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 | Laura M. Lee | May 16, 2019

Stock Assessment—The Basics

Terms

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

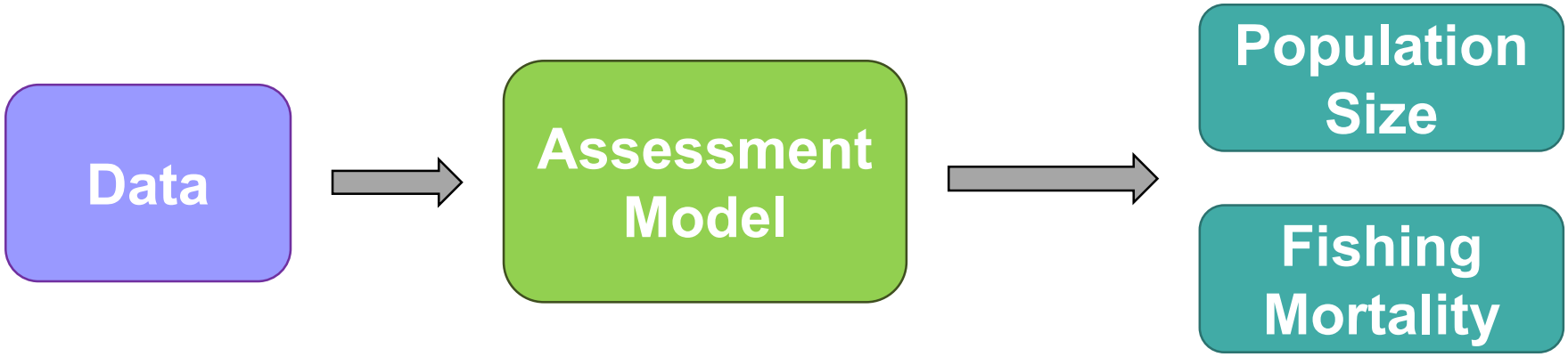
Natural mortality (*M*)—rate at which species dies of natural causes (e.g., predation, disease, competition, cannibalism, old age, parasitism, starvation)

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

Recruitment—the addition of individuals to the stock

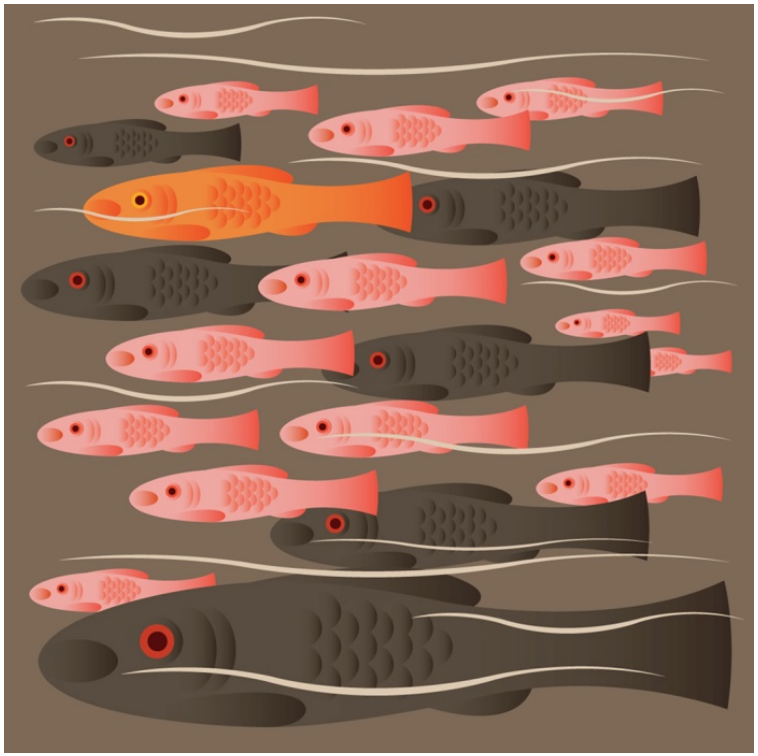
What is a Stock Assessment?

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



What is a Stock Assessment?

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



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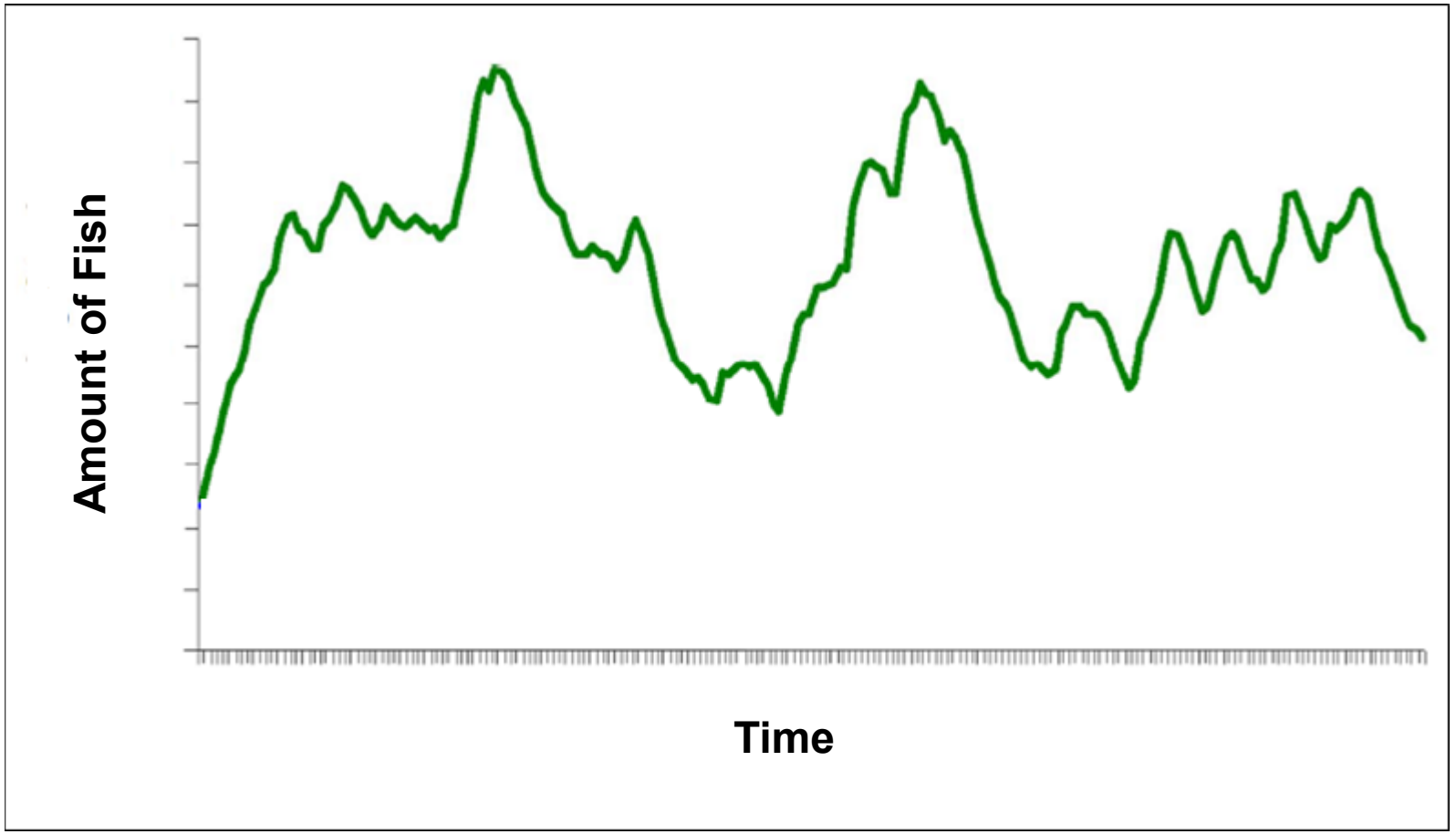
Fish Populations



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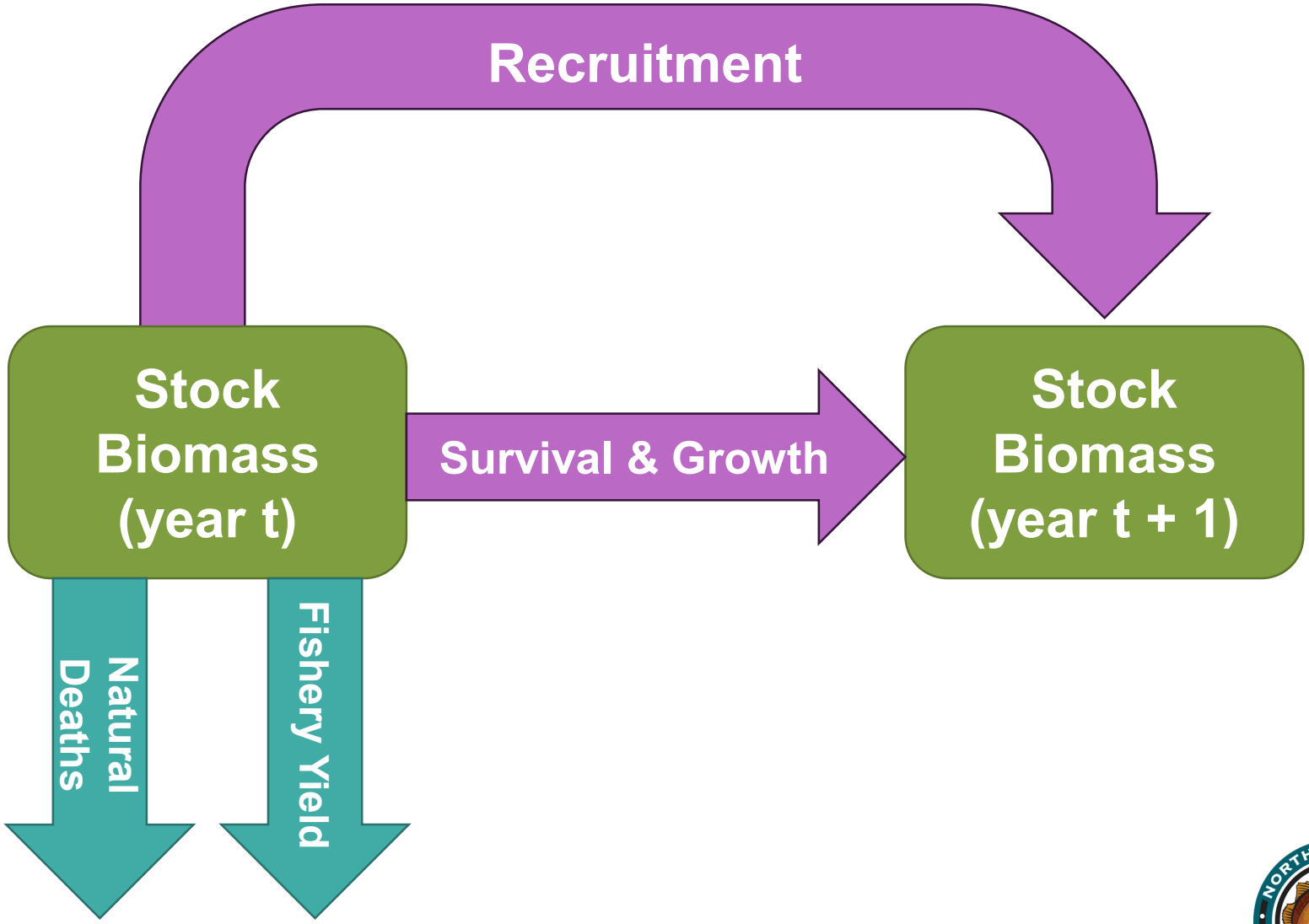
Biological Production



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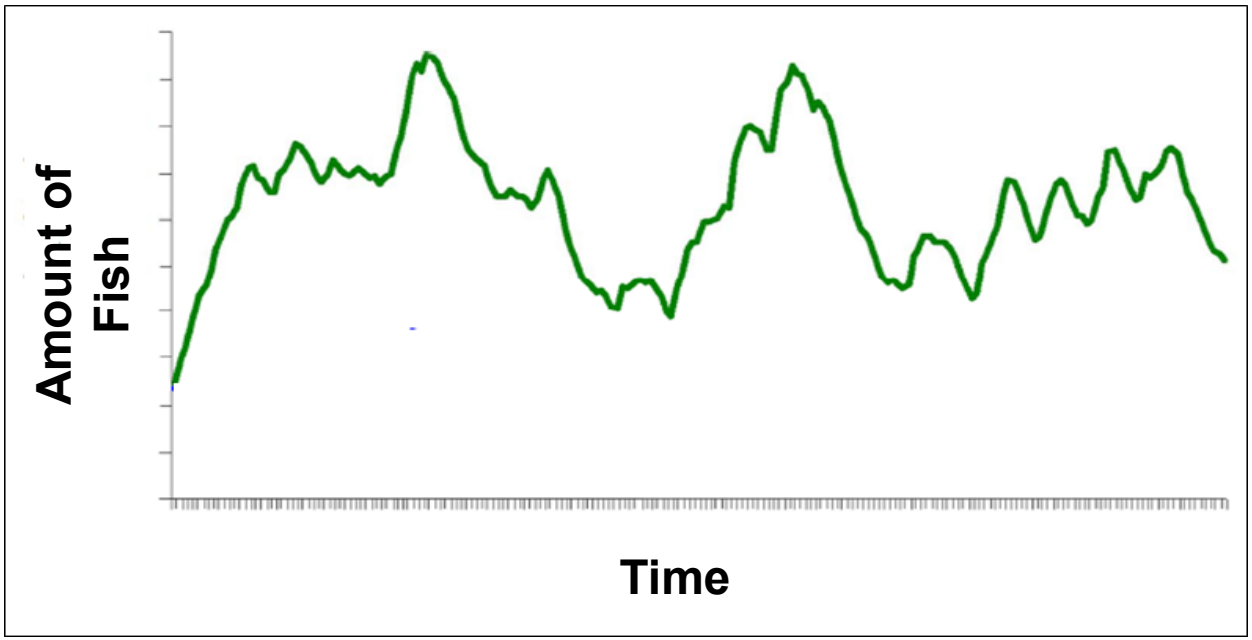
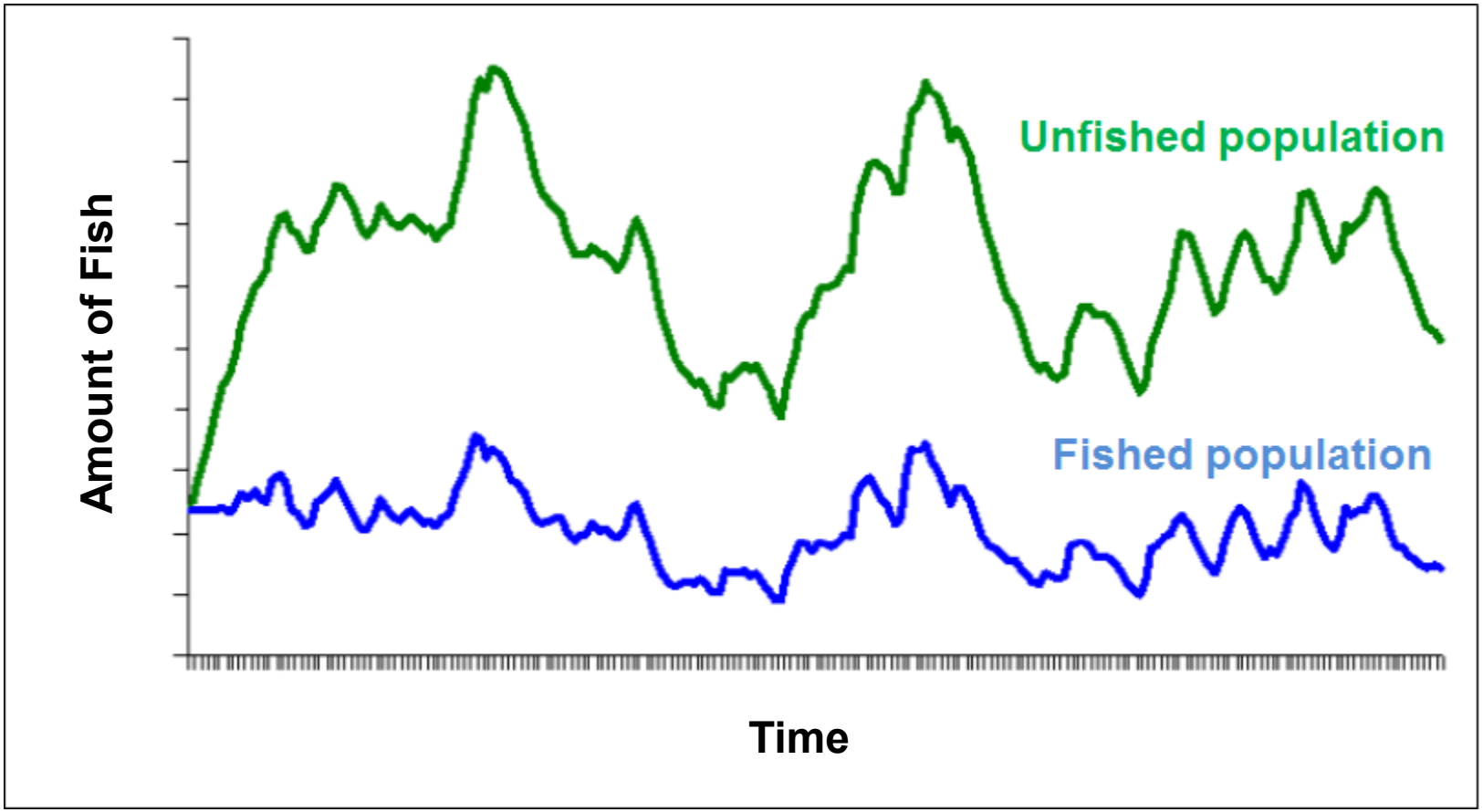
Fish Populations

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



Fished Populations



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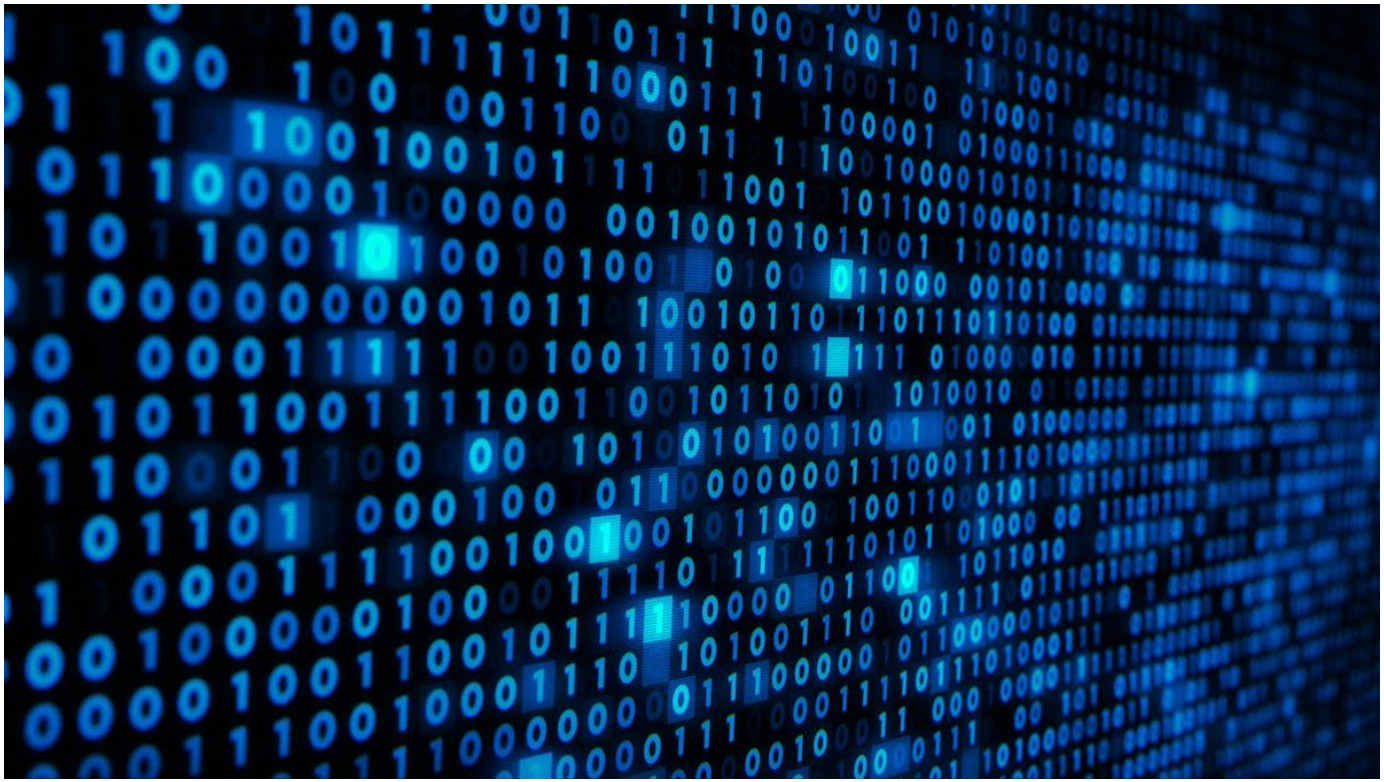
Stock Assessment Models

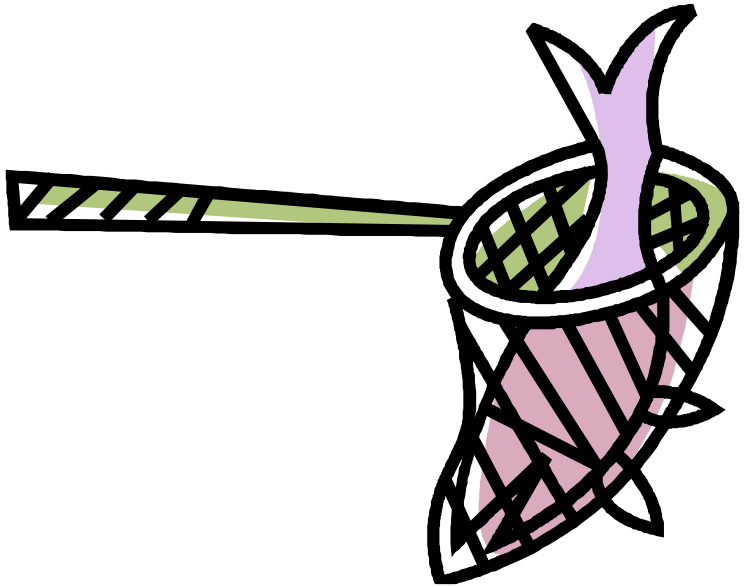
- Mathematical and statistical analyses
- Populations models are built using fishery monitoring and survey data
  - Survey indices are used to establish trend
  - Catch data are used to determine scale or magnitude
  - Models attempt to make both pieces consistent, coherent, and realistic

Data—What the Observations Tell Us



Data Categories

- Catch—the amount of fish removed from a stock by fishing
- Abundance—relative index of the number or weight of fish in a stock
- Biology—provides information on growth, maturity, and natural mortality

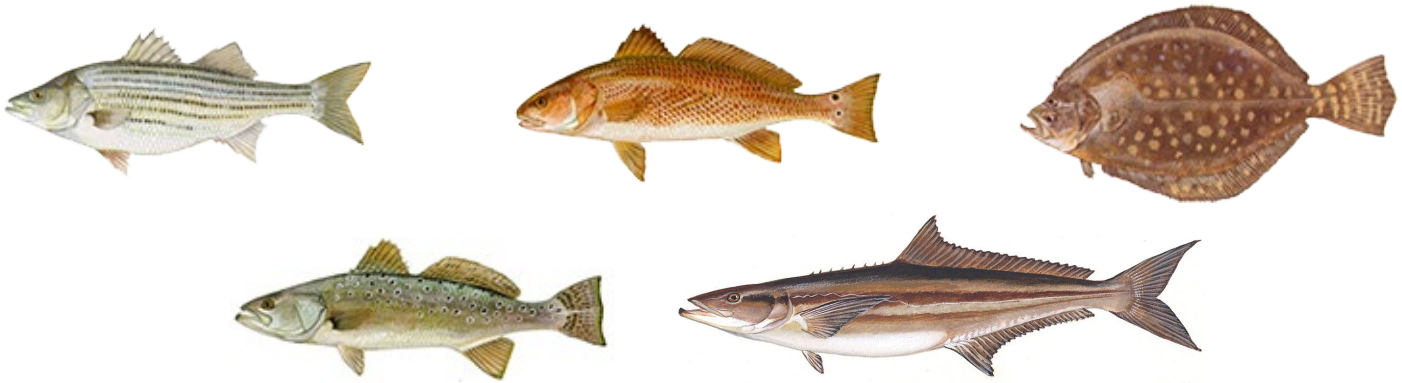


Basic Data Needs

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

Auxiliary Data Needs

- Data classified by age and/or length
- Precision and sample size
- Ageing error
- Tagging/telemetry data
- Environmental information
- Discard/release mortality



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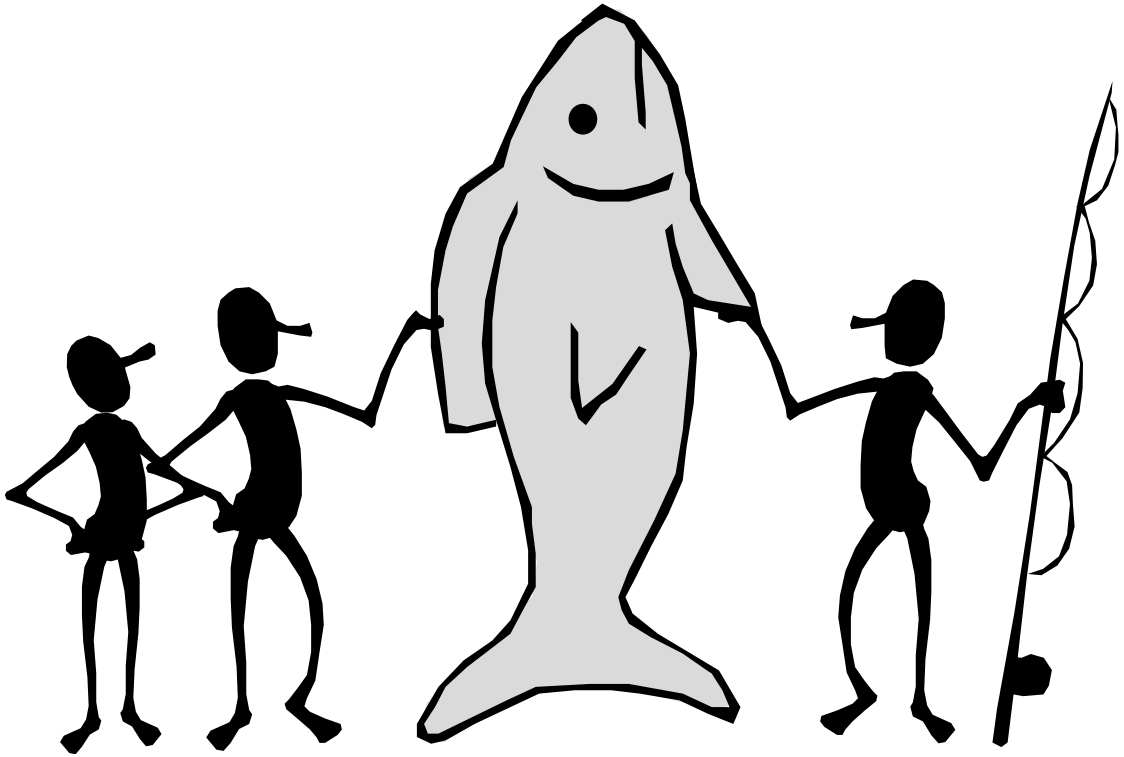
Data Sources

- Fisheries-dependent
- Fisheries-independent



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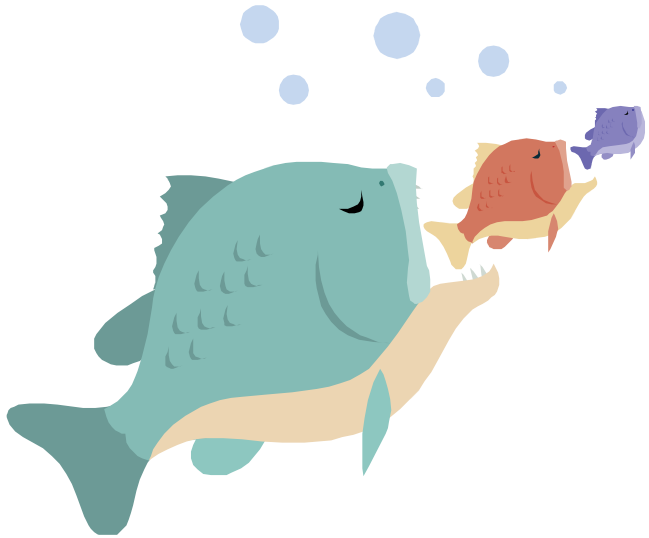
Fisheries-Dependent Data

- Removals
- Fishing effort
- Biological information

Fisheries-Independent Data

- Relative abundance
- Age
- Growth
- Spawning areas
- Maturity
- Gender
- Fecundity

- Stock structure
- Habitat usage
- Feeding habits



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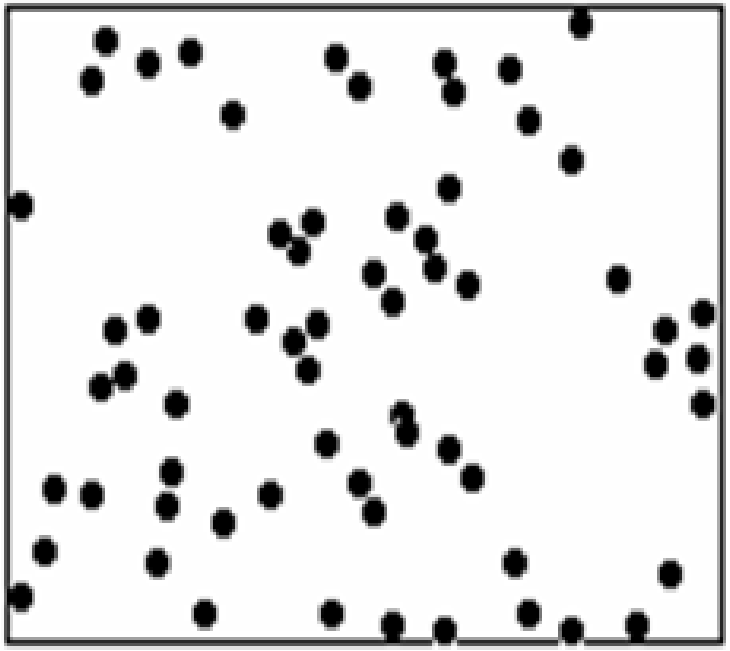
What Makes a Good Survey?

- Random survey design
- Same methods and gear over time
- Spatial coverage



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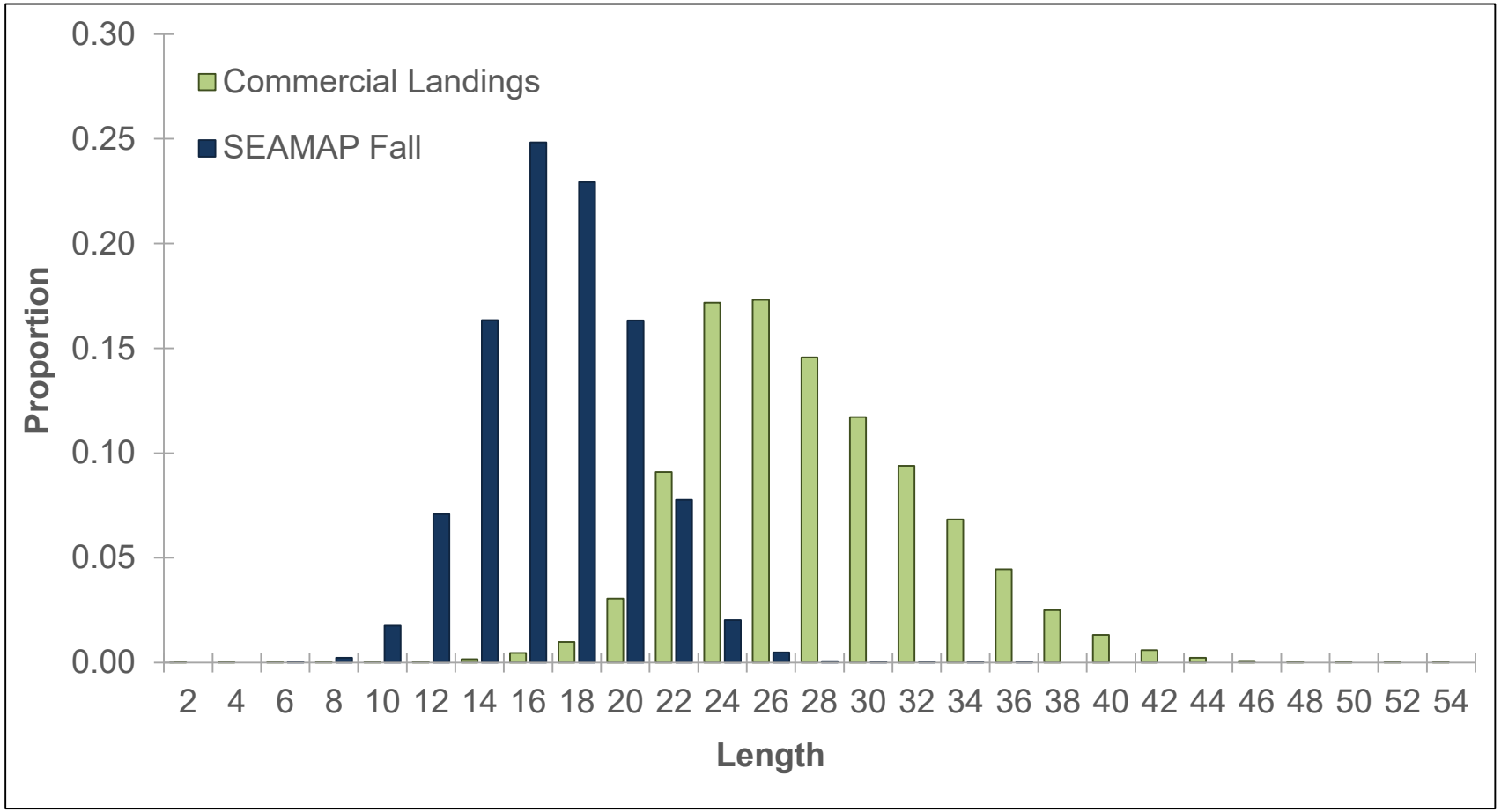
Fishery and Survey Samples



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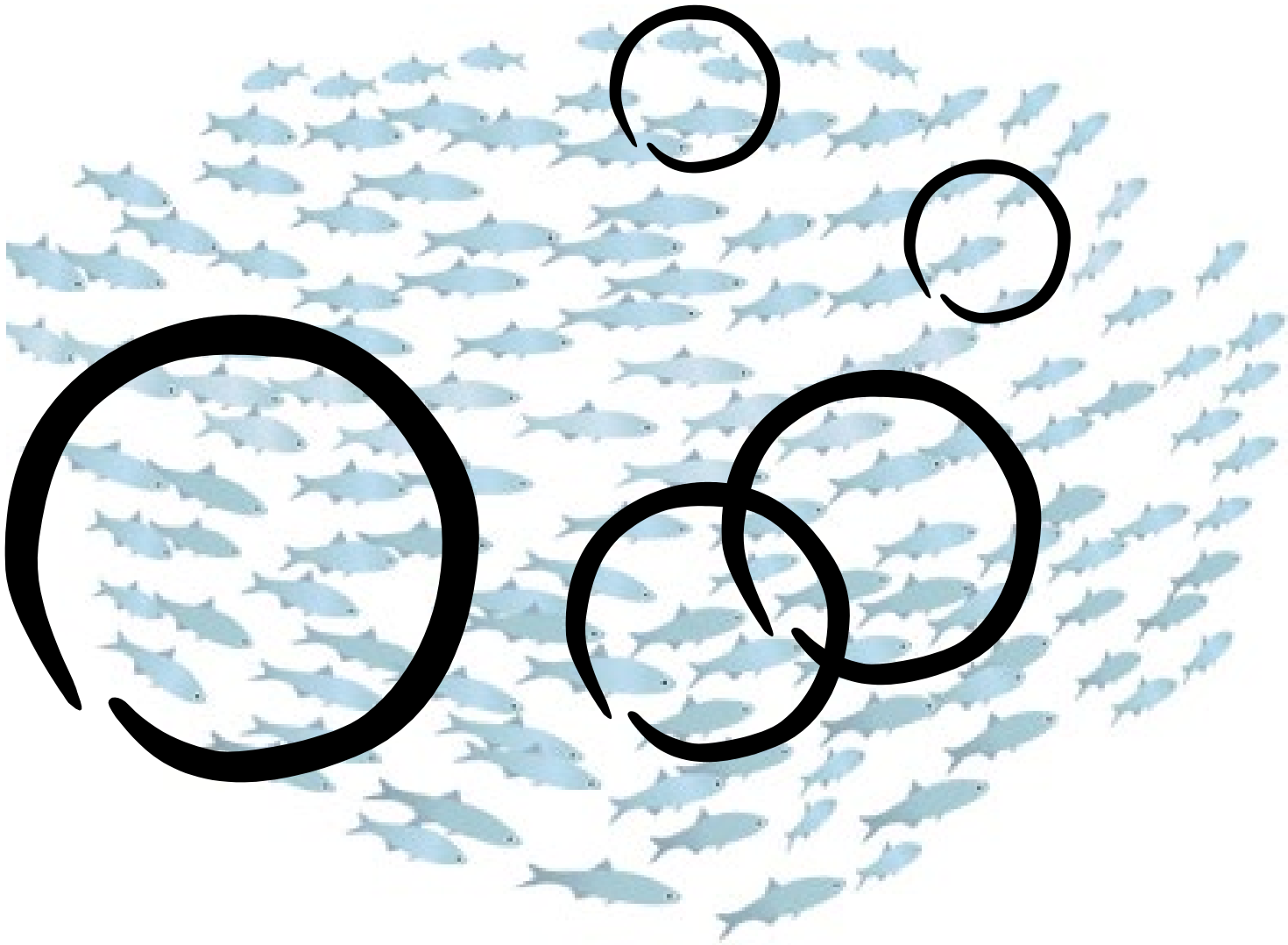

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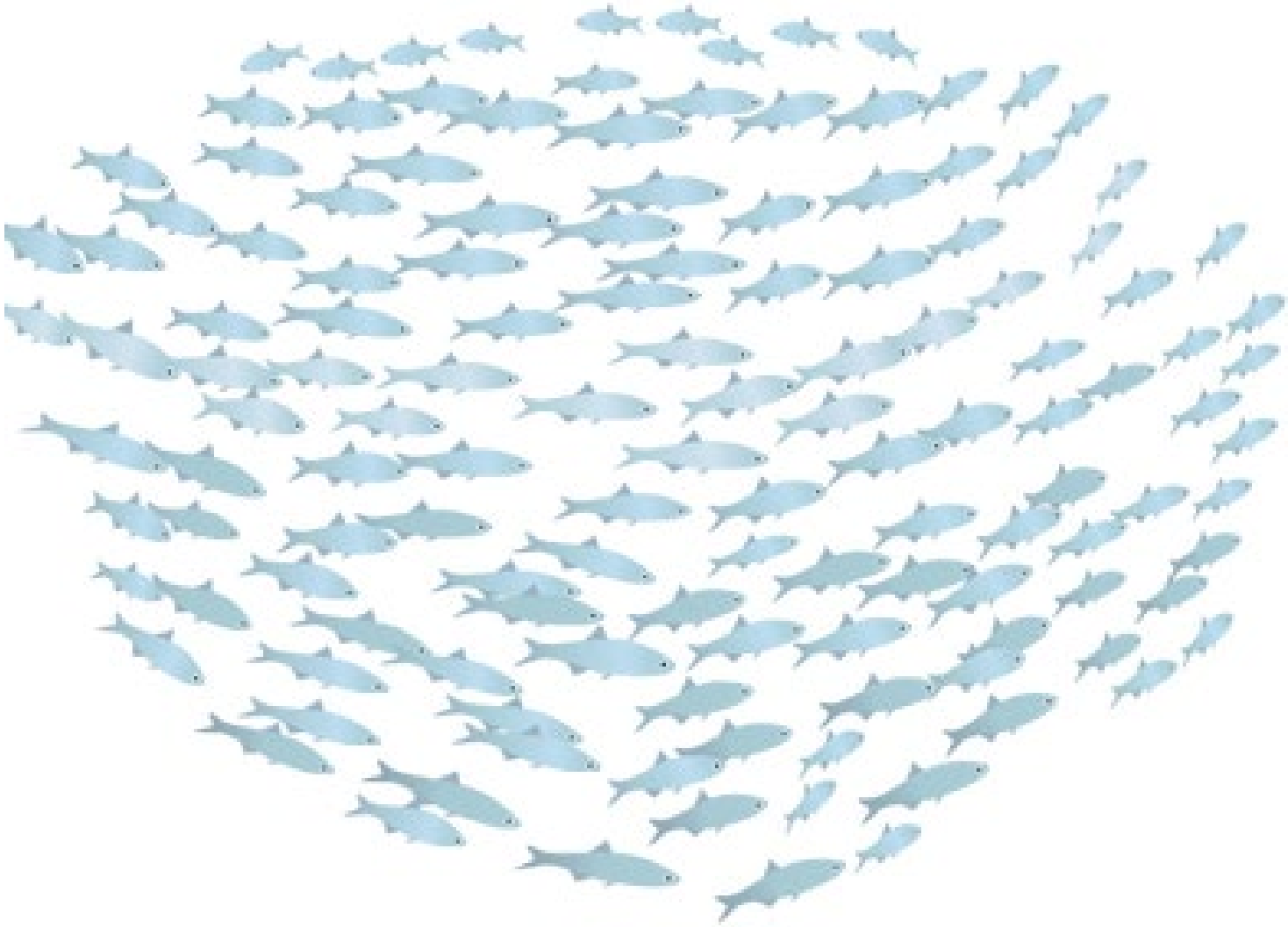

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Model Basics—Tying it All Together

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

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

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

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

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

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

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

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

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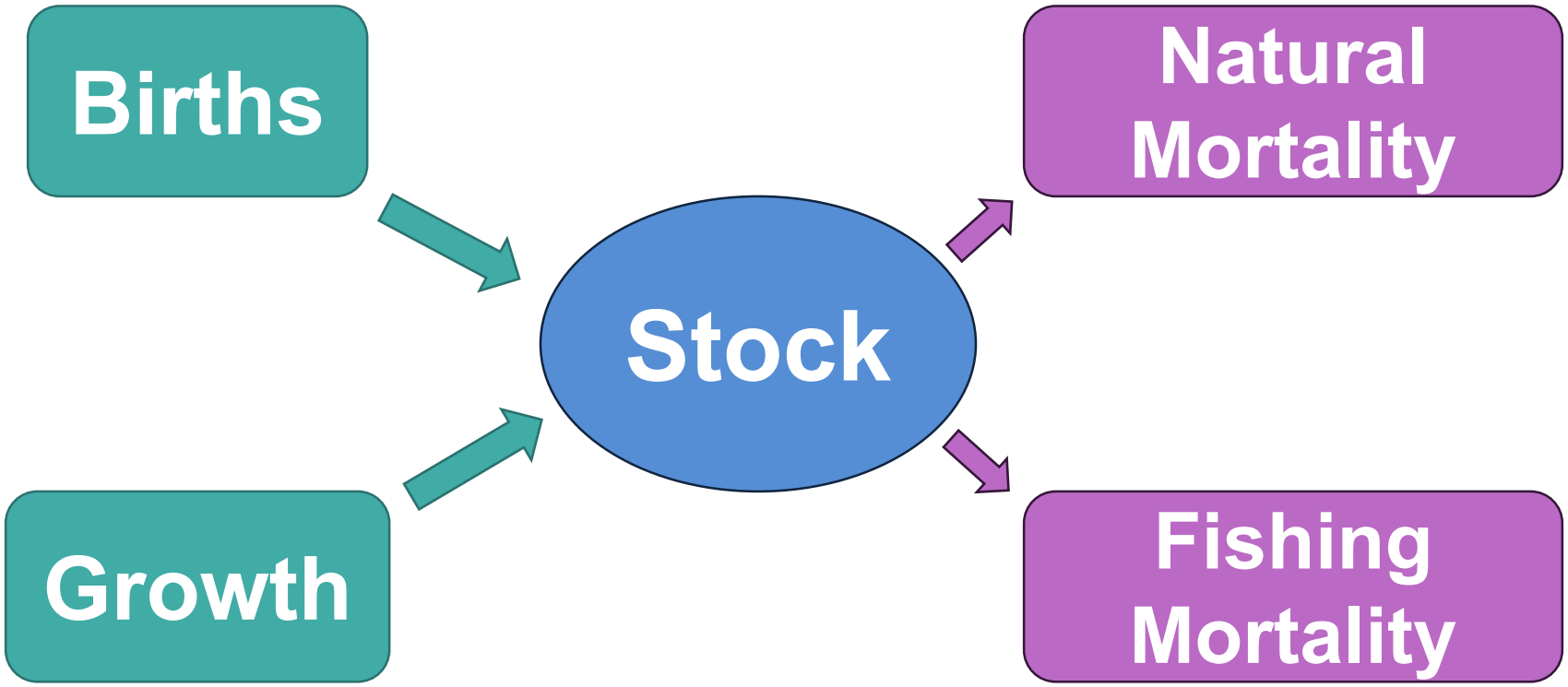
Basic Model



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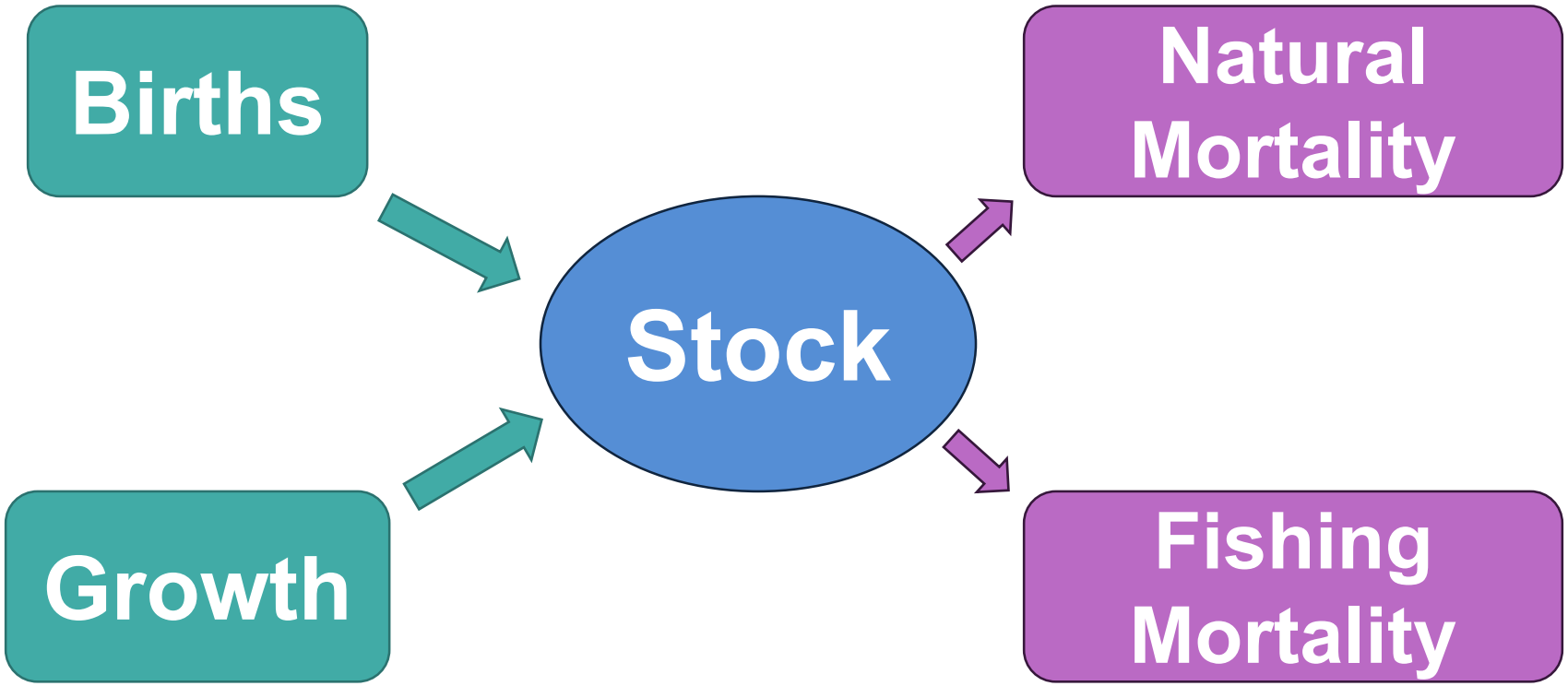
Basic Model



Sampling bias
Environmental factors
Ageing error
Immigration
Gear selectivity
Emigration
Data quality
Species identification
Gear saturation
Model validity
Tag loss and shedding
Unknown factors
Tag reporting rate

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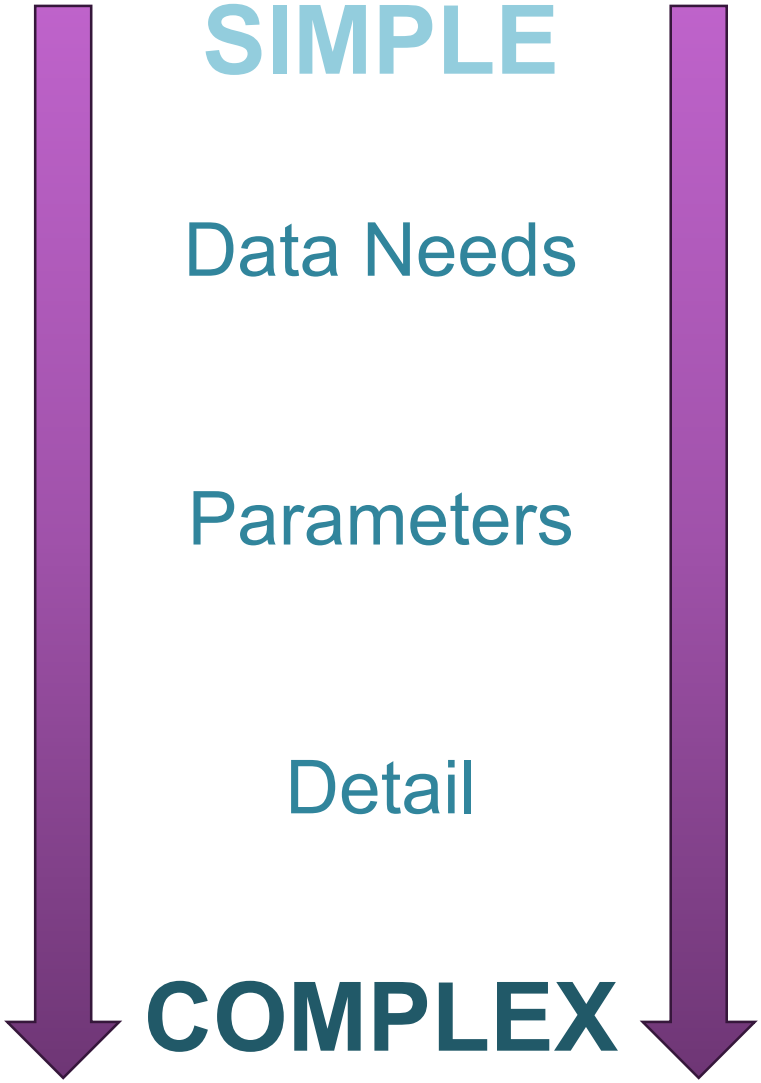
Model Spectrum



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

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Reference Points—Is the Stock Sustainable?

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)

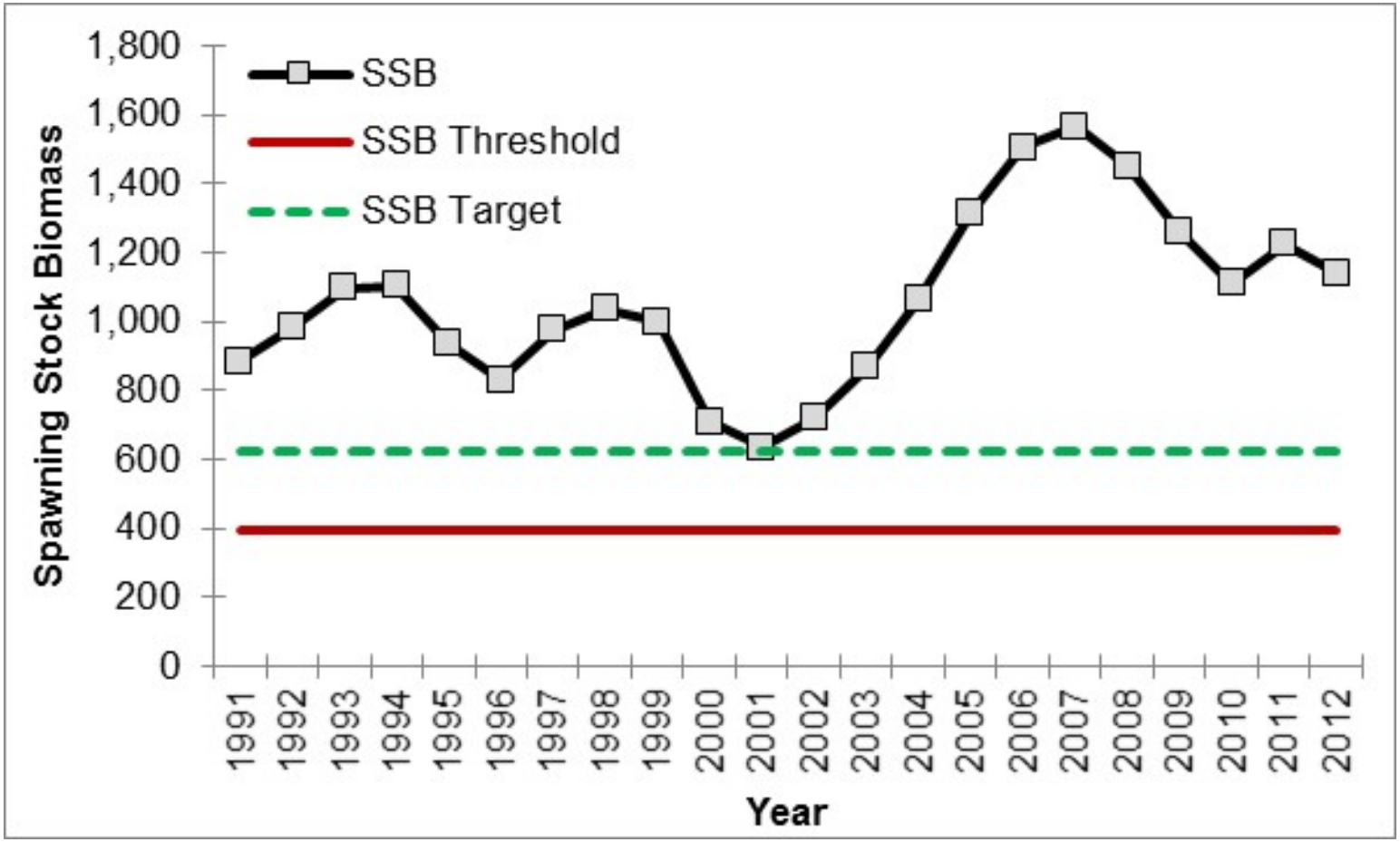
How Reference Points are Decided

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

Reference Points

Population Size	**Greater than**	**Reference Point** →	Not overfished
	Less than	**Reference Point** →	Overfished
Fishing Mortality	**Greater than**	**Reference Point** →	Overfishing
	Less than	**Reference Point** →	No overfishing

Population Size



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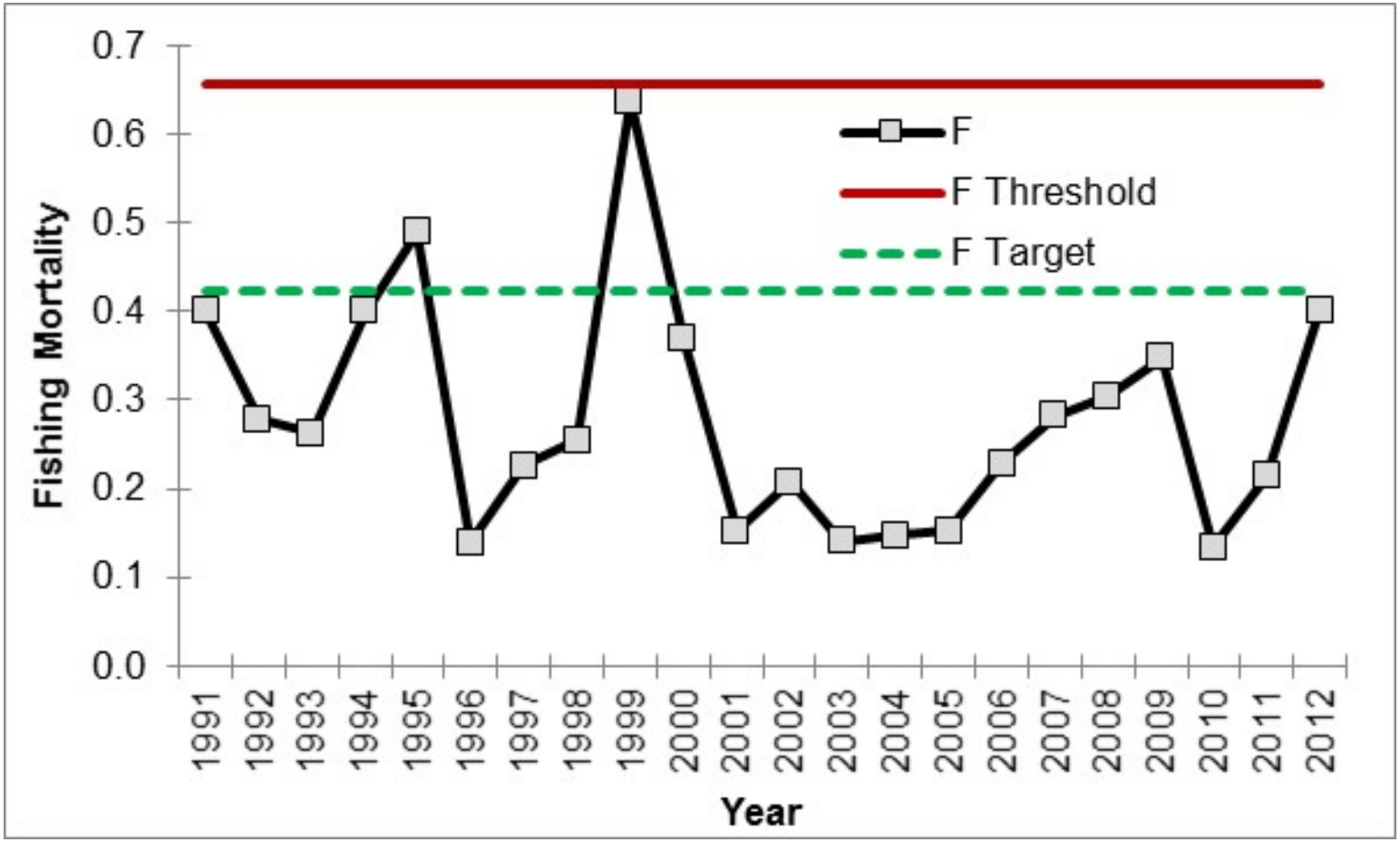
Fishing Mortality (F)



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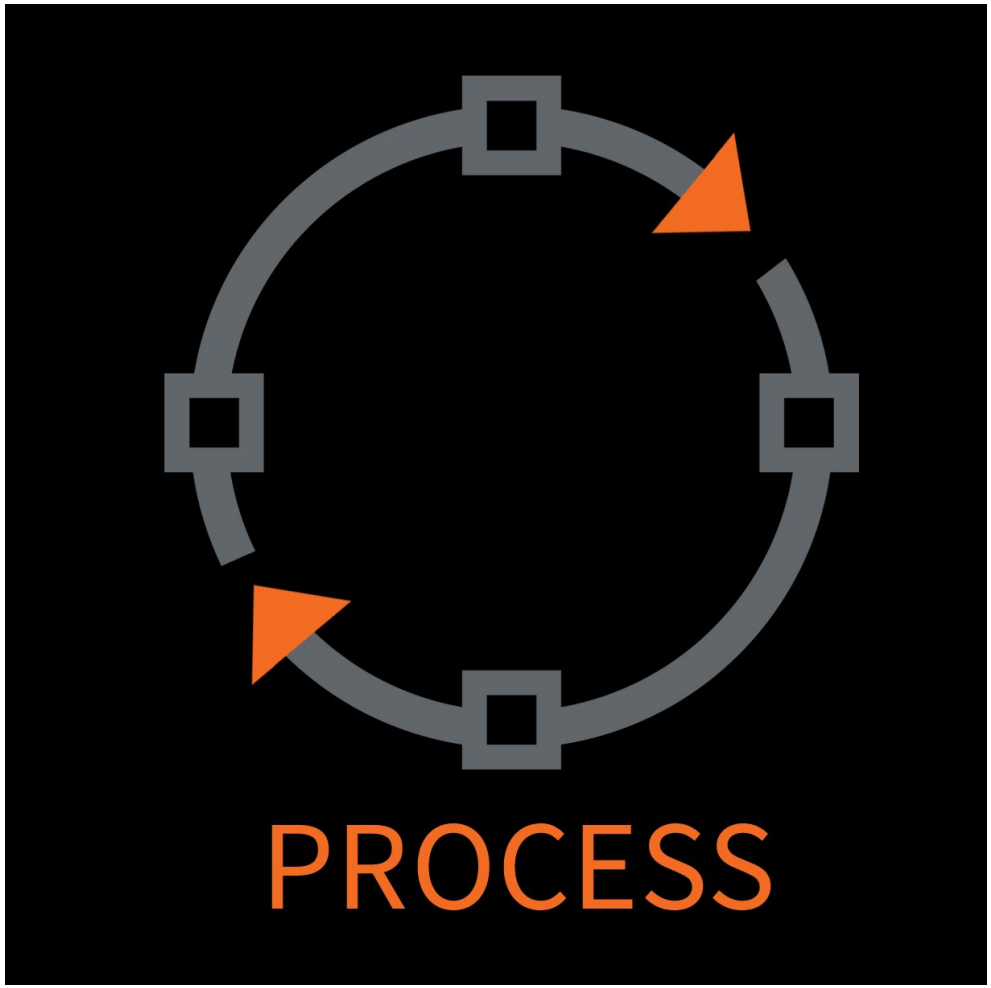
NCDMF Process—Standard Operating Procedure



NCDMF Stock Assessment Process

- Establishes common sense, practical, and professionally sound procedures
- Ensures consistency and increases transparency
- Clarifies the expectations and responsibilities of participants

➢Ultimate goal is to promote quality through consistent implementation

Workshop Series

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Planning Meeting

- Define the unit stock
- Standardize preparation of data
- Identify programs that collect data of potential use to the stock assessment

Data Workshop

- Data quality is tied to assessment quality
- Compile, review, and critically evaluate all available information that has potential use
- Objective data-selection criteria
- Consideration of how the observed data relate to the real population, based on current understanding of the fishery and stock dynamics

Methods Workshop

- Two main objectives:
  - Decide on stock assessment method
  - Decide on reference points
- Assessment method may be an analytical tool or a quantitative model
- Reference points should be appropriate given the life history and management needs

Assessment Workshop

- Determine the status relative to selected reference points
- Identify major uncertainties
- Balance realism and simplicity
- Make best use of the available data
- Standard professional practice is that *results of the stock assessment should not be broadcast before the results have been vetted through the proper channels and given final approval by the NCDMF* in order to avoid misinterpretations by the general public of a draft product

Peer Review Workshop

- Ensure the assessment and results are scientifically sound
- Ensure decision makers are provided adequate advice

Projection Workshop

- Determine the reduction needed to rebuild an overfished stock to sustainable harvest levels

Questions?

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