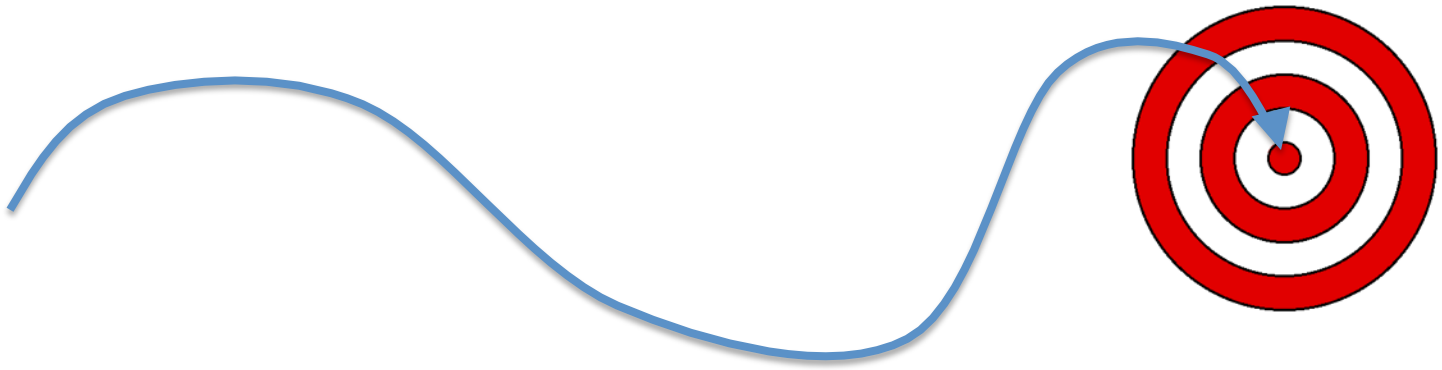
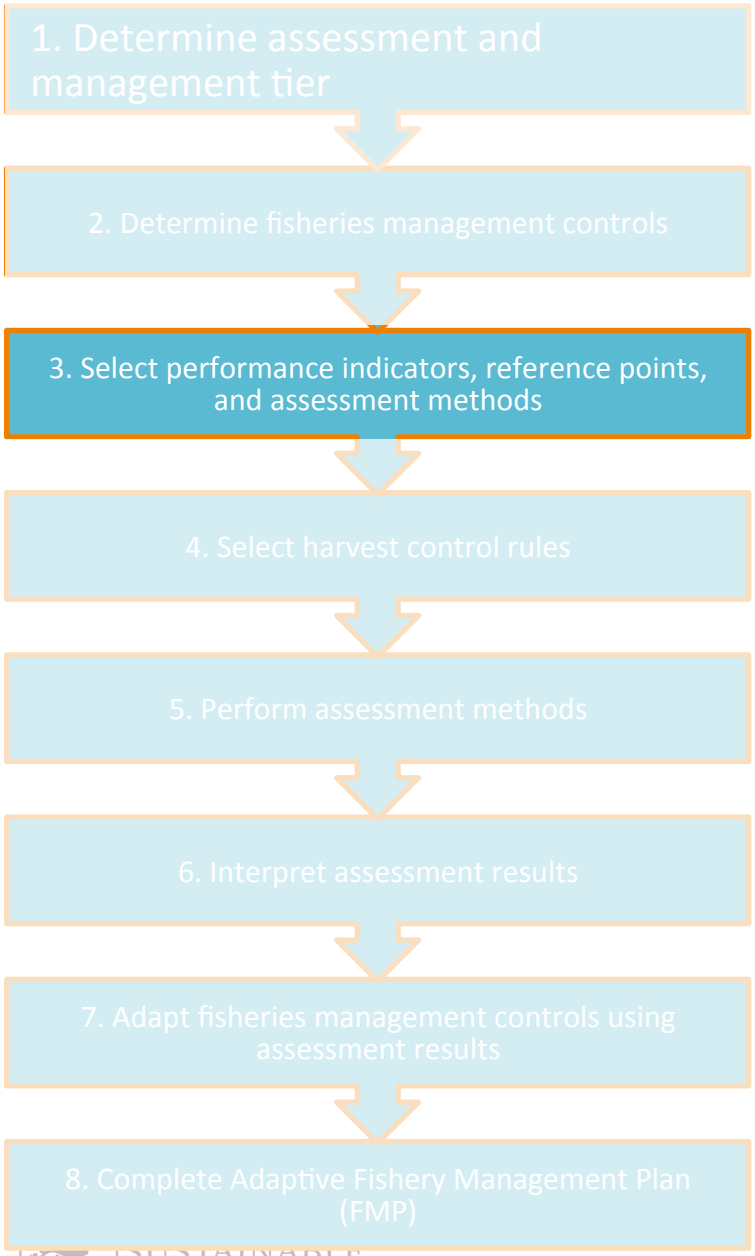


“If you don’t know where you’re going, you’ll wind up someplace else”
-Yogi Berra

Step 3 of AFAM: Select Performance Indicators and Reference Points

Road map for this session

- Presentation
  - What are performance indicators and reference points
  - Background on fish life history information
  - Details and theory of indicators included in toolkit
- Activity
  - Using AFAM, select performance indicators and reference points for your site



Performance indicators provide information about the current performance of the stock - they indicate how things are going

A target reference point is a numerical value that indicates that the performance of a stock is at a desirable level

A limit reference point is numerical value that indicates that the status of a stock is unacceptable (e.g. highly overfished)

1. Determine assessment and management tier

2. Determine fisheries management controls

3. Select performance indicators, reference points, and assessment methods

4. Select harvest control rules

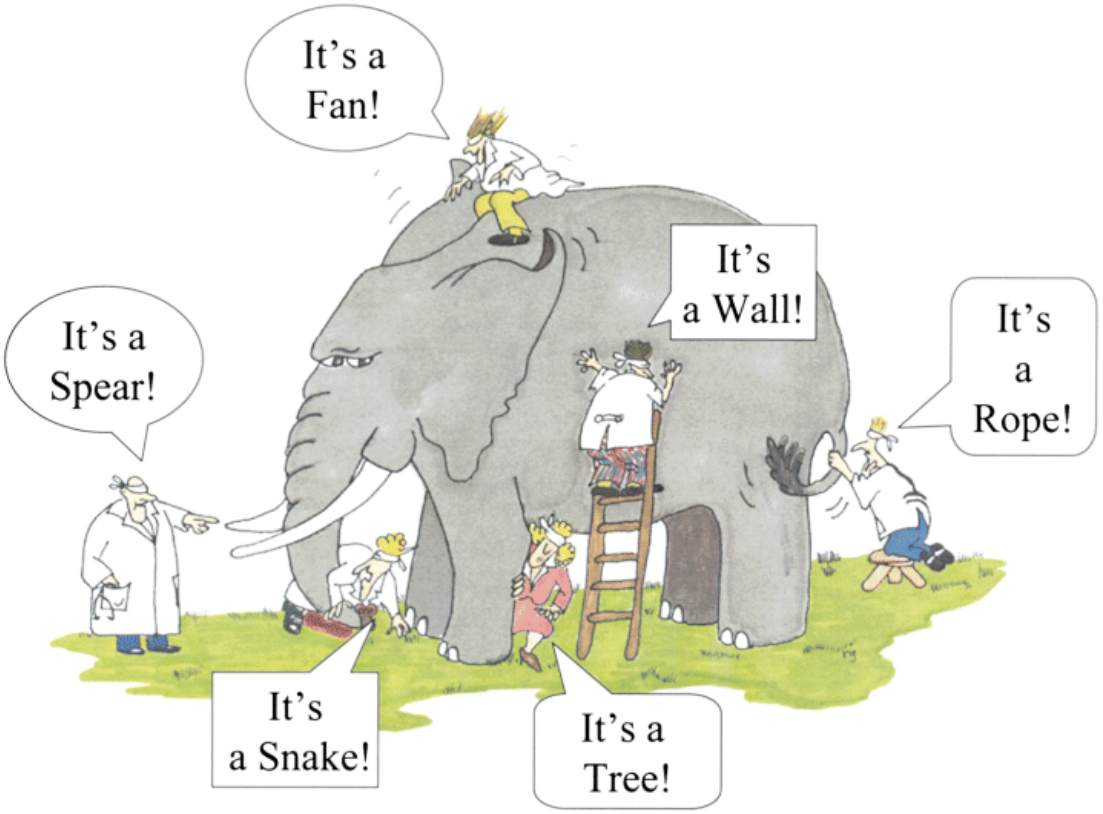
5. Perform assessment methods

6. Interpret assessment results

7. Adapt fisheries management controls using assessment results

8. Complete Adaptive Fishery Management Plan (FMP)

- *No single clue is perfect!*



- *Use multiple clues, from multiple data sources*

1. Determine assessment and management tier

2. Determine fisheries management controls

3. Select performance indicators, reference points, and assessment methods

4. Select harvest control rules

5. Perform assessment methods

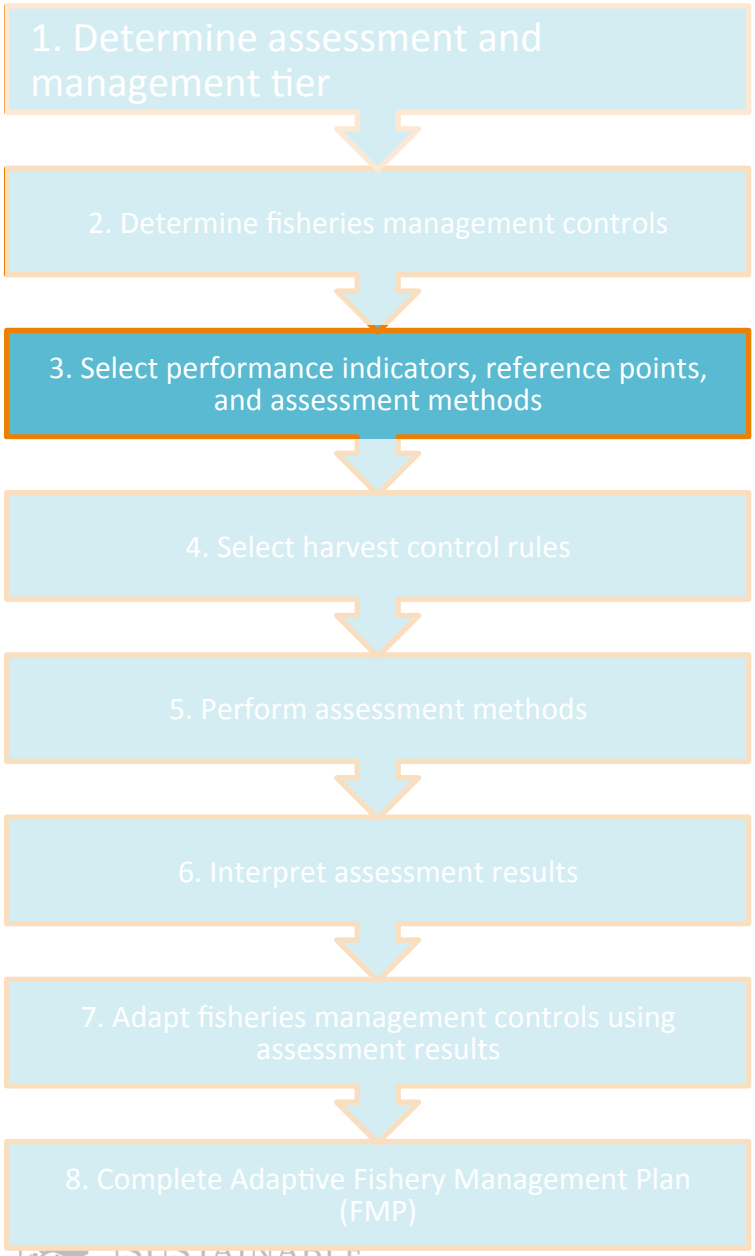
6. Interpret assessment results

7. Adapt fisheries management controls using assessment results

8. Complete Adaptive Fishery Management Plan (FMP)

Example performance indicators and reference points…

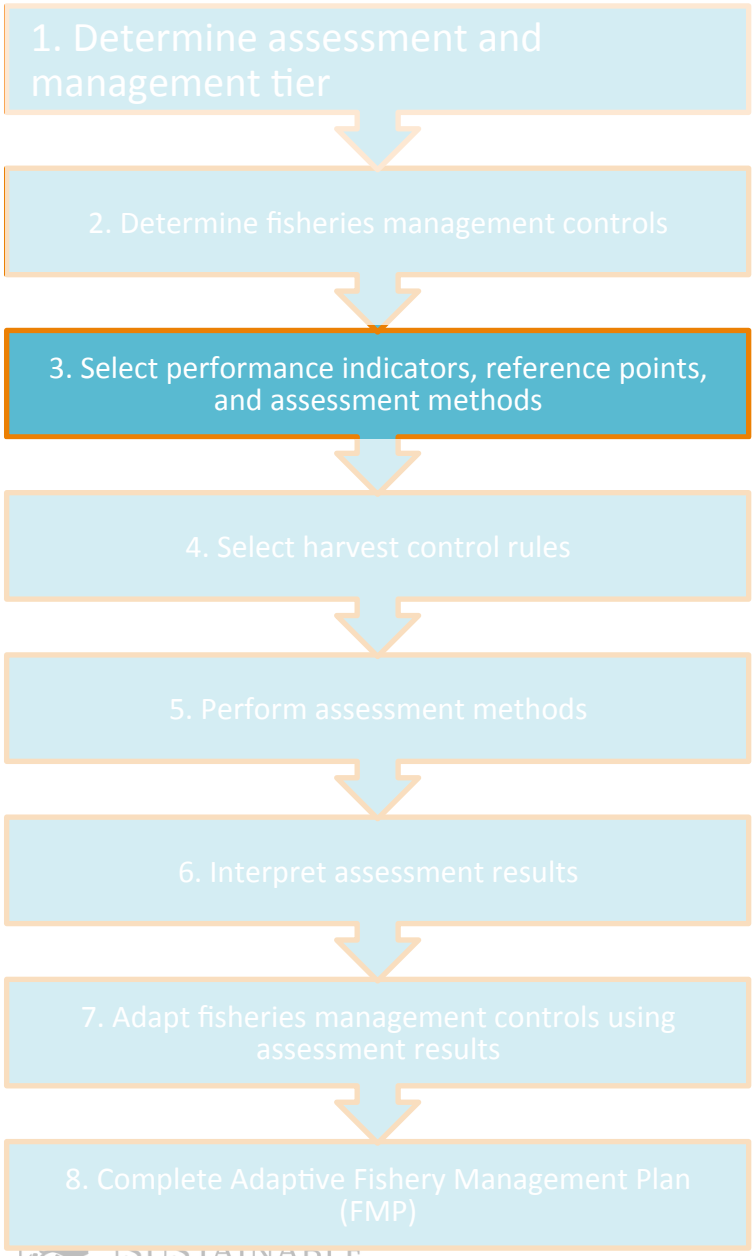
Performance Indicator	Reference Point	Data Required
CPUE	CPUE is stable or increasing	Catch reporting system
Total Catch	Total catch is stable	Catch reporting system
Average Length	Average length is greater than length at maturity	Length composition survey
Fishing Mortality	Fishing mortality is equal to natural mortality	Length composition survey
Spawning Potential Ratio	Spawning potential ratio is greater than 40%	Length composition survey
Ratio of fish density inside/outside NTZ	Density ratio is 40%	Underwater visual survey



Using the AFAM Guidance Document…

Step 3a – Select Performance Indicators

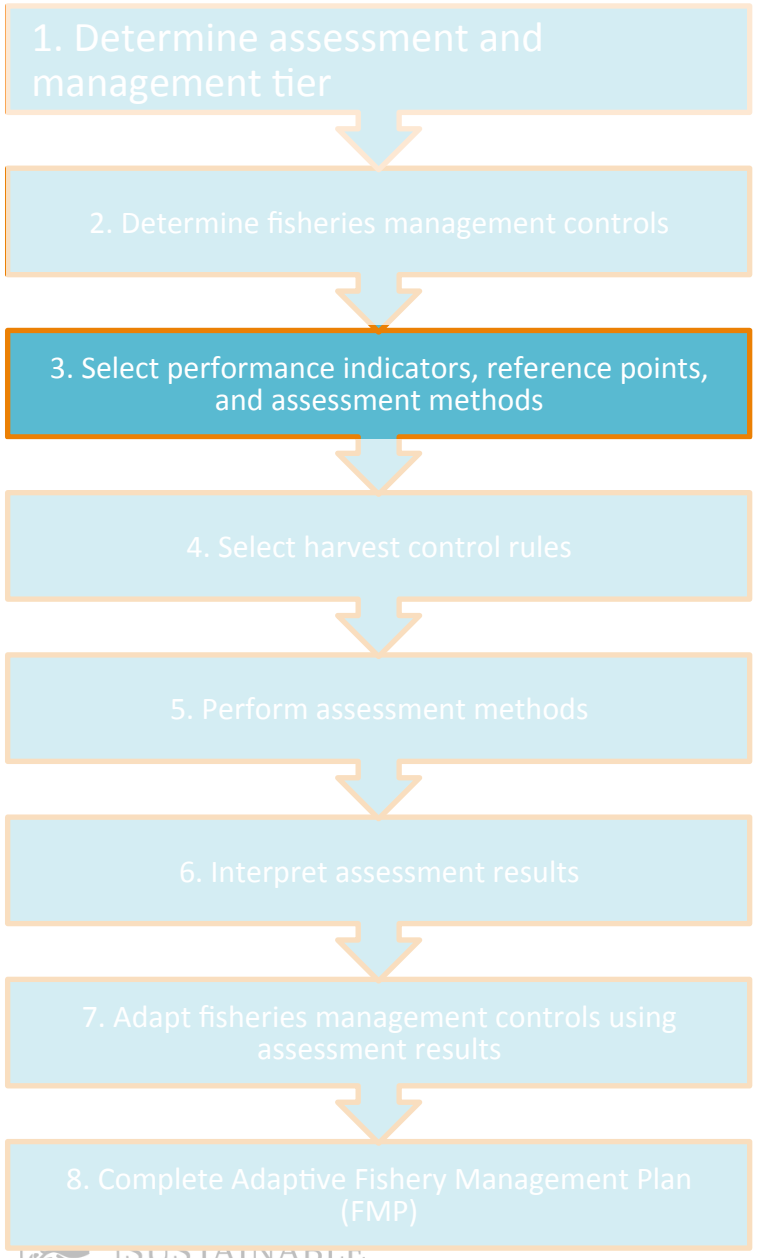
Step 3b – Select Reference Points



Step 3a – Select Performance Indicators

- **Indicators will depend on data availability, target species, assessment and management tier**
- **When possible, select multiple indicators from independent data streams – *but generally don't use more than 3!***
- **Indicators all associated with pros, cons, caveats – none perfect**

See detailed assessment method descriptions



Step 3b – Select Reference Points

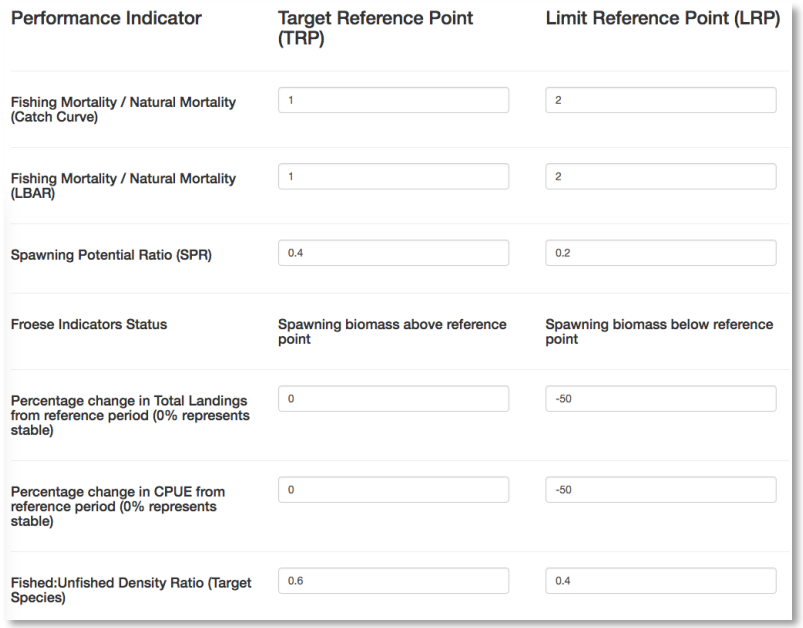
- **For each performance indicator, set a target reference point (TRP) and limit reference point (LRP)**
- **Reference points can be based on literature, trends, or historical data**
- **Local knowledge, along with biological knowledge, should be used when setting reference points**

See

detailed assessment method descriptions

Select performance indicators and reference points

- Dashboard has system for selecting performance indicators and reference points
- Pre-populates standard reference points
- Only shows appropriate indicators as options



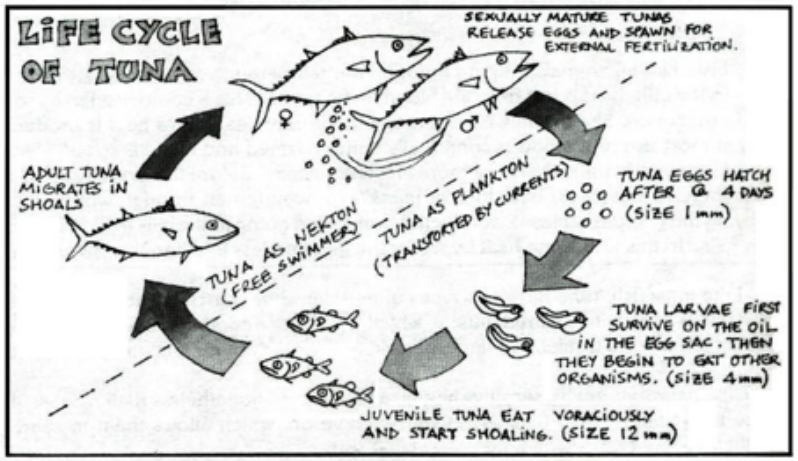
Performance Indicator	Target Reference Point (TRP)	Limit Reference Point (LRP)
Fishing Mortality / Natural Mortality (Catch Curve)	1	2
Fishing Mortality / Natural Mortality (LBAR)	1	2
Spawning Potential Ratio (SPR)	0.4	0.2
Froese Indicators Status	Spawning biomass above reference point	Spawning biomass below reference point
Percentage change in Total Landings from reference period (0% represents stable)	0	-50
Percentage change in CPUE from reference period (0% represents stable)	0	-50
Fished:Unfished Density Ratio (Target Species)	0.6	0.4

Methods included in AFAM

- Length data
  - Fishing mortality from Mean length (LBAR)
  - Fishing mortality from Catch curve
  - Spawning potential ratio
  - Froese sustainability indicators
- Catch and effort data
  - Trends in catch
  - Trends in CPUE
- Underwater visual survey data
  - Fished:unfished biomass ratio (coral reef ecosystem indicator)
  - Fished:unfished density ratio (starget species indicator)

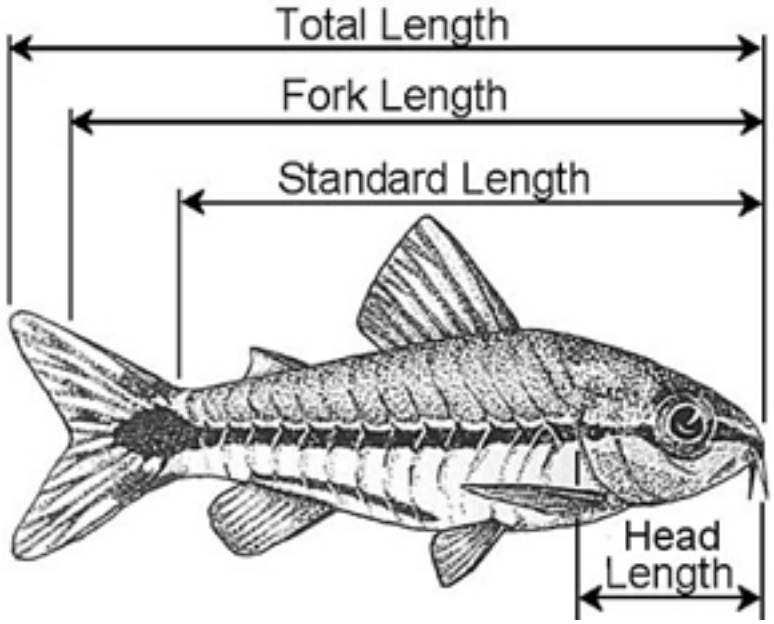
Common Life History Information for Data-Limited Fisheries Assessment

- Age-length conversion parameters (using von Bertalannfy growth equation)
- Length-weight conversion parameters
- Maturity
- Mortality



https://en.wikipedia.org/wiki/Tuna

Measuring fish



Length parameters should be given in terms of one of these types of measurement

http://fishe.edf.org/catch-share-basics/glossary

Age-length conversion parameters (using von Bertalannfy growth equation)

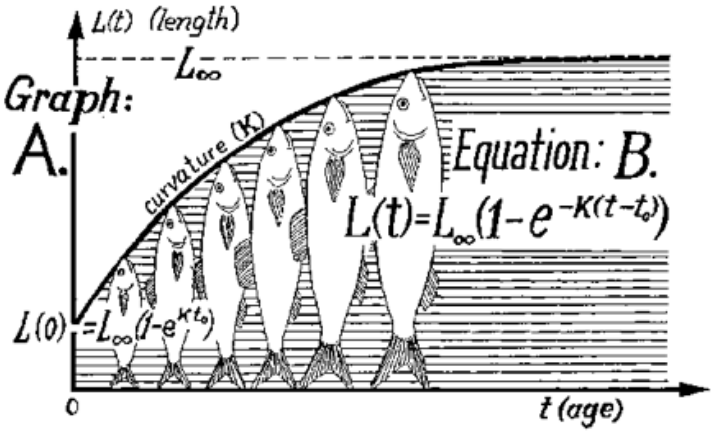
$L_t = L_{infinity} [1 - \exp(-K * (t - t_0))]$

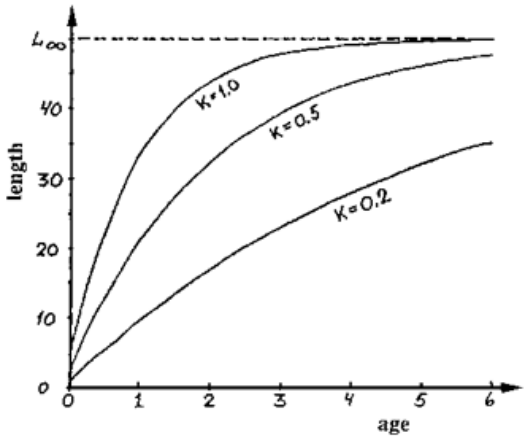
L_t : Length at age t

$L_{infinity}$: Theoretical asymptotic length of infinitely old fish

K: Growth rate

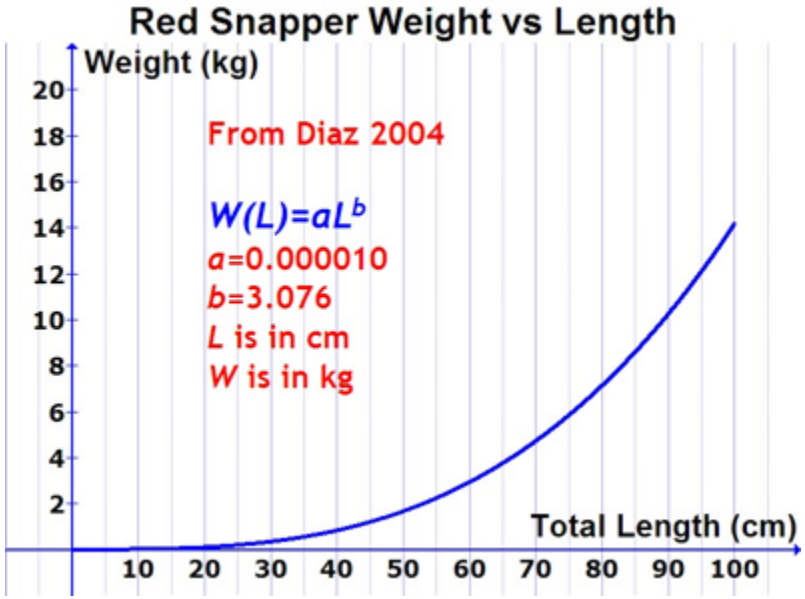
t_0: Theoretical age of zero-length fish





http://www.fao.org/docrep/w5449e/w5449e05.htm

Length-weight conversion parameters

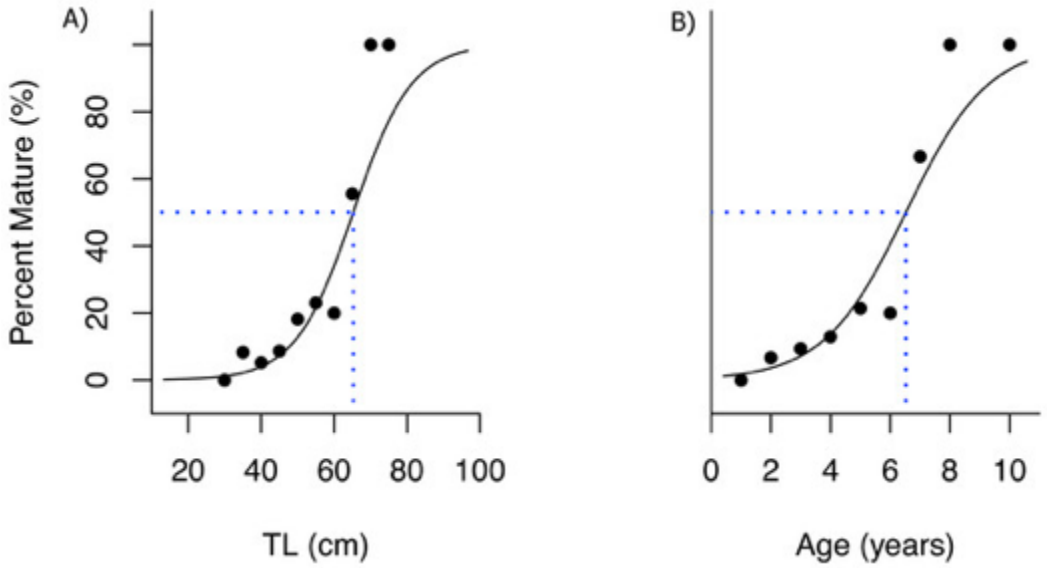


https://en.wikipedia.org/wiki/Standard_weight_in_fish

Maturity

m_{50}: Length (or age) when 50% of fish are mature

m_{95}: Length (or age) when 95% of fish are mature



Typically given m_{50} in the literature

If m_{95} not available, can use relationship $m_{95} = 1.14 * m_{50}$

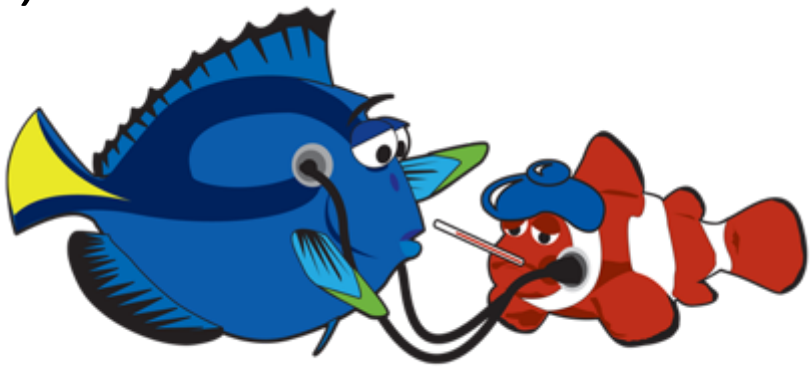
If m_{50} not available, can also be estimated from $L_{infinitiy}$

Mortality

$$Z = F + M$$

Z: Total mortality
F: Fishing mortality (from harvest)
M: Natural mortality (from everything else)

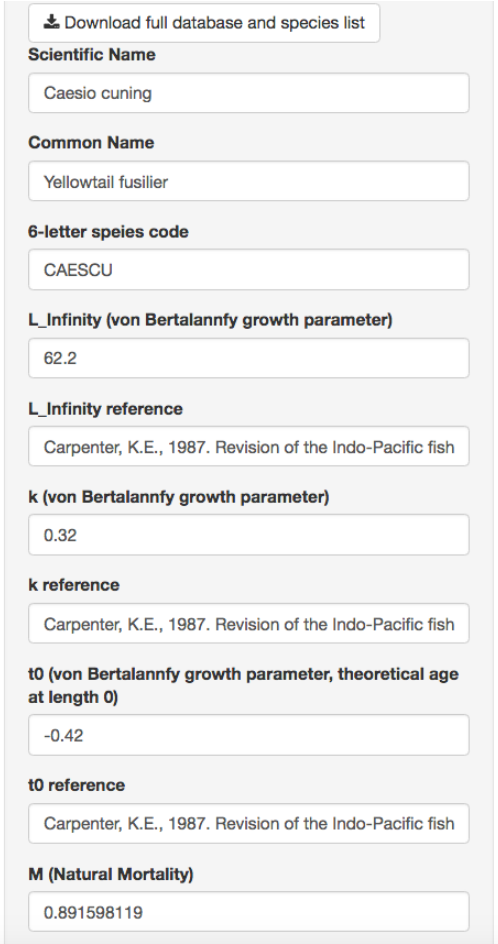
M can come from literature, but there are relationships that can be used if it can't be found (relating it to m_{50} or K) –
Here is a nice online tool



Where to find life history information?

Species Life History "Database"

- Database of > 160 species
- All biological information required for AFAM toolkit
- Automatically populates when using Dashboard



Where to find life history information?

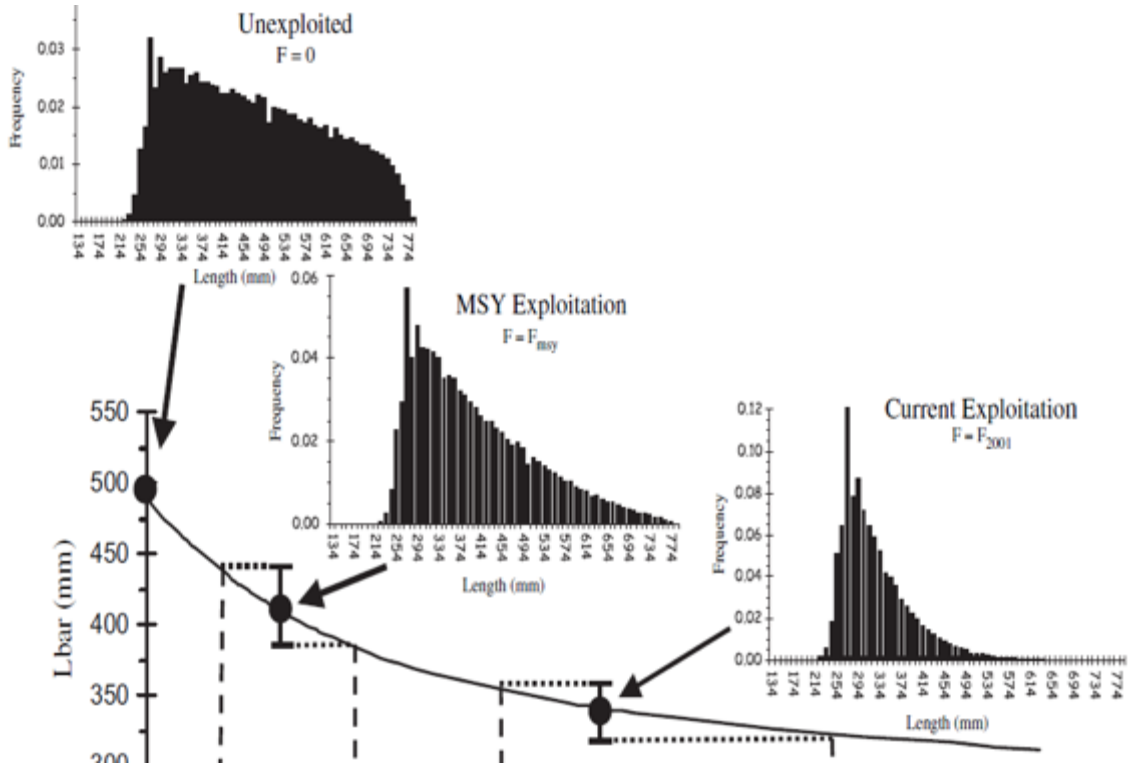
If it's not in our database, check out…

- http://www.fishbase.org/
- Scientific literature
  - Google
  - Google scholar - https://scholar.google.com
- Tool for estimating natural mortality

Fishing Mortality from Average Length (LBAR)

- Inputs
  - Length-frequency data (individual length measurements)
  - Life history information ($L_{infinity}$, natural mortality *M*, and von Bertalanffy growth parameter *k*)
- Outputs
  - Estimate of fishing mortality *F*
  - Ratio of fishing mortality to natural mortality *F/M*

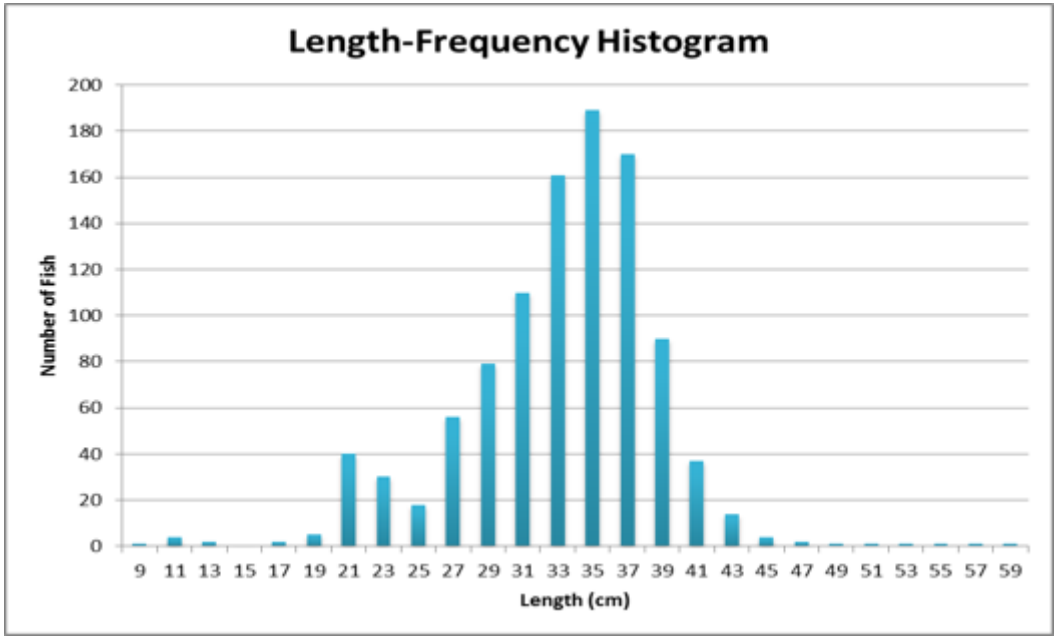
Fishing Mortality from Average Length (LBAR)



Ault et al, 2005

As fishing pressure increases, larger fish disappear and average length decreases

Fishing Mortality from Average Length (LBAR)

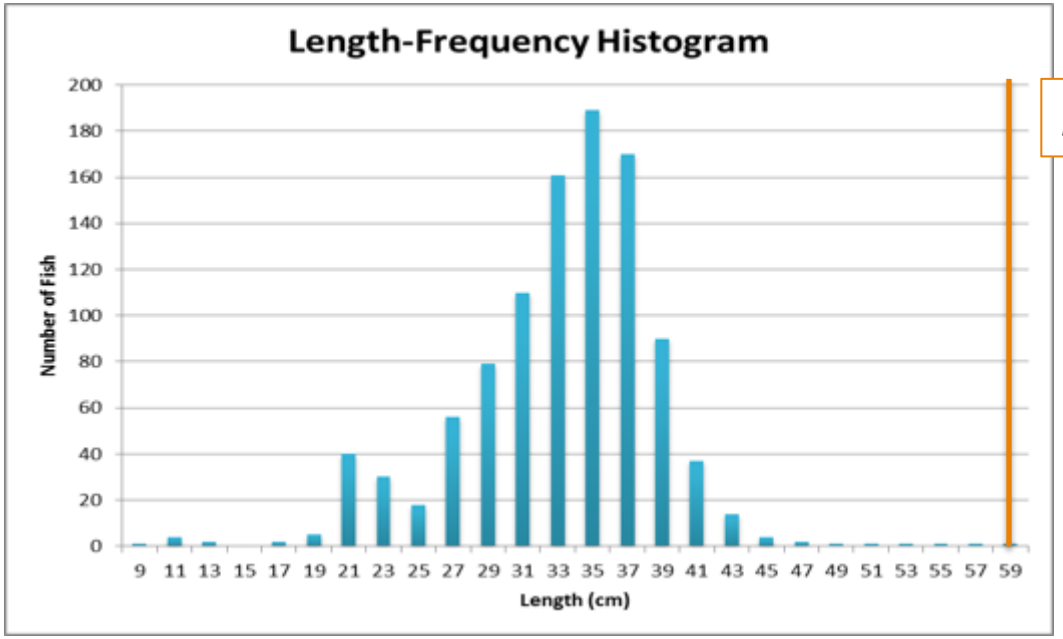


$$Z = K * (L_{infinity} - LBAR) / (LBAR - L_C)$$

$$F = Z - M$$

Z: Total mortality
F: Fishing mortality
M: Natural mortality (life history information)

Fishing Mortality from Average Length (LBAR)



$$Z = K * (L_{infinity} - LBAR) / (LBAR - L_C)$$

$L_{infinity}$ – Asymptotic length of infinitely old fish (life history information

$$F = Z - M$$

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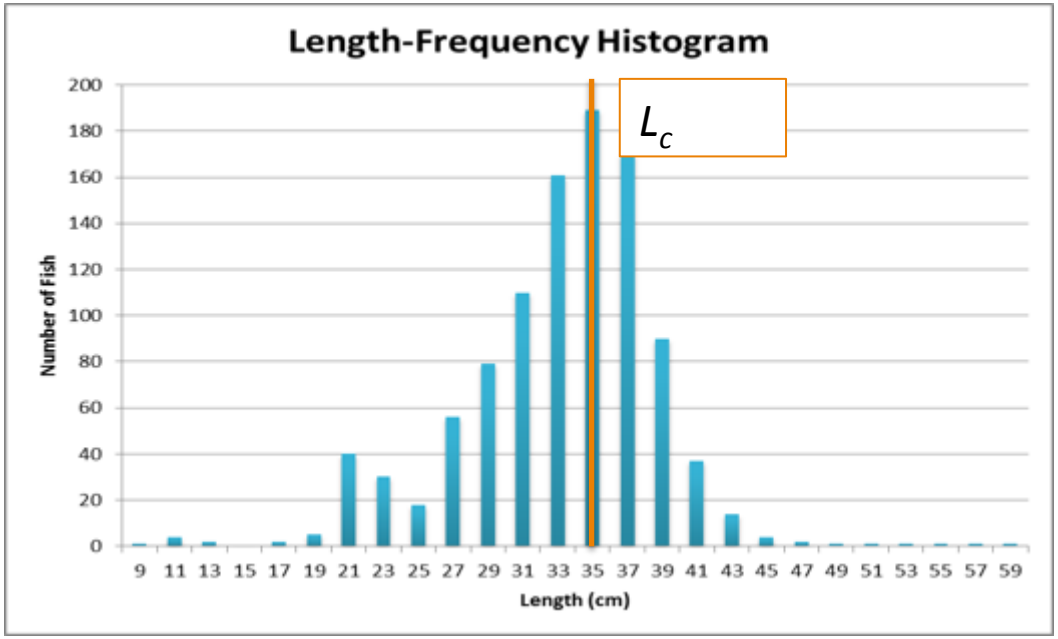
Fishing Mortality from Average Length (LBAR)



$Z = K * (L_{infinity} - LBAR) / (LBAR - L_C)$

L_c –Length at full selectivity (mode of the histogram)

$$F = Z - M$$

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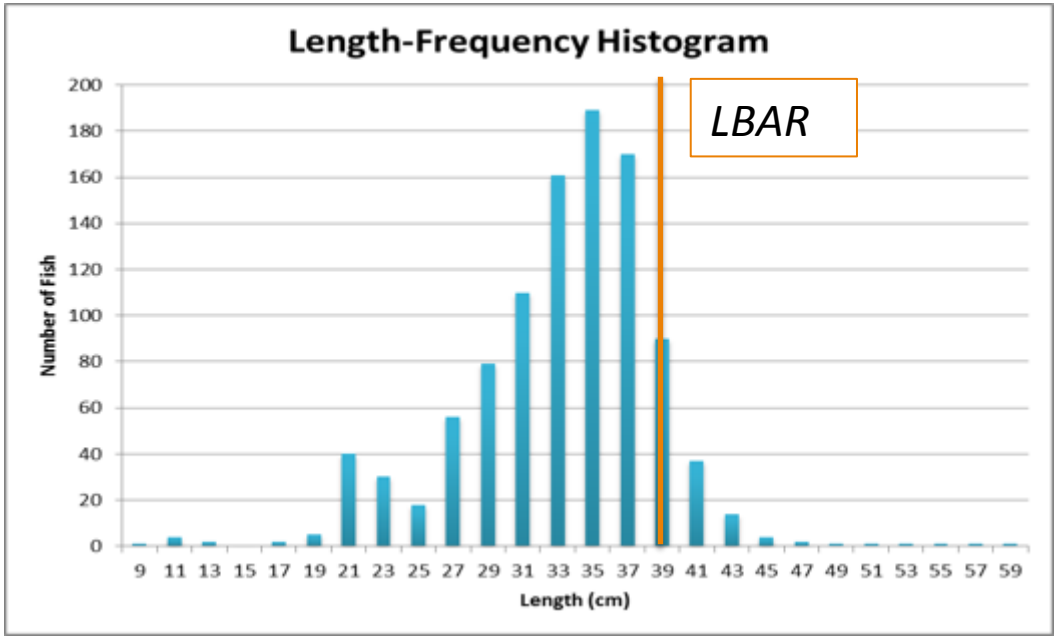
Fishing Mortality from Average Length (LBAR)



$Z = K * (L_{infinity} - LBAR) / (LBAR - L_C)$

LBAR – Weighted mean length between L_c and $L_{infinity}$

$$F = Z - M$$

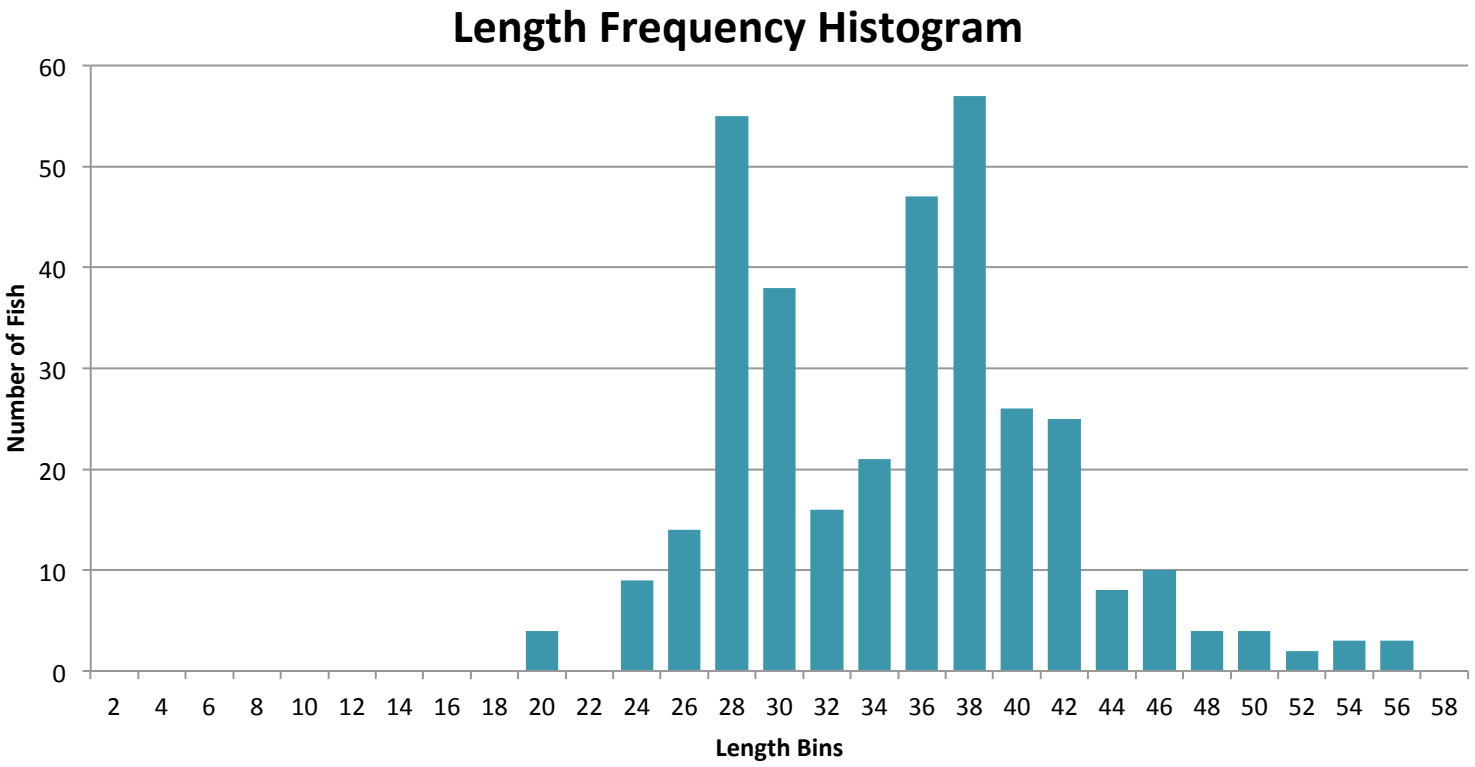
Fishing Mortality from Average Length (LBAR)

- What it tells us:
  - Estimates fishing mortality (*F*)
  - This is used to calculate the ratio *F/M*
- How this information informs management:
  1. Stakeholders set target reference point *F/M*
     - Rule of thumb is *F/M* = 1
  2. Compare target *F/M* with *F/M* from assessment
  3. Adjust fisheries management controls based on how far apart they are

Fishing Mortality from Catch Curve

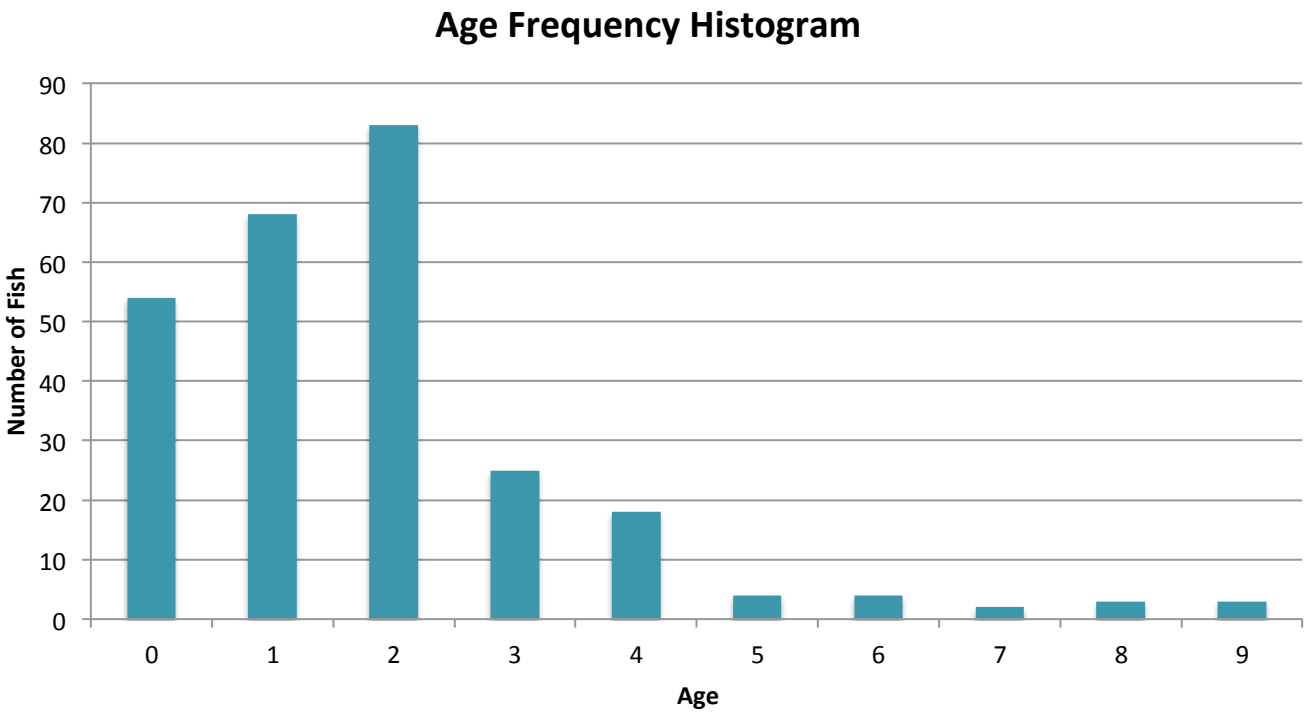
- Inputs
  - Length-frequency data (individual length measurements)
  - Life history information ($L_{infinity}$, natural mortality M, and von Bertalanffy growth parameters k and t_0)
- Outputs
  - Estimate of fishing mortality F
  - Ratio of fishing mortality to natural mortality F/M

Fishing Mortality from Catch Curve



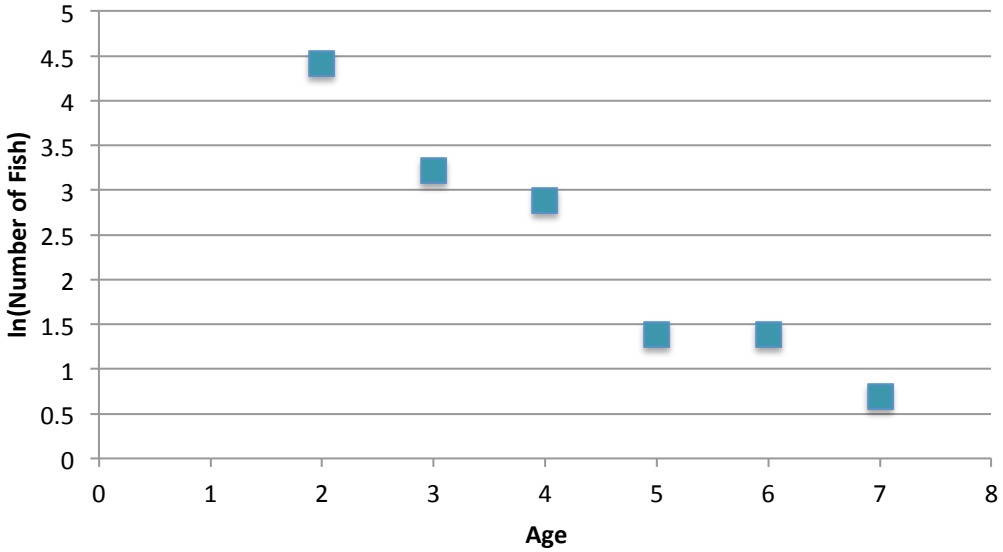
Fishing Mortality from Catch Curve

Convert to age frequency histogram



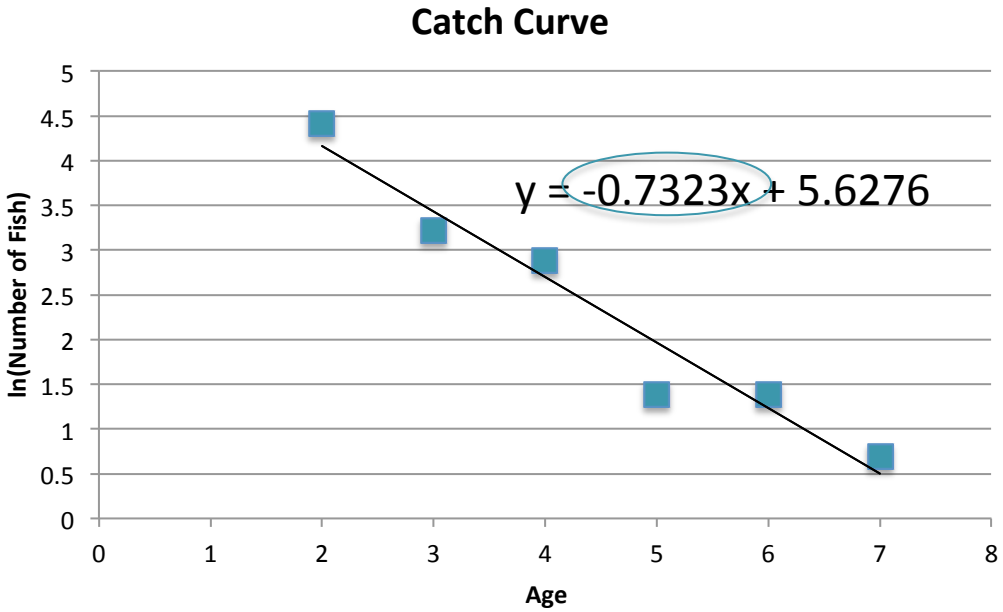
Fishing Mortality from Catch Curve

- *Take right hand side of histogram*
- *Log transform data points (math trick!)*



Fishing Mortality from Catch Curve

- *Fit linear line to points*
- *Negative of slope is total mortality!*



Total mortality
Z = 0.7323

Fishing mortality
F = Z - M

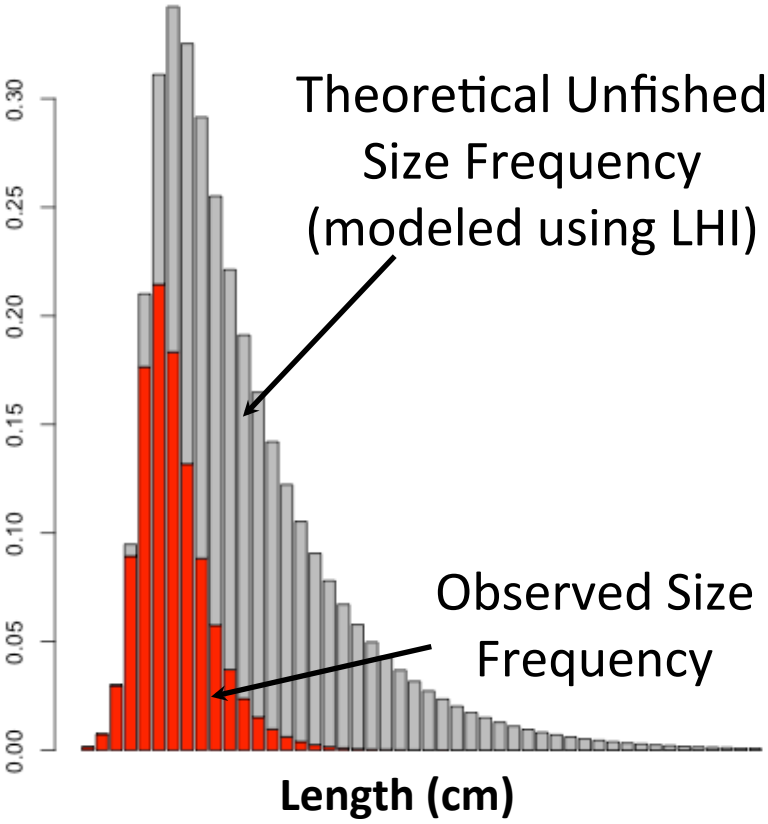
Fishing Mortality from Catch Curve

- What it tells us:
  - Estimates fishing mortality (*F*)
  - This is used to calculate the ratio *F/M*
- How this information informs management:
  1. Stakeholders set target reference point *F/M*
     - Rule of thumb is *F/M* = 1
  2. Compare target *F/M* with *F/M* from assessment
  3. Adjust fisheries management controls based on how far apart they are

Spawning Potential Ratio (SPR)

- Inputs
  - Length-frequency data (individual length measurements)
  - Life history information ($L_{infinity}$, natural mortality M, and von Bertalanffy growth parameter k, length to weight parameters w_a and w_b, length and maturity parameters m_{50} and m_{95})
- Outputs
  - Estimate of spawning potential ratio (SPR)

Spawning Potential Ratio (SPR)



SPR: A measure of current egg production relative to theoretical unfished level

$$SPR = \frac{\text{area of red curve}}{\text{area of grey curve}}$$

The Concept:

> 2 children per couple

Population Growth

2 children per couple

Replacement Level

Population Stable

< 2 children per couple

Population Decline

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Same applies to fisheries

Population Growth

Replacement Level

Population Stable

Population Decline

Spawning Potential Ratio (SPR)

- What it tells us:
  - Estimates Spawning Potential Ratio (SPR)
- How this information informs management:
  1. Stakeholders set target reference point *SPR*
     - Rule of thumb is *SPR* = 0.4
  2. Compare target *SPR* with *SPR* from assessment
  3. Adjust fisheries management controls based on how far apart they are

Froese Sustainability Indicators

- Inputs
  - Length-frequency data (individual length measurements)
  - Life history information ($L_{infinity}$, natural mortality M, and von Bertalanffy growth parameter k, length to weight parameters w_a and w_b, length and maturity parameters m_{50} and m_{95})
- Outputs
  - Percentage of mature fish in the catch
  - Percentage of fish caught within ±10% of optimum length (length and maximum possible yield)
  - Percentage of mega-spawners in catch
  - Determination if spawning biomass is above sustainable reference point

Froese Sustainability Indicators

The Concept

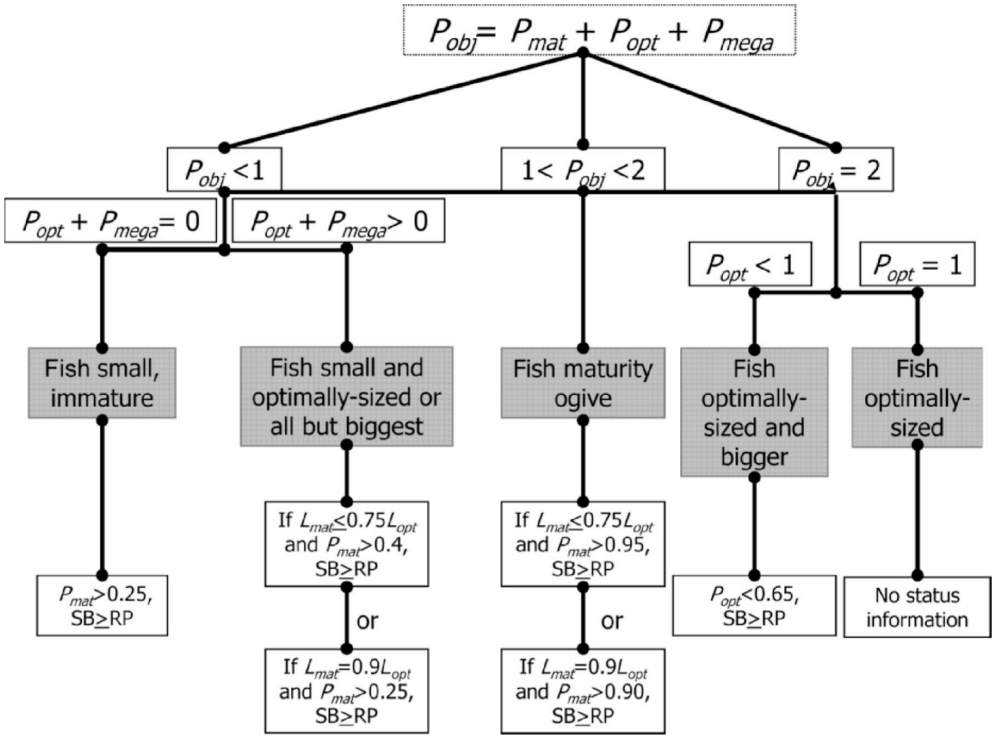
1. ***Let them spawn***
   - Indicator: Percentage of mature fish in the catch
   - Typical target Reference Point: >90%

2. ***Let them grow***
   - Indicator: Percentage of fish caught within ±10% of optimum length (length at maximum possible yield)
   - Typical target Reference Point: 100%

3. ***Let the mega-spawners live***
   - Indicator: Percentage of mega-spawners in catch
   - Typical target Reference Point: <10%

Froese Sustainability Indicators

Based on this information, a decision tree determines if spawning biomass is sustainable



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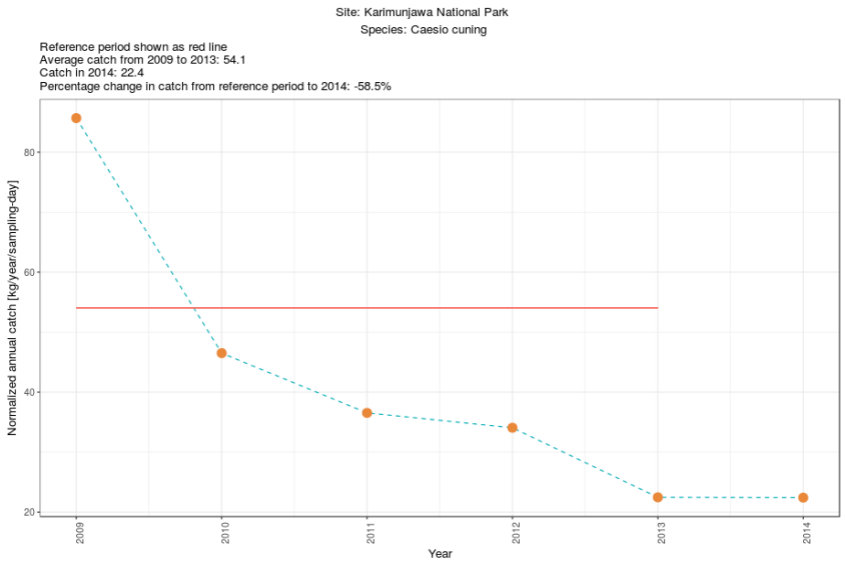
Cope and Punt 2009

Froese Sustainability Indicators

- What it tells us:
  - Percentage of mature fish in the catch
  - Percentage of fish caught within ±10% of optimum length (length and maximum possible yield)
  - Percentage of mega-spawners in catch
  - Whether or not spawning biomass sustainable
- How this information informs management:
  1. Adjust fisheries management controls based on whether or not spawning biomass is sustainable, or if too many immature fish in catch

Trends in Catch

- Inputs
  - Time series of catch data
- Outputs
  - Trend in catch (up, down, or stable)



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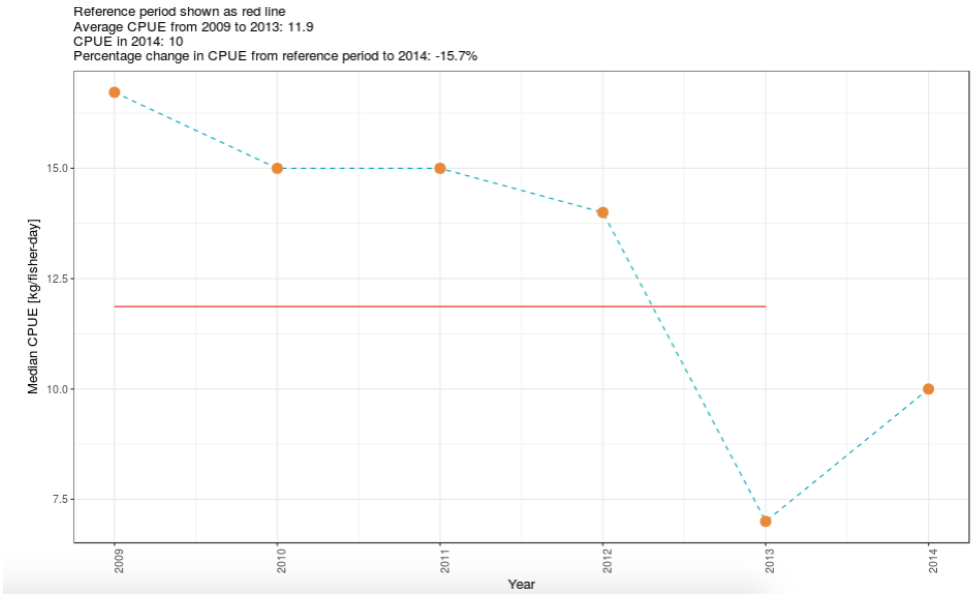
Trends in catch

- What it tells us:
  - Whether catch is increasing, decreasing, or stable
- How this information informs management:
  1. Adjust fisheries management controls based on this information

Trends in CPUE

- Inputs
  - Time series of CPUE data
- Outputs
  - Trend in CPUE (up, down, or stable)

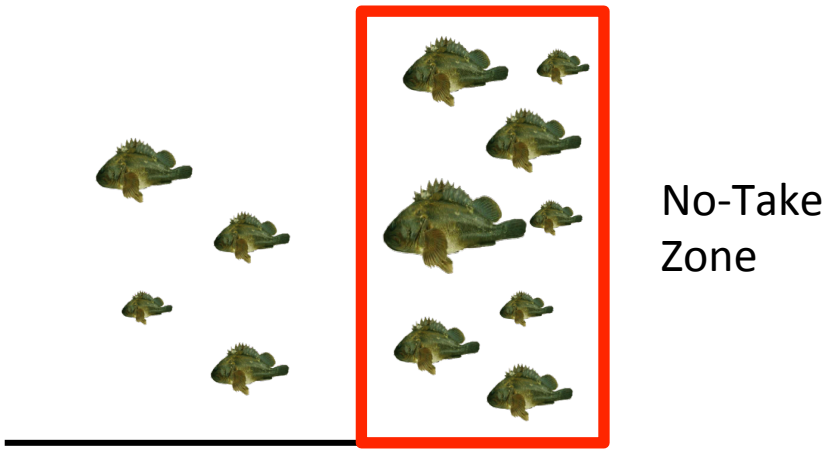


Trends in CPUE

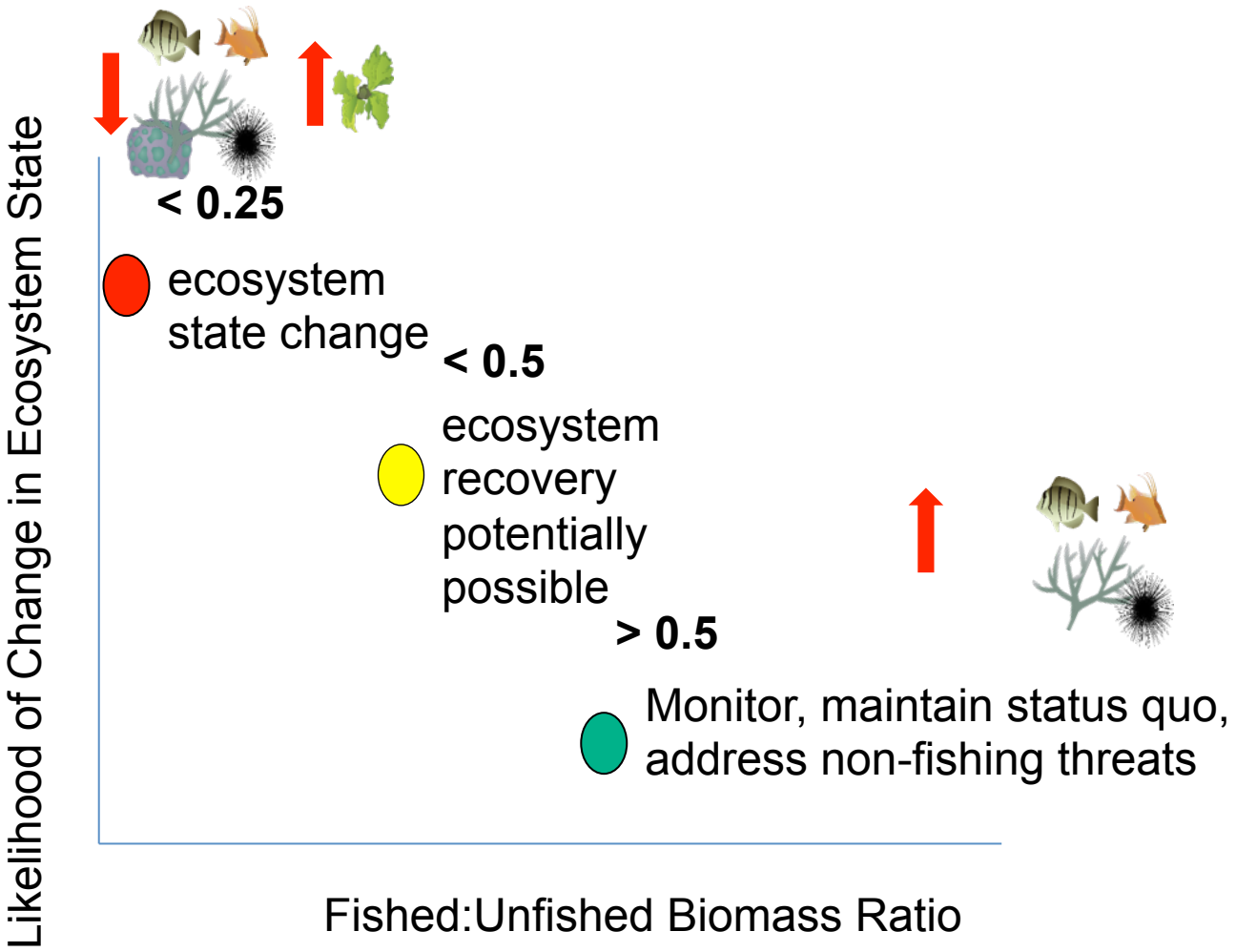
- What it tells us:
  - Whether CPUE is increasing, decreasing, or stable
- How this information informs management:
  1. Adjust fisheries management controls based on this information

Fished:unfished biomass ratio

- Inputs
  - Biomass inside and outside the no-take zone (NTZ)
  - Total biomass across all species (ecosystem-level indicator, i.e., kg/Ha)
- Outputs
  - Ratio of fished biomass relative to unfished biomass



Fished:unfished biomass ratio

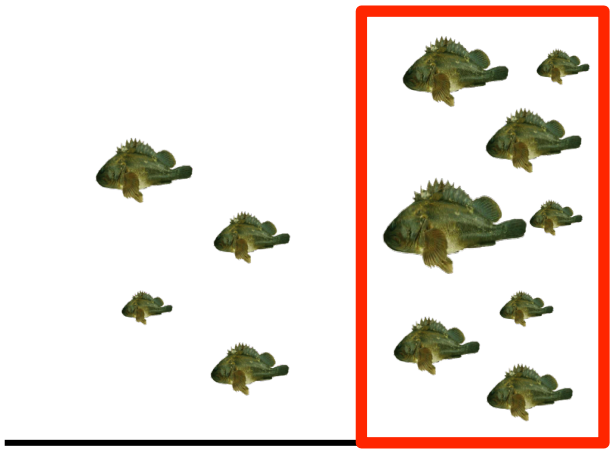


Fished:unfished biomass ratio

- What it tells us:
  - Fished:unfished biomass ratio across all species
- How this information informs management:
  1. Adjust fisheries management controls based on this information

Fished:unfished density ratio

- Inputs
  - Density inside and outside the no-take zone (NTZ)
  - Density only for target species (i.e., individuals/Ha)
- Outputs
  - Ratio of fished density relative to unfished density of target species



Fished:unfished density ratio

- What it tells us:
  - Fished:unfished density ratio of target species
- How this information informs management:
  1. Adjust fisheries management controls of target species based on this information

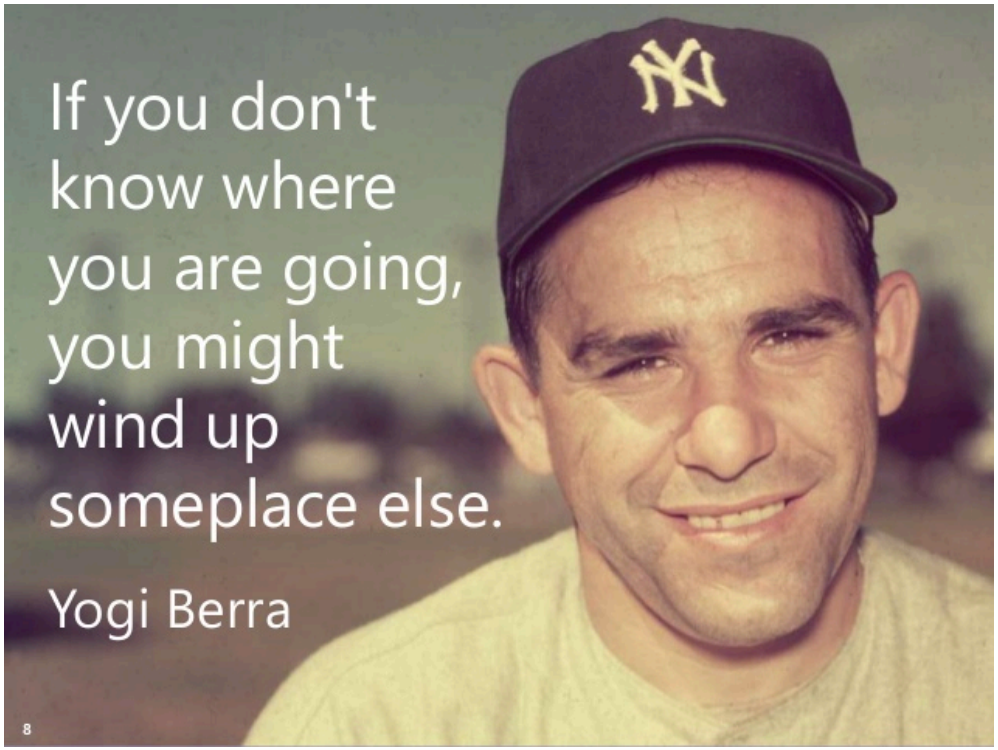
Activity

- Using AFAM Guidance Document, look through instructions and references for Step 3

- Record choices and notes in Your AFAM Toolkit Worksheet

- Record choices in AFAM Toolkit Online Dashboard

Thank you!


If you don't know where you are going, you might wind up someplace else.
Yogi Berra
8