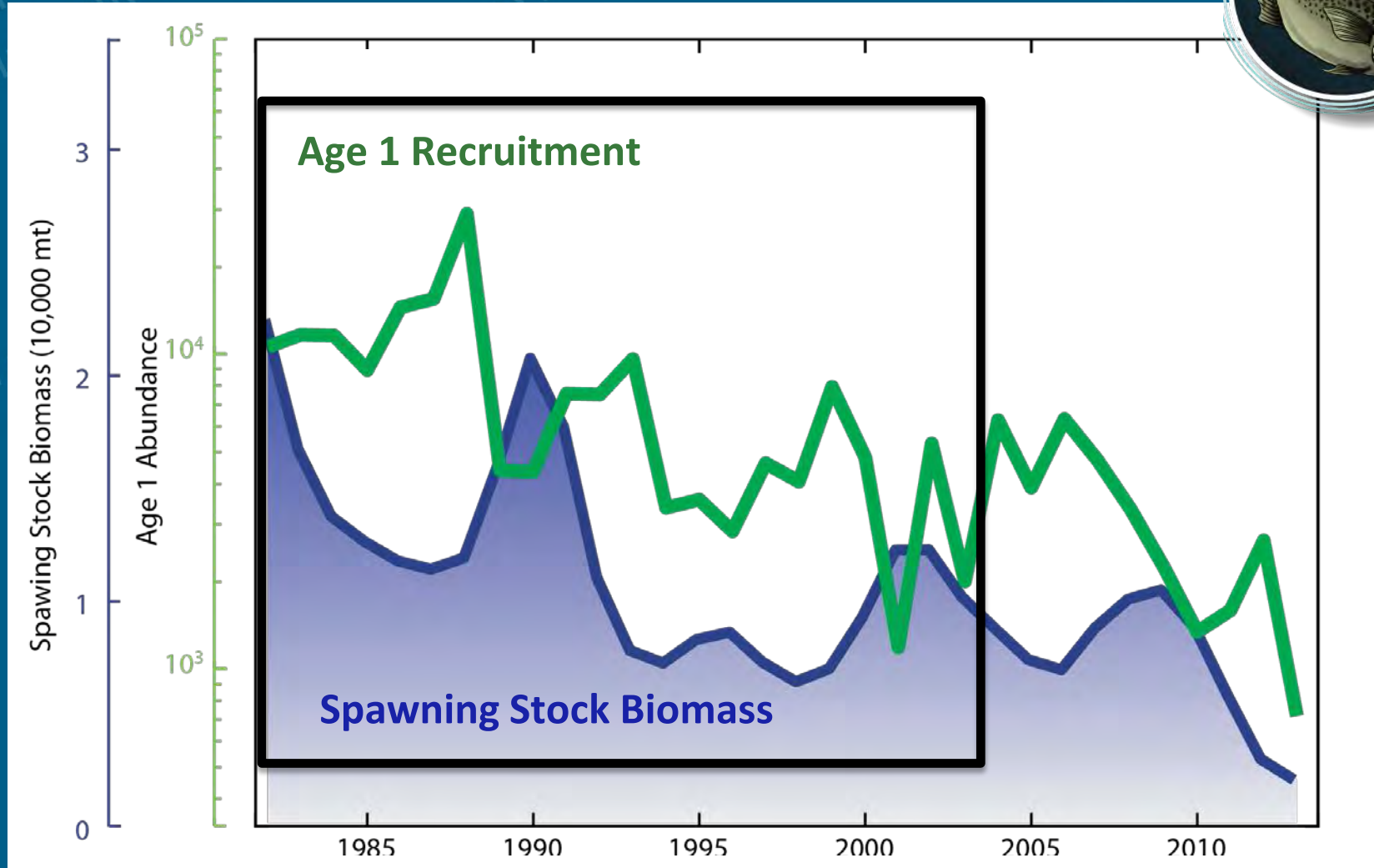
Data from 2014 stock assessment (Palmer, 2014)

Consequences: Cod



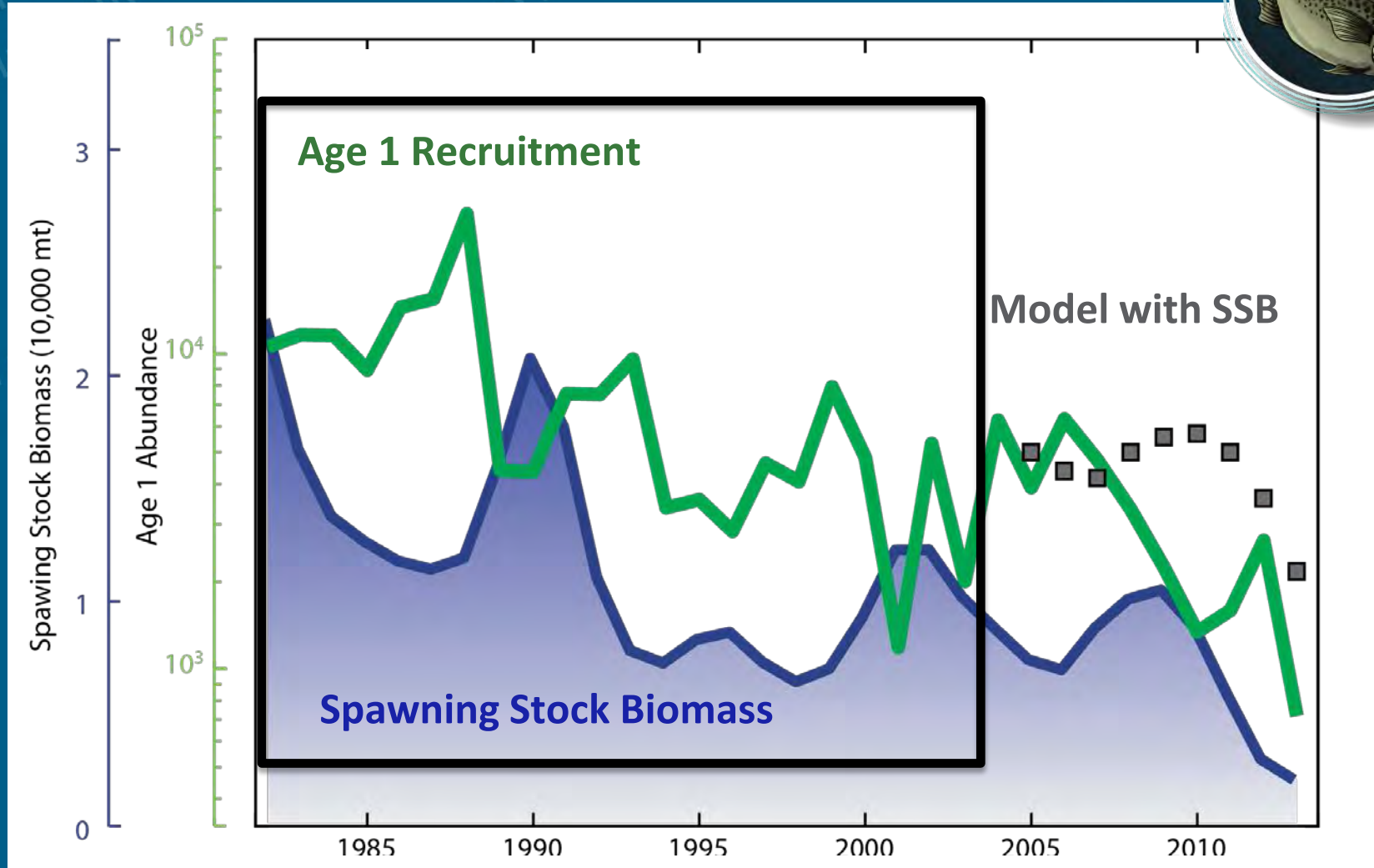
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Consequences: Cod



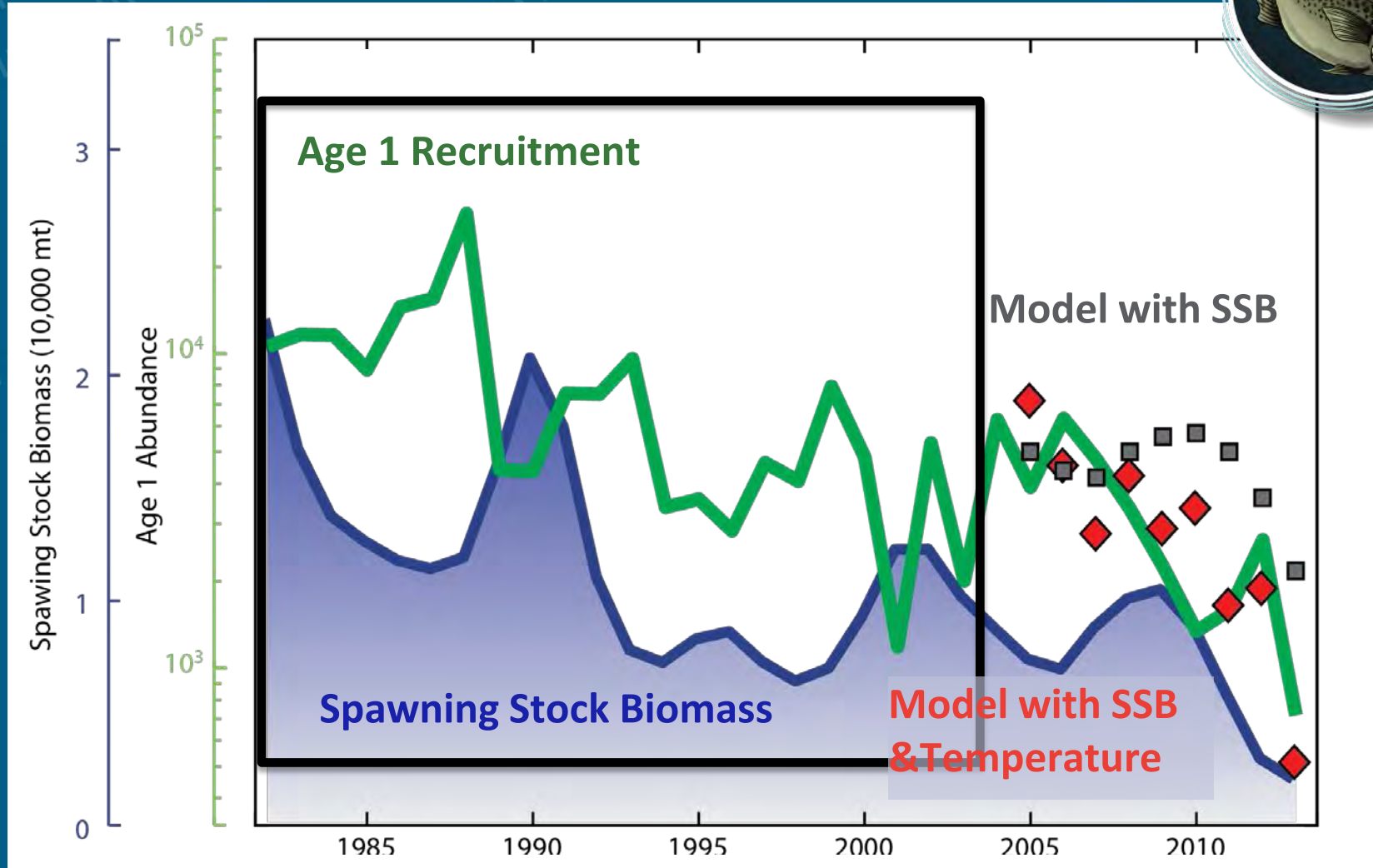
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Consequences: Cod



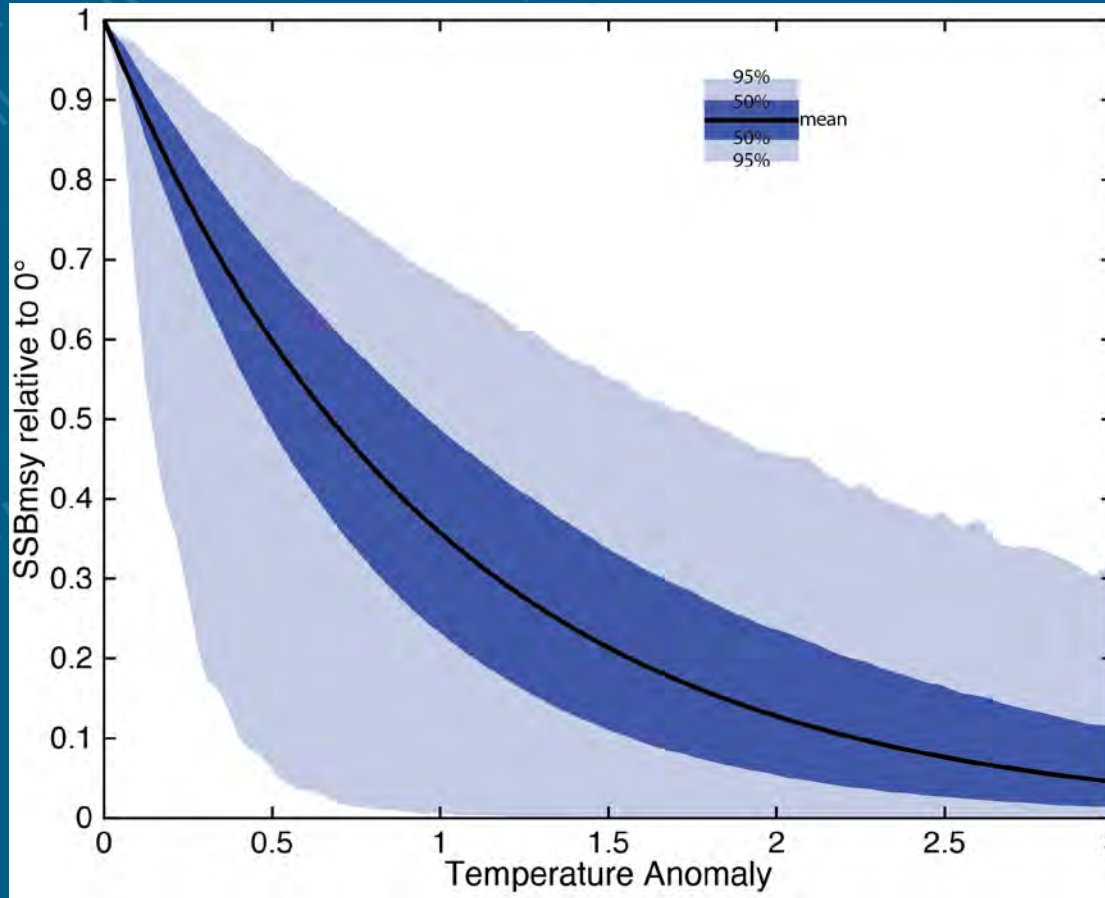
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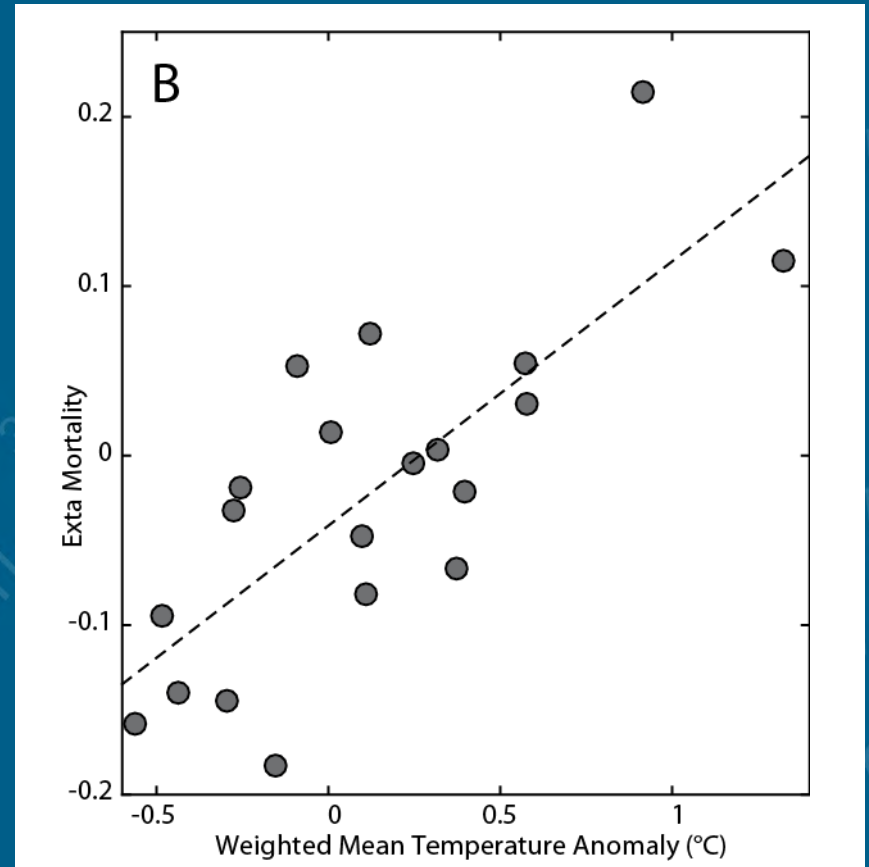
Implications of Recruitment: Temperature



- 2° increase in mean SST = 90% reduction in B_{msy}
- Ignoring temperature leads to unrealistic expectations for the size of the fishery

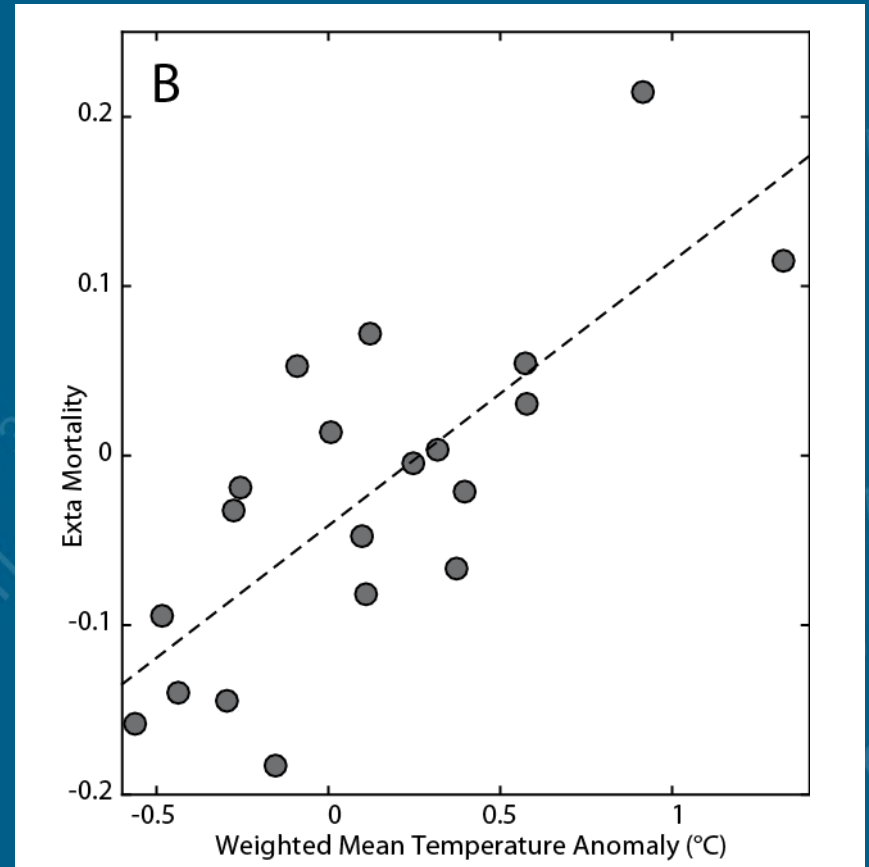
Consequences: Cod

- Mortality is also a function of temperature



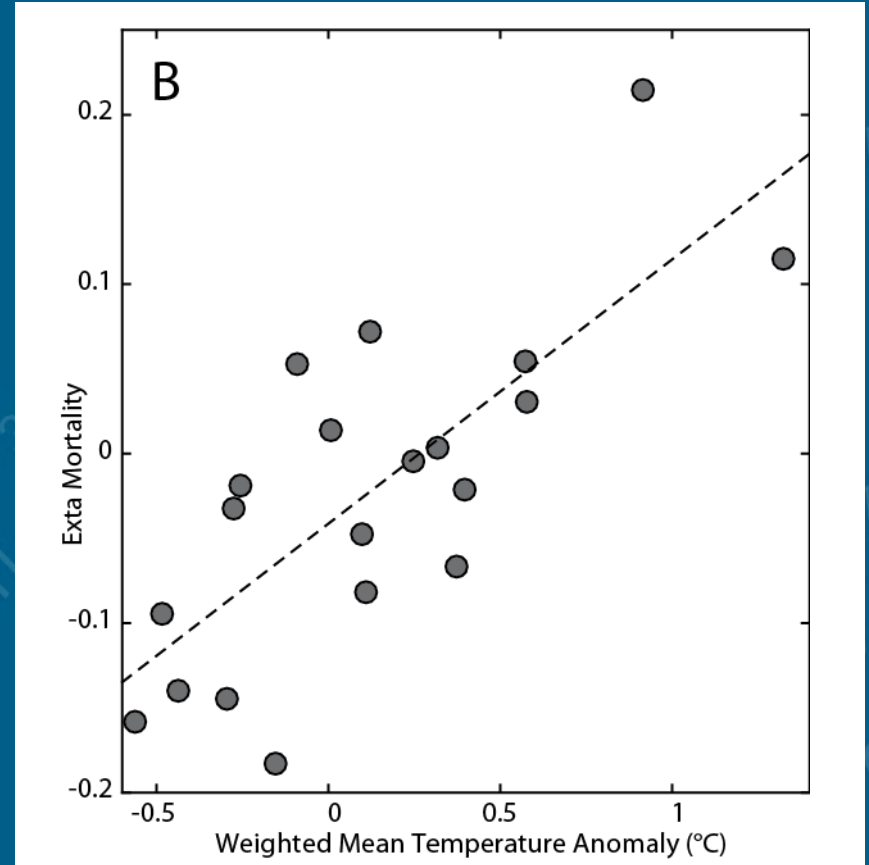
Consequences: Cod

- Mortality is also a function of temperature
- Extra natural mortality means extra fishing mortality, under a fixed quota-system.



Consequences: Cod

- Mortality is also a function of temperature
- Extra natural mortality means extra fishing mortality, under a fixed quota-system.
- Setting quotas without accounting for temperature can lead to overfishing



Consequences of ignoring temperature

- Rebuilding targets are too high
- Quotas are also too high
 - *Even when the industry follows the rules, overfishing still occurs, requiring steeper cuts in the future*
- Fishermen blame the science, resist additional management
 - *cuts recommended for 2012 were spread over 2012-2013, compounding overfishing*

Lessons

- Recognize environmental change
- Include environmental effects in fisheries models
- Consider decadal trends and climate change when setting rebuilding goals



Synthesis

- **Scales:** regional, decadal
- **Decisions:** quota setting
- **Actors:** scientists, managers, industry
- **Context:** history of overfishing, good data, very rapid ecosystem change
- **Barriers:** crisis mode, poor economic state of fishery, culture of mistrust, rigid stock assessment process,

