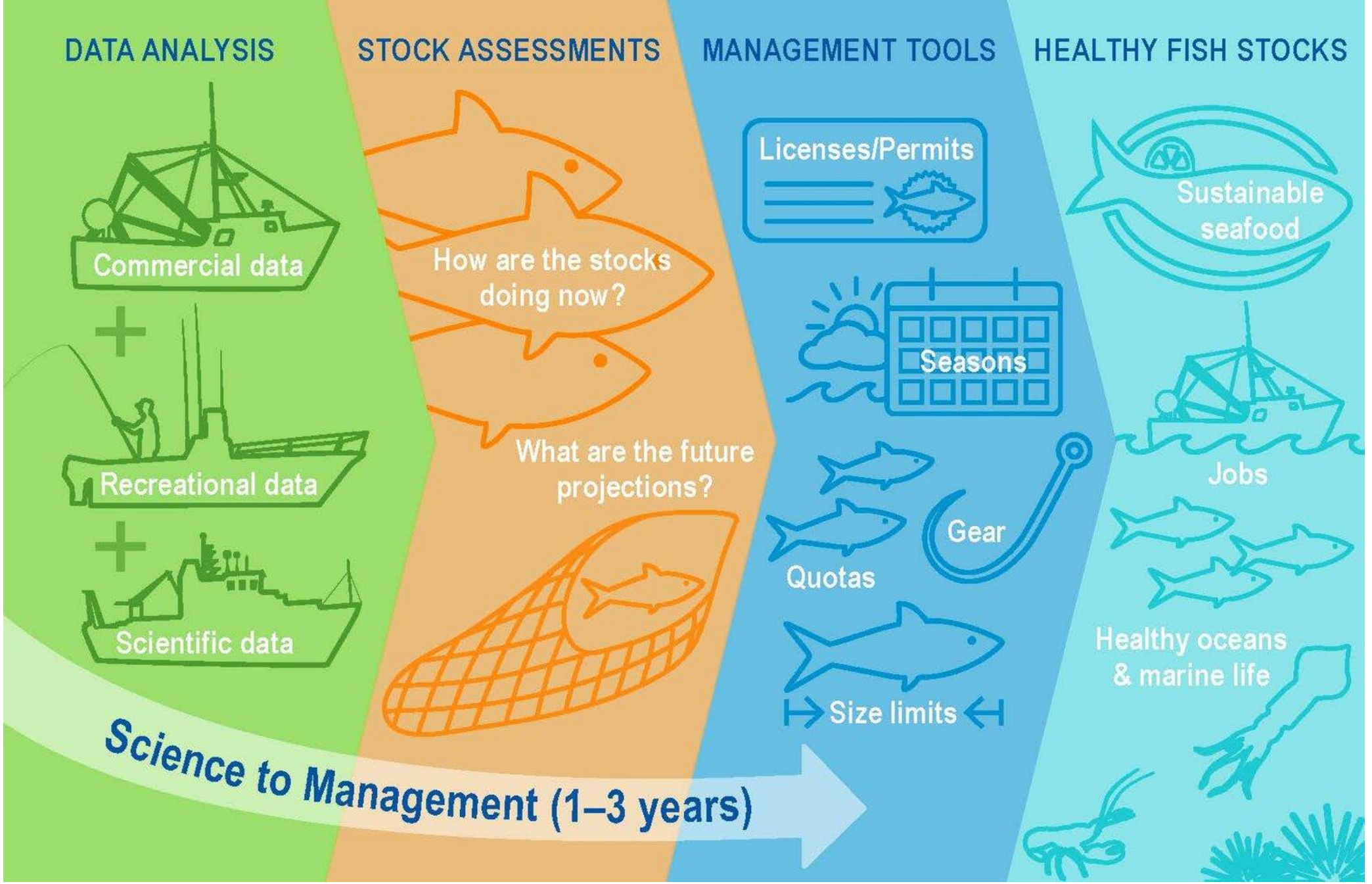
Stock Assessment Fundamentals

A basic introduction to stock assessments and the NCDMF stock assessment process

DEPARTMENT OF ENVIRONMENTAL QUALITY

Marine Fisheries

Marine Fisheries Commission Meeting | CJ Schlick, Ph.D. | May 26, 2022



Stock Assessments — Mid-Atlantic Fishery Management Council (mafmc.org)

Terms

Unit stock—the stock is comprised of those individuals that will be treated as a unit for assessment and management purposes

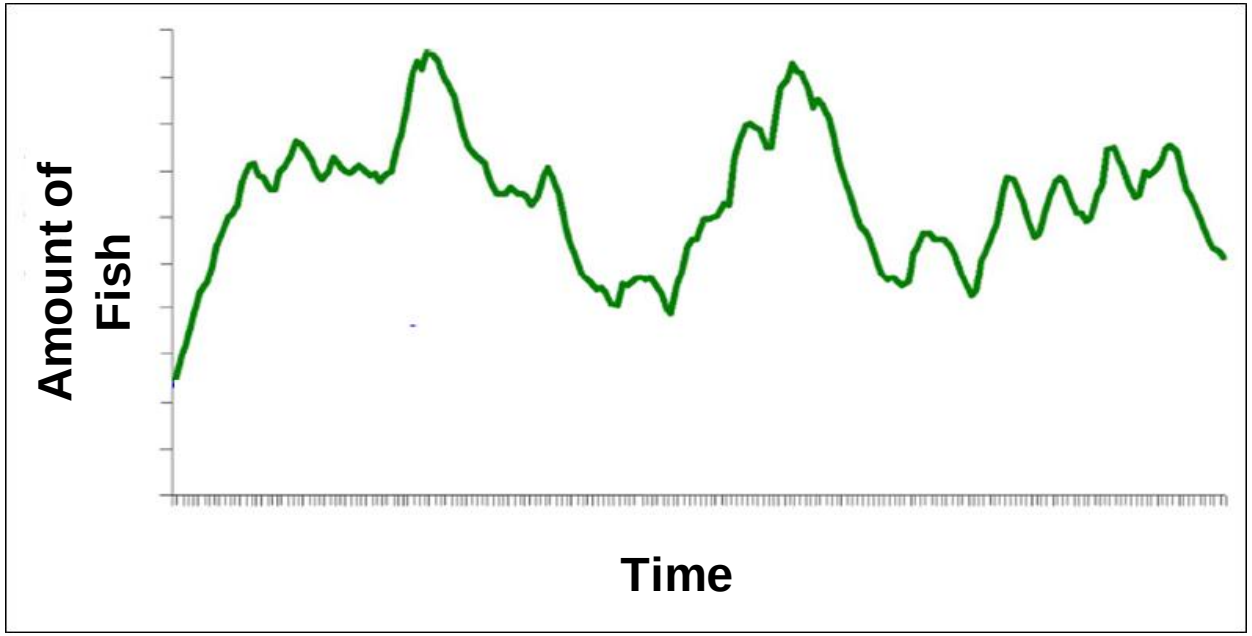
Natural mortality (*M*)—rate at which species dies of natural causes (e.g., predation, disease, competition, cannibalism, old age, parasitism, starvation)

Fishing mortality (*F*)—rate of removal of fish from the stock due to fishing activities

Recruitment—the addition of individuals to the stock

Assessing Fish Stocks

- Fish stocks change over time due to mortality, individual growth, and reproduction (“recruitment”)
- These processes can be influenced by environmental factors

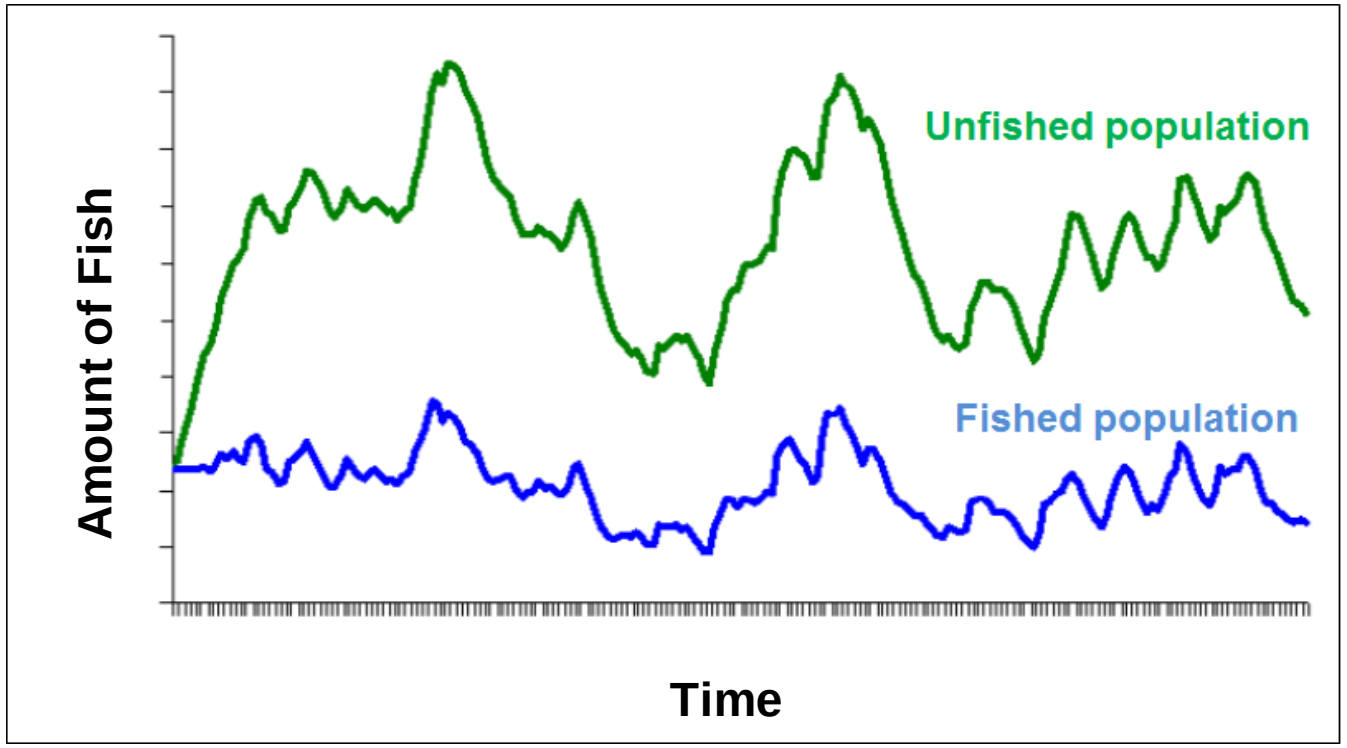


What is a Stock Assessment?

What do stock assessments tell us?

- How many fish are in the stock?
- Are there enough fish in the population to sustain the stock?
- How much can fishermen catch while still maintaining a healthy population?
- How might future abundance and catch be affected by various management options?

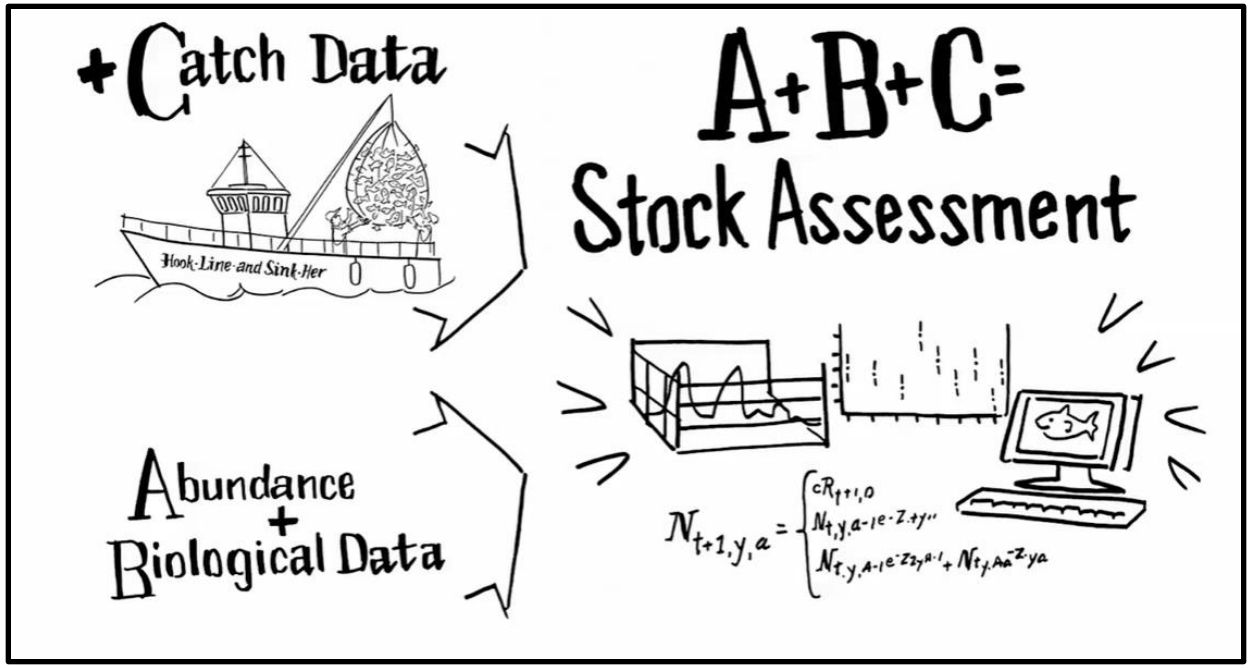
Current conditions are compared to reference values that define desirable stock conditions



Stock Assessment Steps

Estimate of how many fish are out there and how they will respond to fishing

Data → **Assessment Model** → **Population Size**, **Fishing Mortality**



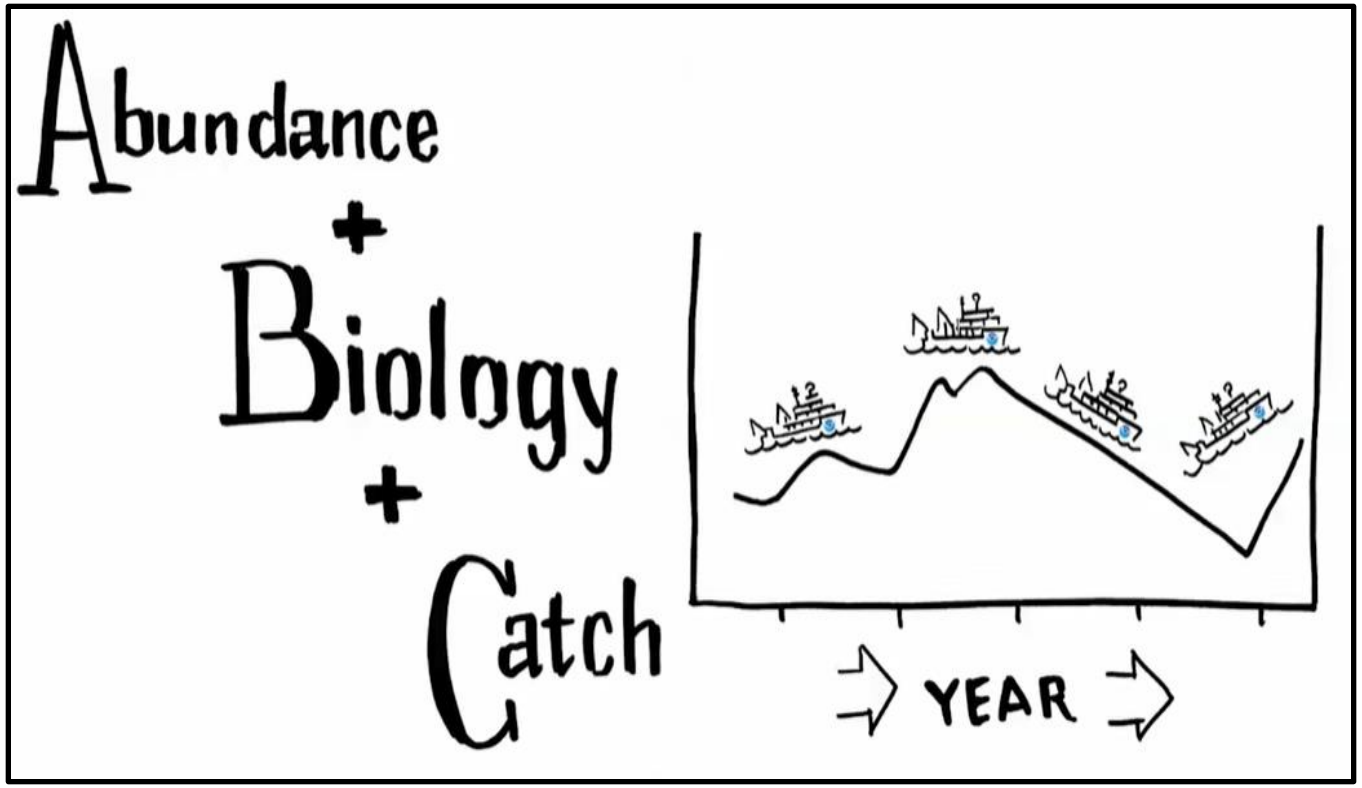
"The ABCs of Stock Assessment" video by NOAA

Data Types

Abundance—relative index of the number or weight of fish in a stock

Biology—provides information on growth, maturity, and natural mortality

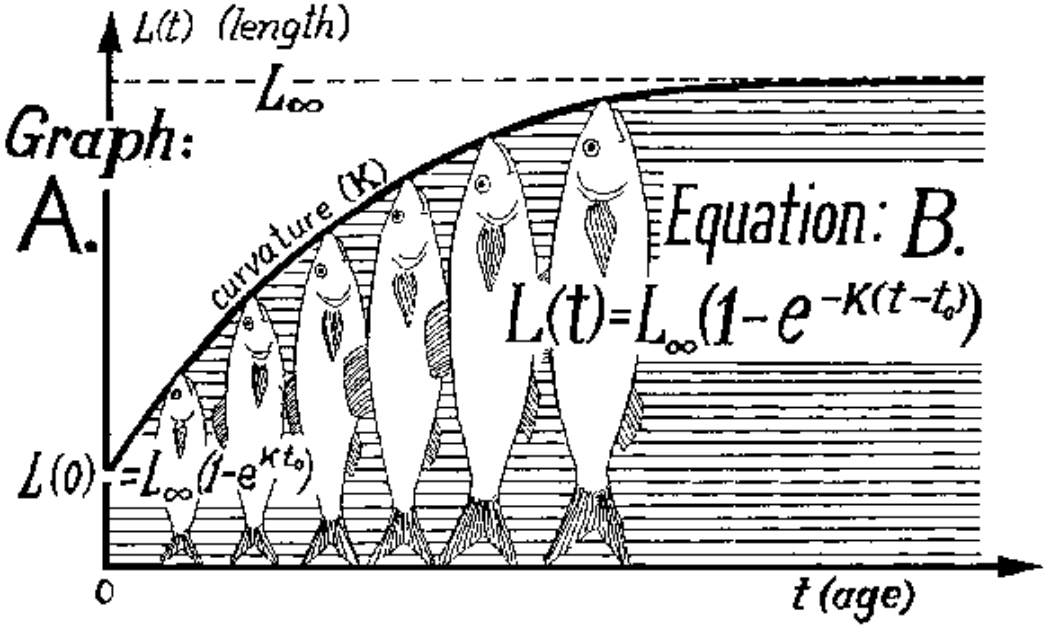
Catch—the number or biomass of fish removed from a stock by fishing

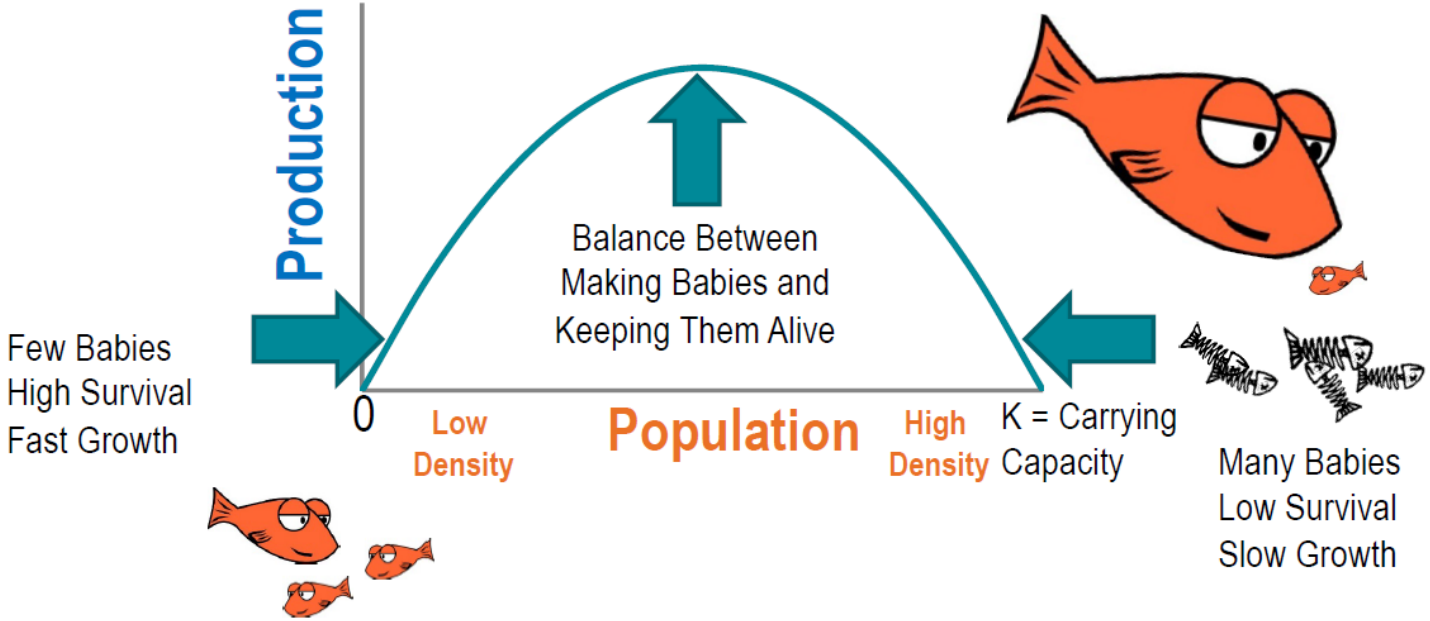


"The ABCs of Stock Assessment" video by NOAA

Basic Data Needs

- Movement/migration/genetics
- Landings/harvest/bycatch/discards
- Survey indices
- Natural mortality rate
- Growth
- Maturity

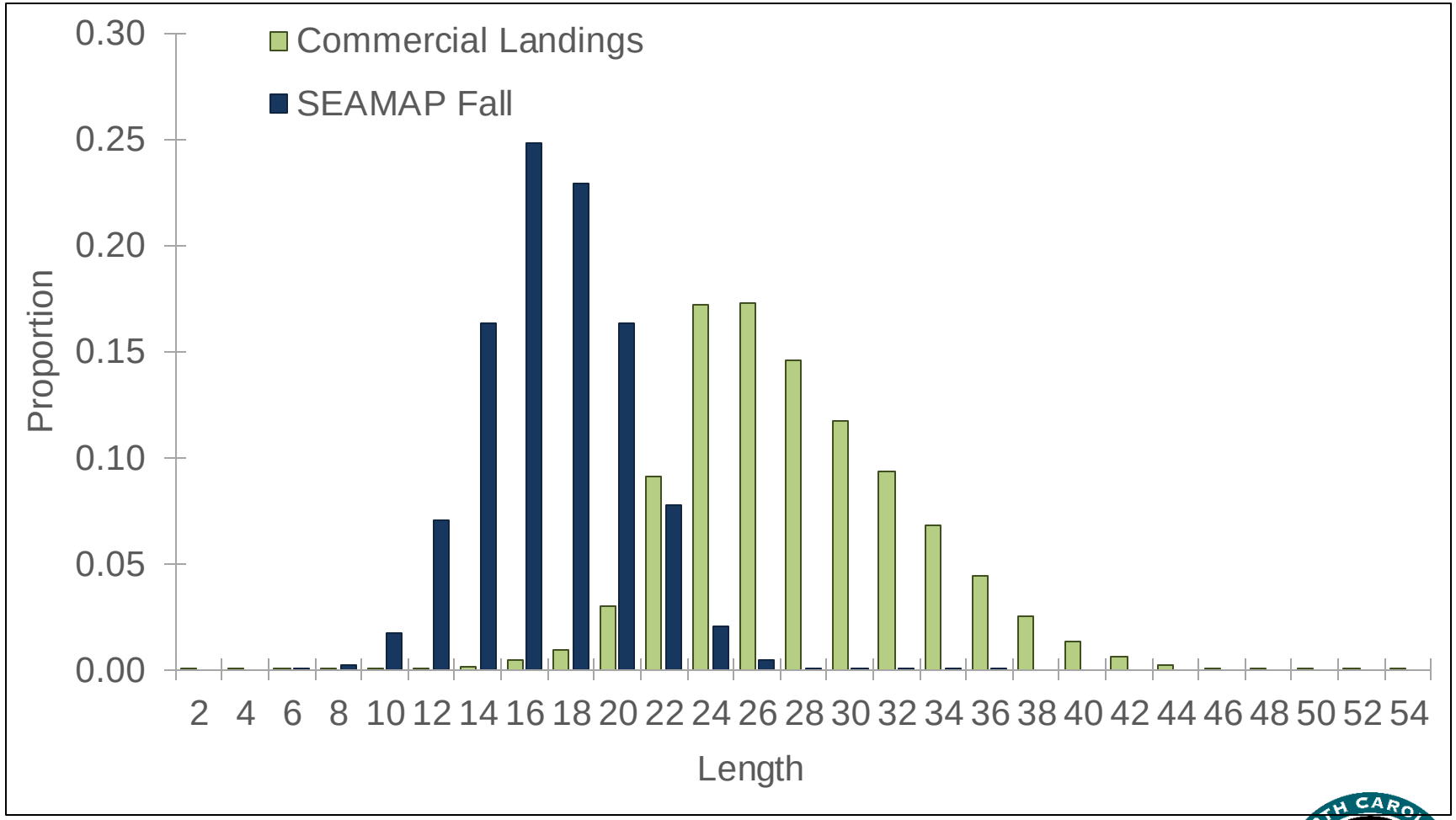




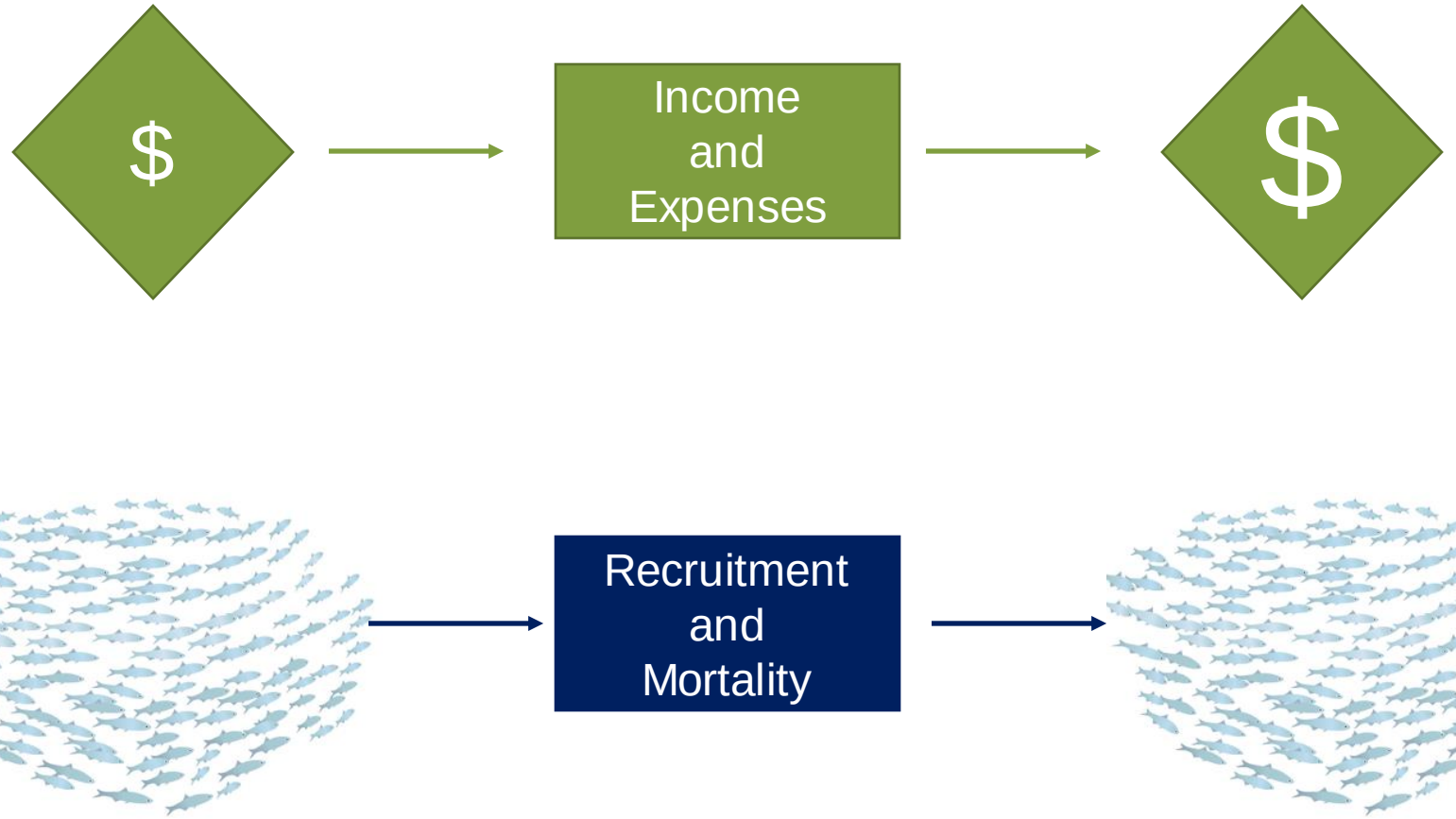
NOAA Fisheries

Primary Data Sources

- Fisheries-dependent
- Fisheries-independent
- Biological data
- Tagging studies



Think About your Bank Account



Not as simple

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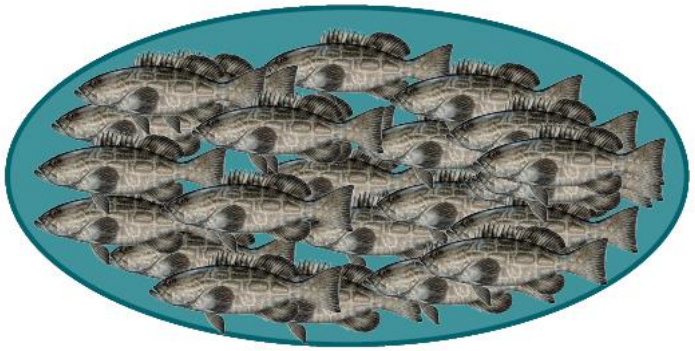
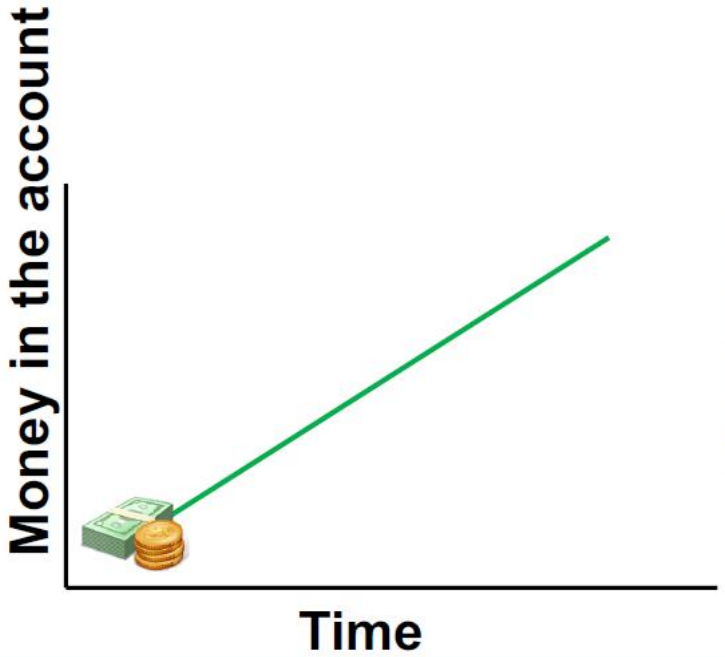
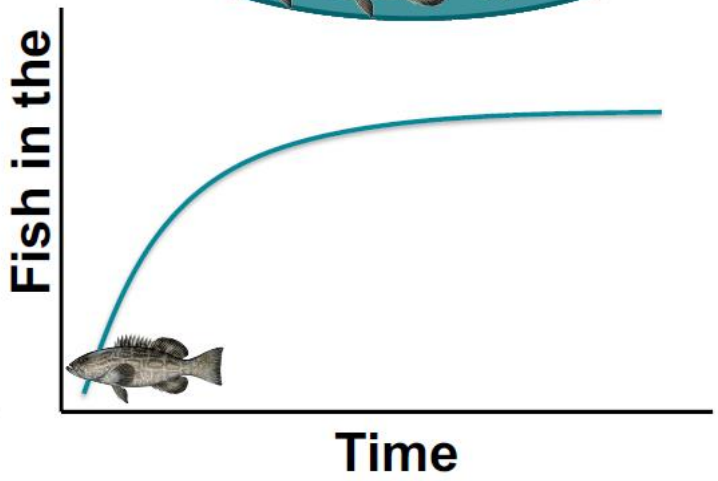






"Counting fish is just like counting trees, except they are invisible, and they keep moving"
-John Shepherd

NOAA FISHERIES

What is a Model?

- A simplified representation of a complex process
- Impossible to characterize all the factors affecting the population dynamics of a fish stock

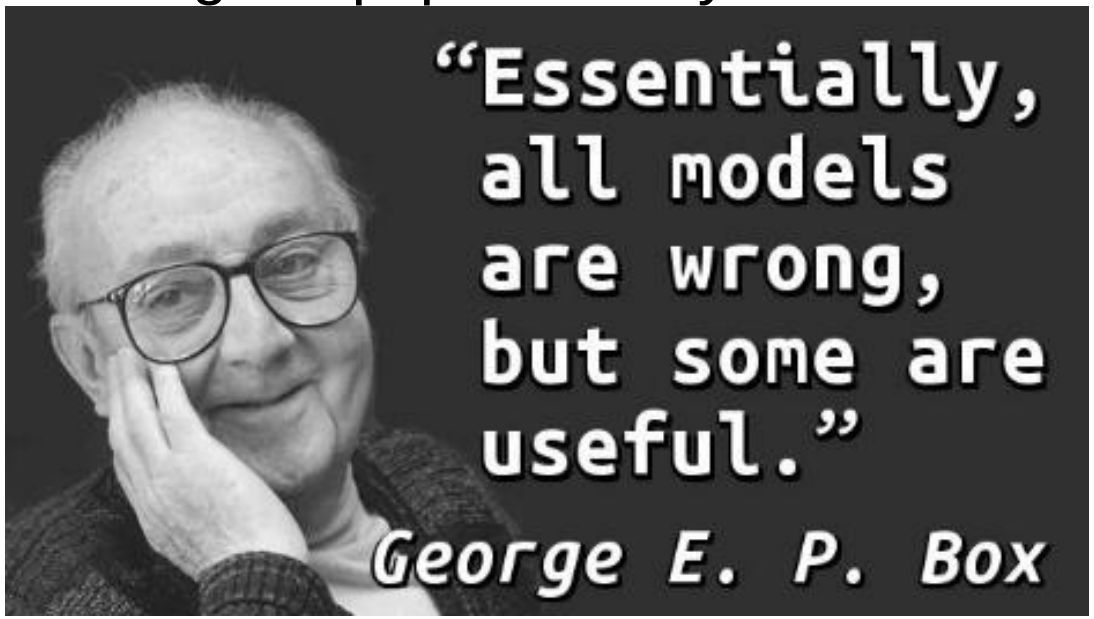
$$N_{1,a} = \begin{cases} R_0\, SSB_{\text{Ratio}} & \text{for } a = 0, \\ N_{1,a-1} e^{-Z_{1,a-1}} & \text{for } 1 \le a < A, \\ N_{1,A-1} e^{-Z_{1,A-1}} \left(\dfrac{e^{-Z_{1,A-1}}}{1 - e^{-Z_{1,A}}} \right) & \text{for } a = A \end{cases}$$

$$SPR_a = \begin{cases} 1.0 & \text{for } a = 0, \\ SPR_{a-1} e^{-M_{a-1}} & \text{for } 1 \le a < A, \\ SPR_{a-1} \left(\dfrac{e^{-M_{a-1}}}{1 - e^{-M_a}} \right) & \text{for } a = A \end{cases}$$

$$\hat{C}_{f,y,a} = \frac{F_{f,y,a}}{M_a + F_{f,y,a}} N_{y,a} \left[1 - e^{-(M_a + F_{f,y,a})} \right] W_a$$

$$\hat{I}_{i,y} = \begin{cases} q_i \sum_a N_{y,a}\, s_{i,a}\, e^{(-\Delta_i z_{y,a})} \\ q_i \sum_a N_{y,a} W_a\, s_{i,a}\, e^{(-\Delta_i z_{y,a})} \end{cases}$$

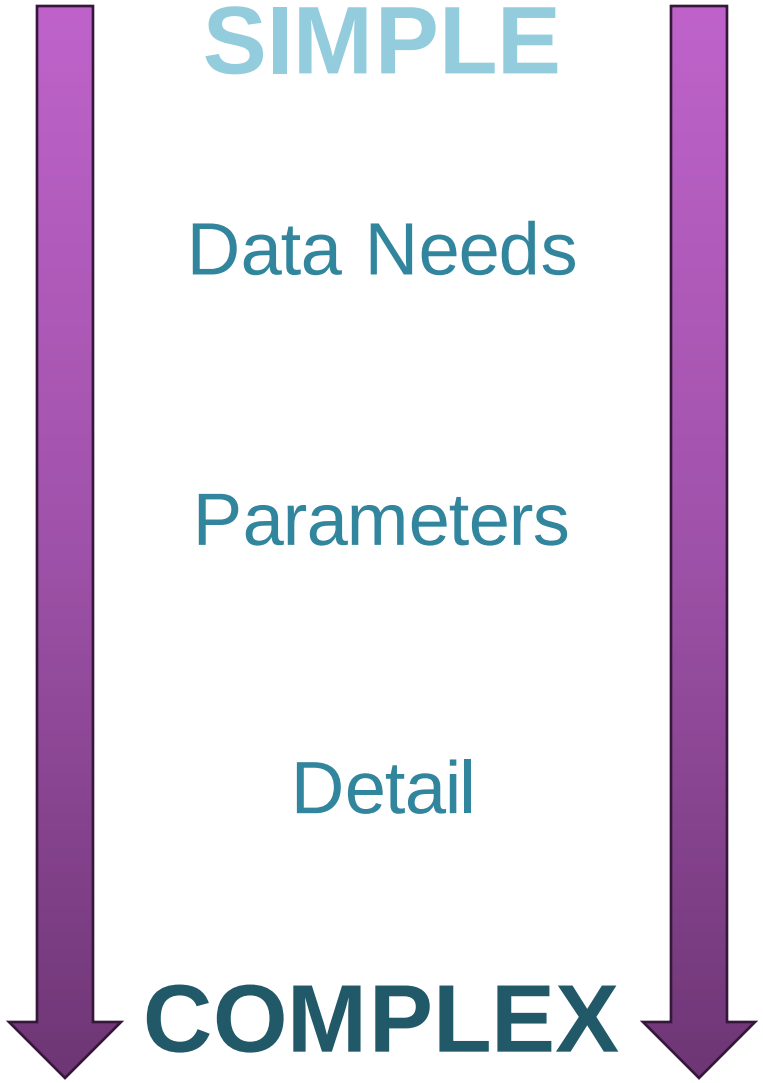
$$N_{y,a} = \begin{cases} \dfrac{0.8 h R_0\, SSB_{y-1}}{0.2 R_0\, SSB_{y-1}\, SPR_0 (1-h) + SSB_{y-1}(h - 0.2)} e^{V_y} & \text{for } a = 0, \\ N_{y-1,a-1} e^{-Z_{y-1,a-1}} & \text{for } 1 \le a < A, \\ N_{y-1,A-1} e^{-Z_{y-1,A-1}} + N_{y-1,A} e^{-Z_{y-1,A}} & \text{for } a = A \end{cases}$$



$$Z_{y,a} = M_a + \sum_f F_{f,y,a}$$

$$F_{f,y,a} = s_{f,a} \hat{F}_{f,y}$$

Model Spectrum



- Index only
- Trend analysis
- Catch curve
- Surplus production
- Catch-survey analysis
- Virtual population analysis
- Tag-based
- Statistical catch-at-age
- Fully-integrated
- Multi-species

Stock Assessment Models

- Vary in complexity, depending on available data
  - The quality of a stock assessment is dependent on the quality and relevance of the input data
  - Incorporation of uninformative data can reduce assessment quality and confidence in results
- Variety of software available
  - Under the hood, most programs are basically the same
  - Stock Synthesis (SS), ASAP, BAM, ASPIC, etc.

Important Considerations

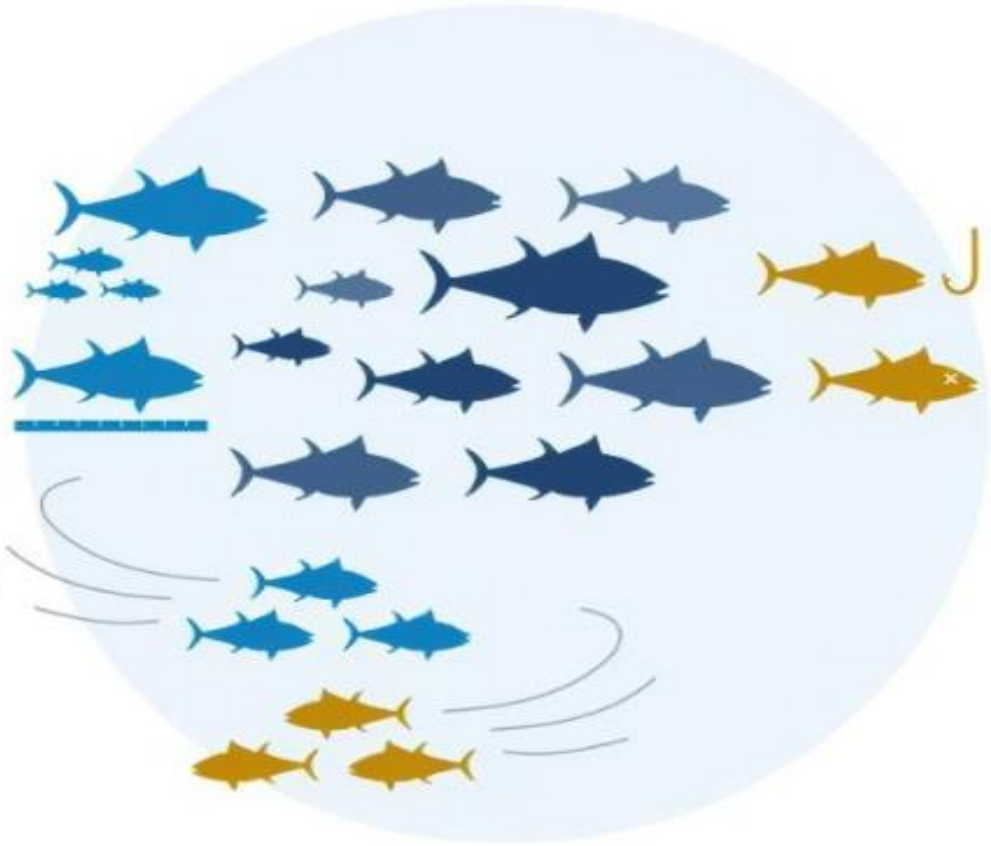
Basic Fish Population Model

POPULATION INCREASES:

Recruitment (reproduction)

Growth (maturity)

Movement (new members)



POPULATION DECREASES:

Catch (fishing mortality)

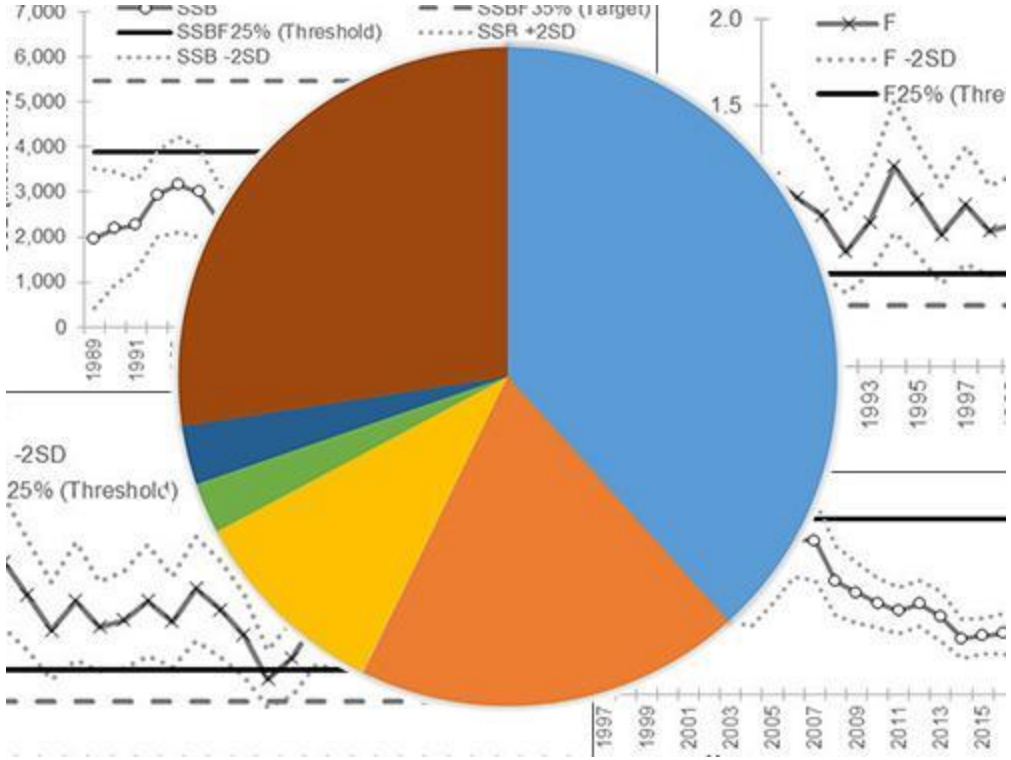
Death (natural mortality)

Movement (members depart)

Hawaii Seafood Council

Model Outputs

- Predicted values
- Fishing mortality
- Population size
- Reference points



Reference Points

- NCDMF uses two types
  - Management reference points (targets)
  - Biological reference points (thresholds)

- Reference points indicate the desired stock state and mark the boundary of undesirable stock conditions

- Provide guidance in determining if
  - Stock size is too small (overfished)
  - Fishing mortality is too high (overfishing)

Reference Points

How they are decided:

- Data-driven
- Life history
- Literature review
- Model considerations
- Management needs

Population Size

Greater than **Threshold** → Not overfished

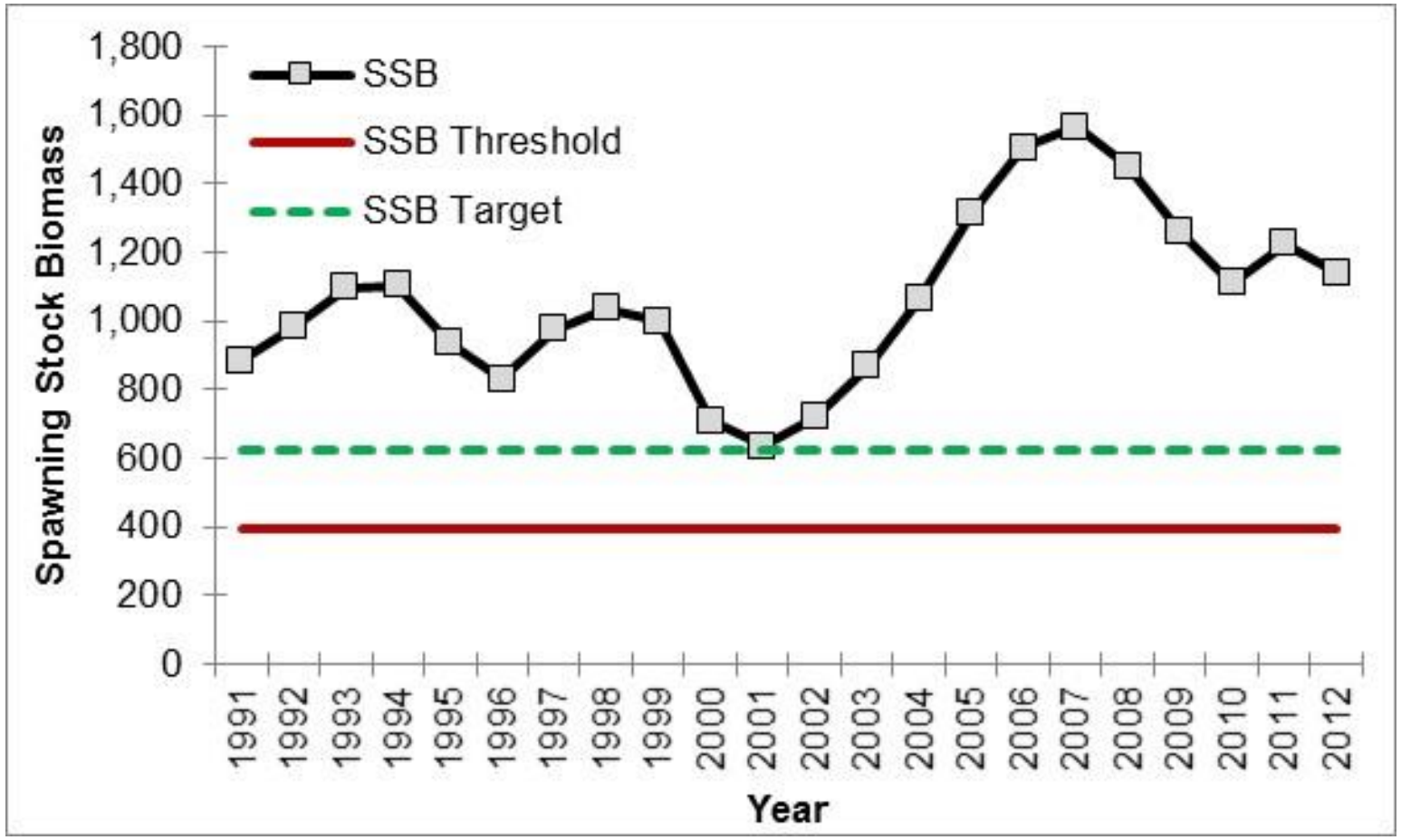
Less than **Threshold** → Overfished

Fishing Mortality

Greater than **Threshold** → Overfishing

Less than **Threshold** → No overfishing

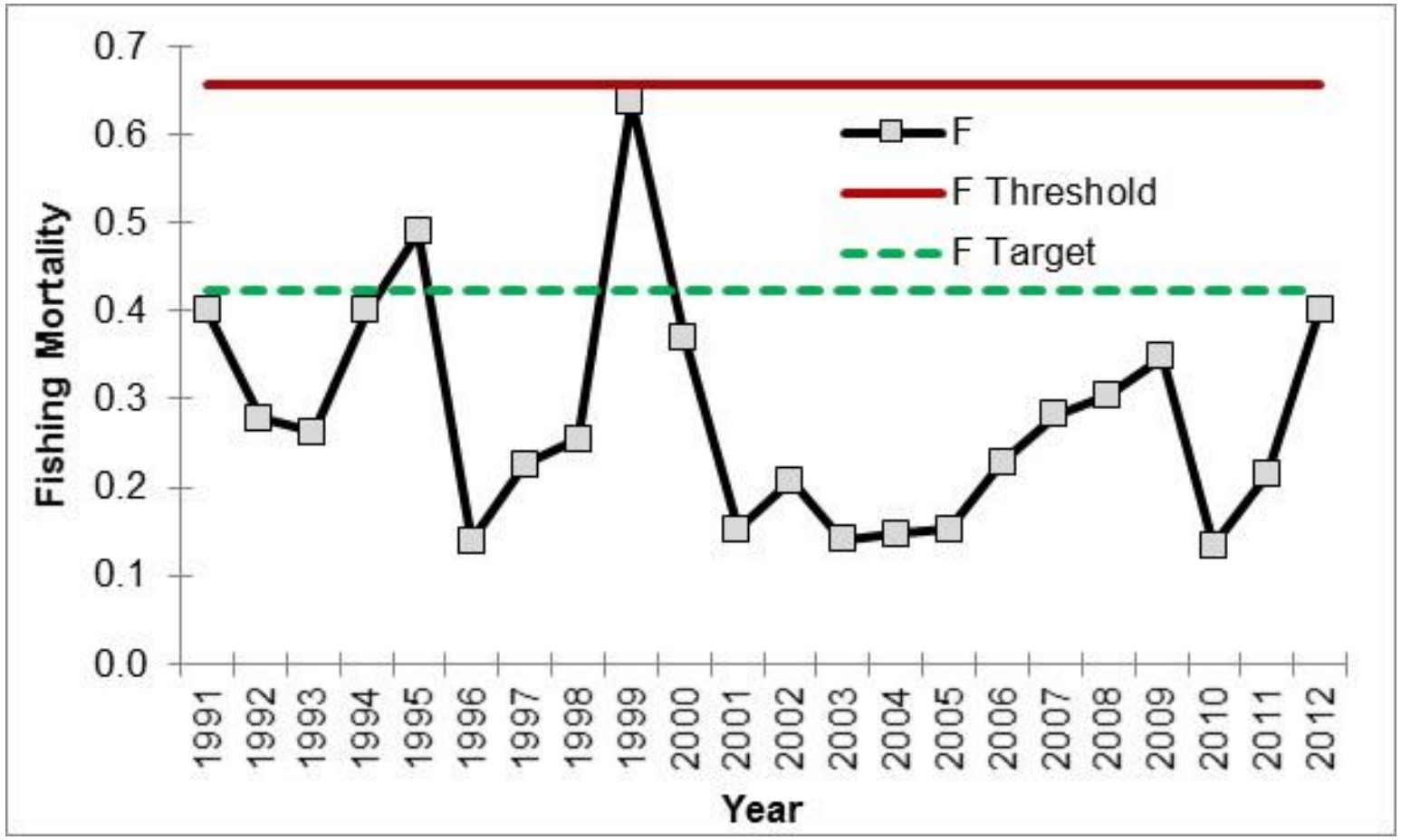
Population Size



Target: Management reference points

Threshold: Biological reference points

Fishing Mortality (F)



Target: Management reference points

Threshold: Biological reference points

NCDMF Stock Assessment Timeline

Data and Stakeholder Input	Planning Workshop	Data Workshop	Methods Workshop	Assessment Workshop	Peer Review Workshop	Inform Management
(months to years)	1-2 days	2-3 days: 7-9 weeks after PW	1-2 days: 4-9 weeks after DW	2-6 days: 4 to 6 months after MW	2 to 10 days: 2 to 4 months after AW	MFC meeting: 4 to 12 weeks after
	• Define the unit stock • Standardize the data summaries • Identify programs that collect data	• Compile data • Critically evaluate all information	• Select method • Select stock status criteria	• Determine species status • Identify major uncertainties • Balance realism and model fit	• External panel of experts • Judge suitability of the science • Examine scientific methods	• NCDMF final decision of use • Present to the Marine Fisheries Commission

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Questions?

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