NOAA FISHERIES

Office of Science and Technology

Stock Assessments in Support of U.S. Fisheries

Jeff Vieser, Contractor with ECSTech in support of NOAA Fisheries Office of Science and Technology

Melissa Karp, Fish Biologist
NOAA Fisheries Office of Science and Technology

Objectives:

- Understand the context for stock assessments in fisheries management
- Learn about data supporting assessments and the assessment process
- Practice interpreting assessment advice to make management decisions

Audience Question:

The Magnuson-Stevens Act states stock assessments are required for all managed fishery stocks.

TRUE or FALSE?

NOAA FISHERIES

Stock Assessments Supporting Management

Magnuson-Stevens Act

NS1

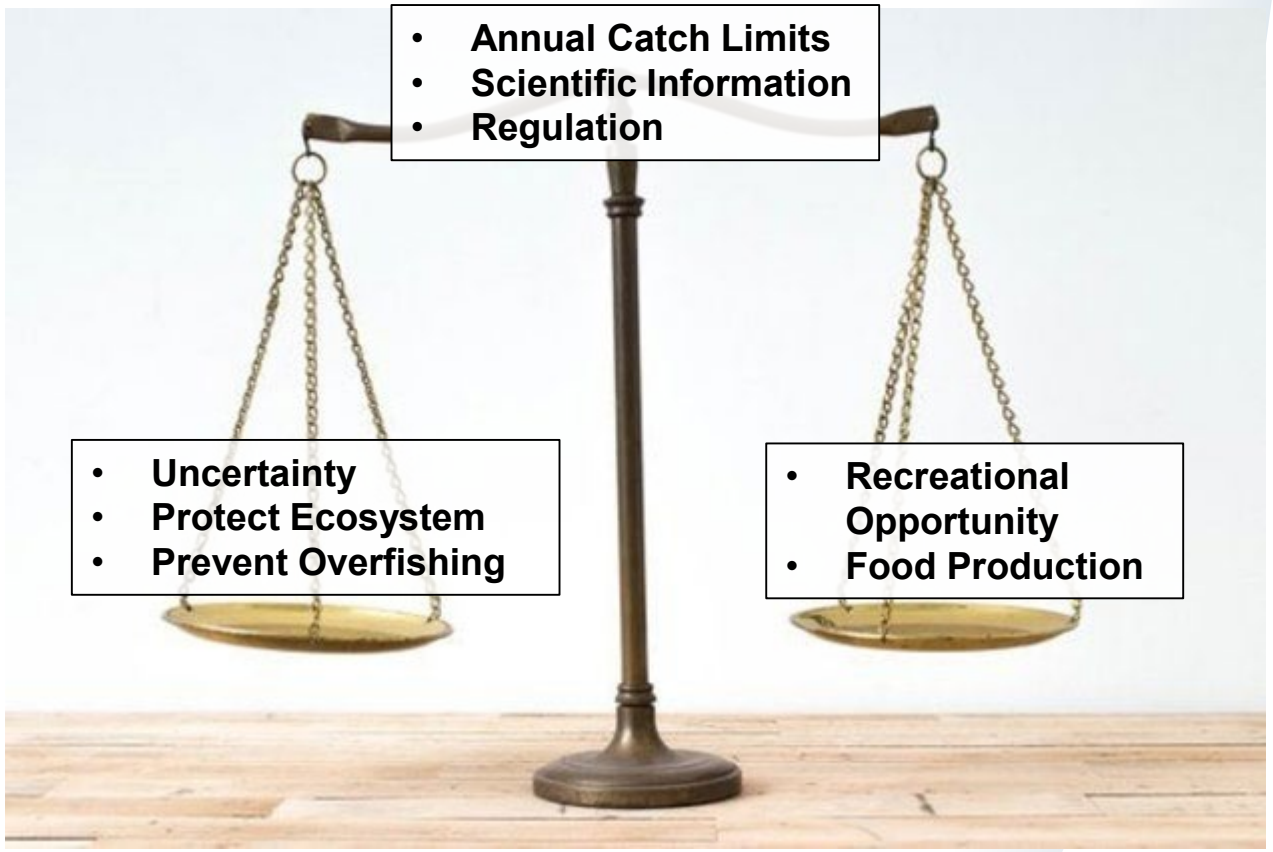
- "…prevent overfishing while achieving…optimum yield"

NS2

- "…best scientific information available"

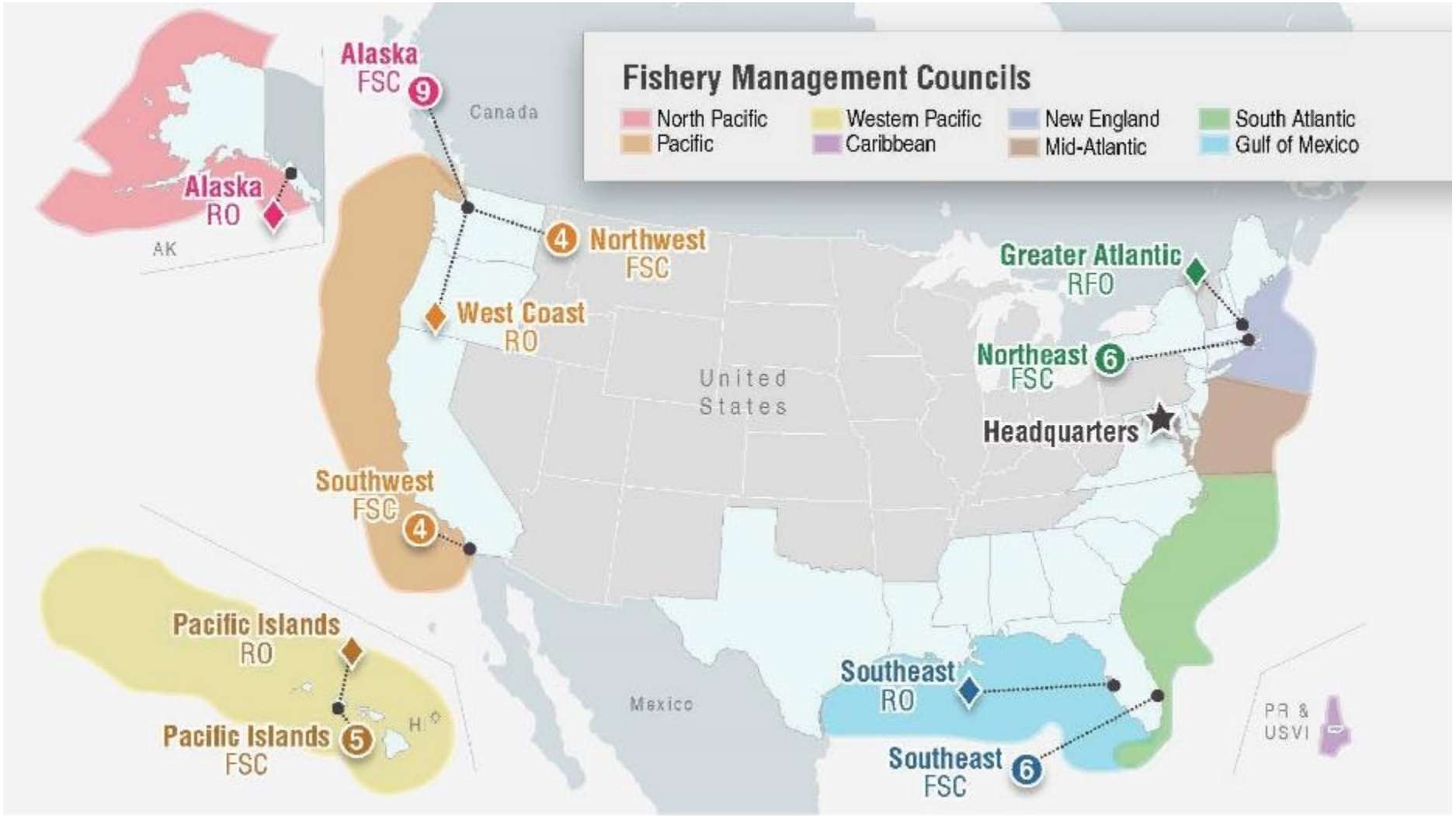
NS3

- "…an individual stock…shall be managed as a unit throughout its range"



NOAA FISHERIES

NOAA Fisheries Science



- 6 Science Centers
- 20+ labs
- Headquarters, OST, NSAP
- 5 Regional Offices

SUPPORTING

- 8 FMCs, 46 FMPs, 450+ stocks
- 16+ management & advisory organizations

NOAA FISHERIES

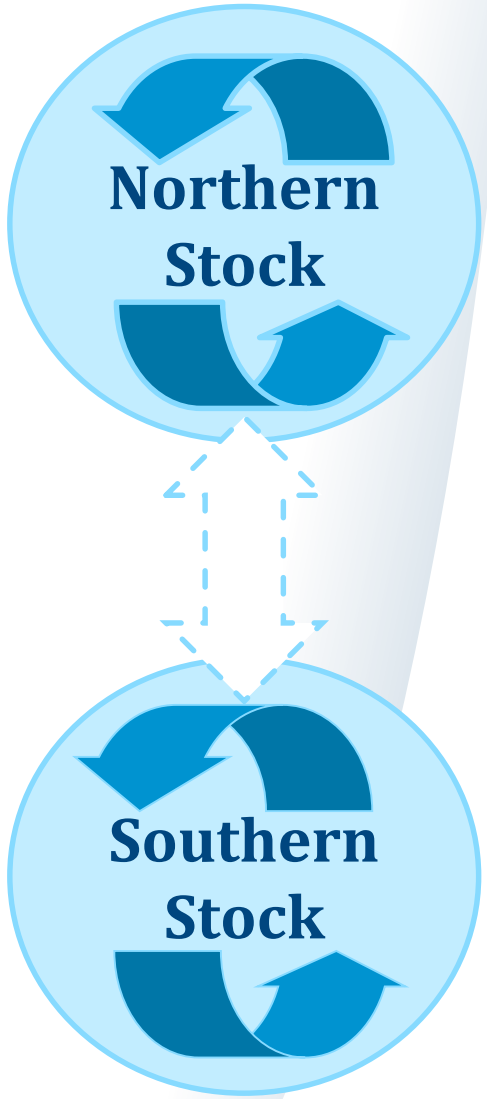
Defining “Stock”

Biological Stocks

- Group of individuals of the same species
- Inhabit the same geographic region
- Mix and interbreed when mature

Management Stocks

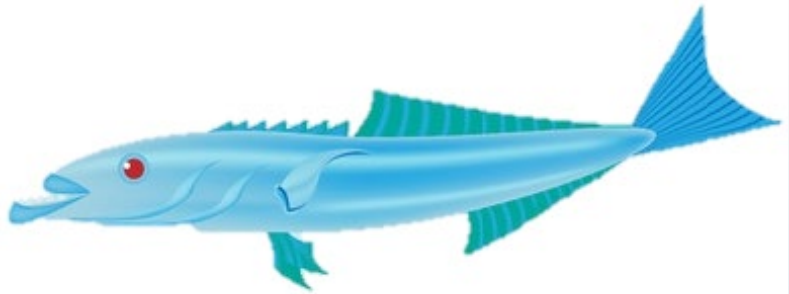
- Often the same as biological stocks
- Exceptions include multispecies complexes, breaks at geopolitical boundaries



NOAA FISHERIES

Today's Mission: Part 1

Understand the context for stock assessments in fisheries management



Species A: Meyer Sole

- High Value
- Commercial Fishery
- Scientific Challenges in Stock Assessment
- Last assessment: 2 Years Ago

Species B: Whitebelly Lemonfish

- Popular Recreationally
- Limited Commercial Fishery
- Some worrying trends in the resource
- Last assessment: 7 Years Ago

NOAA FISHERIES

What is a Stock Assessment?

The primary scientific basis for successful and sustainable fisheries

We use mathematical models to answer two basic questions…

NOAA FISHERIES

Stock Assessments Ask:

1 **Is everything OK?**

What is the status of the stock?

2 **How much is too much?**

What level of catch is sustainable?

NOAA FISHERIES

Objective 2:

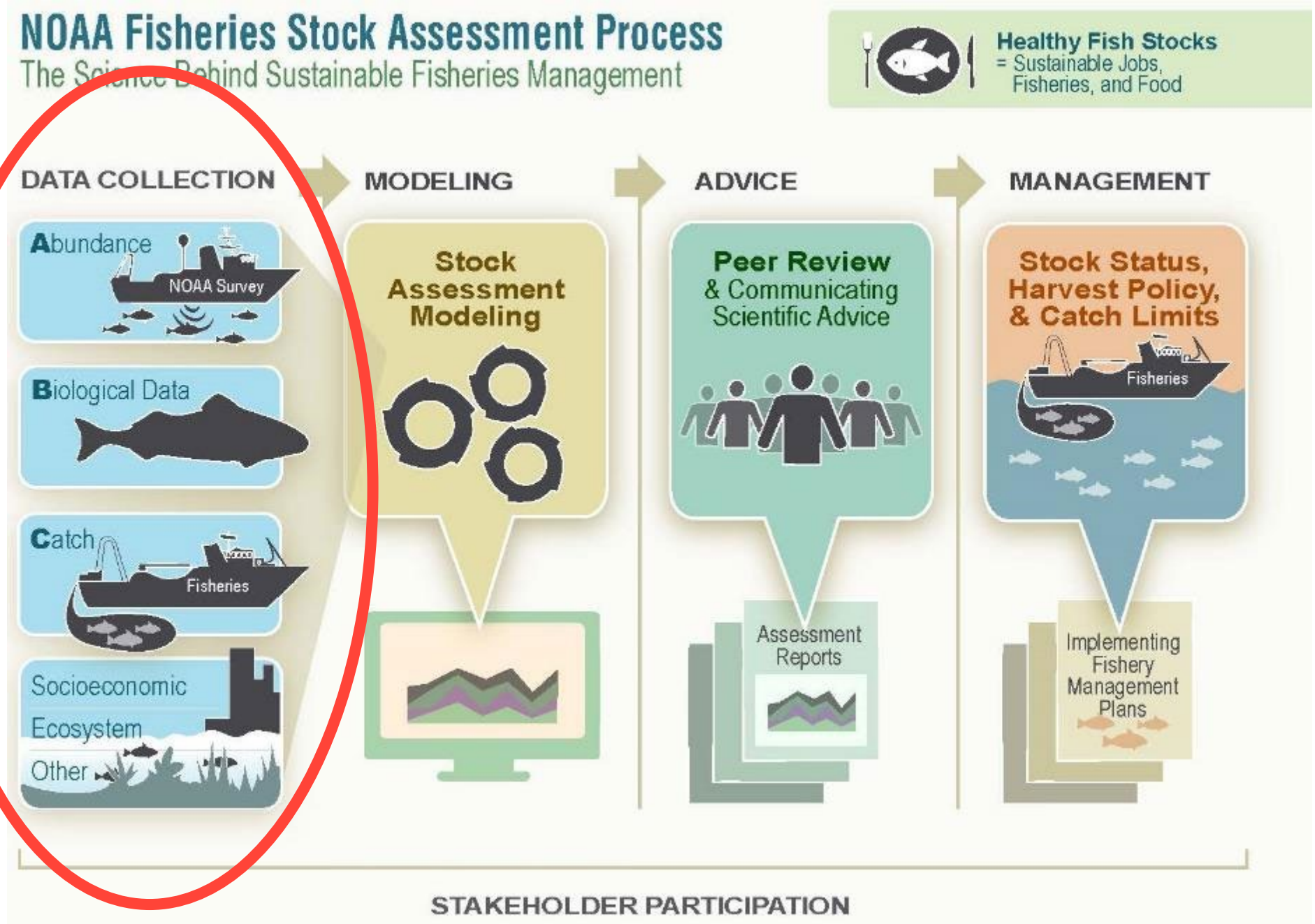
- Understand the context for stock assessments in fisheries management
- Learn about data supporting assessments and the assessment process
- Practice interpreting assessment advice to make management decisions

Audience Question:

What are the three main categories of data used in stock assessments?

Abundance, biology, catch

NOAA FISHERIES



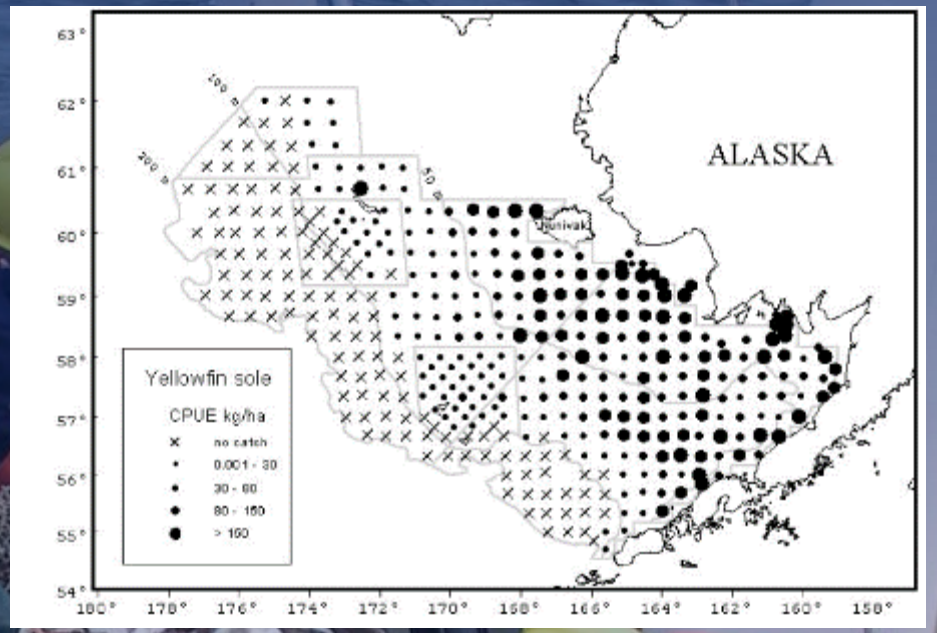
NOAA FISHERIES

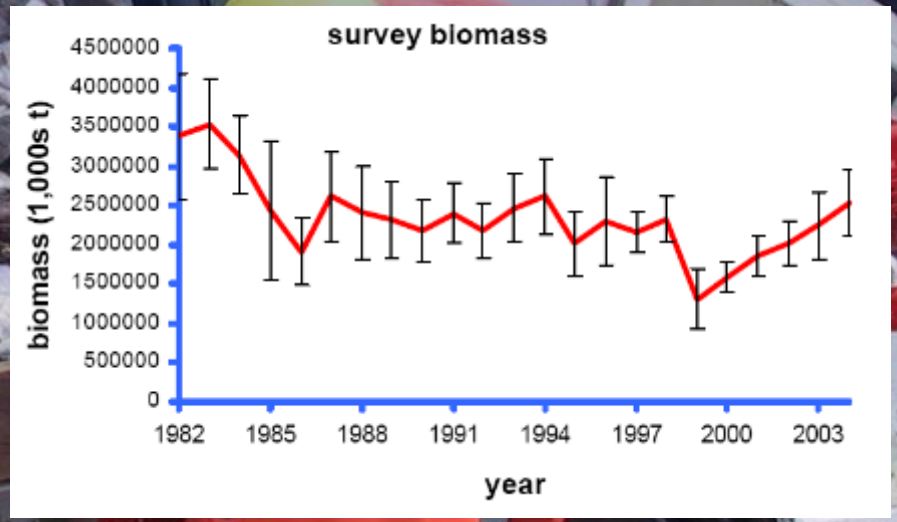
Data Collection & Processing: Abundance

Fishery-Independent:

Scientific Surveys

- Statistical sampling design
- Covers full stock range
- Uses standardized gear and practices
- Extractive methods (e.g., trawl, longline, H/L, pot, trap, gill net, etc.)
- Non-extractive methods (e.g., acoustic, video, aerial, diving, tag/recapture, etc.)





Data Collection & Processing: Abundance, pt. 2

Fishery-Independent:

Scientific Surveys

- Statistical sampling design
- Covers full stock range
- Uses standardized gear and practices
- Extractive methods (e.g., trawl, longline, H/L, pot, trap, gill net, etc.)
- Non-extractive methods (e.g., acoustic, video, aerial, diving, tag/recapture, etc.)

Fishery-Dependent:

Commercial / Recreational Fisheries

- Catch per unit of effort (CPUE)
- May not reflect abundance — market dynamics and changing practices
- Uneven distribution of effort

Audience Question:

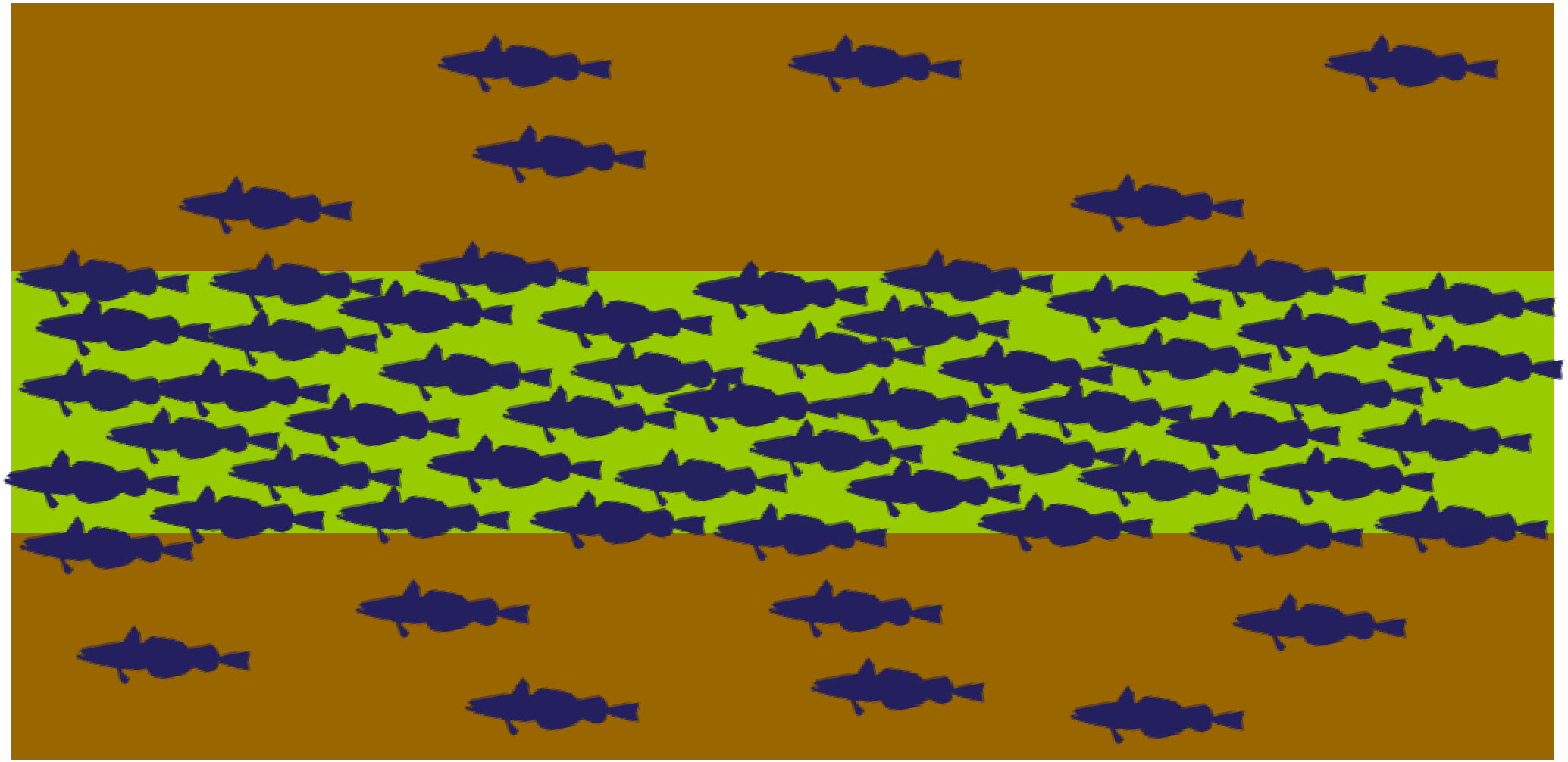
Survey abundance and fishery CPUE trends may differ because of uneven distribution of fishing effort.

TRUE or FALSE?

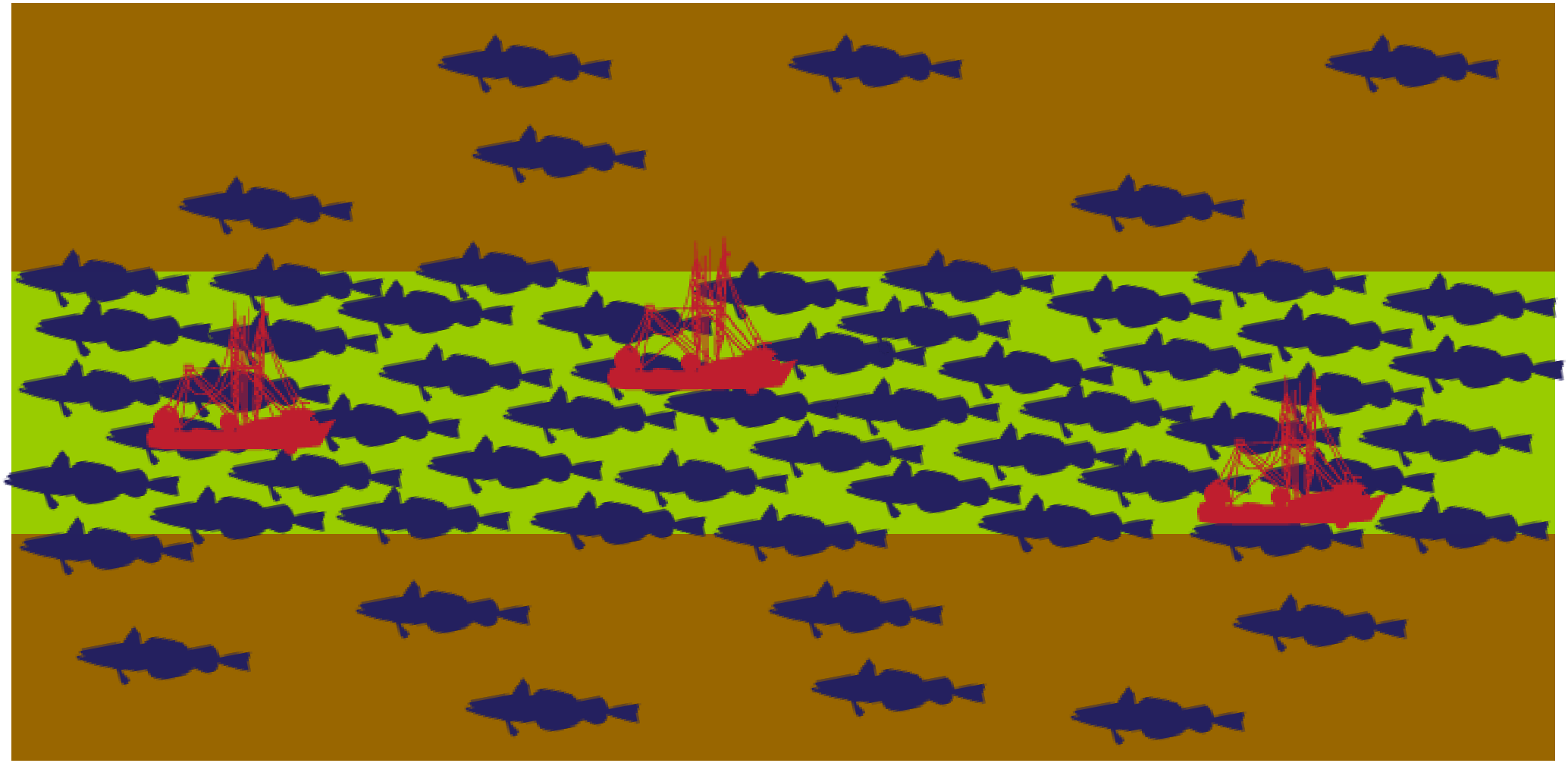
NOAA FISHERIES

Hyperstability

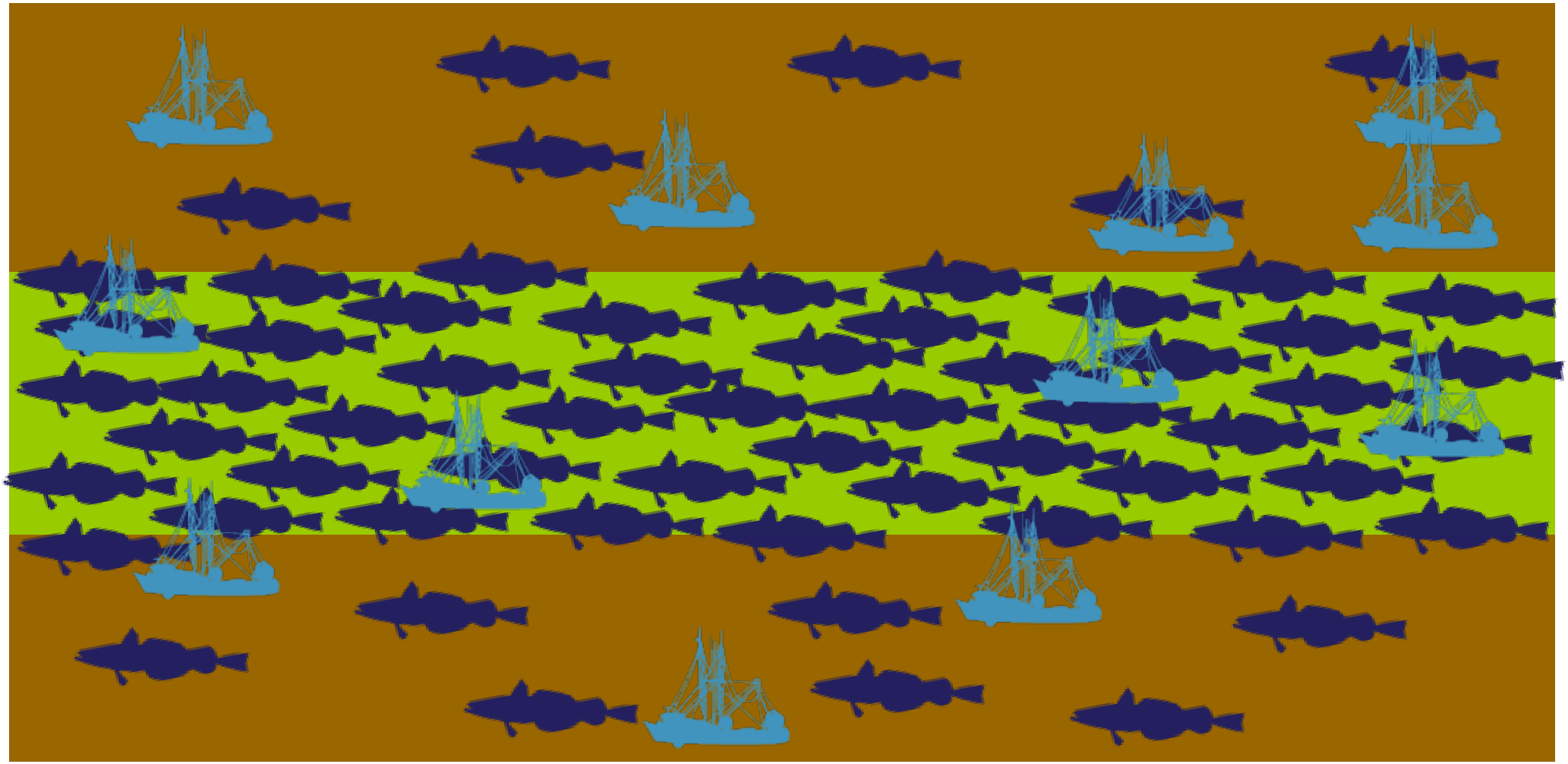
Hyperstability: Healthy Stock



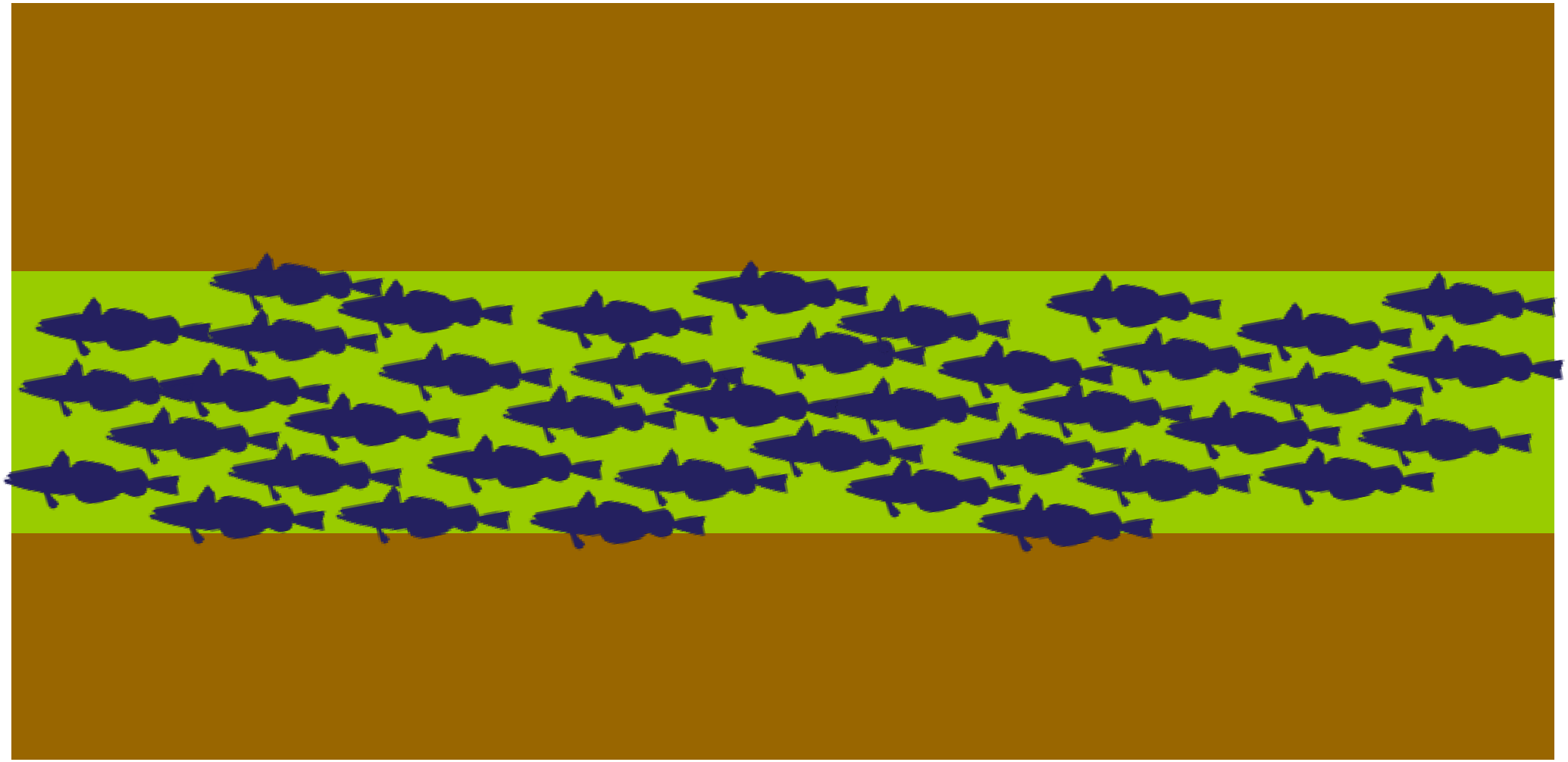
Hyperstability: Fishery Effort



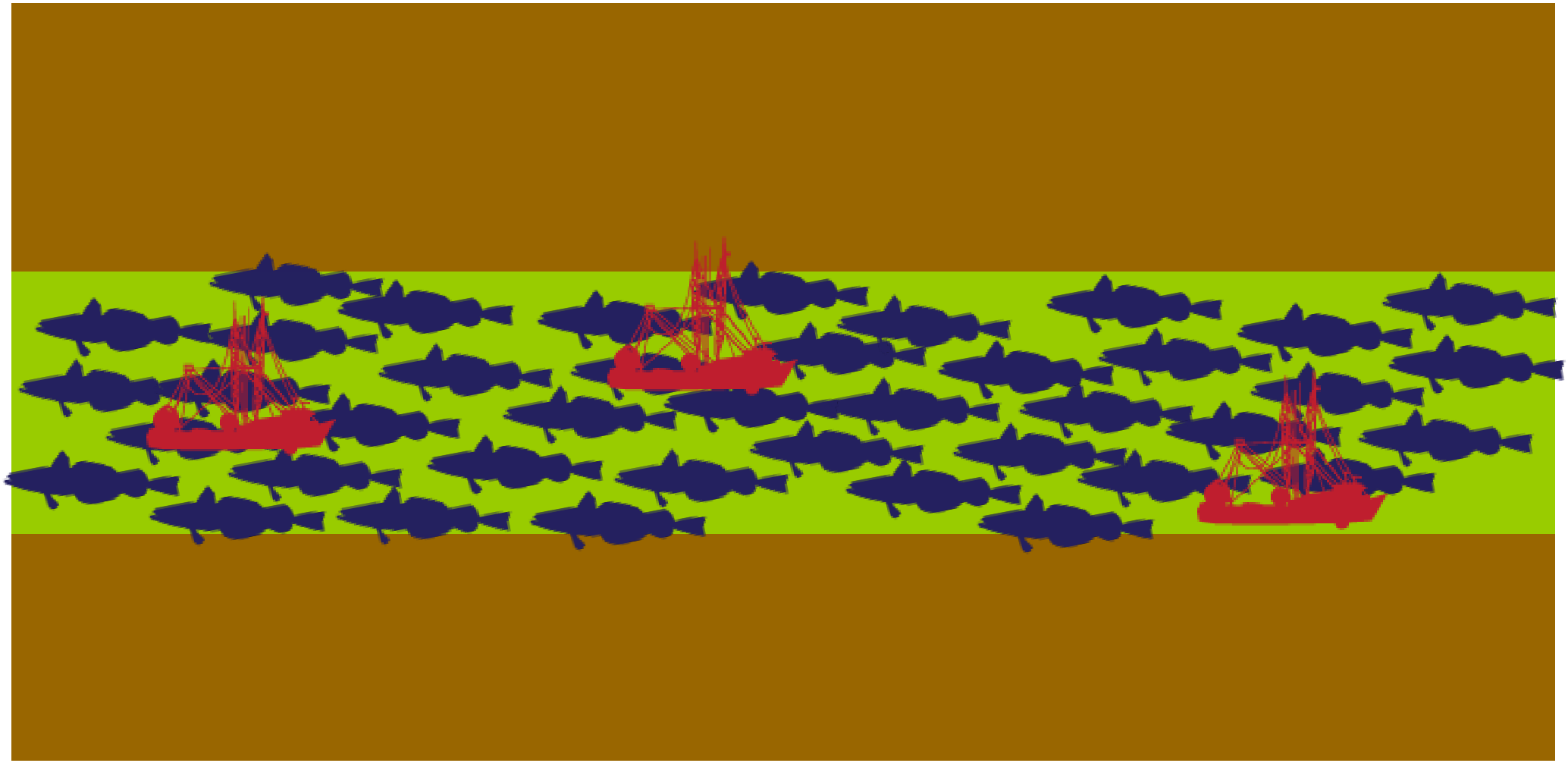
Hyperstability: Survey Effort



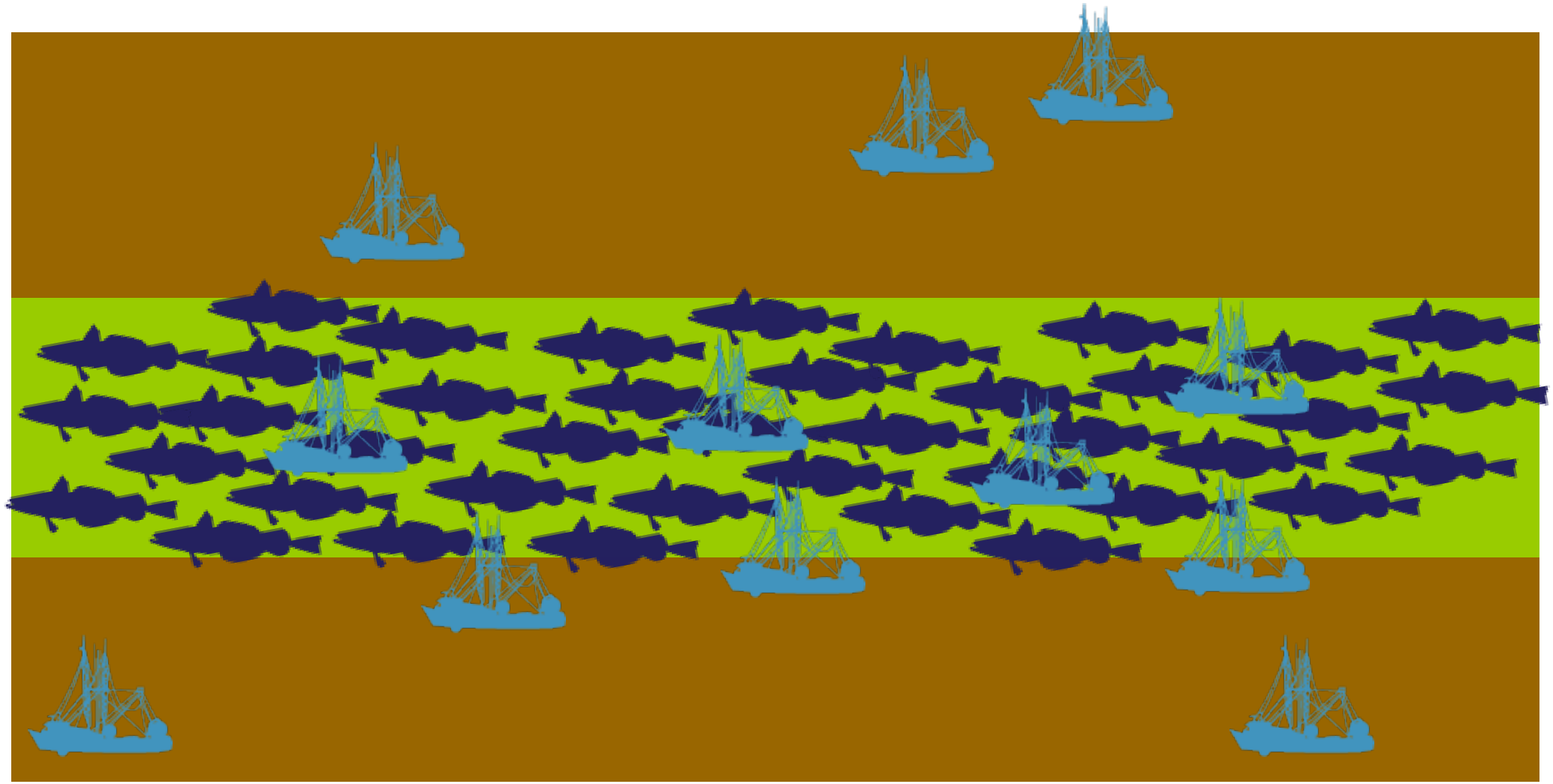
Hyperstability: Declining Stock



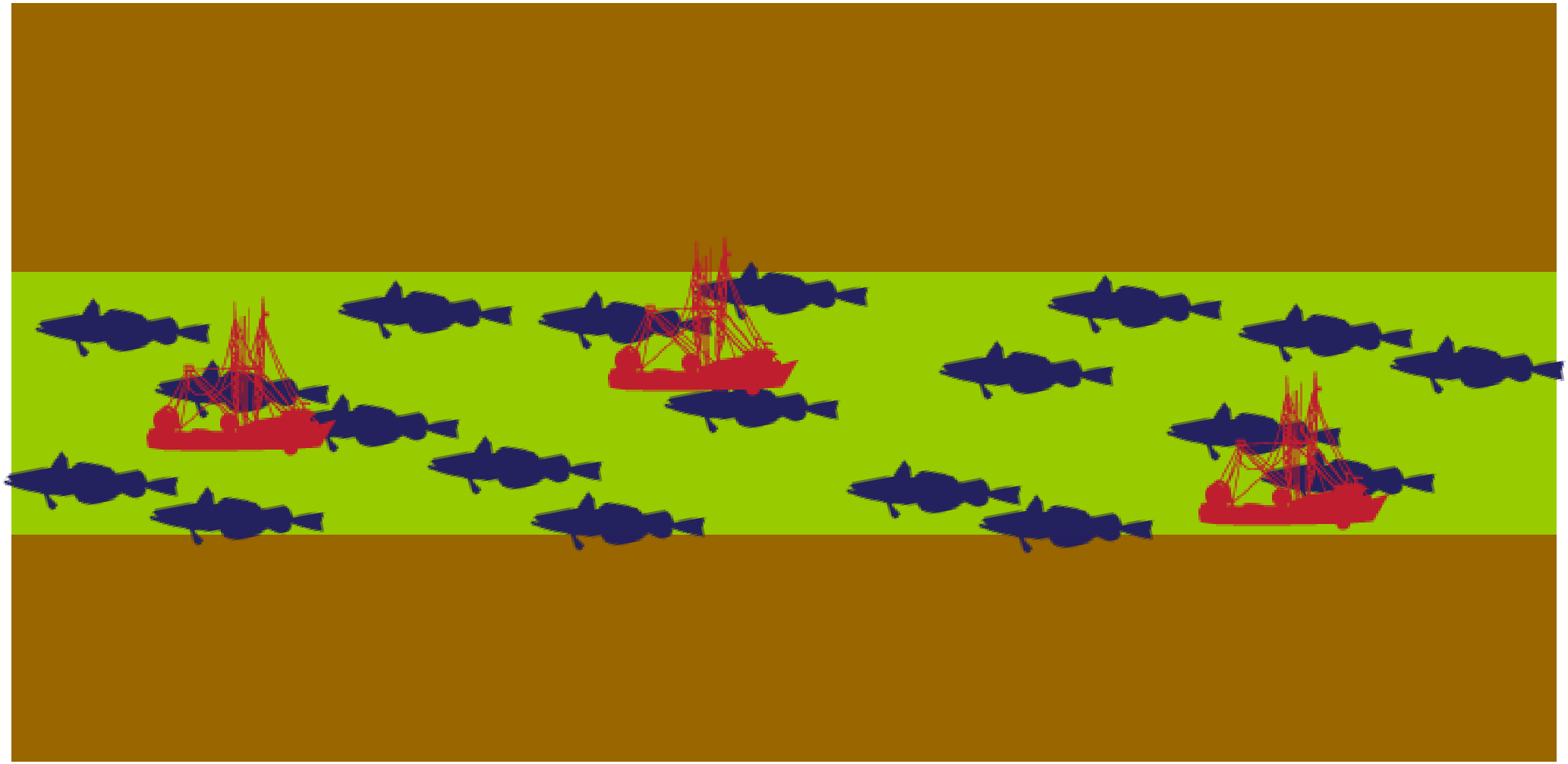
Hyperstability: Declining Fishery



Hyperstability: Declining Survey

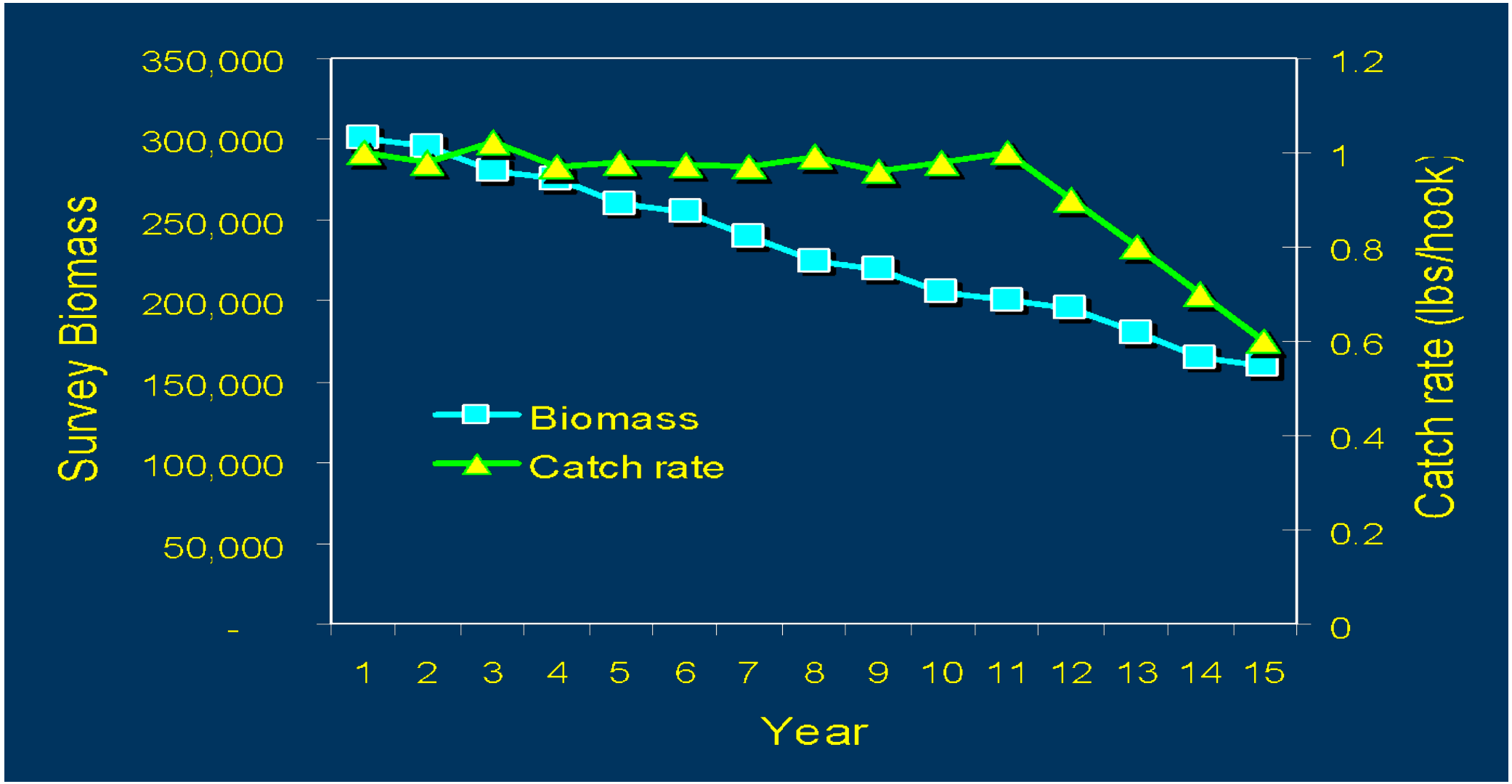


Hyperstability: Depleted Fishery

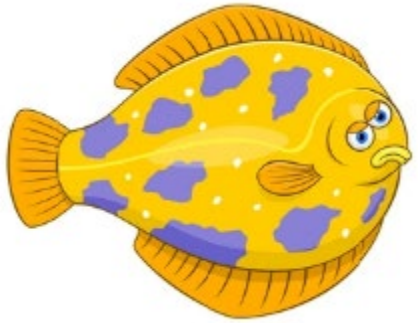


NOAA FISHERIES

Hyperstability: Comparison

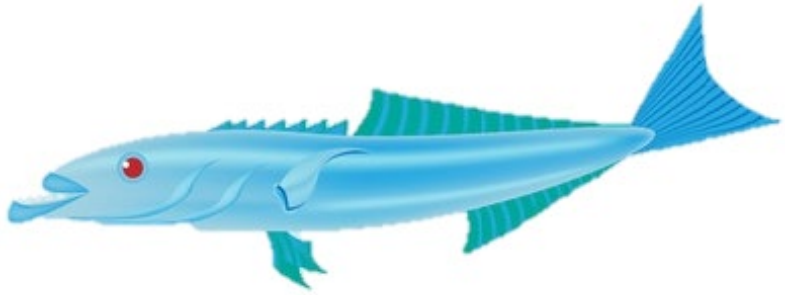


Fisheries Independent Surveys:



Species A: Meyer Sole

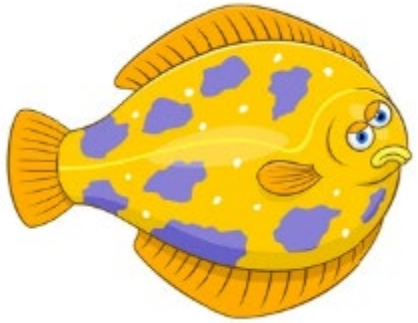
- Bullet 8 – Estimate of biomass
- Bullet 12 – Scientific uncertainty



Species B: Whitebelly Lemonfish

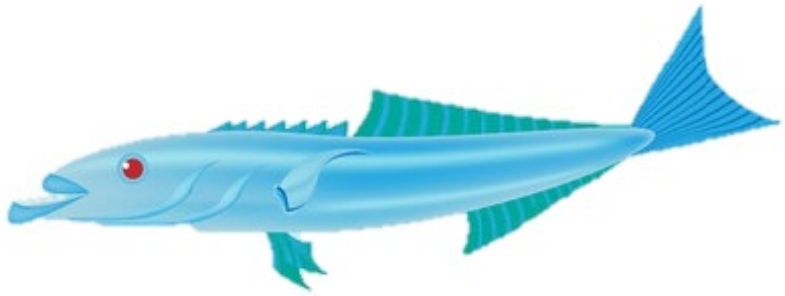
- Has a reliable fisheries independent survey, some data available, but nothing highlighted

Fisheries Dependent Surveys:



Species A: Meyer Sole

- No information highlighted



Species B: Whitebelly Lemonfish

- No information highlighted

Data Collection & Processing: Biology

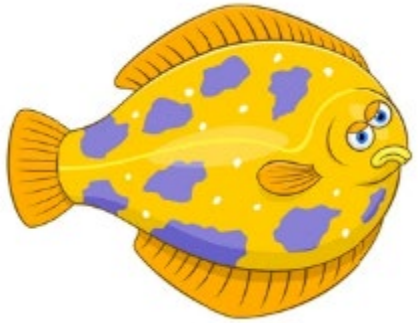
Data Types

- Age
- Length & Weight
- Fecundity
- Natural Mortality
- Growth
- Recruitment
- Movement
- Environmental influences
- Predation
- Diet… and more!

Data Sources

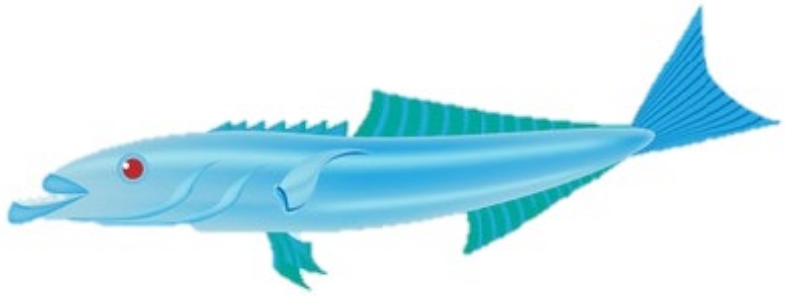
- Fishery-independent surveys
- Fisheries observers
- Port sampling
- Research & tagging studies
- Cooperative research

Biological Data:



Species A: Meyer Sole

- Bullet 4 - Catchability
- Bullet 15 - Predation and/or climate change



Species B: Whitebelly Lemonfish

- Bullet 15 - Stock condition links to environmental conditions
- Bullet 16 - Important information on stock structure and maturity

Data Collection & Processing: Catch

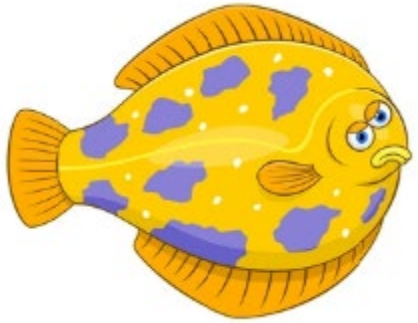
Data Types

- Commercial landings
- Commercial discards
- Recreational catch
- Recreational releases
- Research removals
- Survival rate

Data Sources

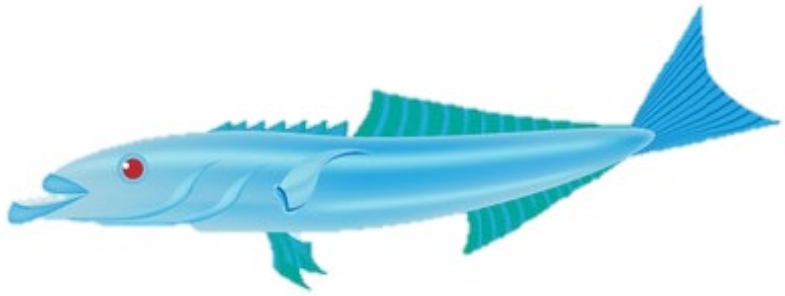
- Fishery Information Networks (state, federal, interstate commissions)
- Dockside monitoring
- Logbooks
- Observer programs
- Marine Recreational Information Program (MRIP)

Catch Data:



Species A: Meyer Sole

- Bullet 1 - Catch trends
- Bullet 10 - Catch levels
- Bullet 11 - Recreational catch estimates

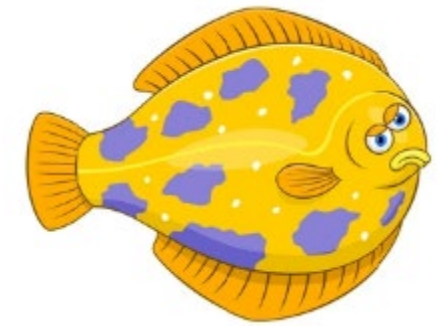


Species B: Whitebelly Lemonfish

- Bullet 1 - Harvest history
- Bullet 3 - Recreational catch history
- Bullet 4 - Shrimp bycatch
- Bullet 5 - Catch monitoring

NOAA FISHERIES

Data Takeaways:

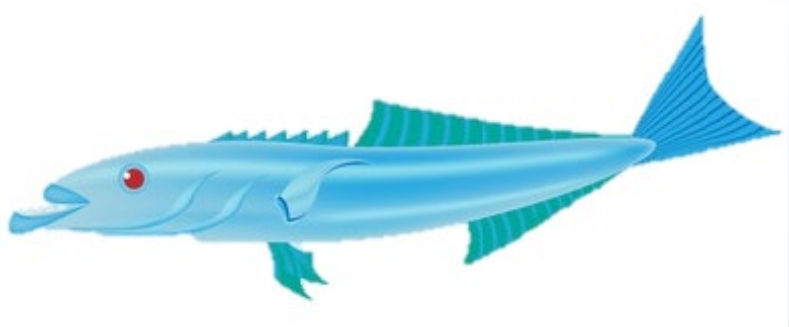


Species A: Meyer Sole

Describe your understanding of these two stocks based on data.

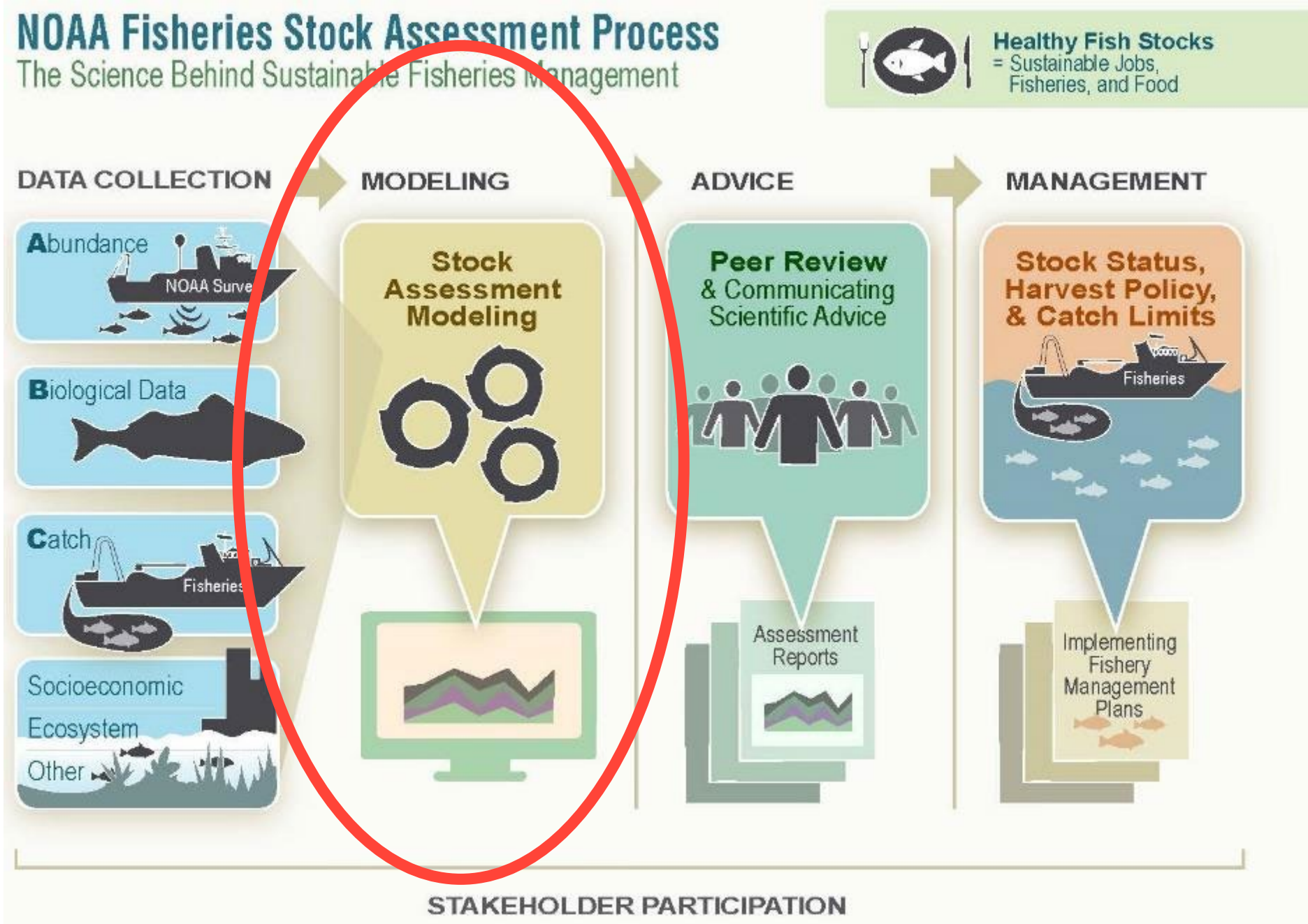
Any concerns?

Any Questions?



Species B: Whitebelly Lemonfish

NOAA FISHERIES



NOAA FISHERIES

Population Dynamics Modeling Basics

Inputs

Removals

Reproduction

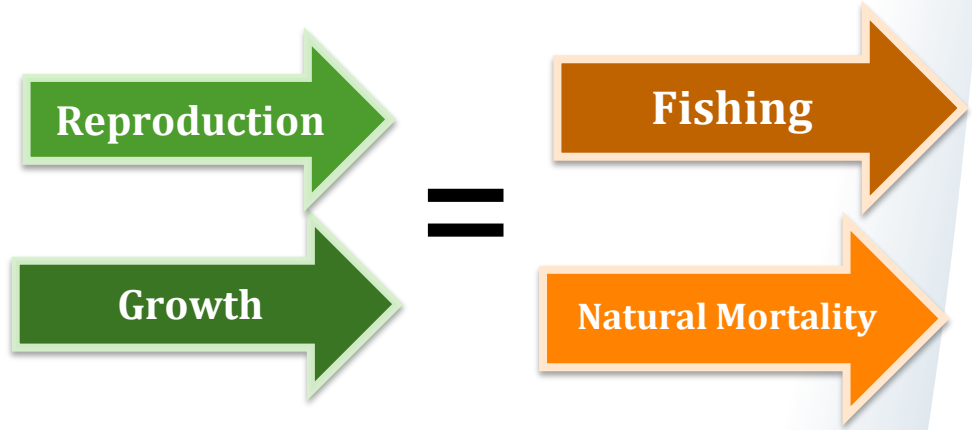
Growth

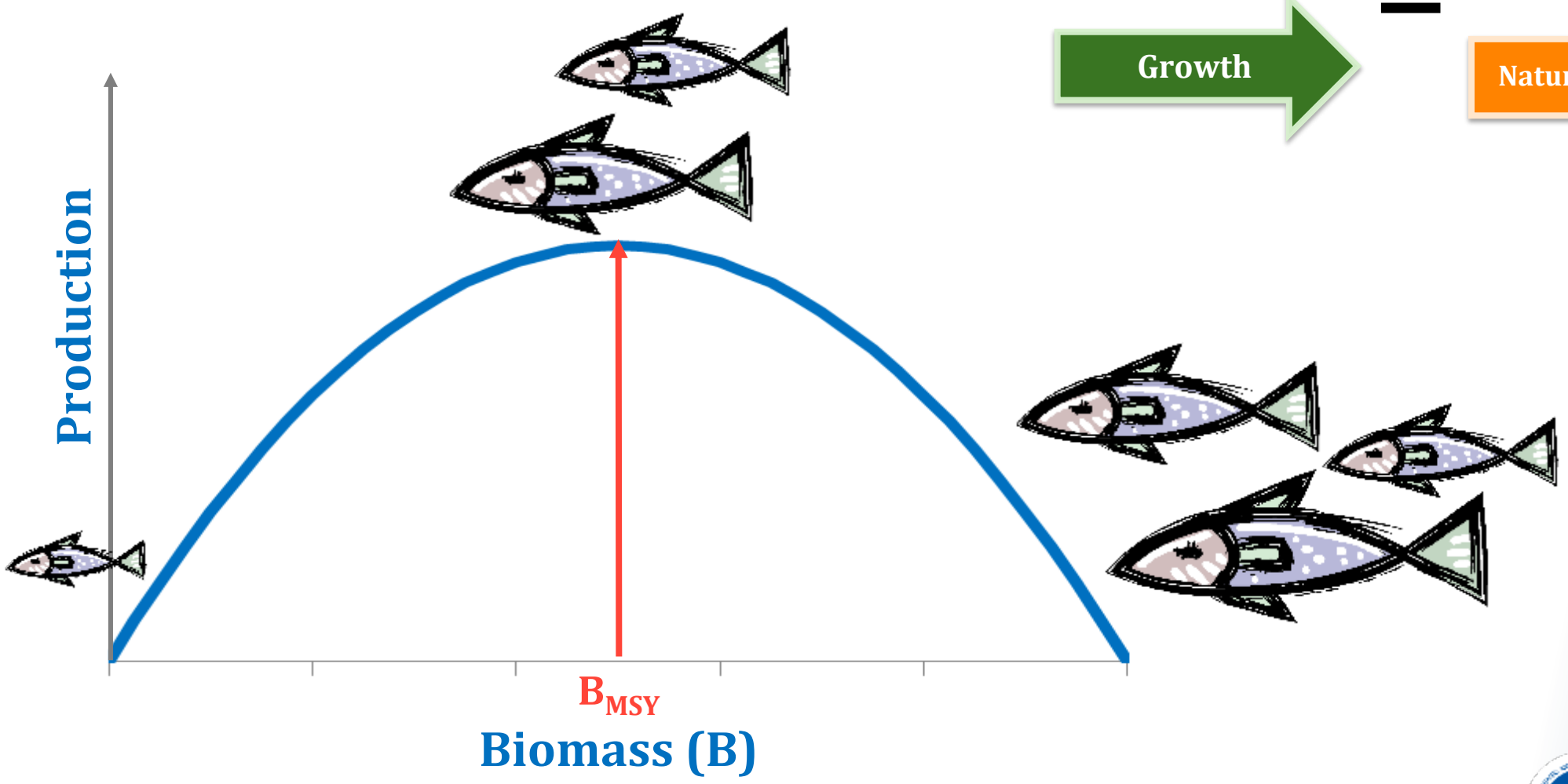
Fishing

Natural Mortality

NOAA FISHERIES

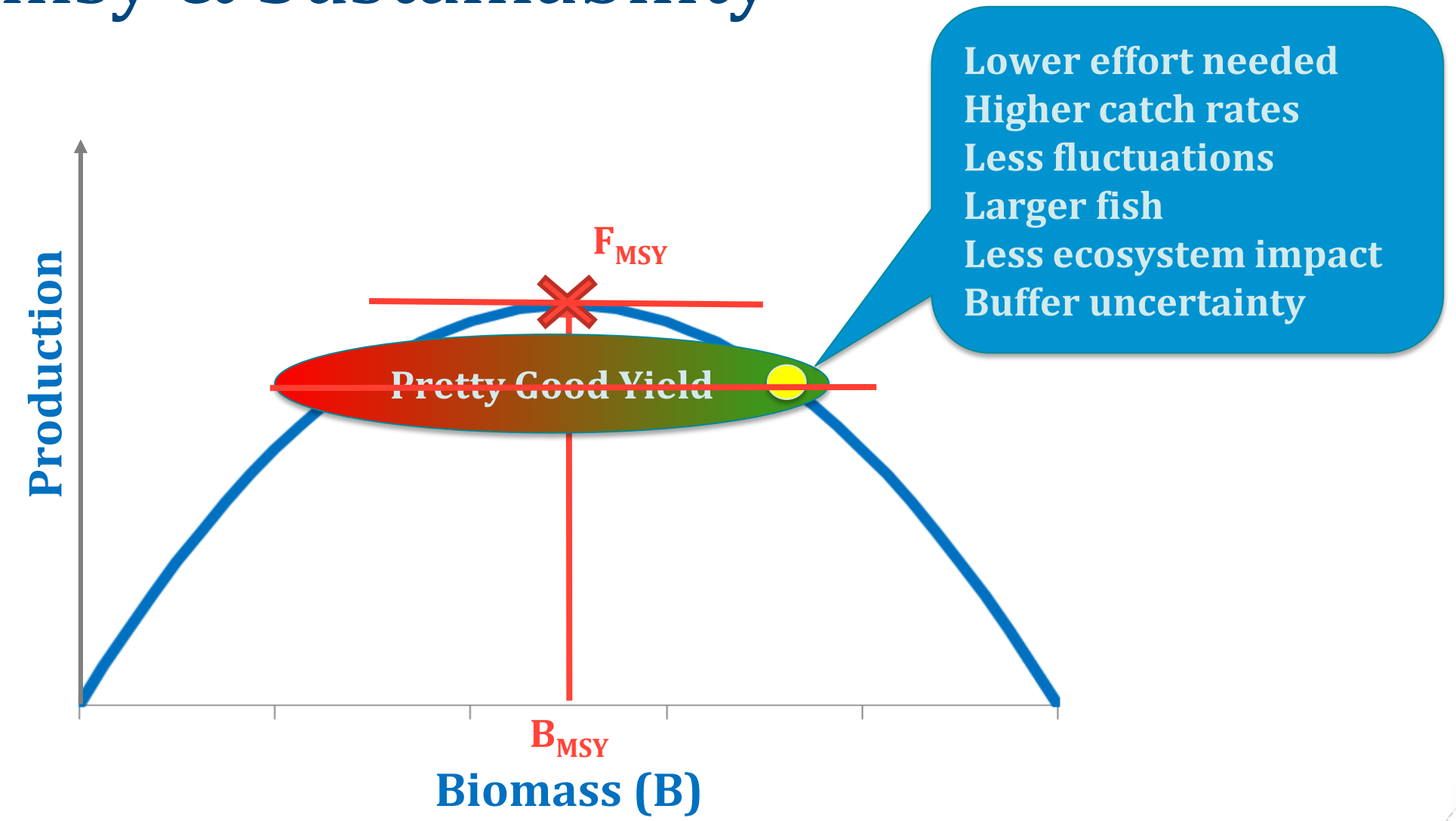
What is Sustainable?





NOAA FISHERIES

Fmsy & Sustainability



NOAA FISHERIES

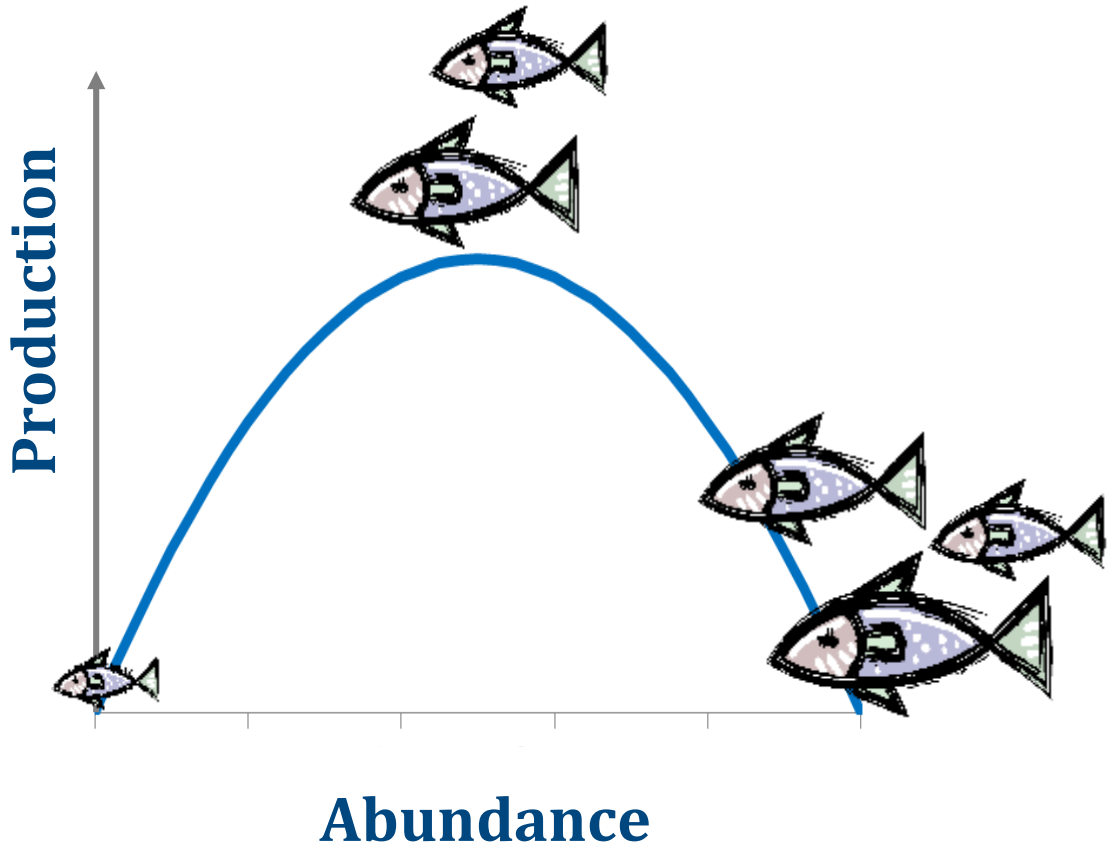
Audience Question:

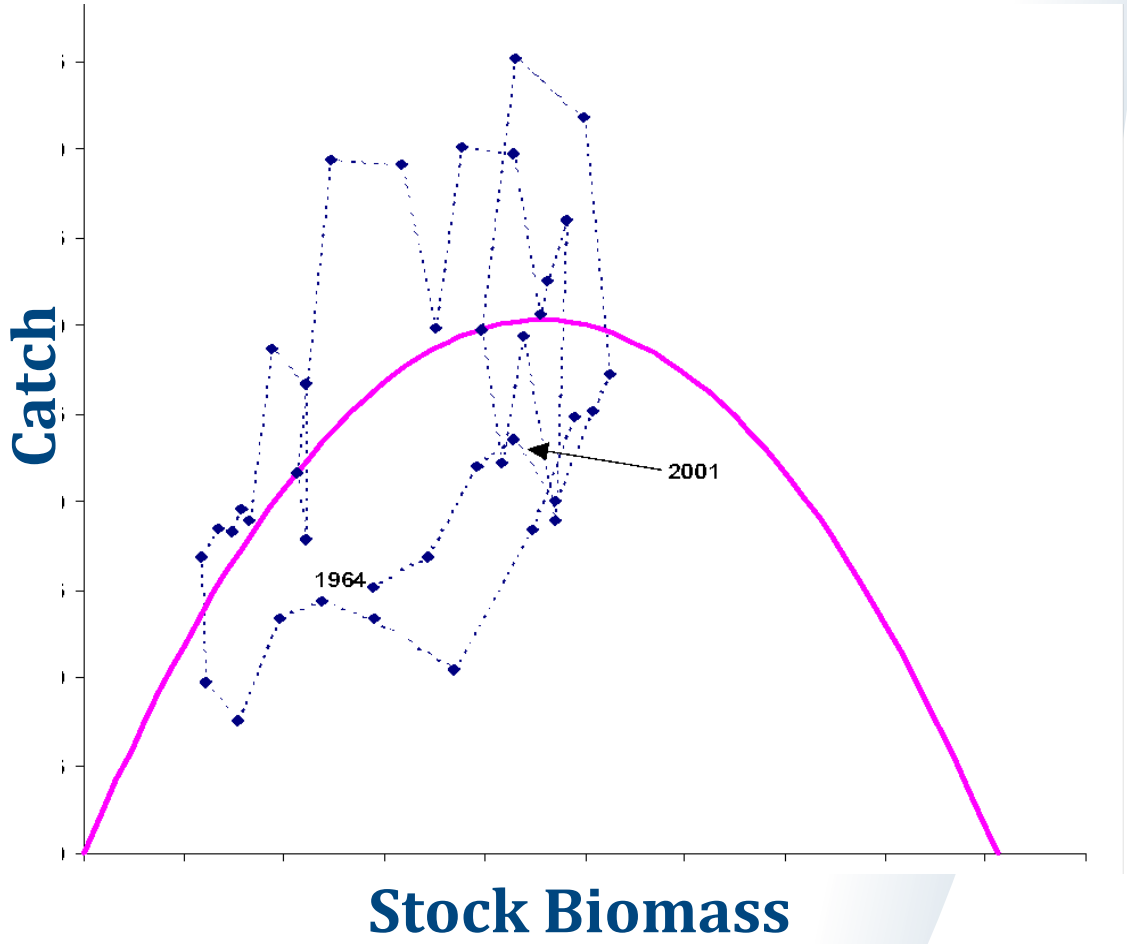
Why might managers set target catch levels slightly lower than MSY?

A. Requires lower fishing effort
B. Provides higher catch rates
C. Buffers uncertainty
D. Minimizes ecosystem impacts
E. All of the above

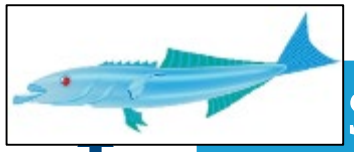
NOAA FISHERIES

Assessment Modeling: Theory vs. Reality

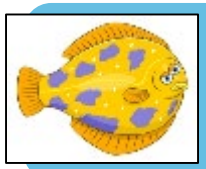




Types of Assessment Models

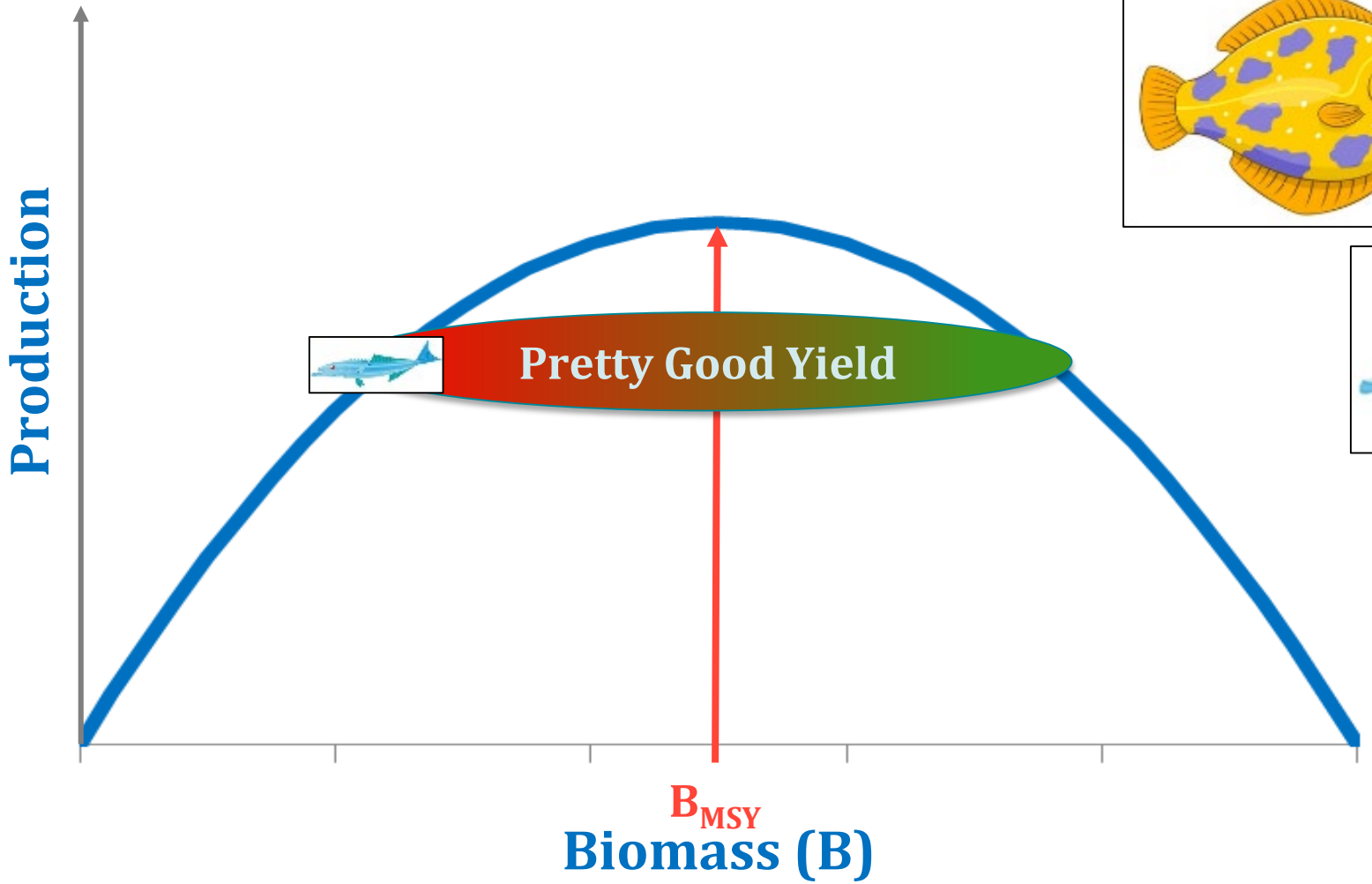


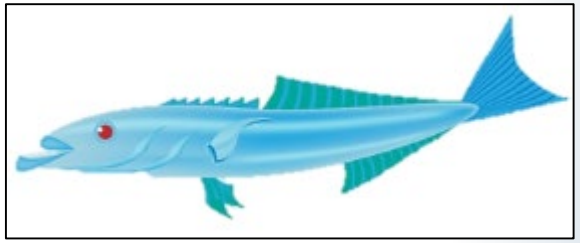
Data Req's

Statistical Catch-at-Age/Length (SCAA/SCAL)	• Length- or age-structured, incorporating complete information • Stock status and forecasts of catch limits relative to ref. points
Virtual Population Analysis (VPA)	• Abundance-at-age calculated backwards in time • Analyses can help provide complete advice on status, forecasts
Aggregate Biomass Dynamics	• Requires at least one abundance index, but not age-specific • Provides estimates of MSY, B/Bmsy, F/Fmsy, catch @ Fmsy
 Index-Based	• Time series analysis of fishery or survey trends • Provides mostly qualitative advice about stock trends
Data-Limited	• Many are catch only; some use biological info • Provides management advice in relative terms

NOAA FISHERIES

Are current harvests sustainable?





NOAA FISHERIES

Audience Question:

What factor is the most important to consider when selecting a stock assessment model?

A. Stock importance

B. Data availability

C. Stock biology

NOAA FISHERIES

Choosing Assessment Methods

"…all models are approximations. Essentially, all models are wrong, but some are useful. However, the approximate nature of the model must always be borne in mind…"

George E.P. Box

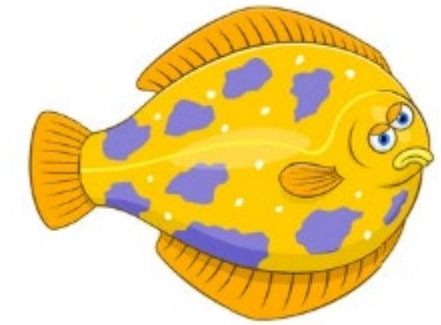
- Models are simplifications
- Choosing a model can depend on:
  - Data availability & quality
  - Stock biology
  - Stock importance
- Multiple methods may be appropriate

Science is really in the business of disproving current models or changing them to conform to new information. In essence, we are constantly proving our latest ideas wrong."

David Suzuki

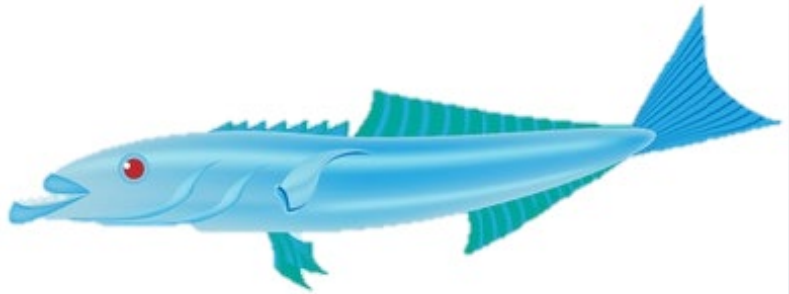
NOAA FISHERIES

Today's Mission: Part 2

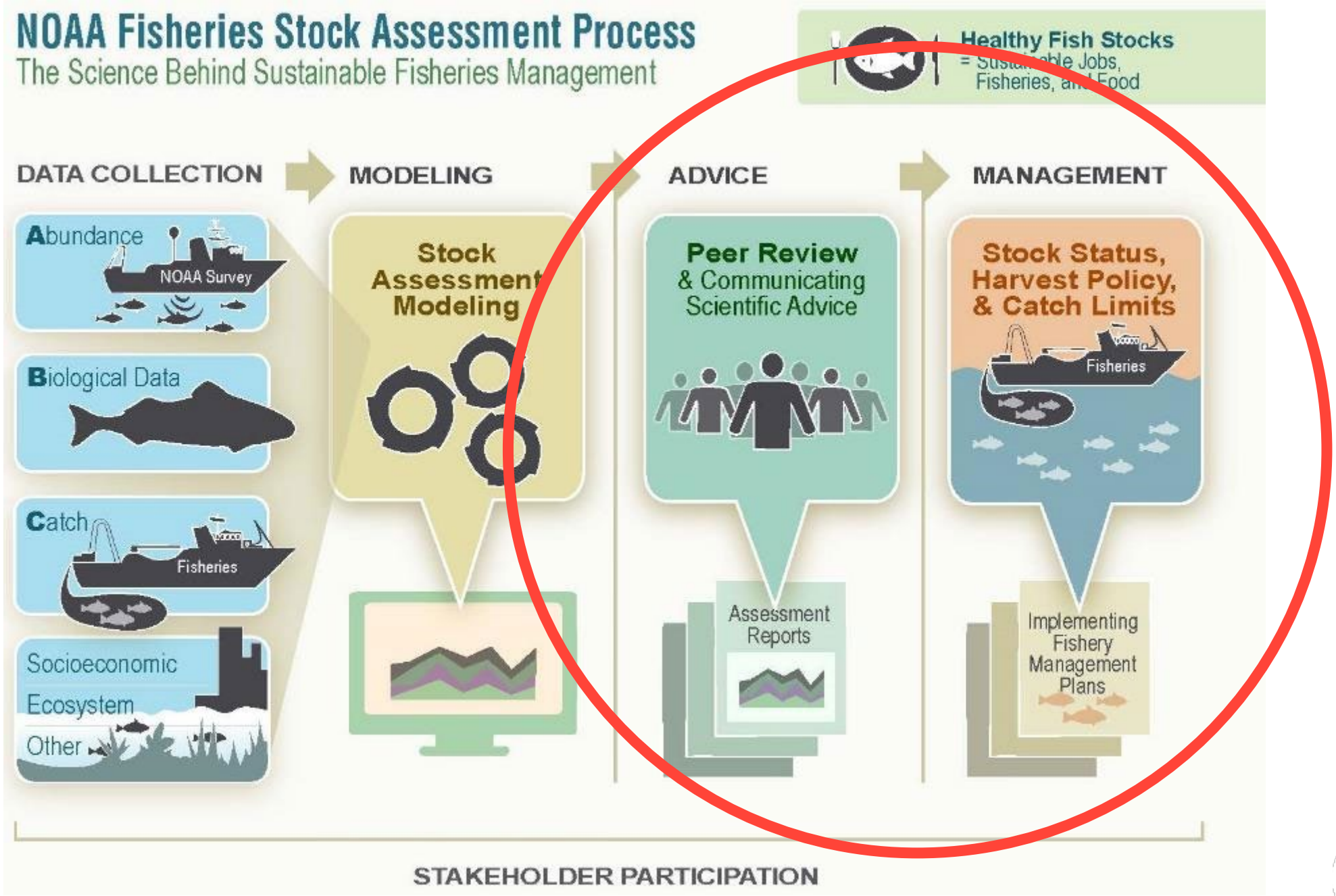


Species A: Meyer Sole

Decide on how best to manage your stock based upon updated stock assessment results



Species B: Whitebelly Lemonfish



NOAA FISHERIES

Role of Council in Assessment Process

- Scientific and Statistical Committee reviews stock assessments to ensure Councils are basing their decisions on the best science information available
  - Helps the Council evaluate the statistical, biological, and other information resulting from stock assessments
  - Develop fishing level recommendations based on assessment results
  - Members may participate directly in assessment
- Council considers SSC recommendations in developing management measures

Key Areas of Advice…

- What are the sustainable biological limits to fishing (i.e. F_{MSY} and B_{MSY})?
- How hard have we been fishing and what is the current stock status?
- What fraction of the stock should be harvested each year?
  - Harvest Policy & Control Rules
- What short-term future catch level (forecast) would implement the harvest policy given the current stock status and prevailing environmental conditions?

Audience Question:

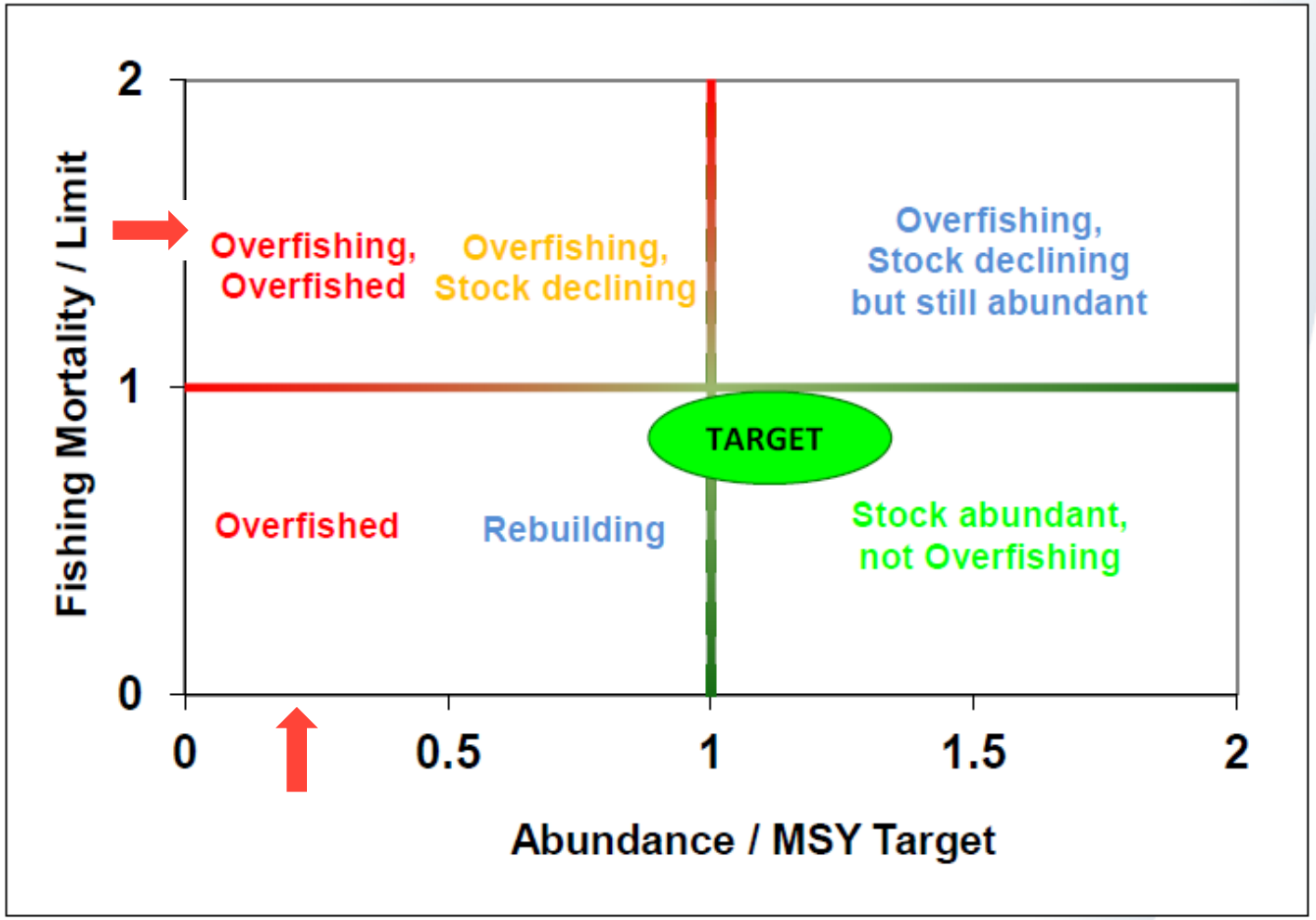
When is a stock considered to be overfished?

A. When current biomass (B) drops below $2*B_{MSY}$ (e.g., $B<2*B_{MSY}$)
B. When current F is greater than F_{MSY} ($F>F_{MSY}$)
C. When current B drops below $½*B_{MSY}$ ($B<½*B_{MSY}$)
D. When current B is greater than B_{MSY} ($B>B_{MSY}$)

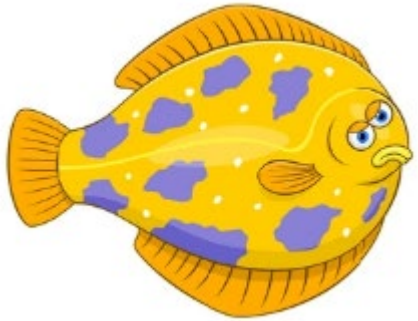
NOAA FISHERIES

Stock Status

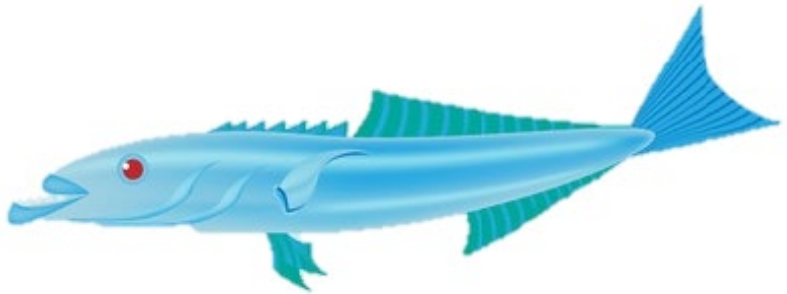
- Current fishing rate and biomass levels relative to management reference points



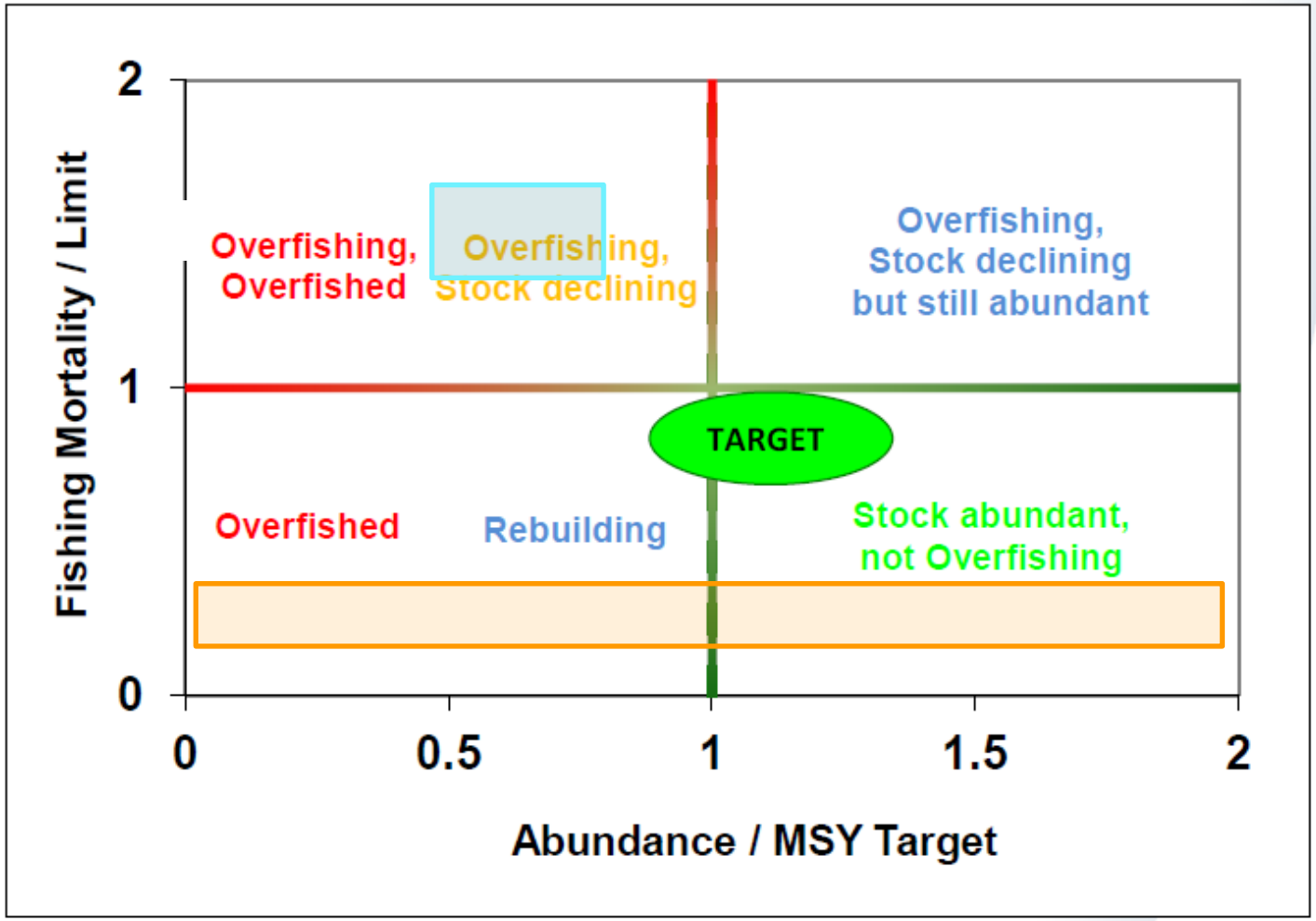
Current Stock Status



Species A: Meyer Sole



Species B: Whitebelly Lemonfish



NOAA FISHERIES

Proactive Short-Term Advice: Catch Levels

- In accordance with harvest policy
  - No more than specified (<=50%) chance of overfishing
  - Rebuild overfished stocks
  - Maximize benefits while protecting marine ecosystems

- **Control Rule:** Formula that calculates future catch level from forecasted biomass

NOAA FISHERIES

Audience Question:

The ABC can be set equal to or greater than the OFL.

TRUE or FALSE?

NOAA FISHERIES

Audience Question:

What does reducing the OFL to the ABC account for?

A. Scientific uncertainty
B. Management uncertainty
C. Implementation uncertainty

NOAA FISHERIES

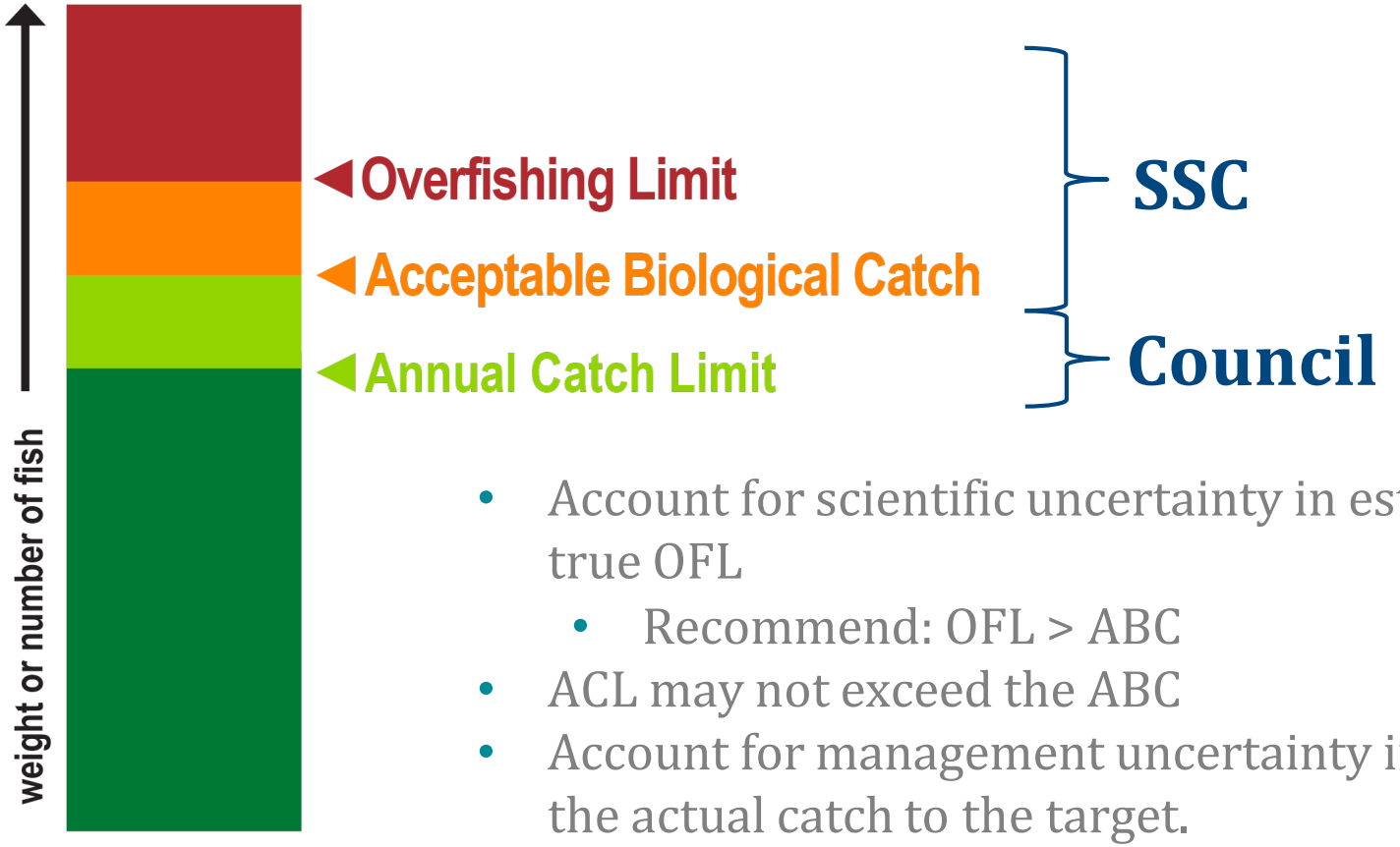
Audience Question:

According to the NS1 guidelines, the risk of overfishing (e.g., exceeding the true OFL) must not be larger than what?

A. 40%
B. 50%
C. 60%
D. 90%

NOAA FISHERIES

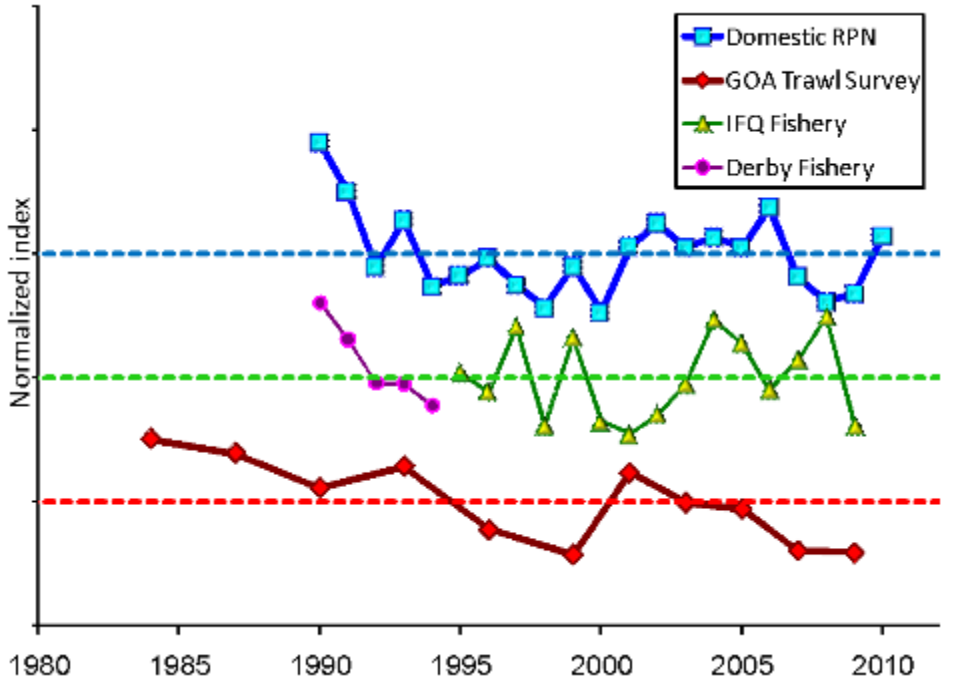
Know Your Reference Points
OFL, ABC, ACL, and ACT



- Account for scientific uncertainty in estimating the true OFL
  - Recommend: OFL > ABC
- ACL may not exceed the ABC
- Account for management uncertainty in controlling the actual catch to the target.
  - For example: ACL > ACT

Catch Advice: Uncertainty

- **Uncertainty is the Reality**
  - Models are simplifications & data are incomplete
  - Uncertainty ≠ bad science
- **Scientific Uncertainty**
  - **Data/Observation:** sampling variability from surveys, error in observations, lack of information
  - **Model/Assessment:** arises during the modeling and assessment process and includes: parameter uncertainty, accuracy of assumptions, choice of modeling approach
  - **Ecosystem:** unknown or poorly understood ecosystem relationships and their effects on single-species management advice
- **Management Uncertainty**
  - **Implementation:** uncertainty in performance of management actions, leading to uncertainty in whether the target is being met



Catch Advice: Uncertainty & Sensitivity Analysis

- Methods for characterizing scientific uncertainty:
  - Statistical error
  - Sensitivity analysis
  - Multiple models
  - Retrospective analysis

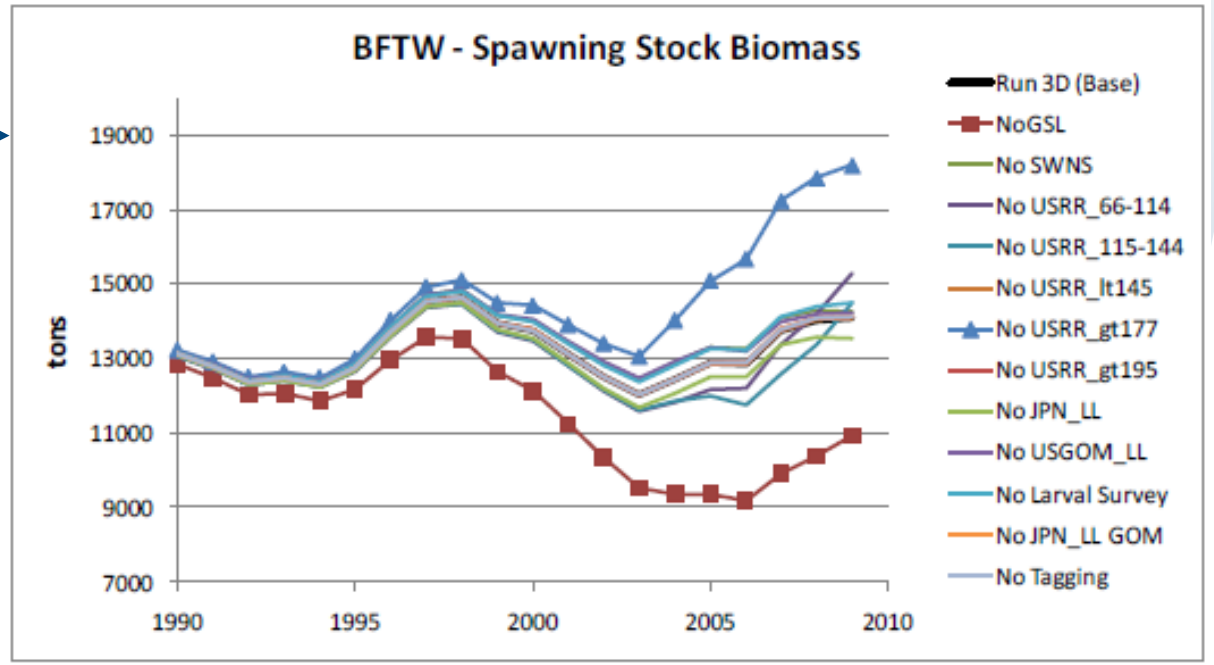


Image sources:
https://science.howstuffworks.com/nature/climate-weather/storms/spaghetti-models.htm
ICES J Mar Sci, Volume 72, Issue 1, January 2015, Pages 99–110, https://doi.org/10.1093/icesjms/fsu198

Catch Advice: Uncertainty & Multiple Models

- Methods for characterizing scientific uncertainty:
  - Statistical error
  - Sensitivity analysis
  - Multiple models
  - Retrospective analysis

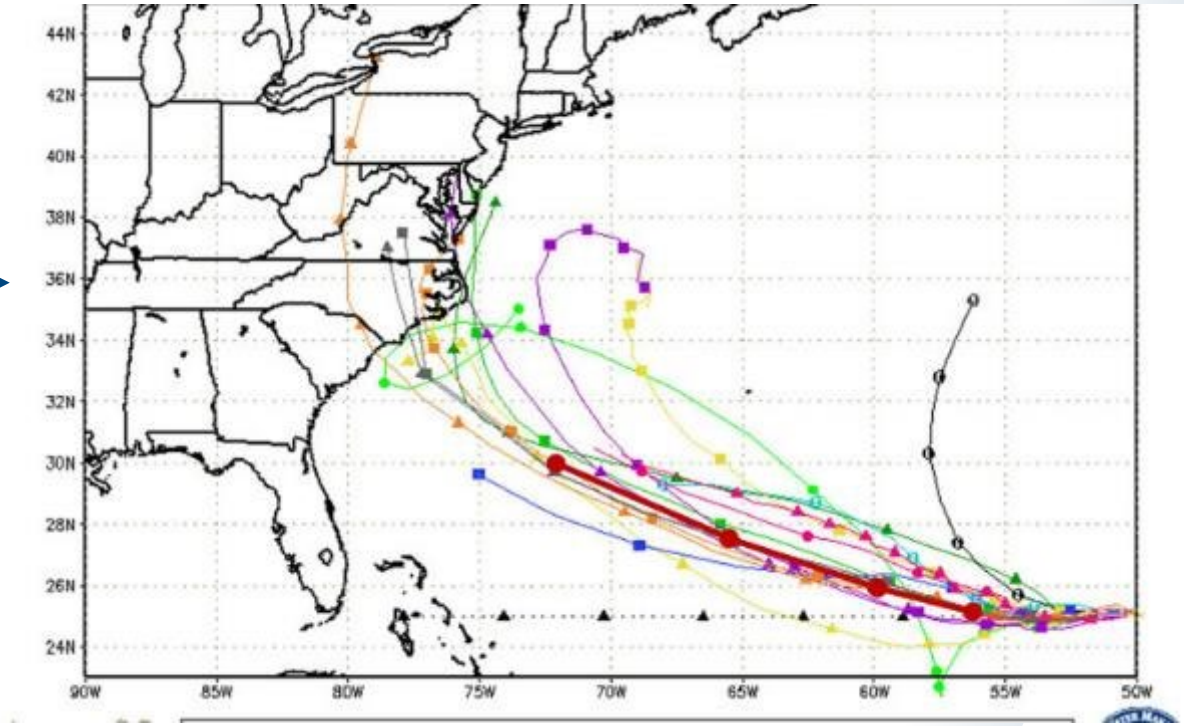


Image sources:
https://science.howstuffworks.com/nature/climate-weather/storms/spaghetti-models.htm
ICES J Mar Sci, Volume 72, Issue 1, January 2015, Pages 99–110, https://doi.org/10.1093/icesjms/fsu198

Catch Advice: Uncertainty & Retrospective Analysis

- Methods for characterizing scientific uncertainty:
  - Statistical error
  - Sensitivity analysis
  - Multiple models
  - Retrospective analysis

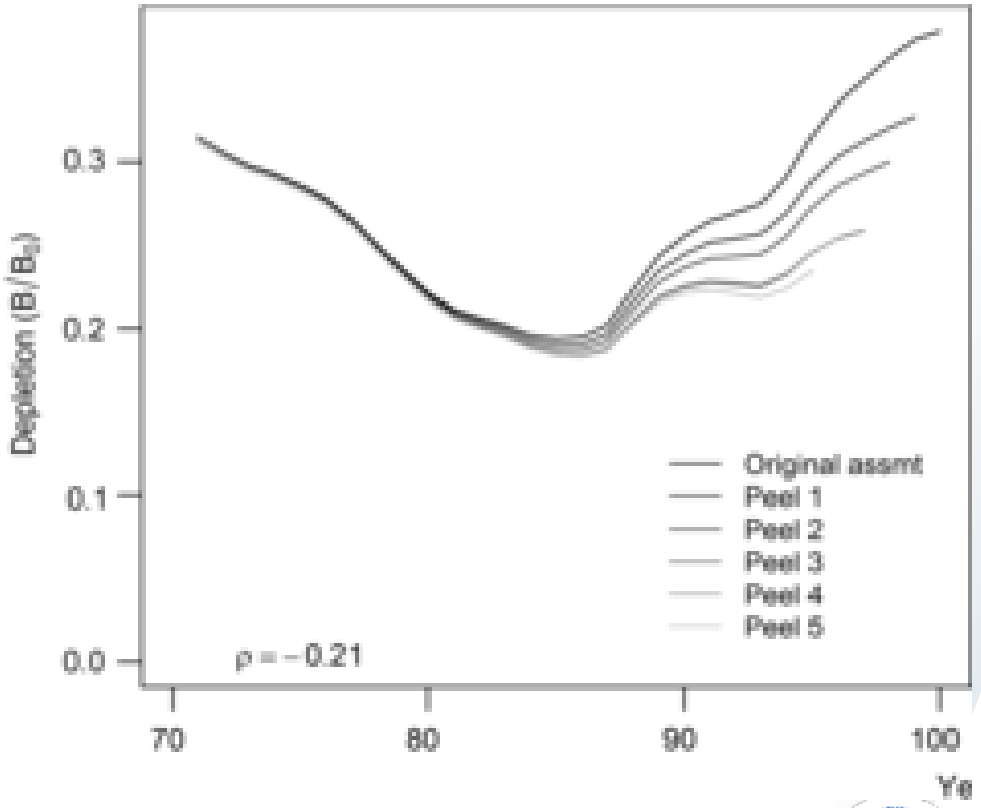
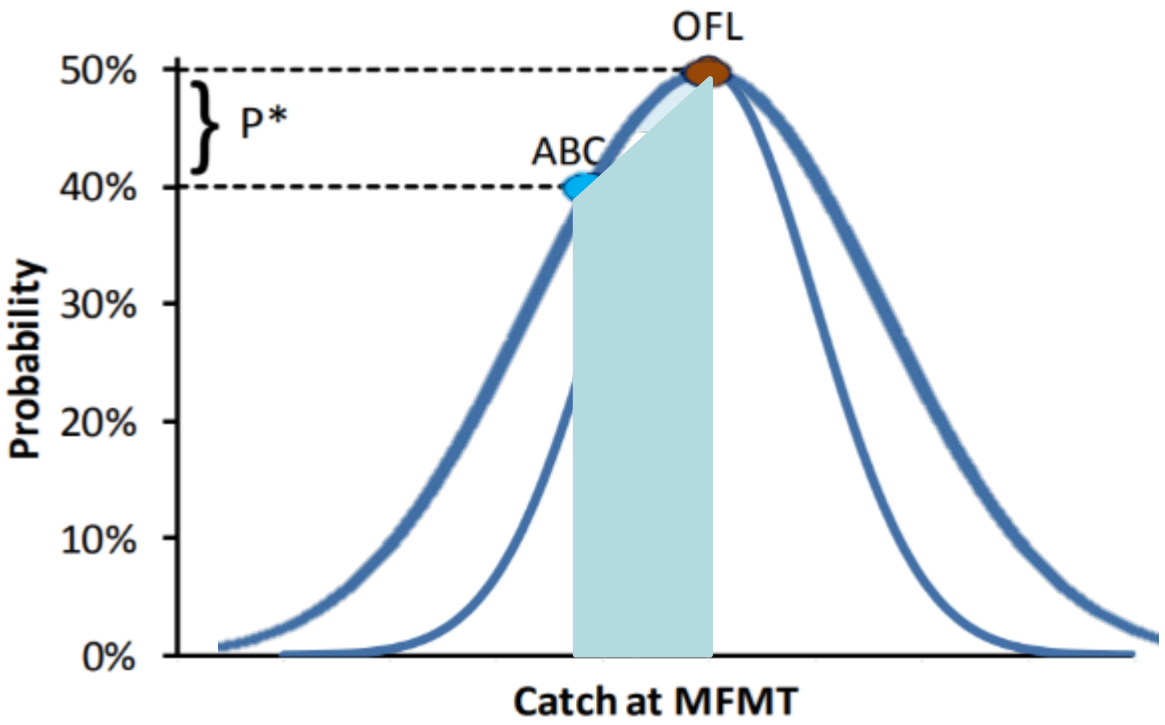


Image sources:
https://science.howstuffworks.com/nature/climate-weather/storms/spaghetti-models.htm
ICES J Mar Sci, Volume 72, Issue 1, January 2015, Pages 99–110, https://doi.org/10.1093/icesjms/fsu198

Proactive Short-Term Advice: Uncertainty

- SSCs expected to address scientific uncertainty with ABCs (safety buffer)
- P* harvest control rule
  - Fig: uncertainty around OFL
  - P* = P* is the allowable probability that the ABC will exceed the OFL (overfishing). Should not exceed 50%
  - Using P* = 40% identifies an ABC that has 40% chance of exceeding true OFL
  - Council determines P* through their Risk Policy
- Multiplier approach: ABC = 0.75*OFL



Audience Question:

In data-poor situations where uncertainty is difficult to quantify, the buffer between the OFL and ABC should still be created, and can be based on borrowed information from other stocks. This buffer should be as large as or larger than for other stocks where we are able to calculate uncertainty.

TRUE or FALSE?

NOAA FISHERIES

Uncertainty and the Data-Poor Situation

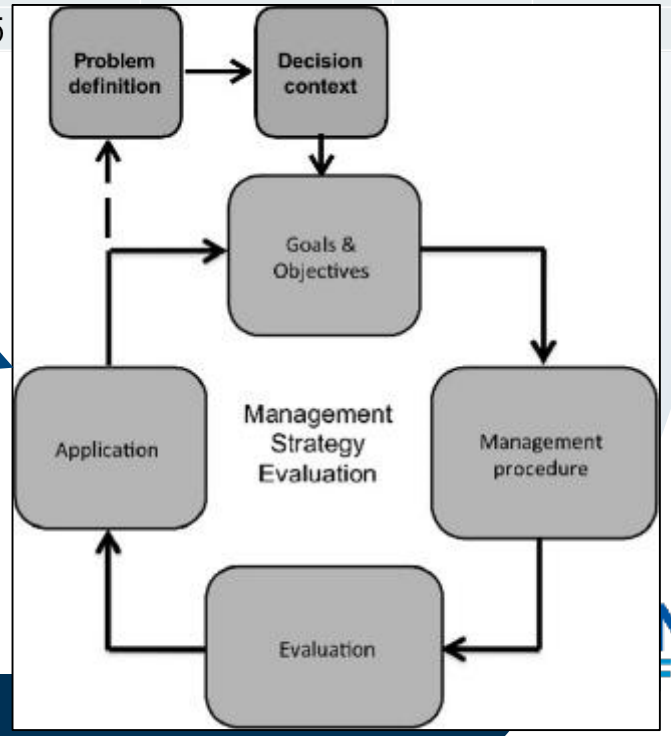
- MSY or proxies cannot be calculated
  - Catch level that constitutes overfishing is unknown
- Statistical uncertainty may be relatively low with data-poor methods
- However, the buffer should increase with less information
  - Need to account for unmeasured (*likely*) uncertainty
  - Size of buffer can be "borrowed" from similar species (should not be less)

NOAA FISHERIES

Uncertainty & Decision Support Tools

- **Decision Tables**
  - Show expected outcomes given a range of management decisions and assessment scenarios
  - Communicates risks and tradeoffs
- **Management Strategy Evaluations**
  - Uses computer simulation to run many times to reveal the performance characteristics of an entire fishery science-to-management process

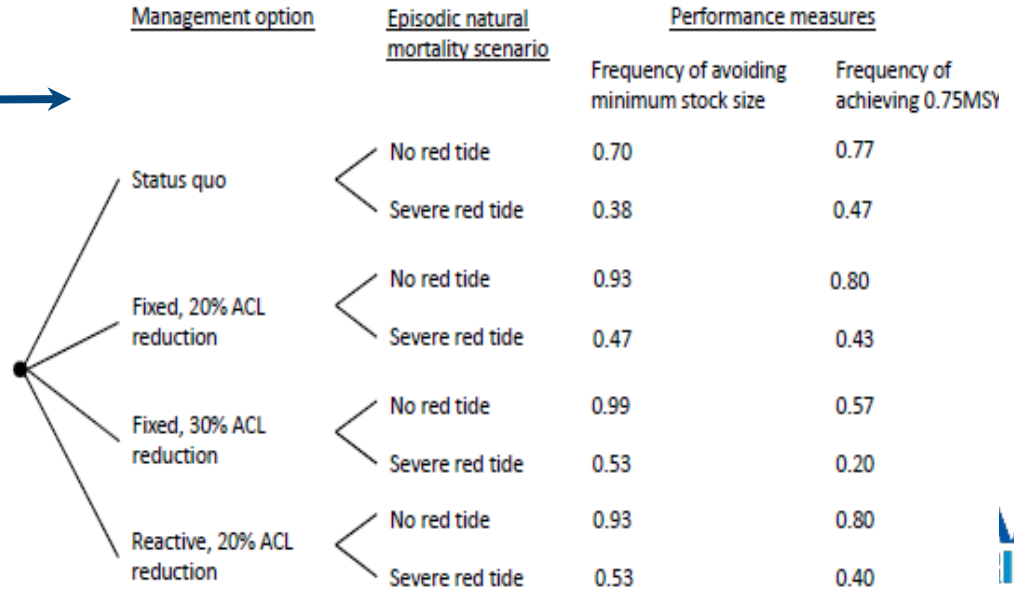
	2015	2016	2017
	But Rec is not		
Set ABC assuming high recruitment (rec)	P(overfishing | Med rec)		
0.3	36%	39%	40%
0.35	41%	45%	47%
0.4	46%	51%	54%
0.45	51%	56%	60%
0.5	56%	62%	66%
	P(overfishing | Low rec)		
0.3	43%	54%	59%
0.35	49%	63%	68%
0.4	56%	70%	76%
0.45	62%	77%	82%
0.5			



Uncertainty & Decision Support Tools, pt. 2

- **Decision Tables**
  - Show expected outcomes given a range of management decisions and assessment scenarios
  - Communicates risks and tradeoffs
- **Management Strategy Evaluations**
  - Uses computer simulation to run many times to reveal the performance characteristics of an entire fishery science-to-management process
  - *Example*: Gulf of Mexico red-tide events

	2015	2016	2017
	But Rec is not		
Set ABC assuming high recruitment (rec)	P(overfishing | Med rec)		
0.3	36%	39%	40%
0.35	41%	45%	47%
0.4	46%	51%	54%
0.45	51%	56%	60%
0.5	56%	62%	66%
	P(overfishing | Low rec)		
0.3	43%	54%	59%
0.35	49%	63%	68%
0.4	56%	70%	76%
0.45	62%	77%	82%
0.5	68%	82%	87%



Summary

Assessments designed to answer management questions

Abundance, biology, and catch are key inputs

Variety of advanced technical methods tuned to diverse data availability scenarios

Assessments produce estimates of stock abundance, fishing mortality, and productivity

Stock forecasts provide technical basis to guide setting Annual Catch Limits

For More Information

NMFS Stock Assessment Site

https://www.fisheries.noaa.gov/topic/population-assessments#fish-stocks

NMFS Stock Assessment Improvement Plan

https://www.fisheries.noaa.gov/feature-story/updated-stock-assessment-improvement-plan-builds-past-success

Status of Fisheries and FSSI Quarterly Reports

https://www.fisheries.noaa.gov/national/population-assessments/fishery-stock-status-updates

StockSMART– Explore and Visualize Stock Assessment Results

https://www.st.nmfs.noaa.gov/stocksmart

Thank You for Your Attention

QUESTIONS?