Stock Assessment for Fisheries Management

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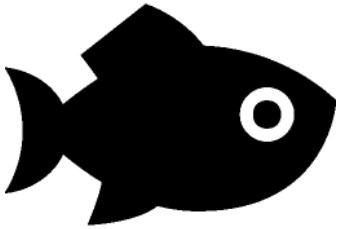
*Fish are **born**, they **grow**, they **reproduce** and they **die** – whether from natural causes or from fishing. **That's it**.*

Modelers just use complicated (or not so complicated) math to iron out the details.



Session Outline

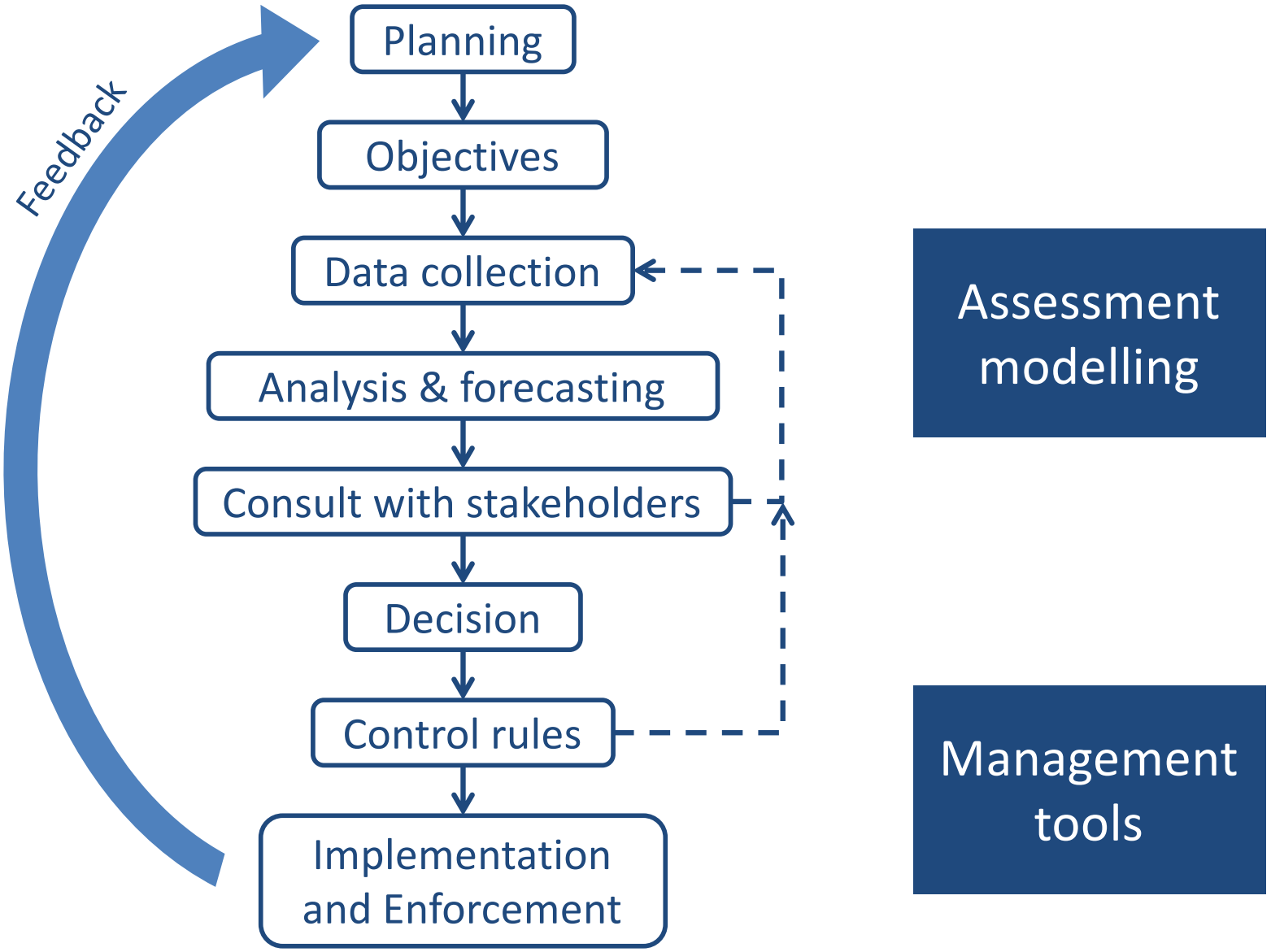
- **Introduction to Stock Assessment**
  - Types of Data
  - Biological Reference Points
- **Population Dynamics Models**
  - The Basic Population Dynamics Model
  - Mortality, Age Structure, Stock Recruitment
- **Applying Models to Data**
  - Indices of Abundance, CPUE, Stock Estimates
  - Biomass Dynamics & Age-Structured Models

Introduction to Stock Assessment

- The aim for fishery managers is to maintain a healthy fish population **and** a healthy fishing industry, while preserving vital recreational communities.

- A **stock assessment** provides decision makers with the information necessary to make **reasoned** choices.

The management process

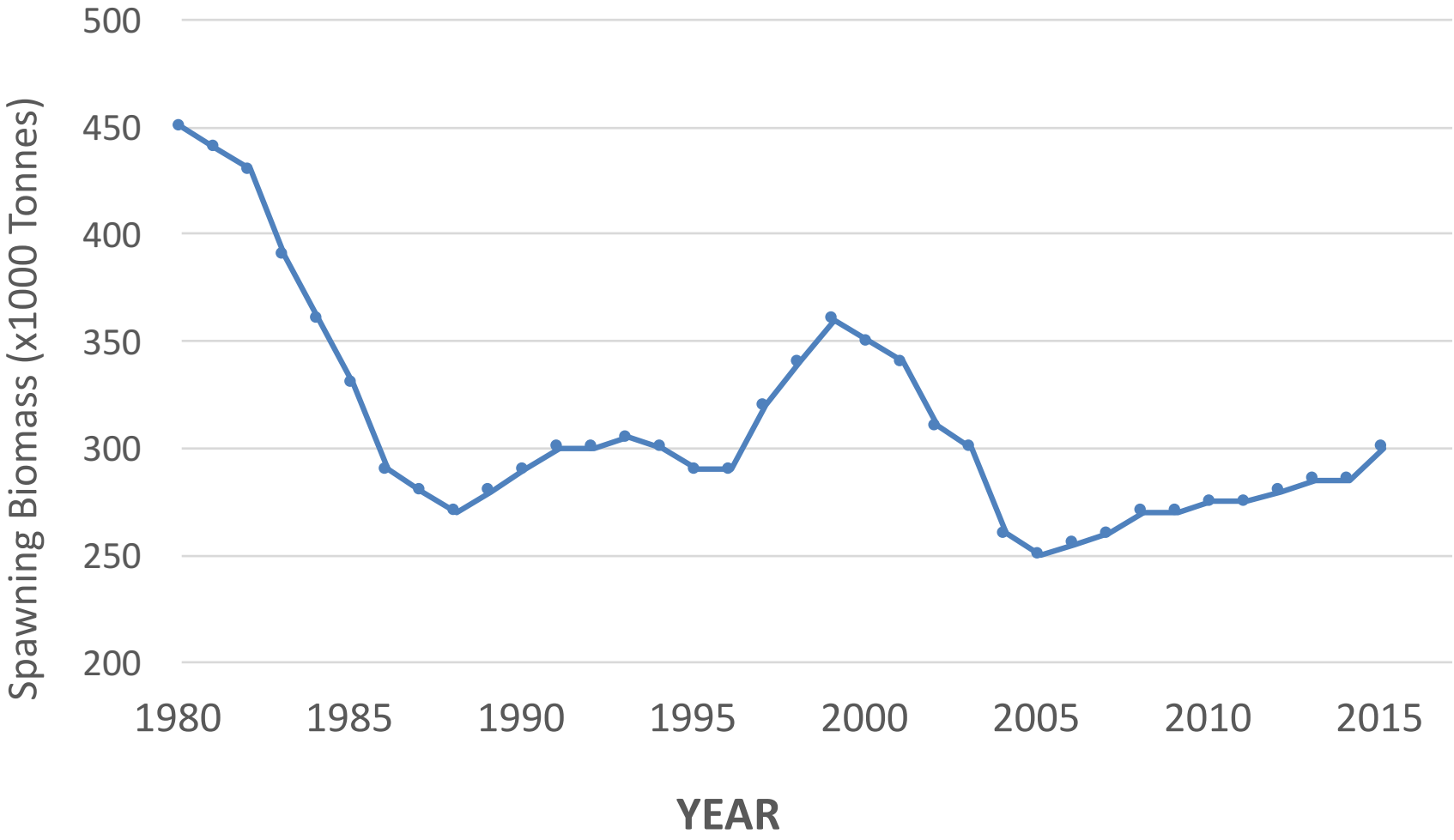


Introduction to Stock Assessment

- A fishery stock assessment describes the **past** and **current status** of the stock
  - Major questions include:
  - How big is the stock?
  - Is it growing or reducing in size?

- An assessment may also attempt to make **predictions** about how the stock will respond to current and future management options.

Monitoring & Managing Biomass

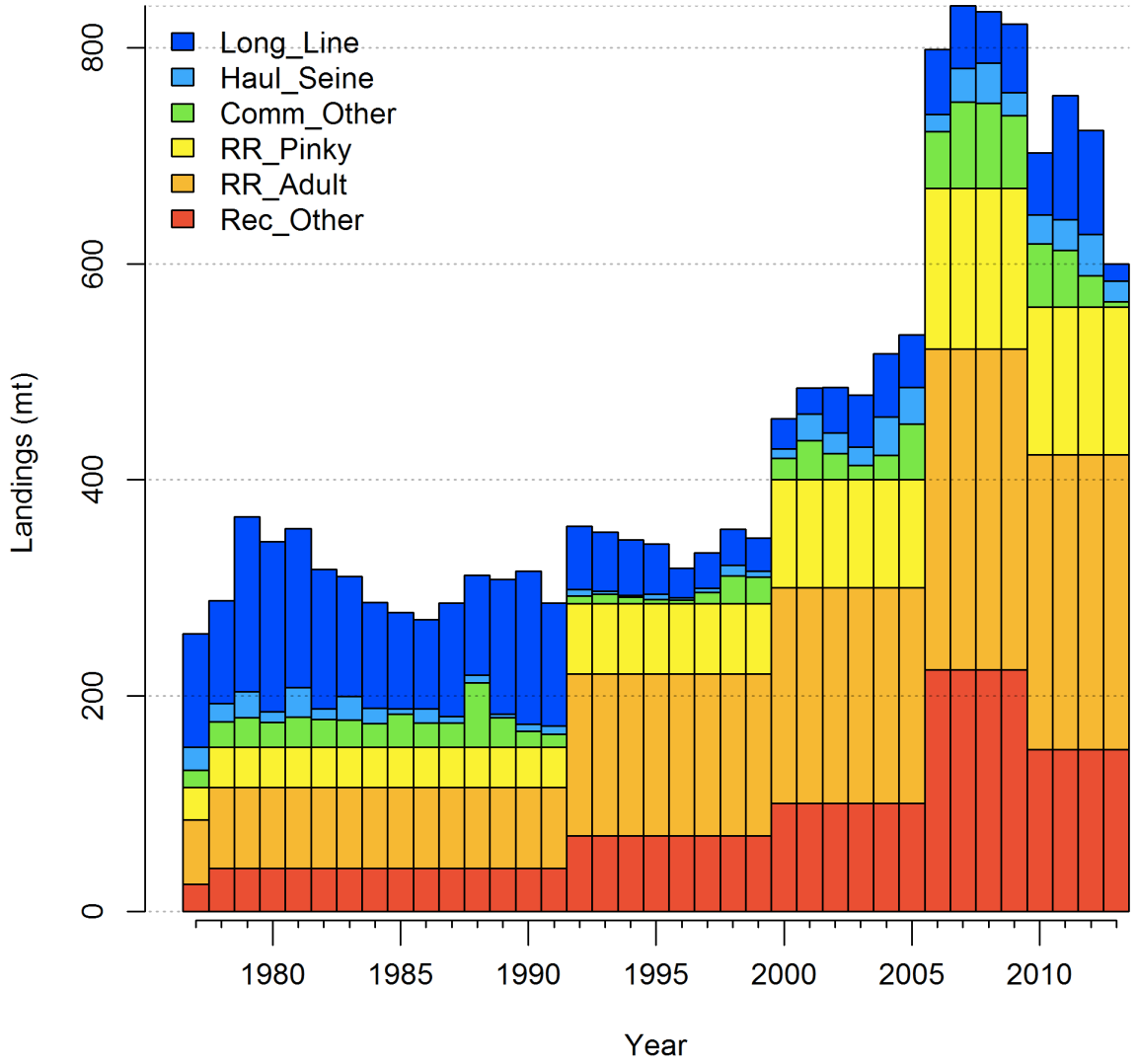


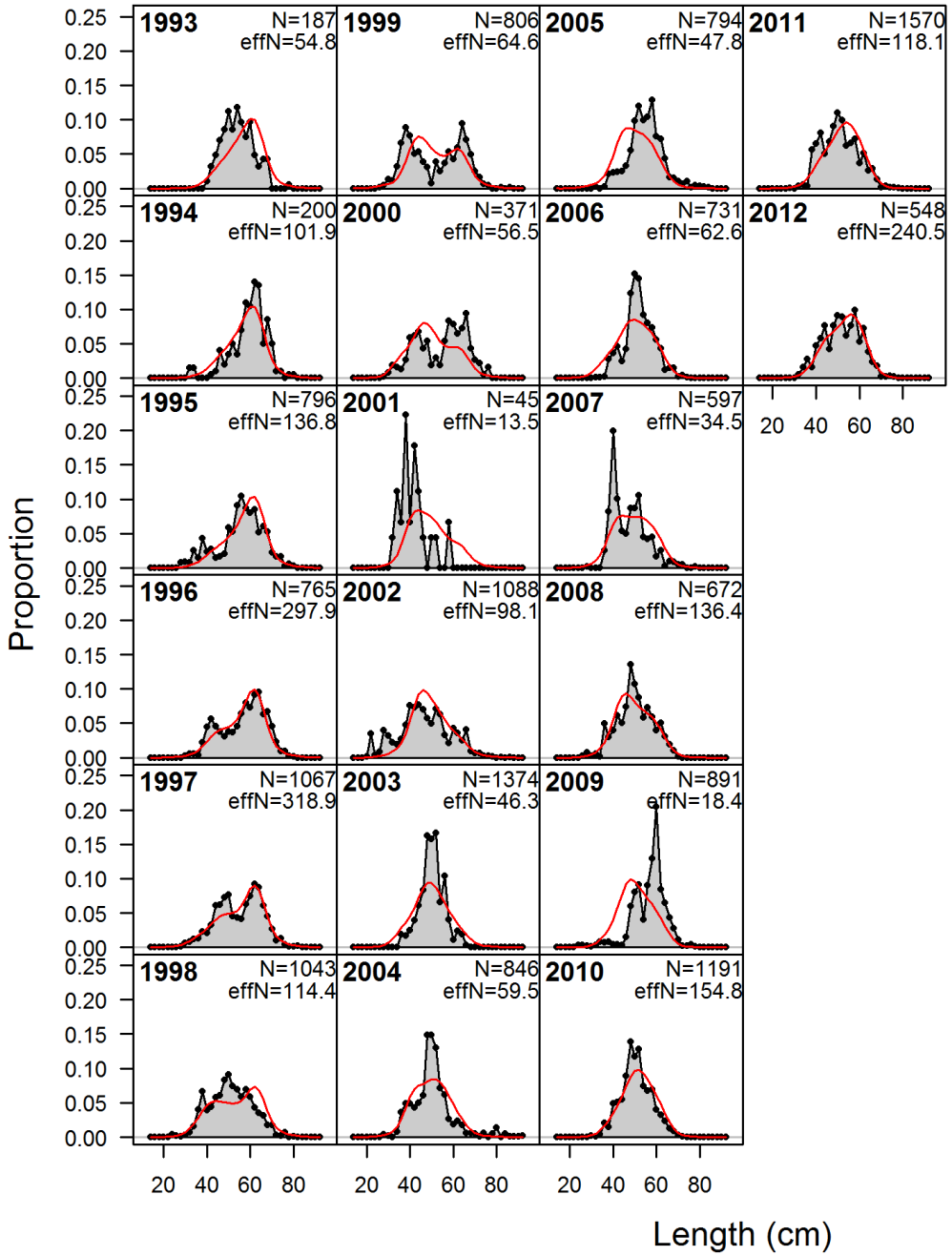
Types of Data for Assessment

- Fishery-Dependent Data
  - Landing Records (often total weight)
  - Portside Sampling (size and age sampling)
  - Onboard Observers (samples, bycatch, discard)
  - Logbooks & Vessel Trip Reports (e-log, VMS)

- Fishery-Independent Data
  - Research Surveys (Trawl, Acoustic, Video, Tagging)
  - Future Opportunities

Example Catch Data

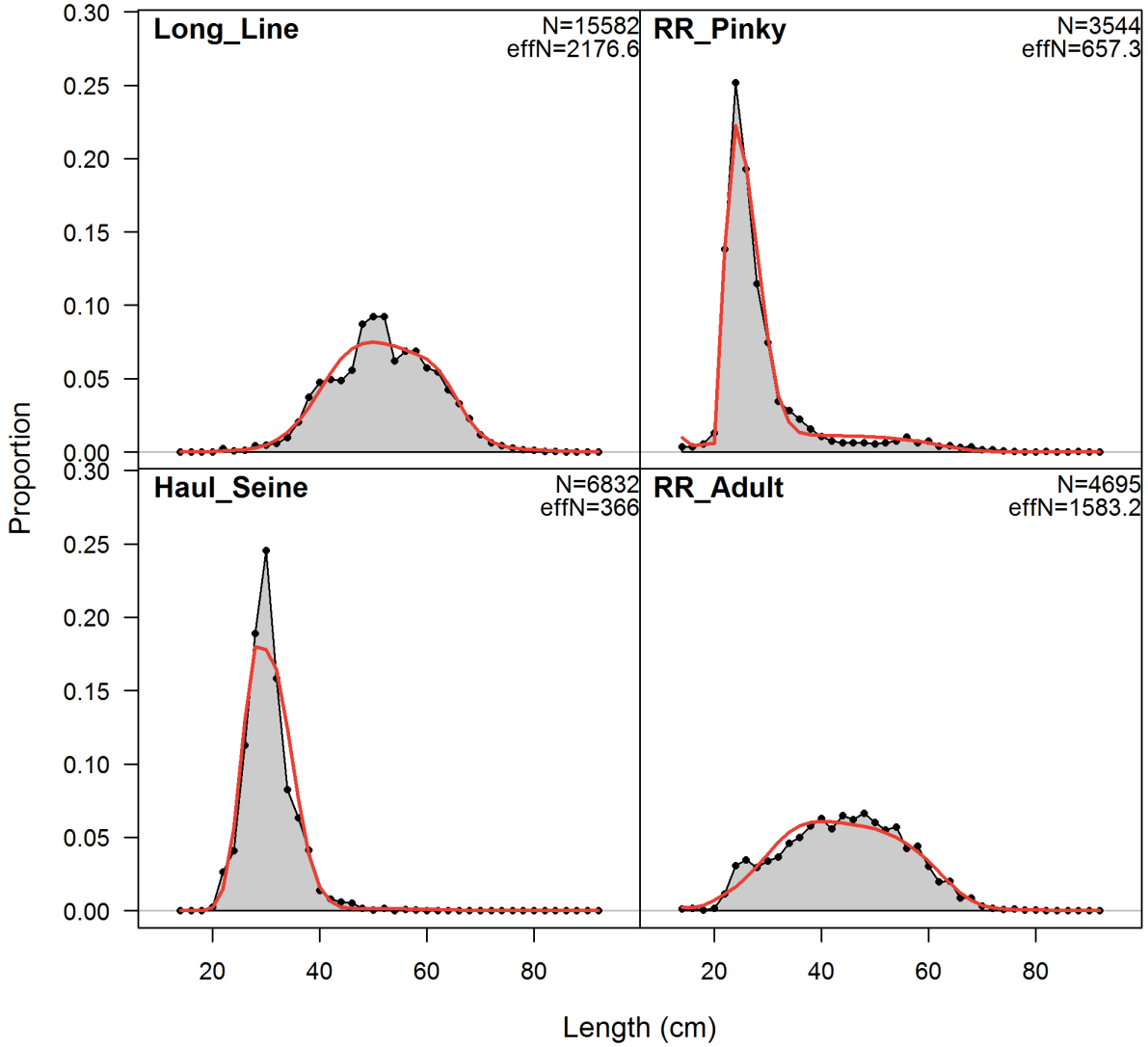




Example Size Composition Data

- Collected Every Year
- Provides information on recruitment, and changes in selective fishing pressure
- Can also collect **age** data via otolith analysis

Example Size Composition Data



Biological Reference Points

- Targets versus Limits
- Overfished of Overfishing?
- Fishing Mortality Thresholds
- Uncertainty

"Targets are stock size and fishing mortality levels that managers aim to achieve and maintain. Limits are levels they wish to avoid."

Biological Reference Points

- A biological reference point is a **concrete number**, a value for example, of stock size or fishing mortality.

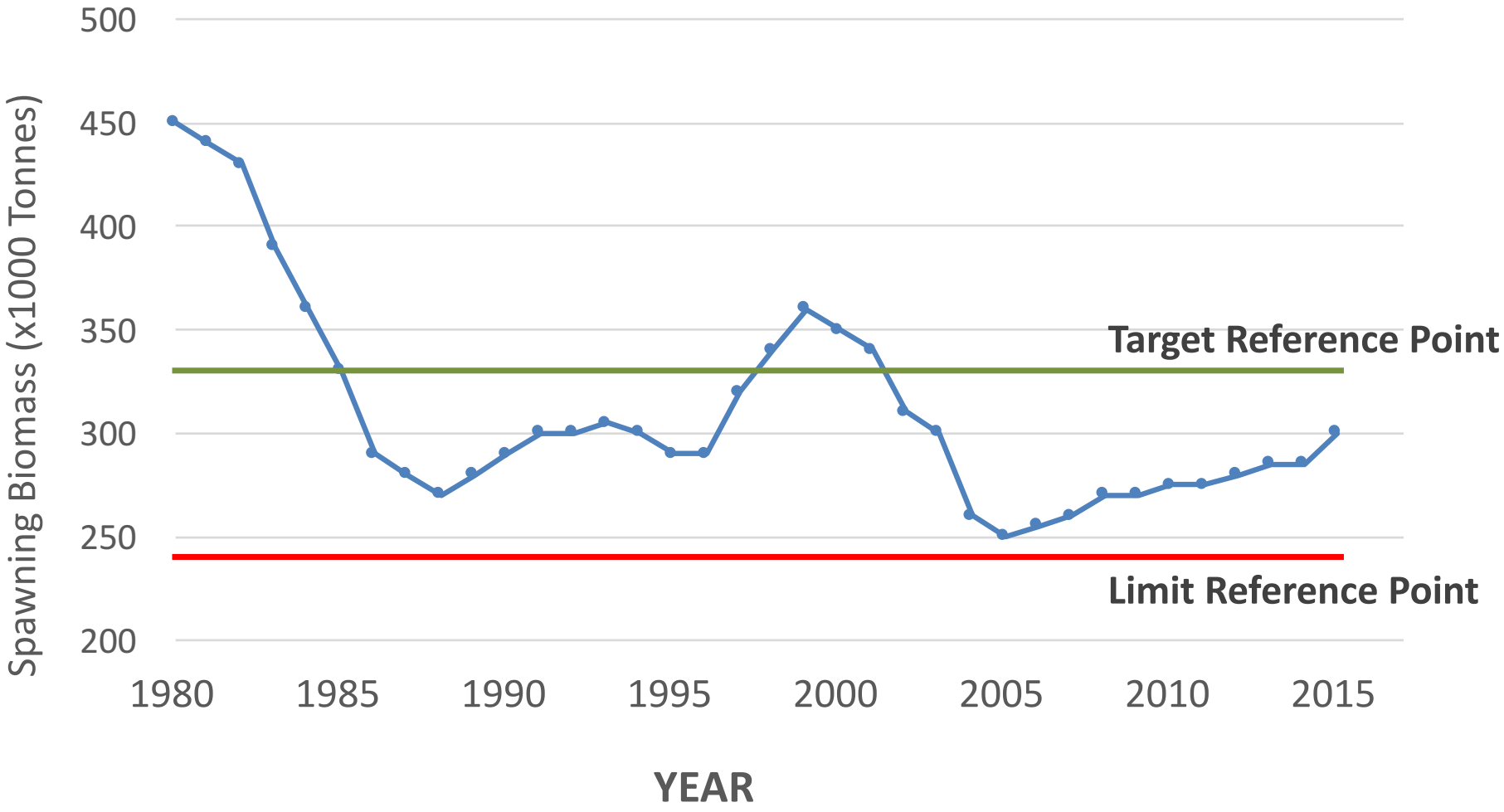
- Biological reference points give decision makers guidance in determining whether populations are too small or fishing pressure is too great.

- They help provide **targets** for how large the population or how intense the fishing pressure should be.

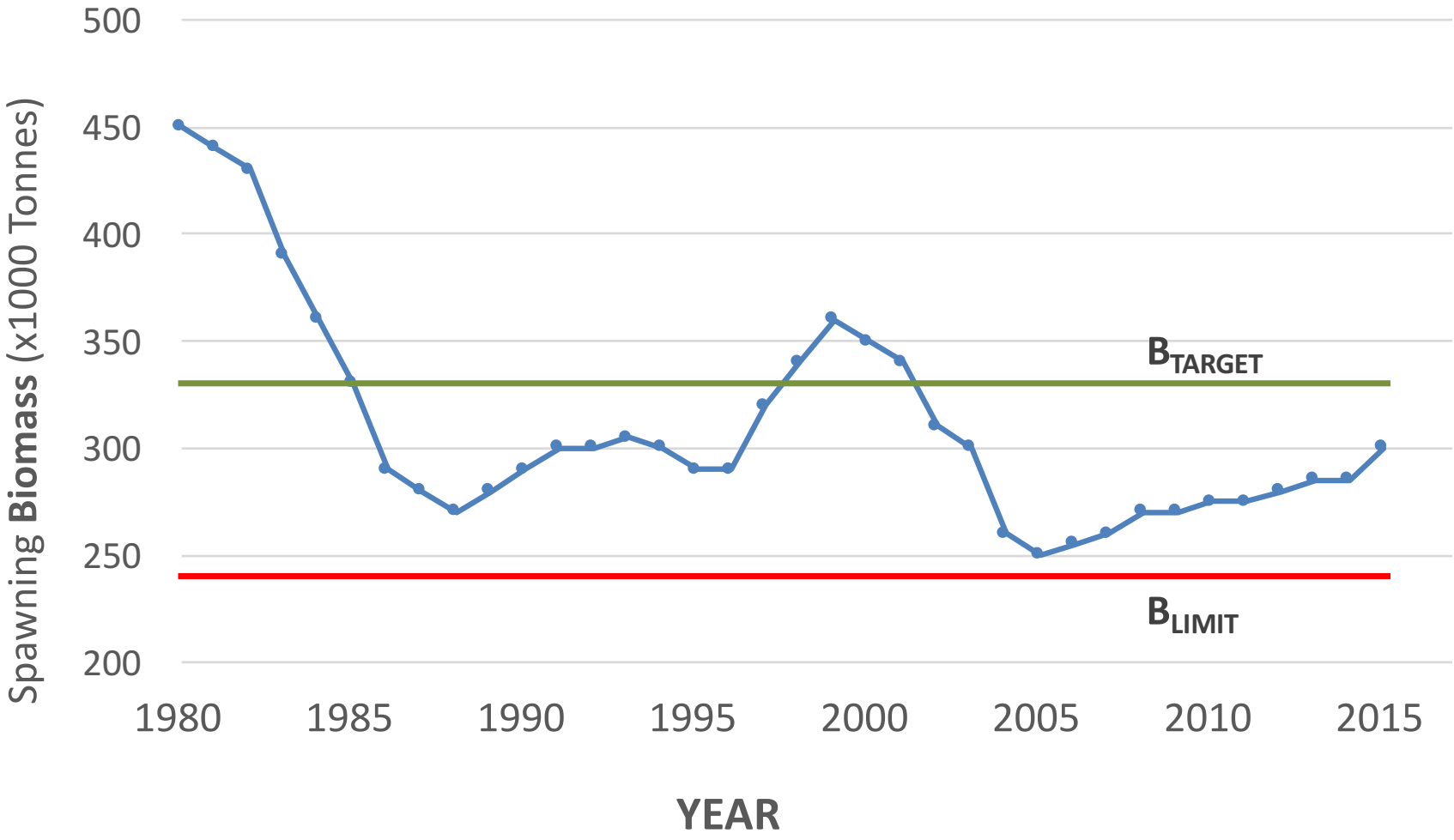
Targets versus Limits

- **Targets** are values for stock size and fishing mortality rates that a manager aims to achieve and maintain.
  - Targets are typically obtained via some combination of biological and socioeconomic factors.
  - The biomass at which the fishery can support **Maximum Sustainable Yield (MSY)**, is an example of a target.
  - Can also consider the **fishing mortality** that supports MSY
- **Limits**, or thresholds, are levels of biomass, or fishing mortality that managers aim to **avoid.**

Monitoring & Managing Biomass

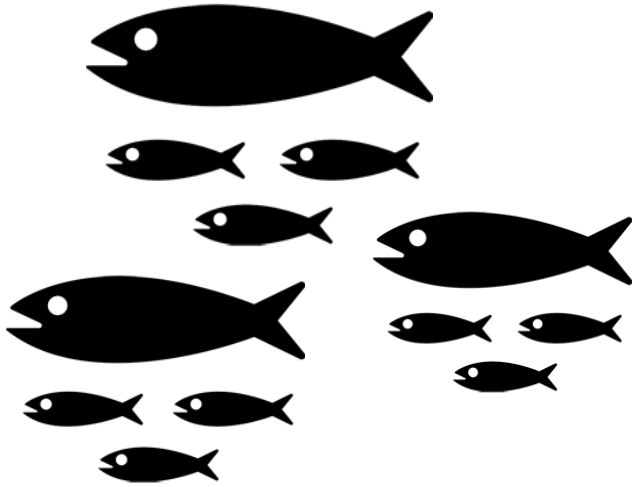


Monitoring & Managing Biomass



Monitoring Fishing Mortality

- **Fishing Mortality Rate,** is the rate at which fish are removed from the stock by harvesting.



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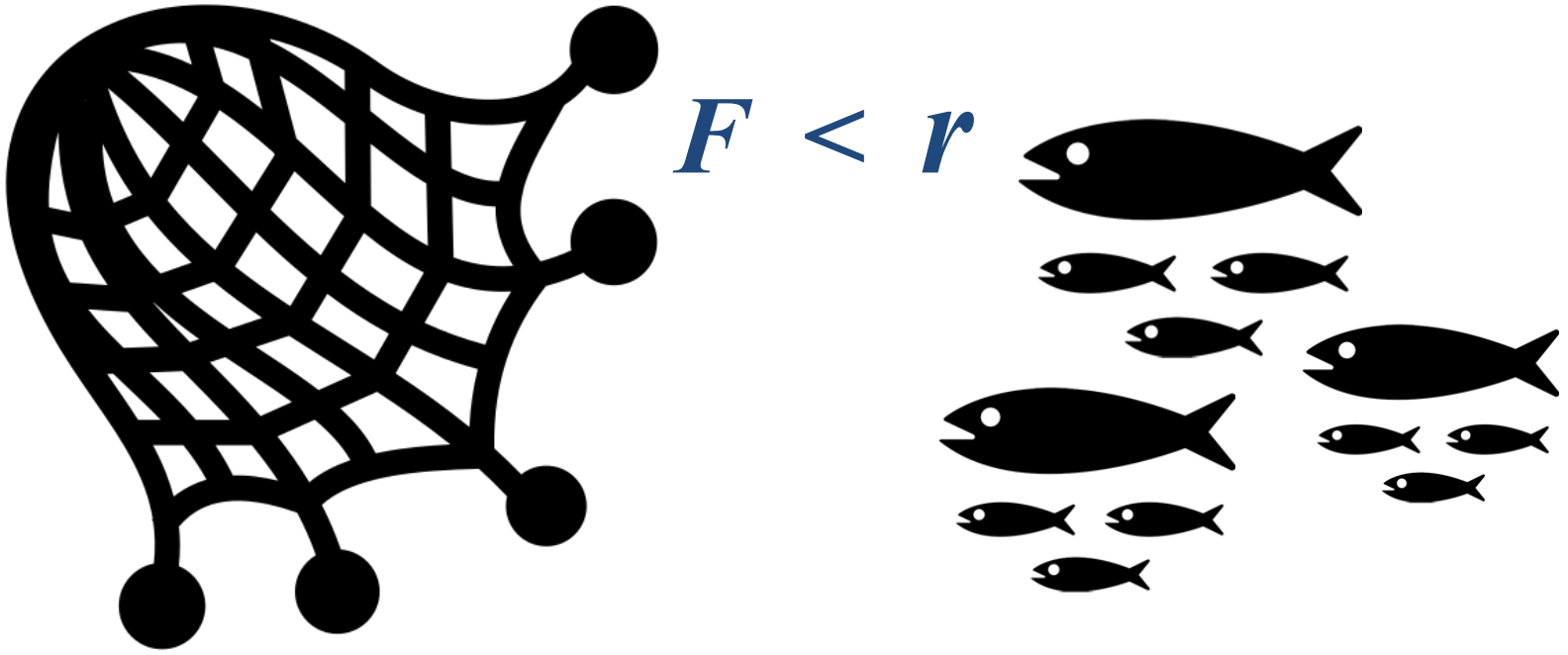

Overfished or Overfishing?

- Stock assessment attempt, in part, to determine whether **overfishing** is occurring, and whether a stock is in an **overfished** state:

	$B < B_{LIMIT}$	$B \geq B_{LIMIT}$
$F \geq_{LIMIT}$	Overfished Overfishing	Not Overfished Overfishing
$F <_{LIMIT}$	Overfished Not Overfishing	Not Overfished Not Overfishing

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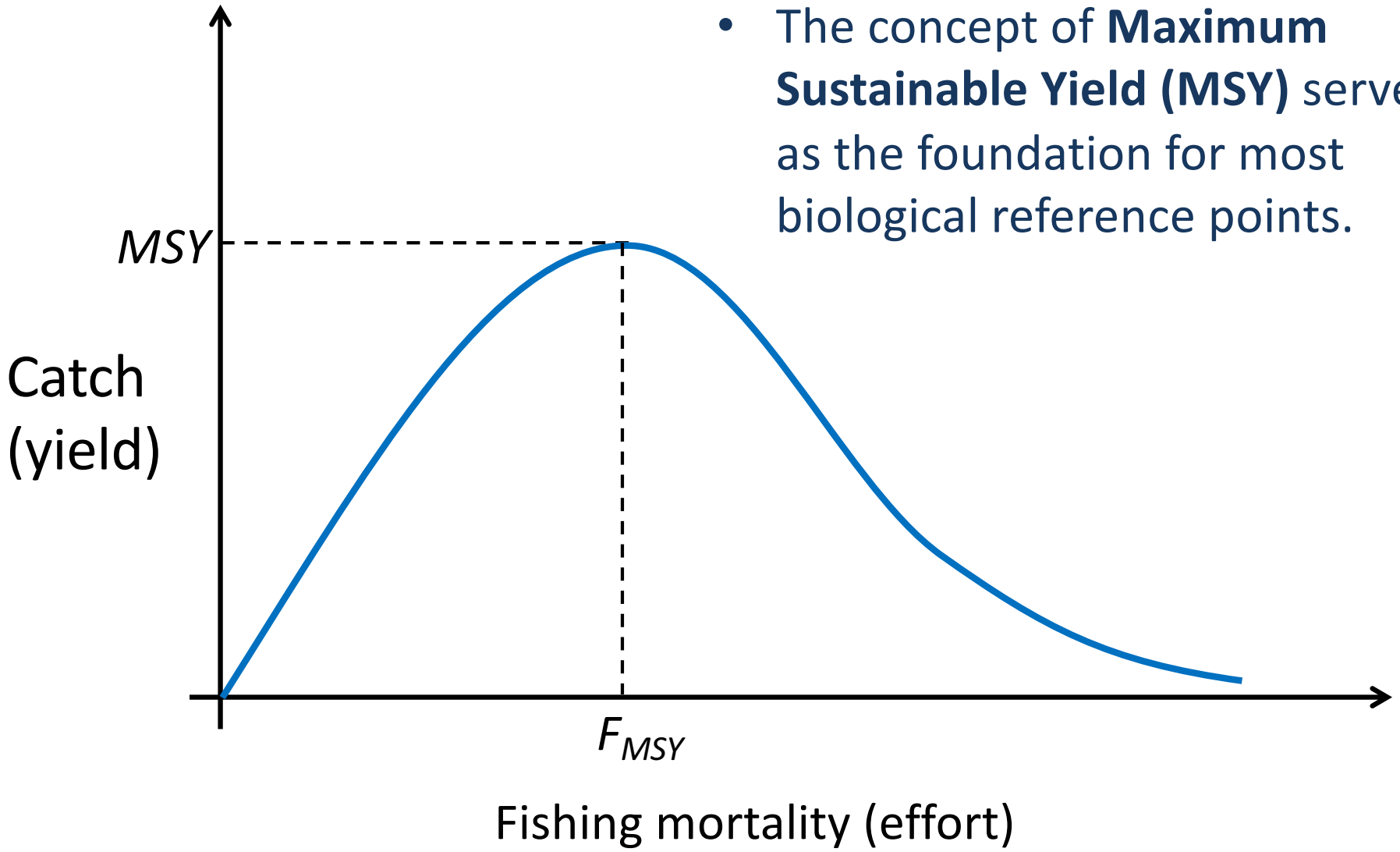
Maximum Sustainable Yield



- The concept of **Maximum Sustainable Yield (MSY)** serves as the foundation for most biological reference points.

Population Dynamics Models

- Population dynamics models are the basis of stock assessment modelling
  - The Basic Population Dynamics Model can be used to calculate next year's population

$$N_{t+1} = N_t - D_t + R_t$$

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NUMBERS NEXT YEAR = NUMBERS THIS YEAR
- NUMBER THAT DIE (Fishing or Natural)
+ NUMBER THAT ARE BORN (Recruitment)

Population Dynamics Models

- Adding Complexity: Types of Mortality
  - There are two types of mortality, fishing catch (***C***) and natural mortality (***M***)

$$N_{t+1} = N_t e^{-M} - C_t + R_t$$

Population Dynamics Models

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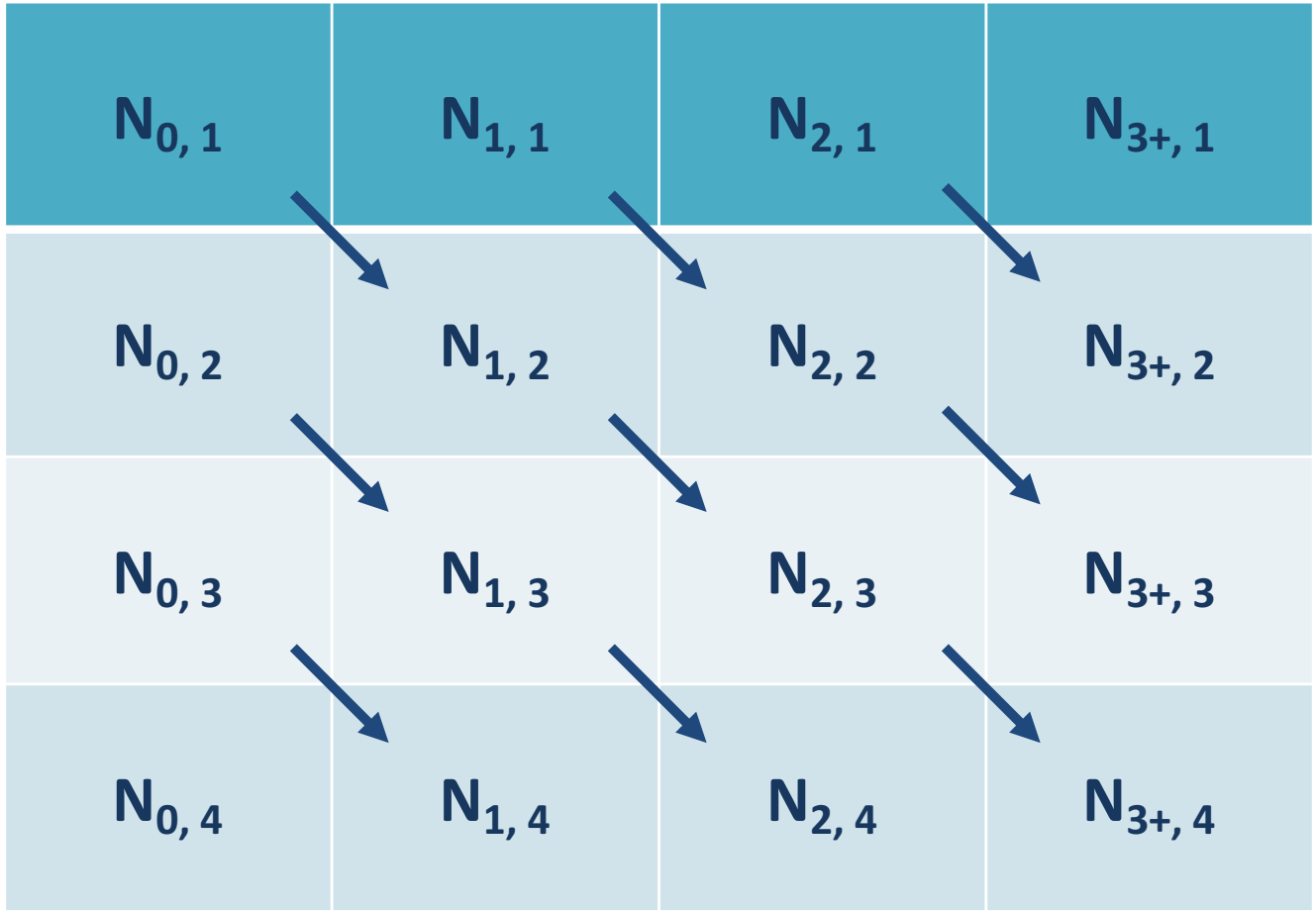
NUMBERS NEXT YEAR = NUMBERS THIS YEAR * PROPORTION THAT SURVIVE
- NUMBER THAT GET CAUGH (Fishing)
+ NUMBER THAT ARE BORN (Recruitment)

Population Dynamics Models

- Adding Complexity: Age Structure



Population Dynamics Models

- Adding Complexity: Age Structure

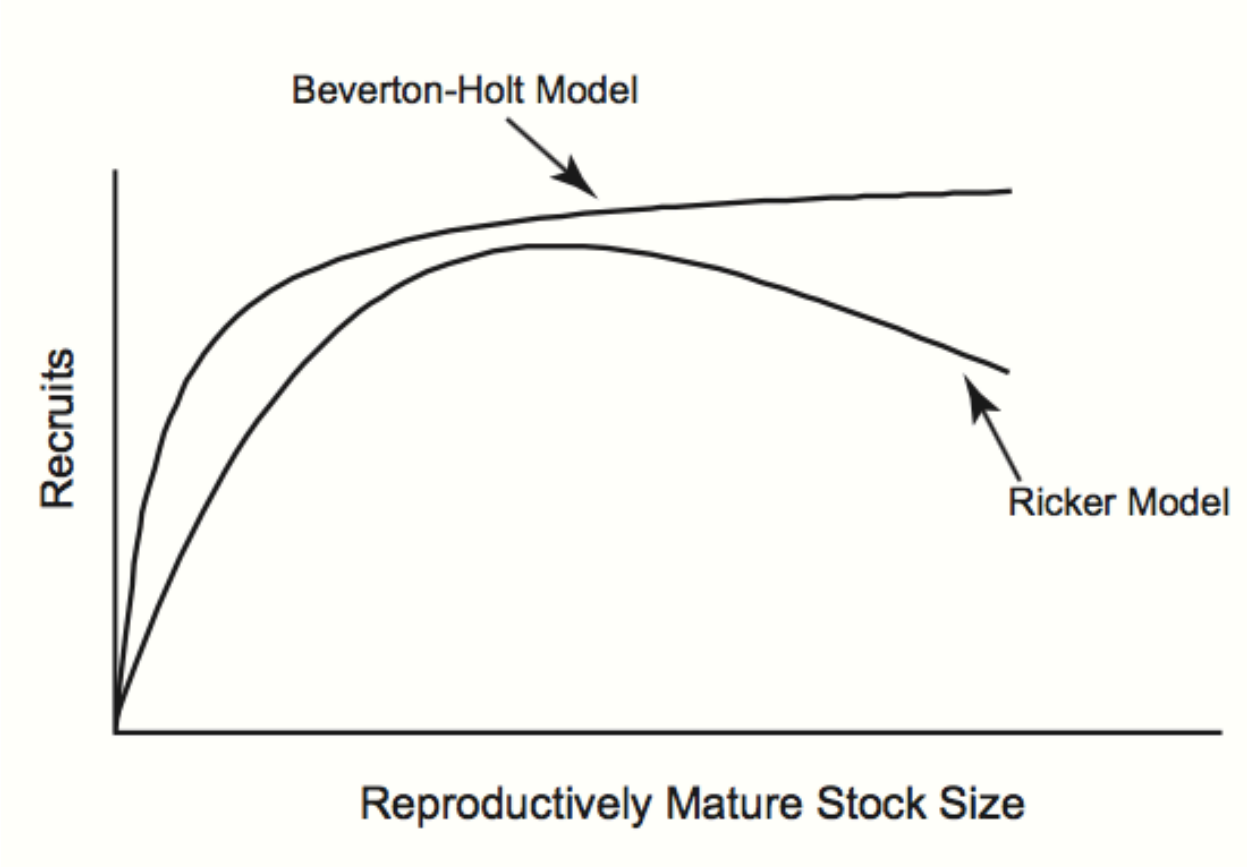
$$N_{a+1,\,t+1} = N_{a,t}\, e^{-(M+S_a F_t)}$$

NUMBERS, **AT AGE** NEXT YEAR = NUMBERS, **AT AGE** THIS YEAR * PROPORTION THAT SURVIVE

Where, SURVIVAL **(Z)** RELATES TO NATURAL MORTALITY **(N)**
And, FISHING **(F)**, PROPORTIONAL TO SELECTIVTY **(S)**

Population Dynamics Models

- Adding Complexity: Stock Recruitment Relationships



Applying Models to Data

- Indices of Abundance, CPUE, Stock Estimates

  - Catch data is most commonly applied to a stock assessment models.
  - But most stock assessment models also require some kind of **index of abundance**. An index of abundance is a value that indicates the **trend in relative abundance** over time.
  - A total biomass estimate may be possible via **acoustic surveys** or **tag-recapture** experiments

Applying Models to Data

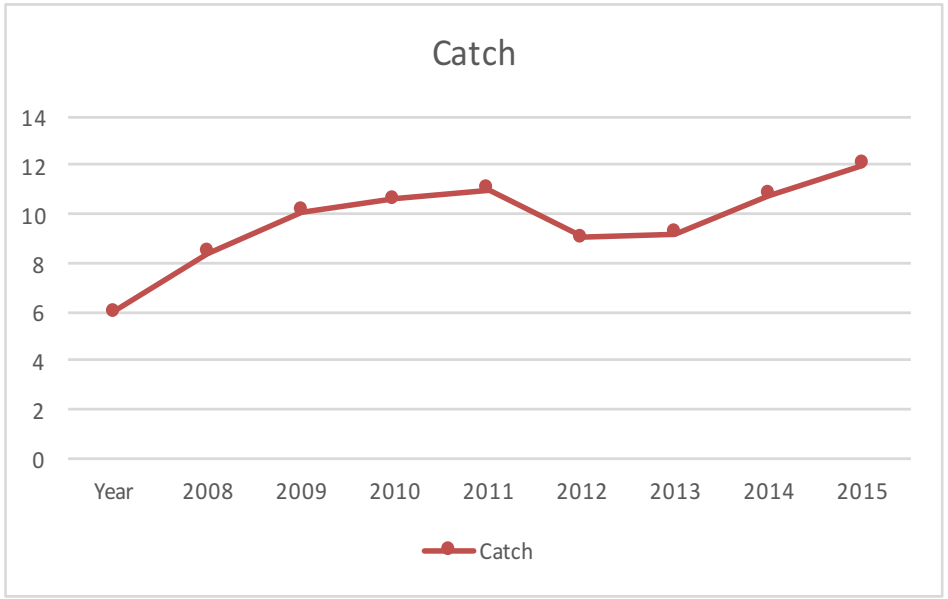
- Indices of Abundance, CPUE, Stock Estimates
  - Index may simply be the number of fish caught in a regular survey experiment.
  - This can be used to provide information on **relative change** in a fishery.
  - For example, if our **index** drops by 10 percent, then we assume that the **total biomass** has dropped by 10 percent too.

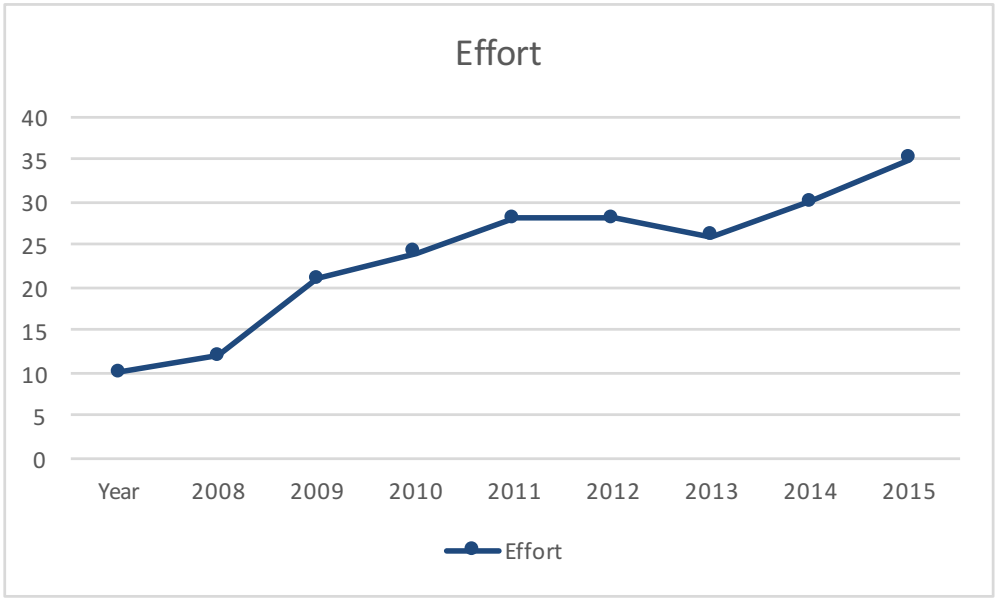
Applying Models to Data

- Catch-Per-Unit Effort (**CPUE**)
  - Catch- per-unit effort estimates may come from **fishery-dependent** or **fishery-independent data**.
  - Fisheries-independent data can be more reliable, by always using the same gear, sampling the same waters, and surveying at the same time each year
  - Fisheries-dependent data can be used, but with caution, and with **standardisation techniques**

Applying Models to Data

- Catch-Per-Unit Effort (**CPUE**)

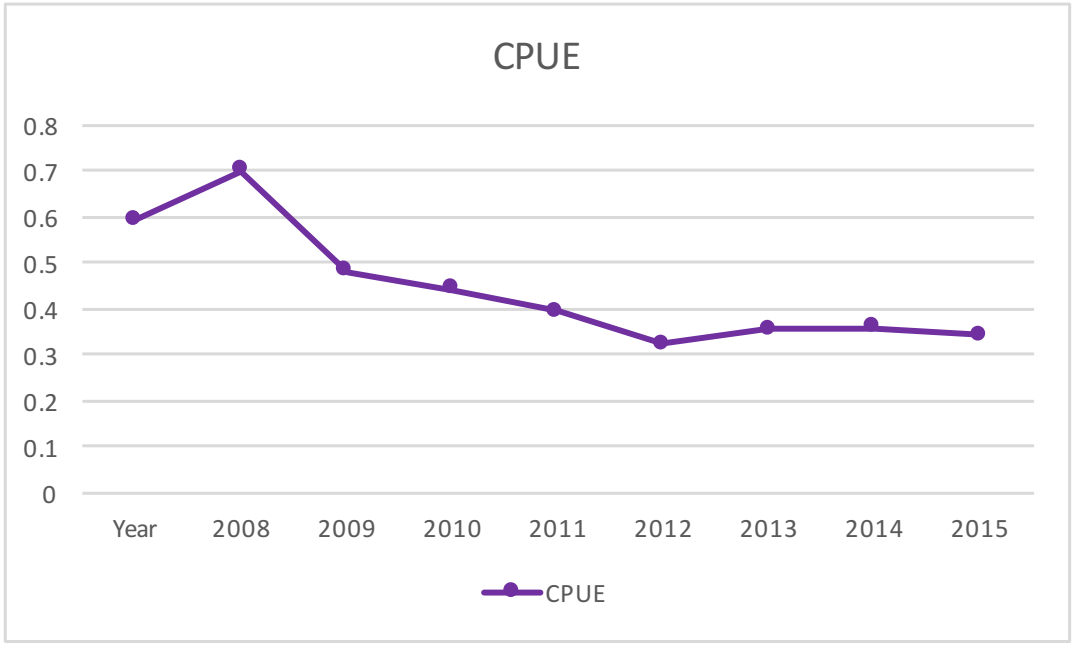




– Both catch and effort are increasing …

Applying Models to Data

- Catch-Per-Unit Effort (**CPUE**)



  - And **CPUE**, the **index of abundance**, has been in decline, possibly due to stock decline

References and Recommended Reading

- Much of the material in these slides is inspired by:
  - **A Guide to Fisheries Stock Assessment**. Andrew B. Cooper, Department of Natural Resources, **University of New Hampshire**
  - **Modelling and Quantitative Methods in Fisheries.** Malcolm Haddon, Chapman & Hall CRC, **2001**

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