SEDAR 49 Assessment Introduction

SEDAR 49 Review Workshop

November 1, 2016

Southeast Fisheries Science Center,
Sustainable Fisheries Division,
Miami, FL

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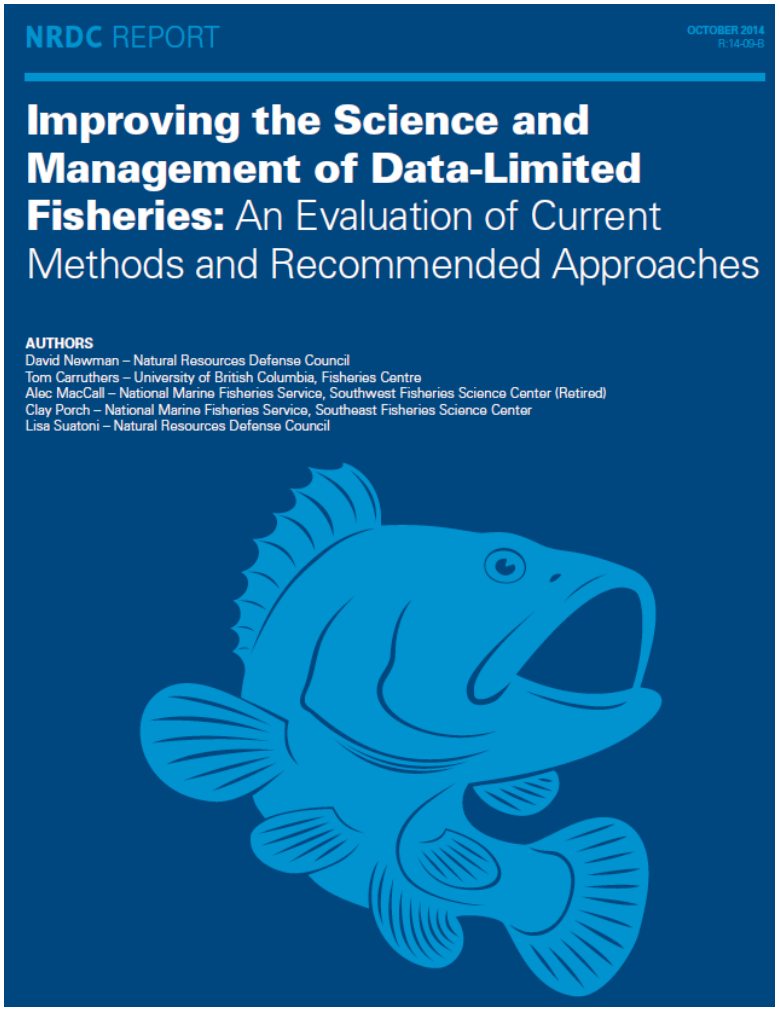
Outline

- Brief background on data-limited assessment framework
  - DLMtool (Carruthers et al. 2014)
    - Review of methods used in SEDAR 49
      - Catch recommendations
    - Management strategy evaluation

Data-limited approaches

Many methods in the literature but they are not readily available, easily tested or compared

1. How do methods perform comparatively?
2. What are the performance trade-offs?
3. What methods are inappropriate for a given stock/fishery/data quality?



DLMtool: R package (Carruthers et al. 2014, 2015), http://www.datalimitedtoolkit.org/

DLMtool applications

- Mid-Atlantic Fishery Management Council
  - Black sea bass (Nov 2015) , Atlantic mackerel (April 2015), Blueline Tilefish (2016)
- New England Fishery Management Council
  - Catch Advice Methods for the Northeast Multispecies Fishery
- California Department of Fish and Wildlife
- SEDAR 46
  - U.S. Caribbean Data-limited Species

Data-Limited Methods Toolkit (DLMtool) Stock Evaluation Approach

(1) Methods used in SEDAR 49
- Catch Recommendations

(2) Management Strategy Evaluation (MSE)

Comparison to current method: status quo

SEDAR 49 Species	Tier	Years	OFL	ABC (= ACL)
Red Drum	--	--	--	--
Lane Snapper	3a	1999-2008	Mean + 2 SD	Mean + 1 SD
Wenchman	3a	1999-2008	Mean + 2 SD	Mean + 1 SD
Yellowmouth Grouper	3a	1995-2008	Mean + 2 SD	Mean + 1 SD
Snowy Grouper	3b	1992-2008	Mean	Mean
Speckled Hind	3b	1992-2008	Mean	Mean
Lesser Amberjack	3a	2000-2008	Mean + 2 SD	Mean + 1 SD
Almaco Jack	3a	2000-2008	Mean + 2 SD	Mean + 1 SD

From GMFMC (2011)

Reference period in SEDAR 49

- Historical reference period specified in FMP
- Methods considered use average catch over a period of reference years [t_1,t_2]
  - E.g., CC1_Ref

$$C^{AVE} = \frac{\sum_{y=t_1}^{y=t_2} \mathrm{Cat}_y}{1 + t_2 - t_1}$$

- No reference period specified in FMP for Red Drum
  - Currently using recent period (2010-2014) for demonstrative purposes
    - Generic method from Geromont and Butterworth (2014)

Method types considered during SEDAR 49

- Catch-based
  - Status quo
- Index-based
  - Index of abundance indicator
- Depletion-based
- Length-based
  - Mean length indicator
  - Mean length-based mortality estimator
- Age-based

Method types excluded from analysis

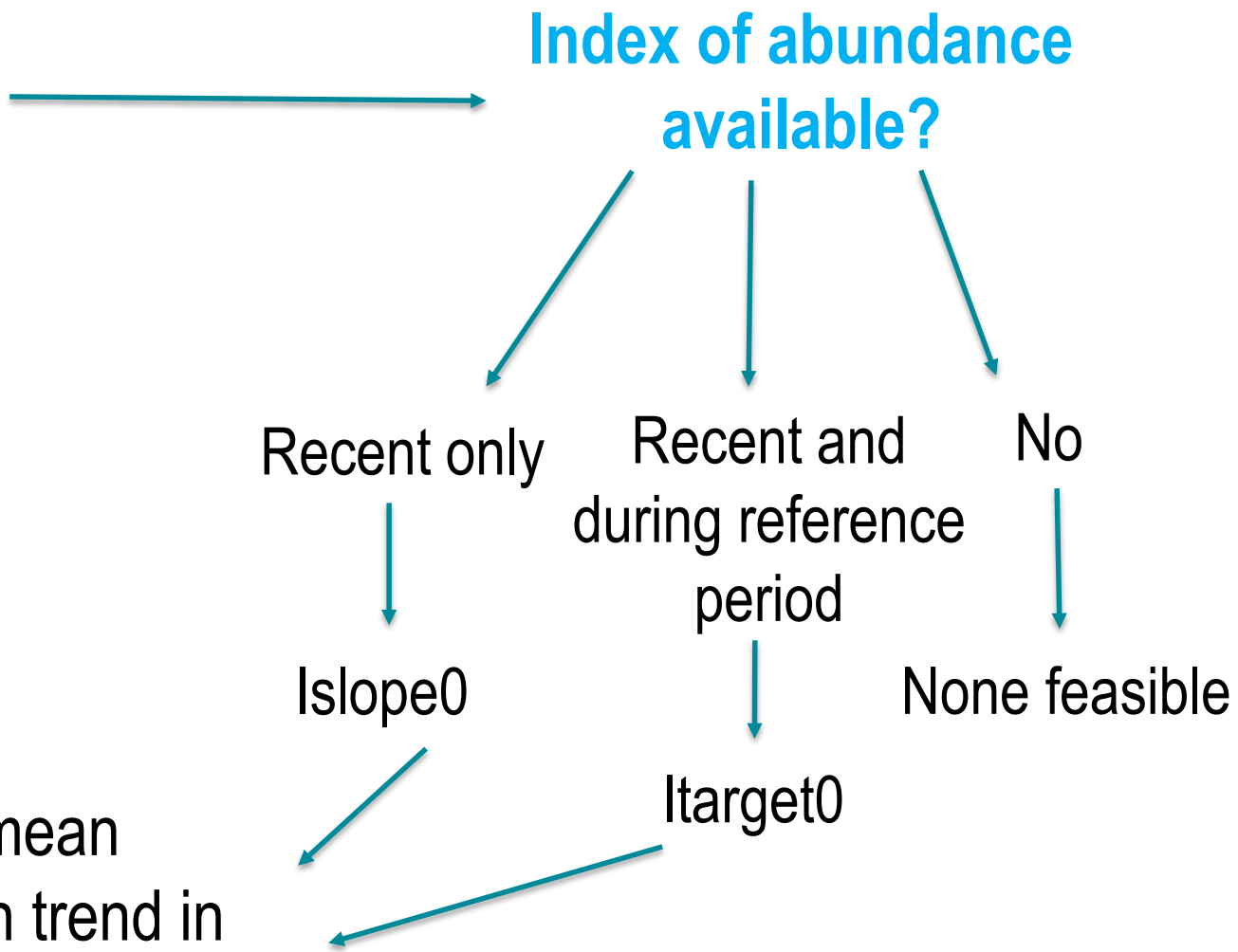
- Catch-based
  - Status quo
- Index-based
  - Index of abundance indicator
- ~~Depletion-based~~ – no reliable estimates
- Length-based
  - Mean length indicator
  - ~~Mean length-based mortality estimator~~
- Age-based

Exclusion of mean length estimator results

- Mean length-based mortality estimator
  - Lack of representative data (e.g., bias in length data)
  - Illogical or implausible results (e.g., Z – M = 0)
    - Produces F estimate of 0 when we know fishing is occurring
  - Variability in management by region or fisher behavior
    - State-specific slot limits for Red Drum
    - Commercial longline fishing effort on deep-water groupers

Indicator-based methods: index

Status Quo:
Fixed at mean landings during reference period



Adjusts the mean landings based on trend in Index, ***allows feedback***

Indicator-based methods: index

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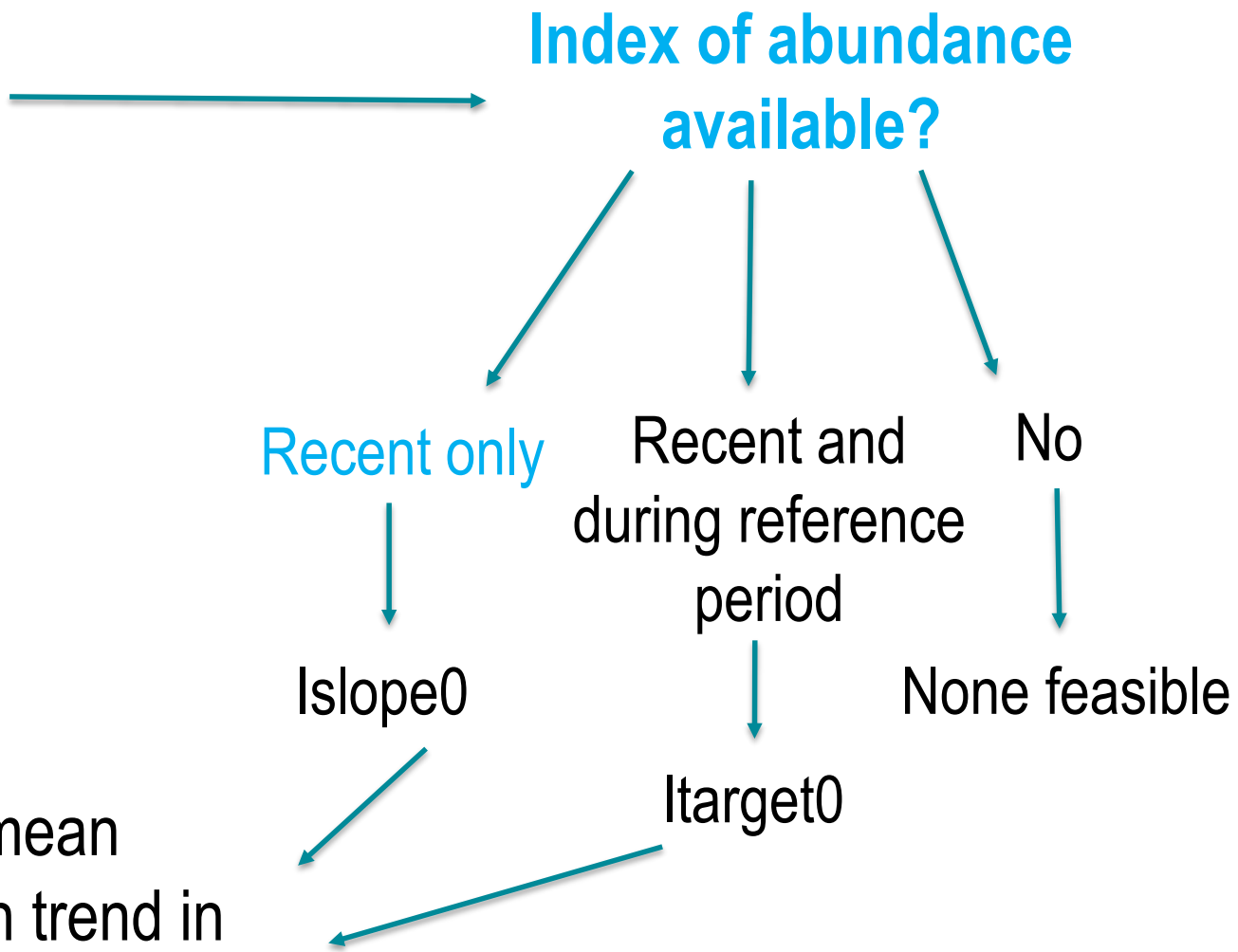

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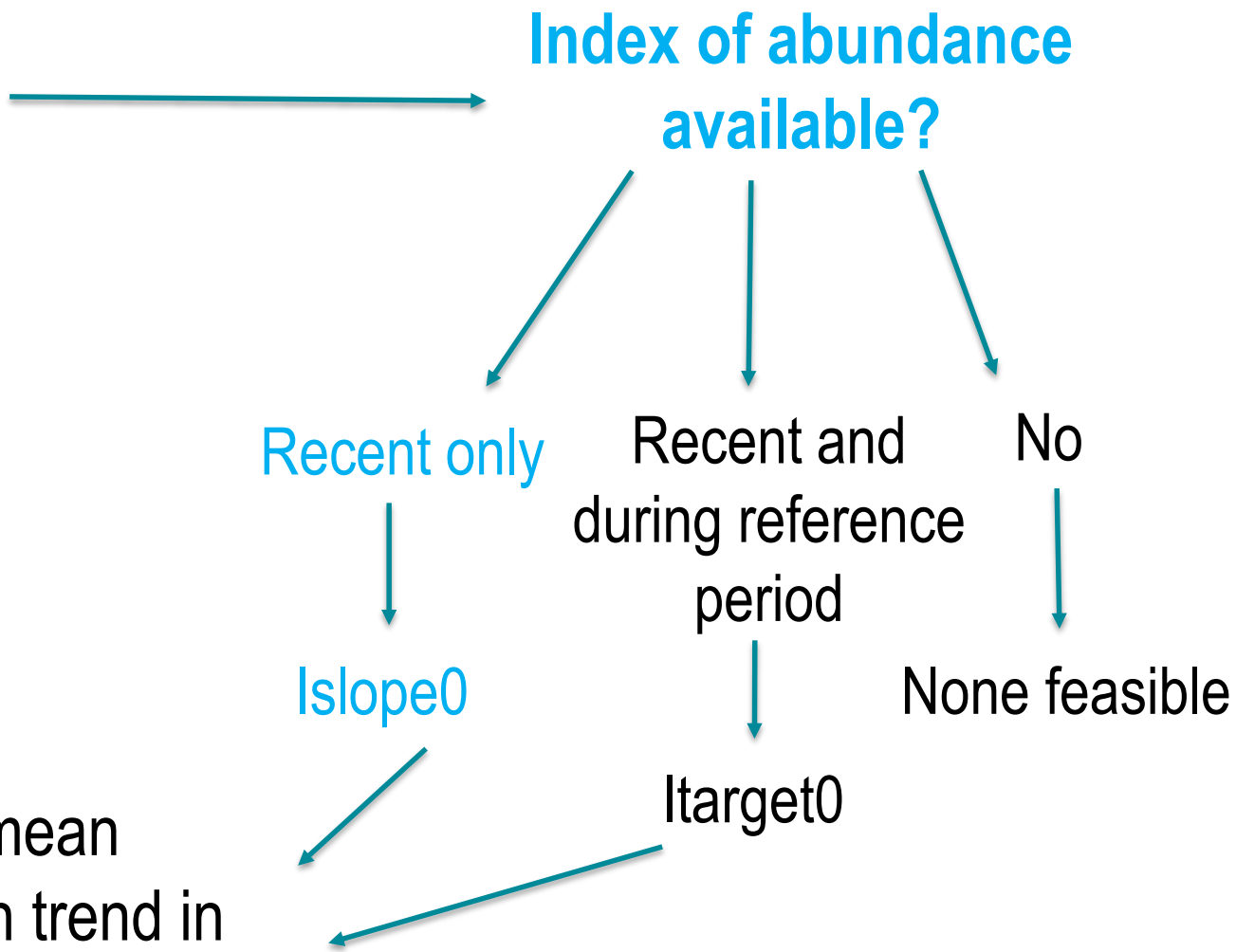

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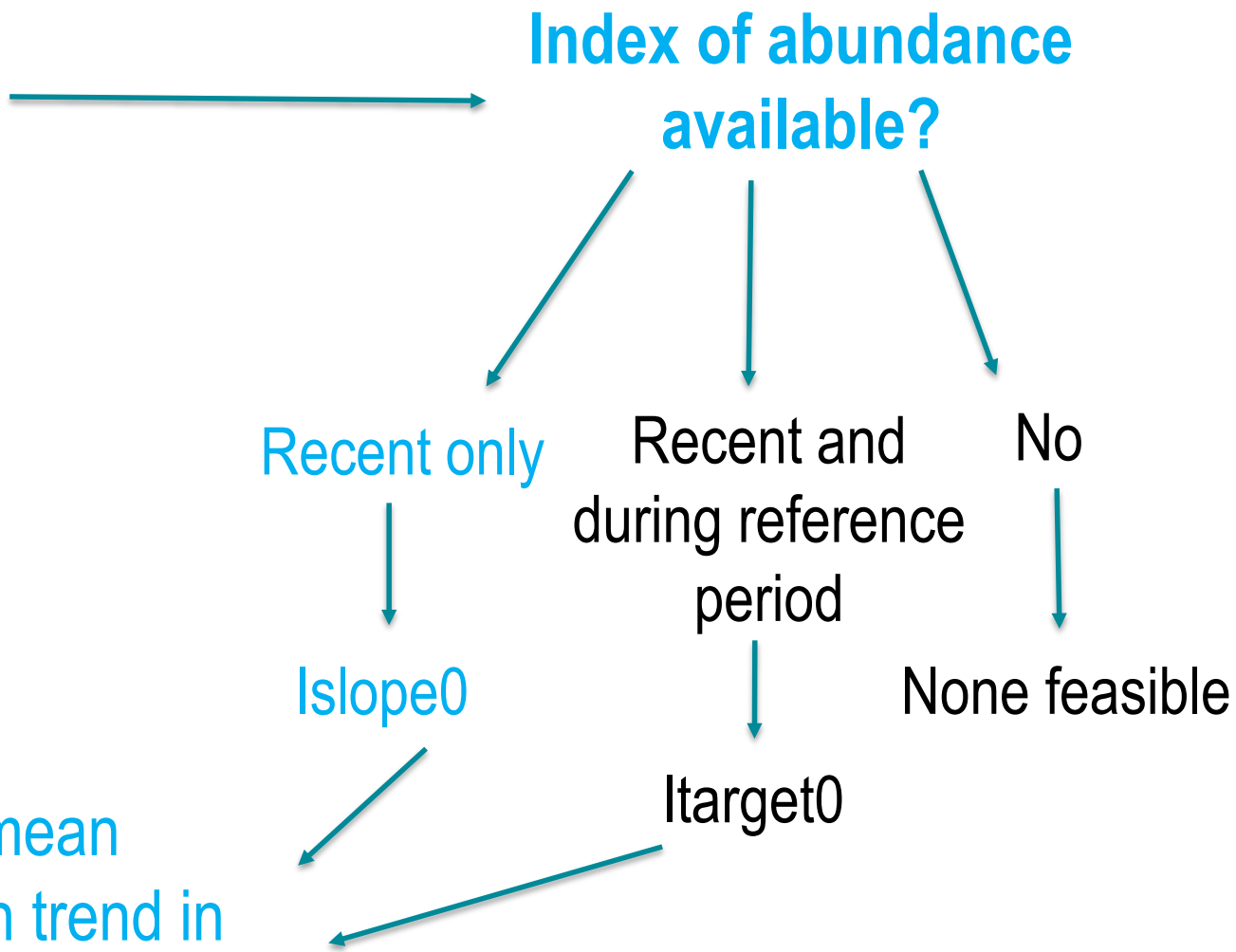

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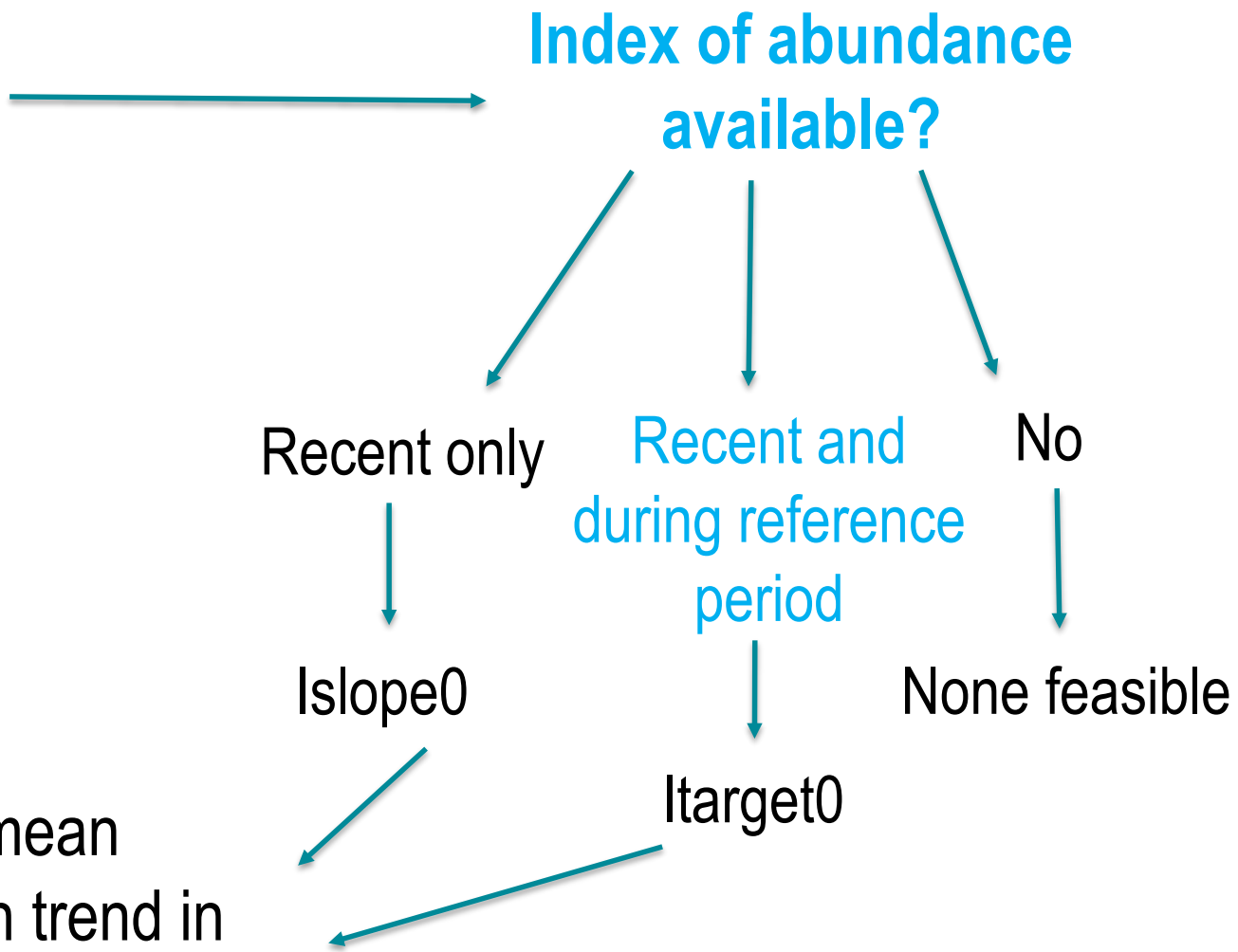

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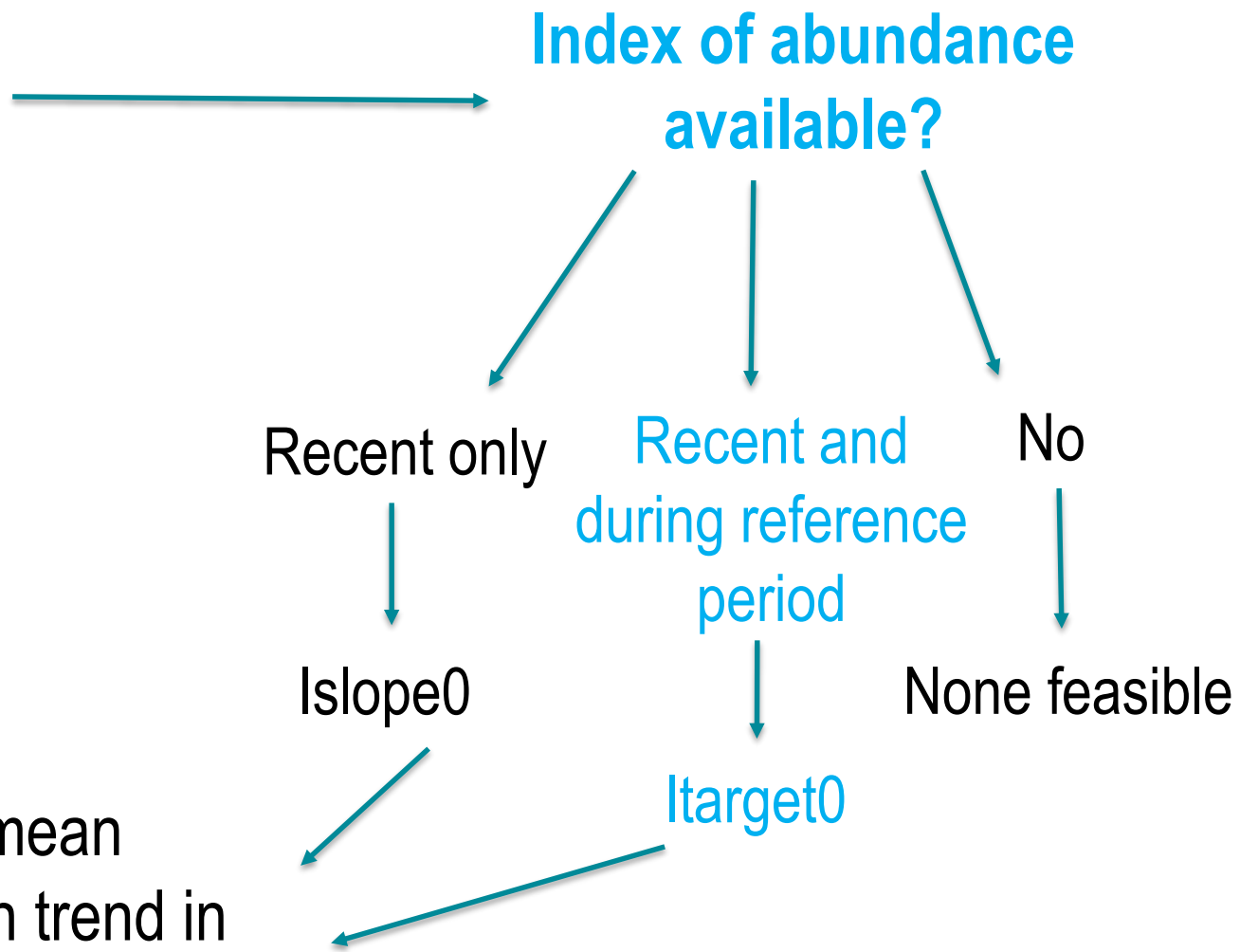

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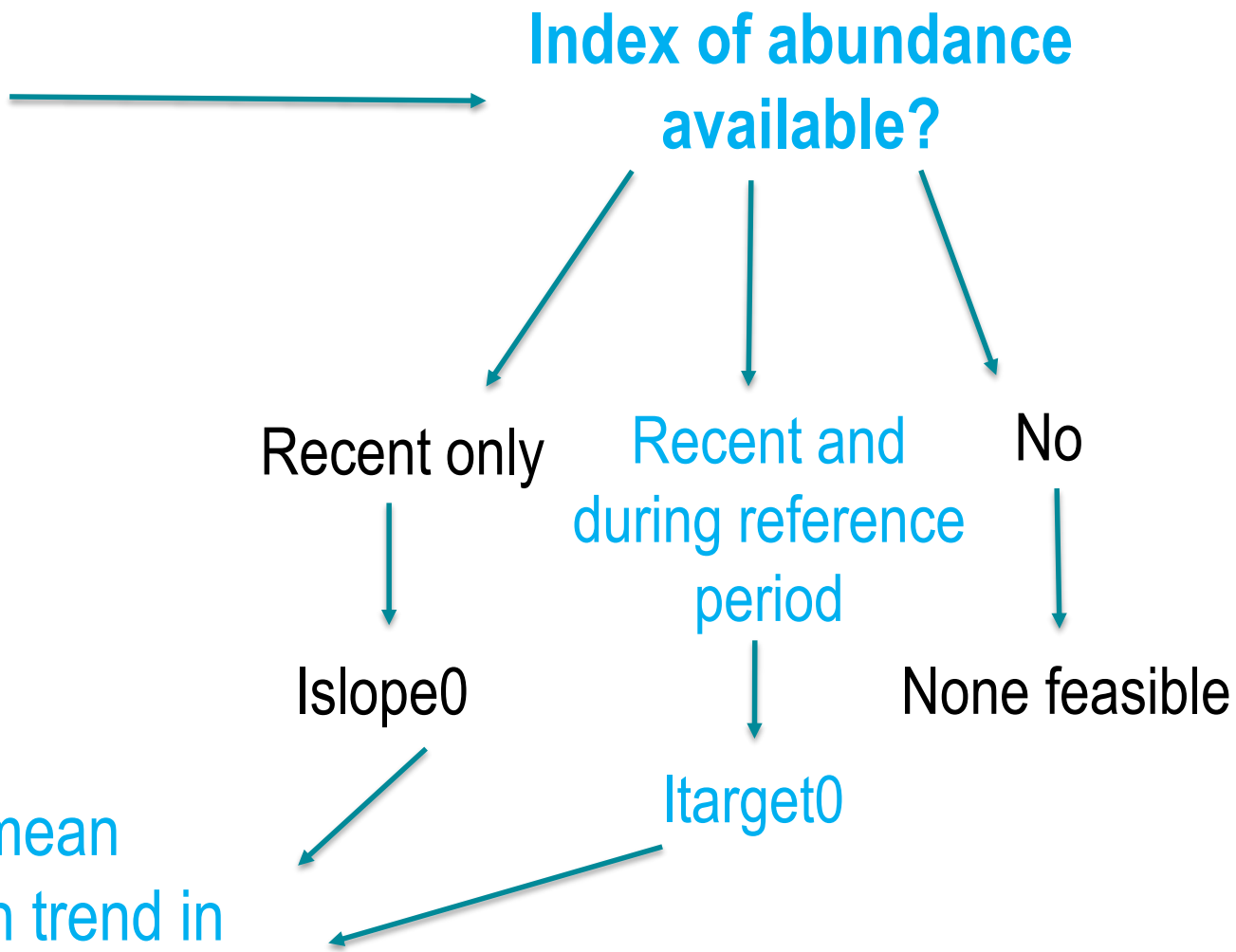

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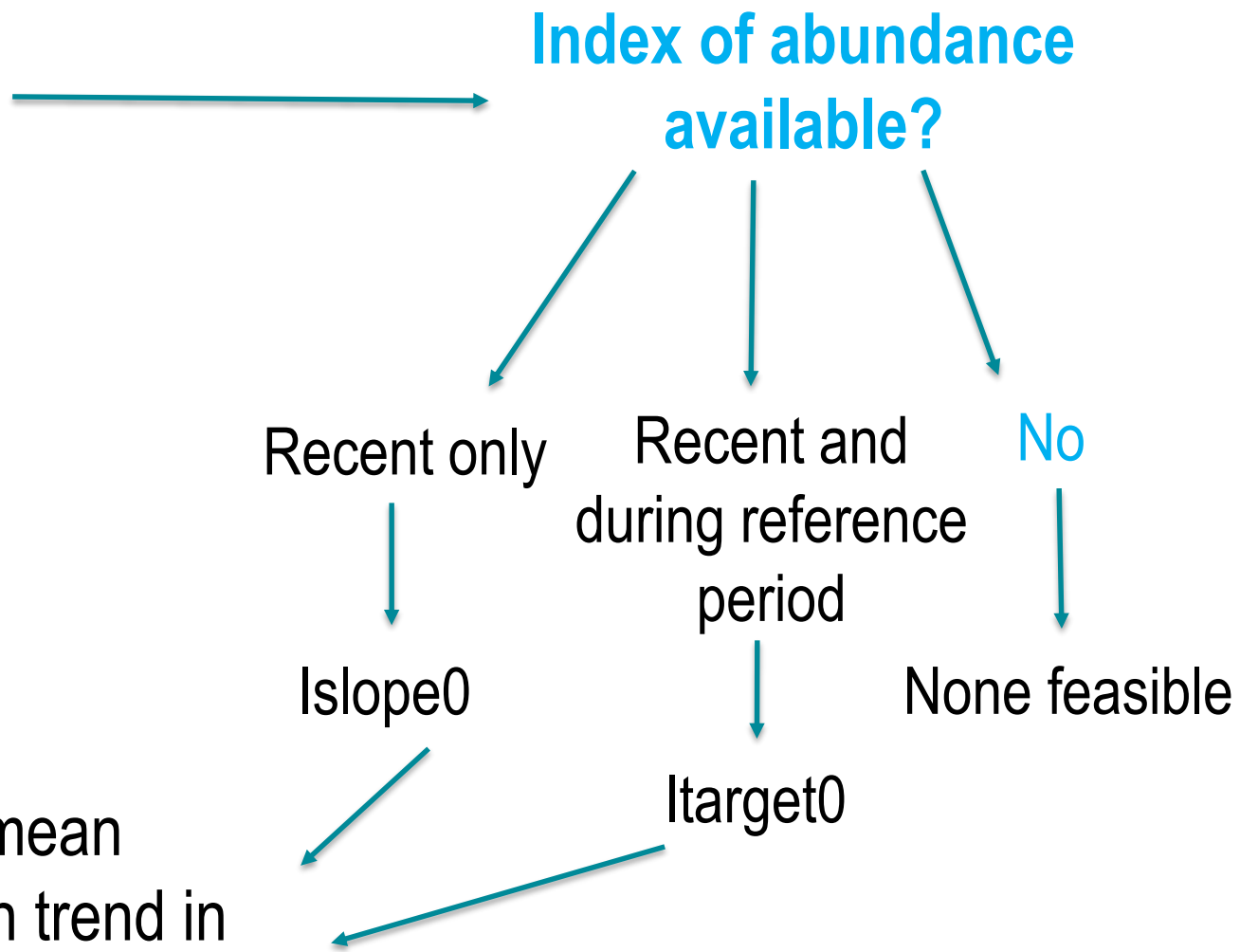

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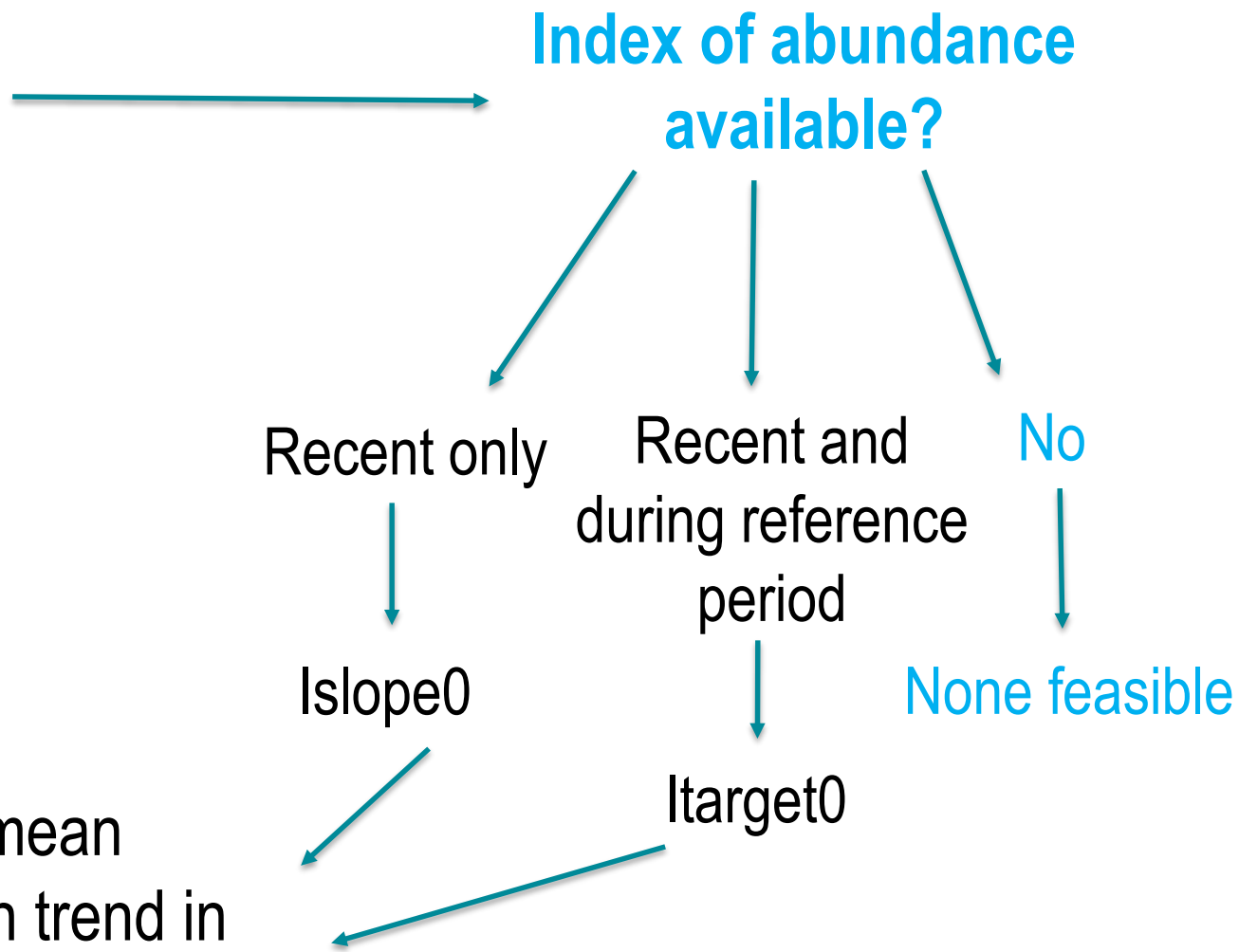


Adjusts the mean landings based on trend in Index, ***allows feedback***

Methods: Islope0

Method	Data Inputs													
	Mort	FMSY_M	L50	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	ML	CAA
Indicator (Index-based)														
Islope0 - index CPUE														

TAC = Catch recommendation

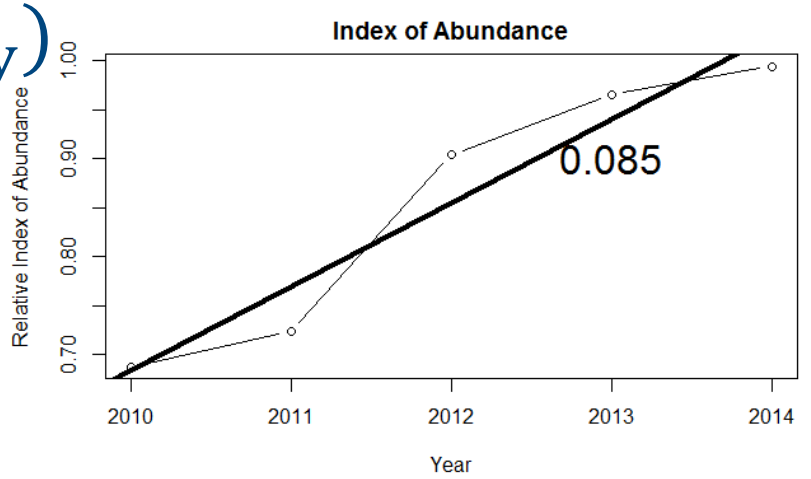
Modified from Geromont and Butterworth (2014)

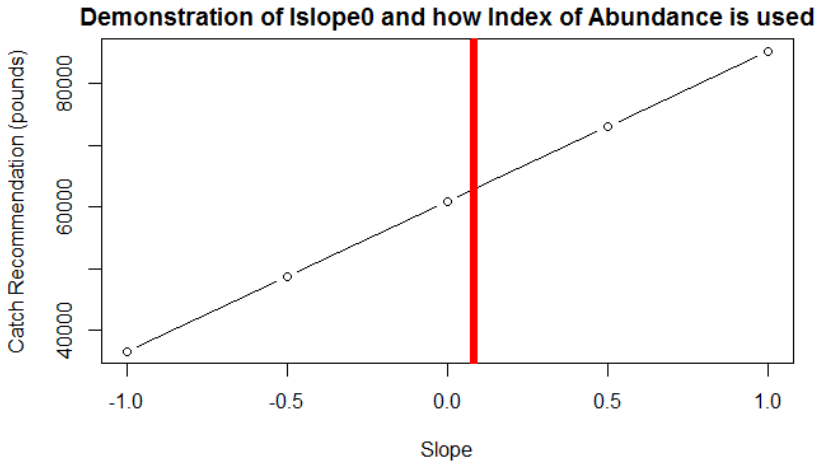
$$TAC_{y+1} = C^{AVE} \times (1 + 0.4 \text{ x } S_y)$$

S_y = slope of CPUE for the most recent 5 years

Explored sensitivity of scalar

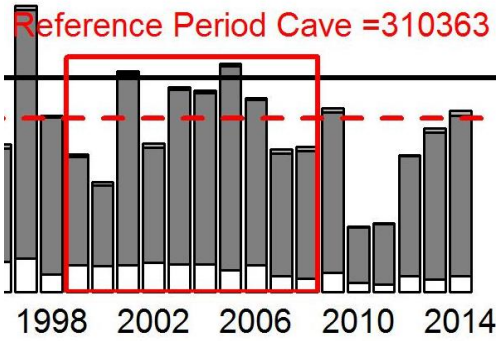
- Similar performance in MSE





Index-based methods

Mean Catch:
Mean landings during reference period (Status Quo)



Recent index of abundance increasing

Islope0: adjust **catch recommendation** upwards based on slope of index in recent period

Recent index of abundance decreasing

Islope0: adjust **catch recommendation** downwards based on slope of index in recent period

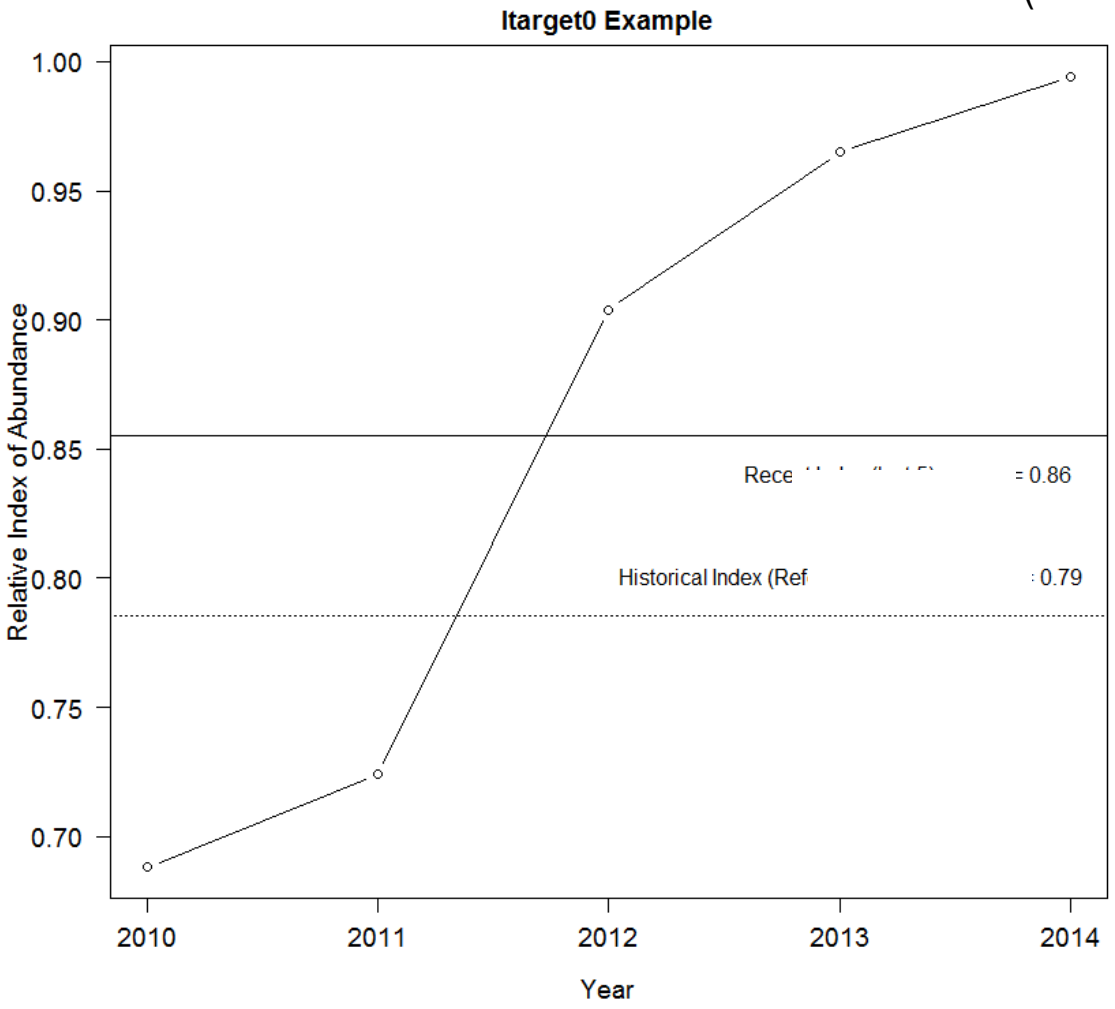
Methods: Itarget0

Method	Data Inputs													
	Mort	FMSY_M	L50	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	ML	CAA
Indicator (Index-based)														
Itarget0 - target CPUE														

I_y^{recent} = average CPUE for recent period (2010-2014)

I^{AVE} = average CPUE over reference period specified in FMP

From Geromont and Butterworth (2014)



Methods: Itarget0

Method	Data Inputs													
	Mort	FMSY_M	L50	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	ML	CAA
Indicator (Index-based)														
Itarget0 - target CPUE														

TAC = Catch recommendation Modified from Geromont and Butterworth (2014)

If $\mathrm{I}_{\mathrm{y}}^{recent} > \mathbf{0.8}\ \mathrm{I}^{AVE}$:

$$\mathrm{TAC}_{\mathrm{y+1}} = 0.5\ x\ C^{AVE}\left[1 + \frac{\left(\mathrm{I}_{\mathrm{y}}^{recent} - \mathbf{0.8}\ \mathrm{I}^{AVE}\right)}{\left(\mathrm{I}^{target} - \mathbf{0.8}\ \mathrm{I}^{\mathrm{AVE}}\right)}\right]$$

If $\mathrm{I}_{\mathrm{y}}^{recent} \leq \mathbf{0.8}\ \mathrm{I}^{AVE}$:

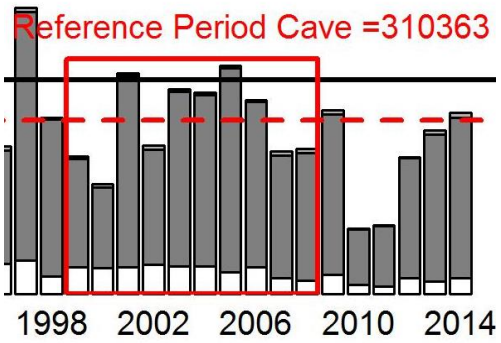
where $I^{target} = \mathbf{1.5}\ \mathrm{I}^{\mathrm{AVE}}$

$$\mathrm{TAC}_{\mathrm{y+1}} = 0.5\ x\ C^{AVE}\left[\frac{\mathrm{I}_{\mathrm{y}}^{recent}}{\mathbf{0.8}\ \mathrm{I}^{AVE}}\right]^{2}$$

Scalars (0.8 and 1.5) can be modified

Index-based methods

Mean Catch:
Mean landings during reference period (Status Quo)



Recent index of abundance above target

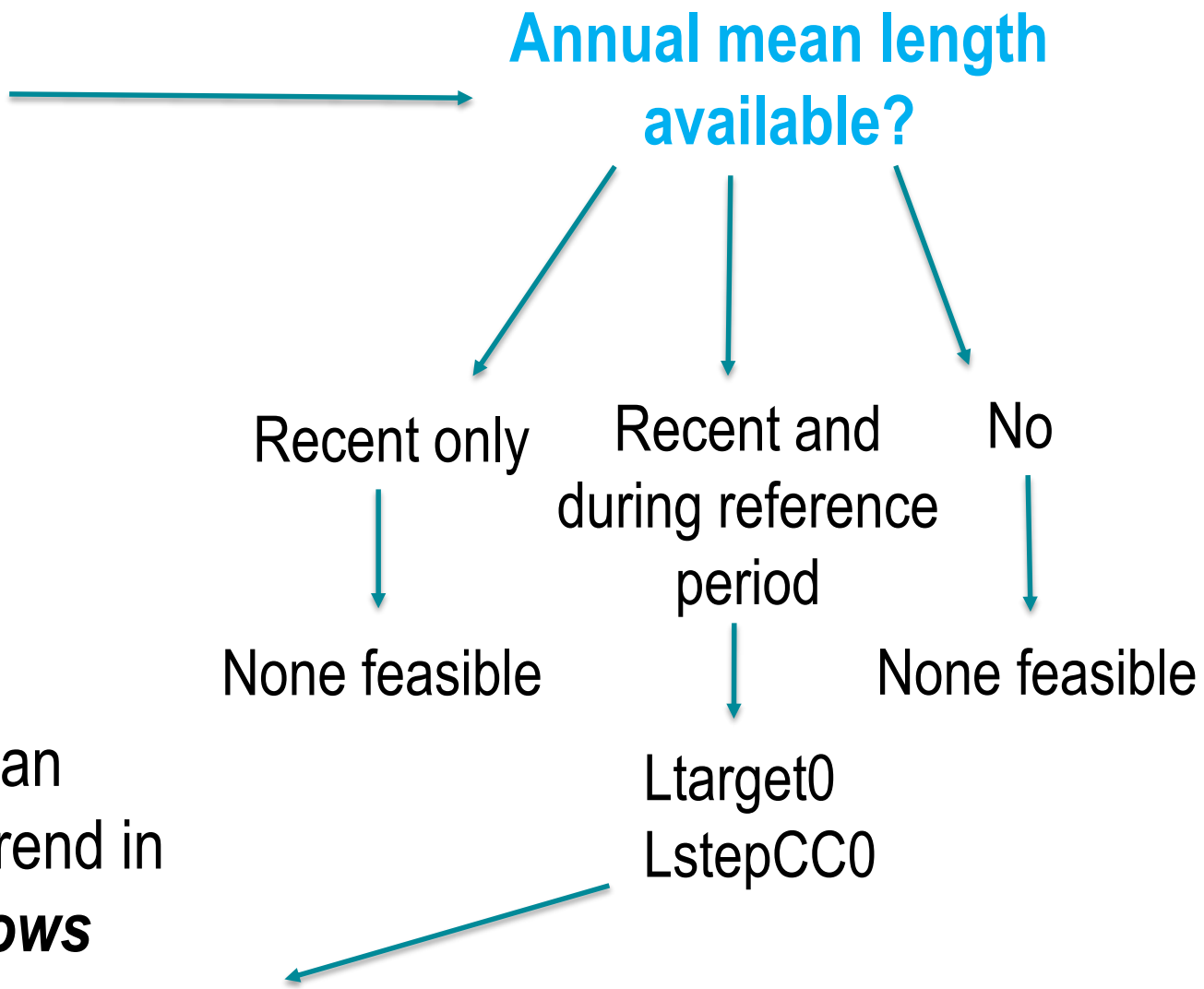
Itarget0: incrementally adjust **catch recommendation** upwards to reach target abundance

Recent index of abundance below target

Itarget0: incrementally adjust **catch recommendation** downwards to reach target abundance

Indicator-based methods: mean length

Status Quo:
Fixed at mean landings during reference period



Adjusts the mean landings based on trend in mean length, ***allows feedback***

Indicator-based methods: mean length

Status Quo:
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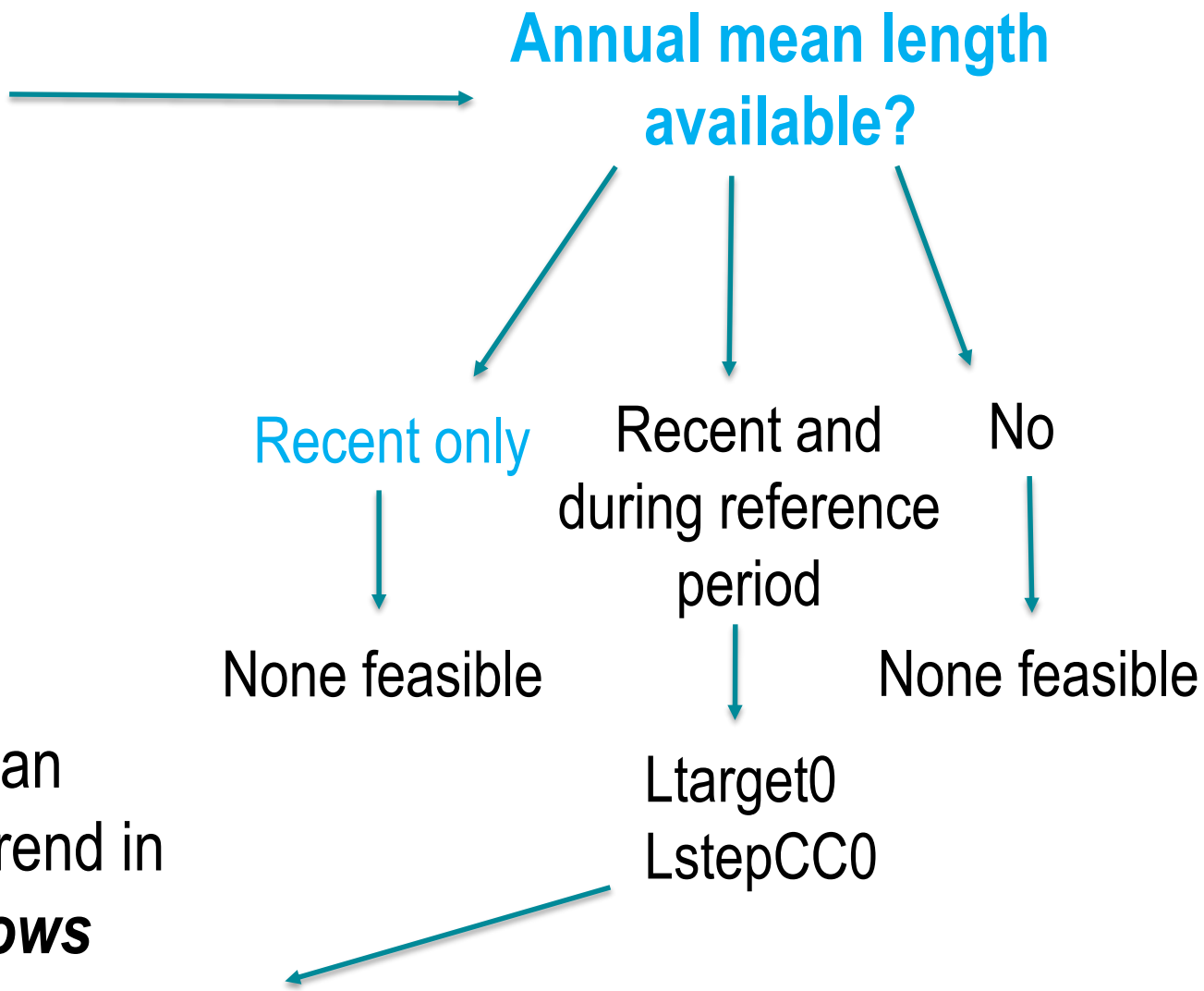

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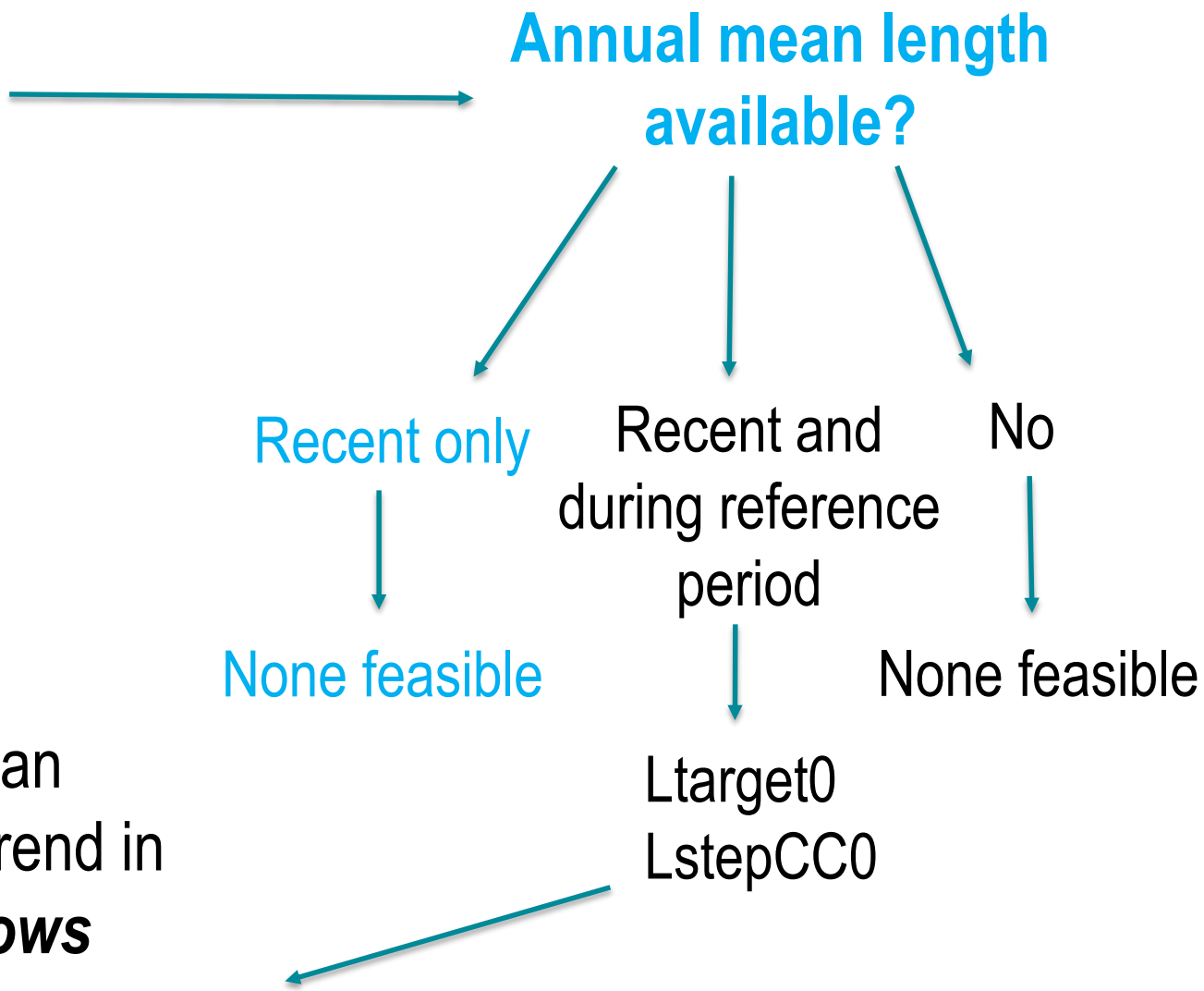

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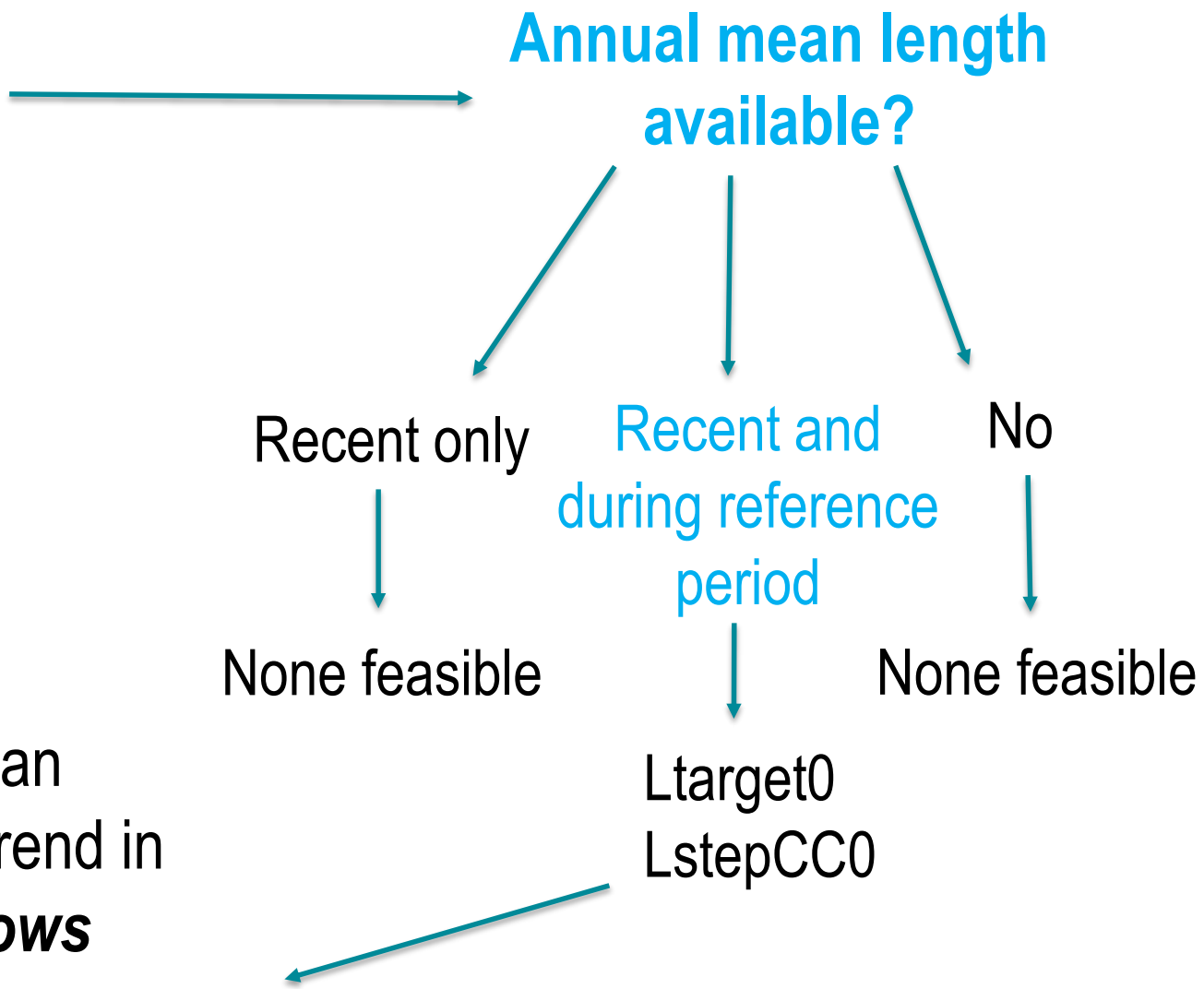

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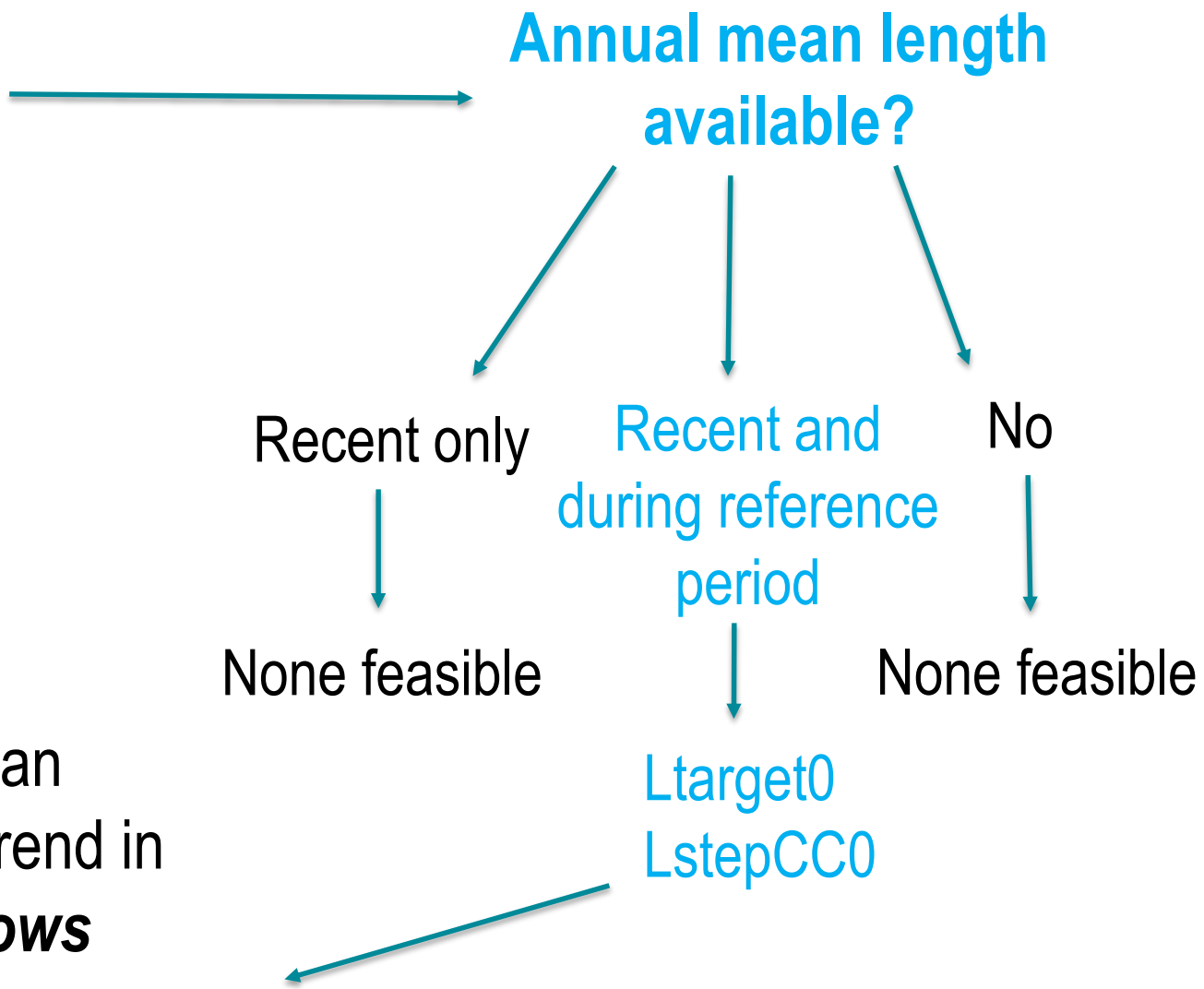

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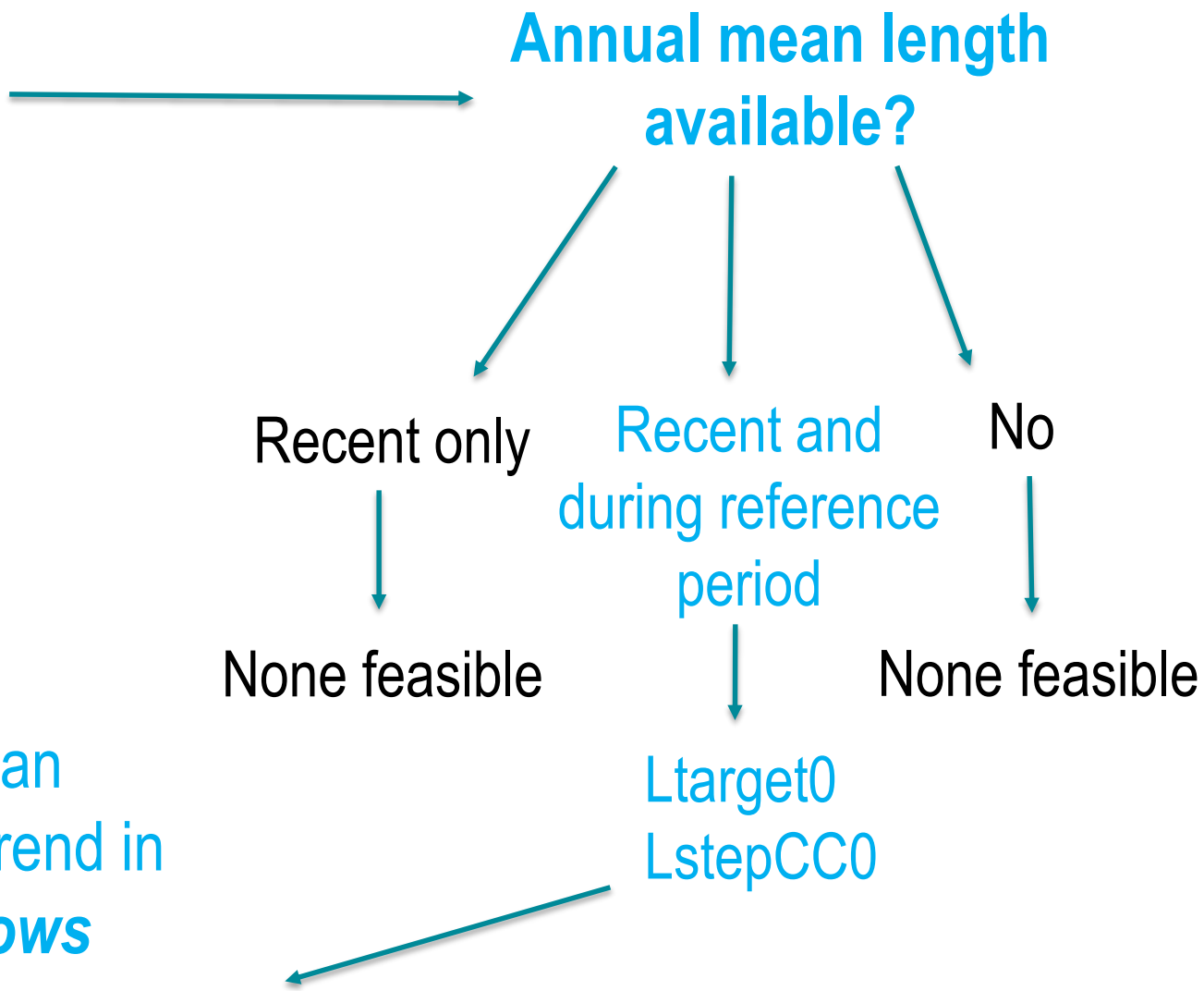

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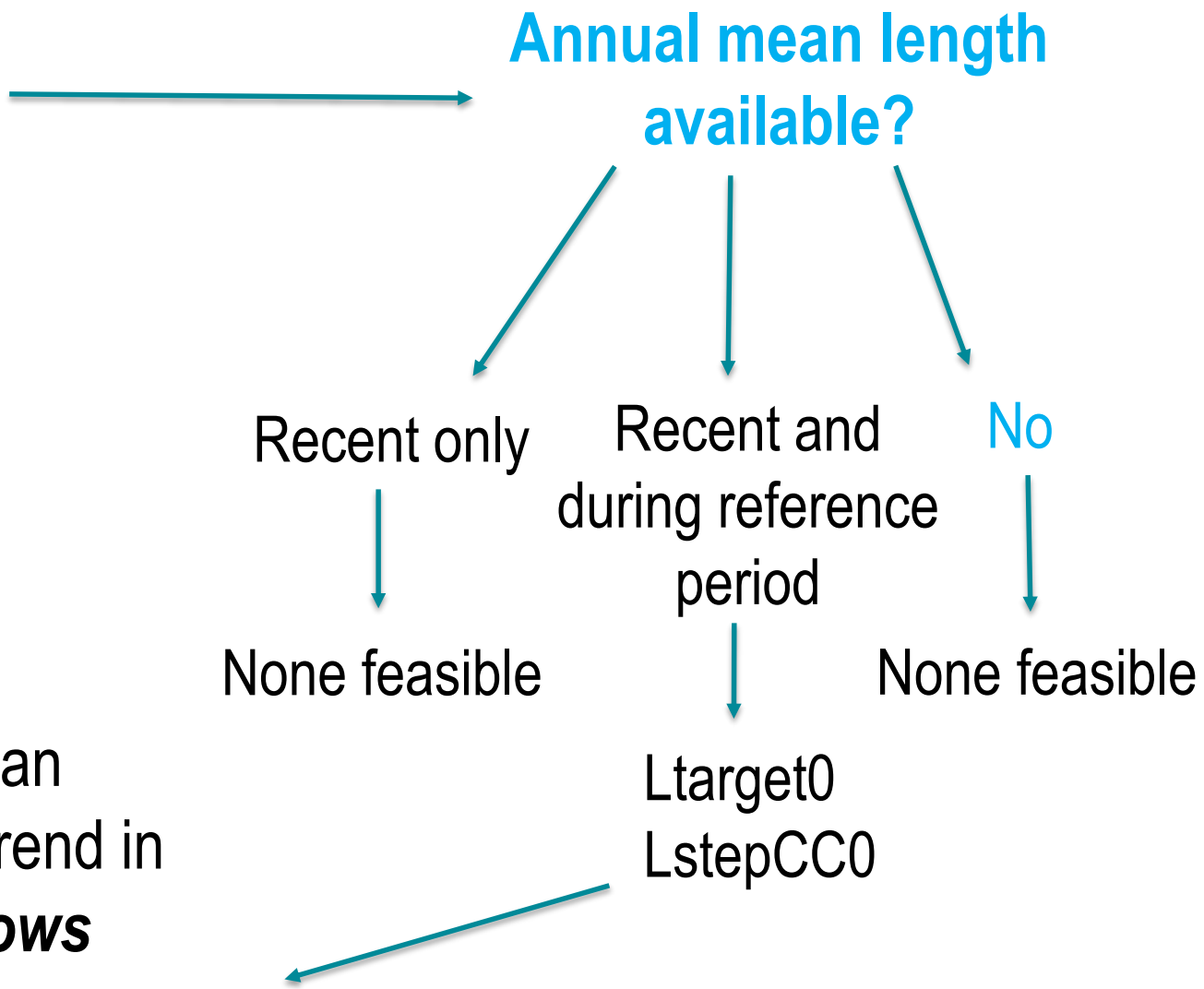

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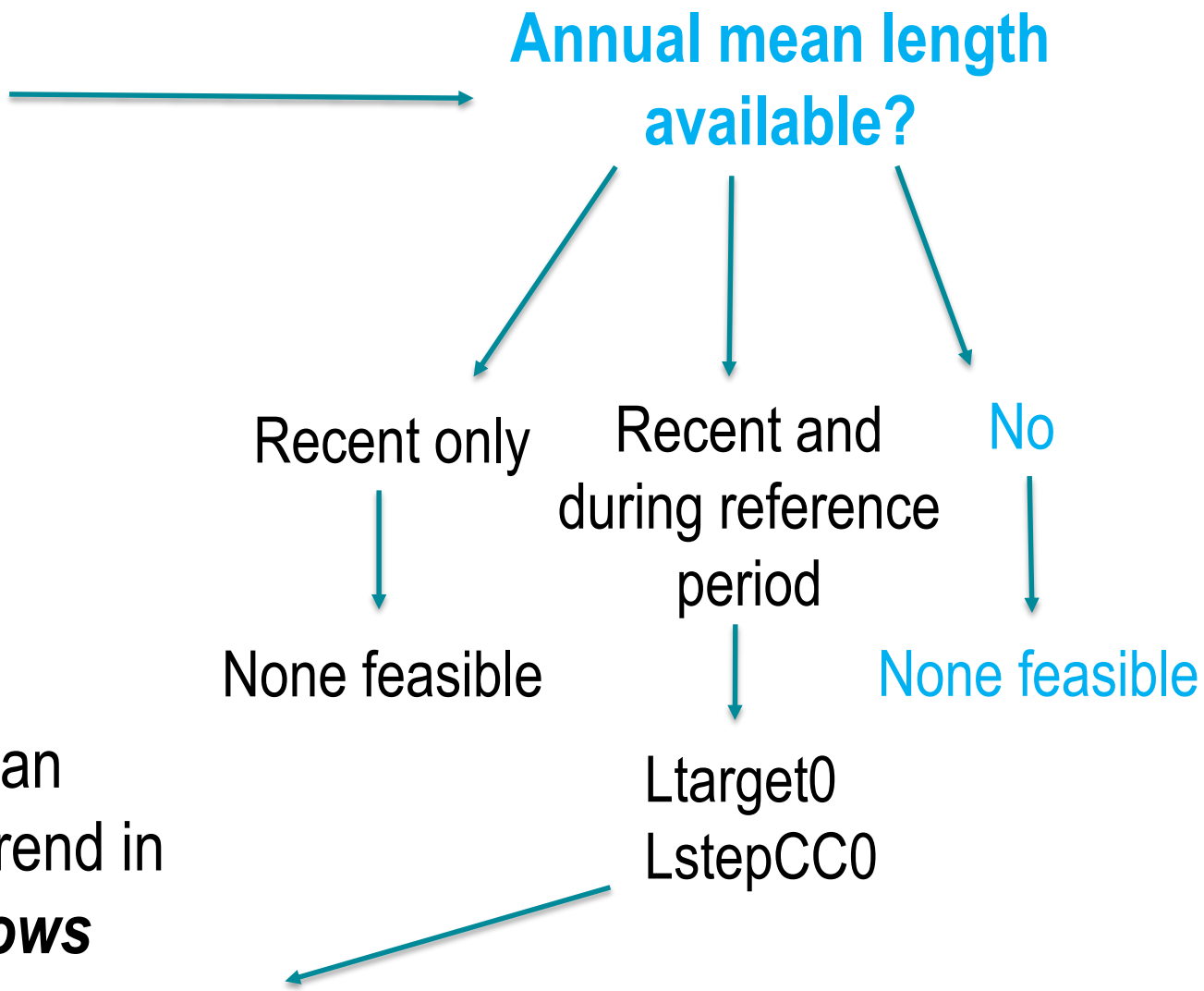


Adjusts the mean landings based on trend in mean length, ***allows feedback***

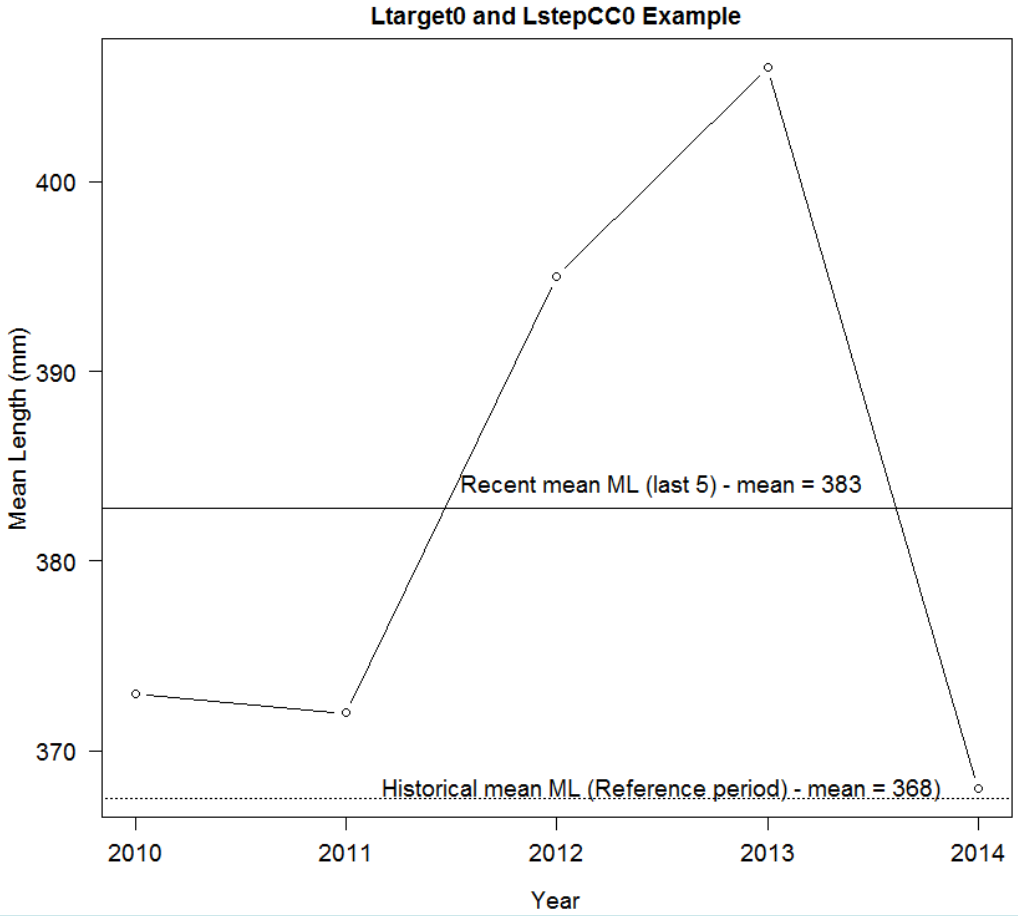
Methods: Ltarget0 & LstepCC0

Method	Data Inputs													
	Mort	FMSY_M	L50	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	ML	CAA
Indicator (Length-based)														
Ltarget0 - mean length target														
LstepCC0 - mean length step														

L_y^{recent} = mean length for recent time period (2010-2014)

L^{AVE} = mean length for reference period specified in FMP

Modified from Geromont and Butterworth (2014)



Methods: Ltarget

Method	Data Inputs													
	Mort	FMSY_M	L50	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	ML	CAA
Indicator (Length-based)														
Ltarget0 - mean length target														

TAC = Catch recommendation

From Geromont and Butterworth (2014)

If $L_y^{recent} > 0.9\ L^{AVE}$:

$$TAC_{y+1} = 0.5 \times C^{AVE} \left[1 + \frac{(L_y^{recent} - 0.9\ L^{AVE})}{(L^{target} - 0.9\ L^{AVE})}\right]$$

where $L^{target} = 1.05\ L^{AVE}$

Scalars (0.9 and 1.05) can be modified

If $L_y^{recent} \leq 0.9\ L^{AVE}$:

$$TAC_{y+1} = 0.5 \times C^{AVE} \left[\frac{L_y^{recent}}{0.9\ L^{AVE}}\right]^2$$

Methods: LstepCC0

Method	Data Inputs													
	Mort	FMSY_M	L50	vbLinf	vbK	vbt0	wla	wlb	steep	MaxAge	Cat	Ind	ML	CAA
Indicator (Length-based)														
LstepCC0 - mean length step														

TAC = catch recommendation

From Geromont and Butterworth (2014)

If $L_y^{recent} / L^{AVE} < 0.96$,

$$TAC_{y+1} = C^{AVE} - 2 * (0.05 * C^{AVE})$$

else If $L_y^{recent} / L^{AVE} < 0.98$,

$$TAC_{y+1} = C^{AVE} - (0.05 * C^{AVE})$$

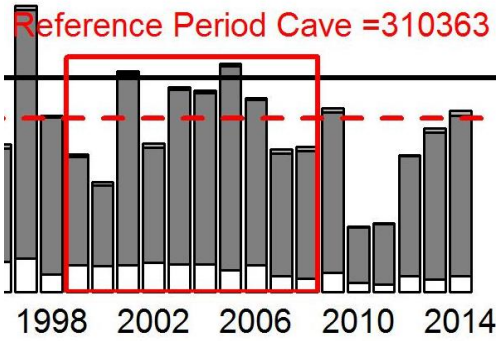
else $L_y^{recent} / L^{AVE} > 1.05$,

$$TAC_{y+1} = C^{AVE} + (0.05 * C^{AVE})$$

Target levels (0.96, 0.98, and 1.05) can be modified

Length-based methods

Mean Catch:
Mean landings during reference period (Status Quo)



Recent mean length above target

Ltarget0 and LstepCC0: incrementally adjust **catch recommendation** upwards to reach target length

Recent mean length below target

Ltarget0 and LstepCC0: incrementally adjust **catch recommendation** downwards to reach target length

Age-based methods for Red Drum

- Catch Curve Analysis
  - Conducted externally and within DLMtool

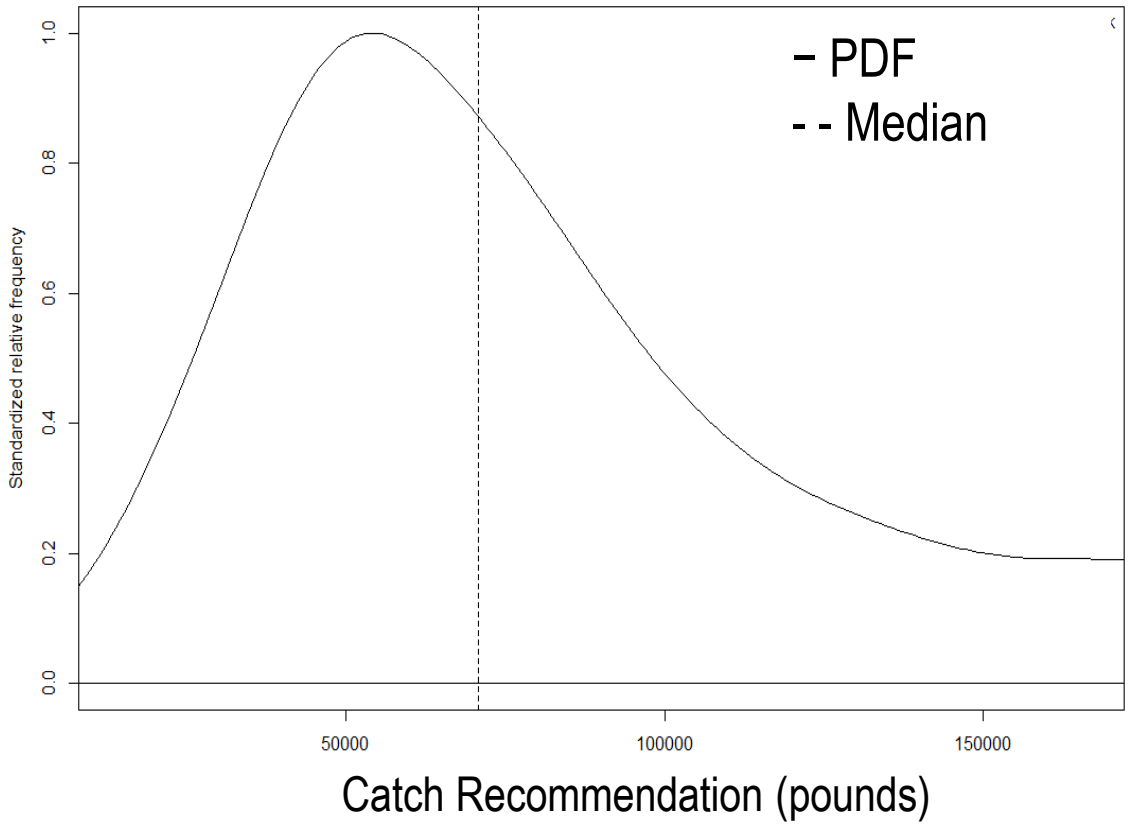
- Multiple methods in DLMtool implement a catch curve to estimate current abundance from a total mortality estimate and current catch (2014)

- No methods met the performance criteria for Red Drum

(1) DLMtool Catch recommendations using real data

Point estimates and CVs provided developed at DW

Explore sensitivity of catch recommendations to varying input data through sensitivity examinations



10,000 random draws of data inputs create distribution above

DLMtool: Selection of methods for calculating catch recommendations

Should take into account:

1. Real data: whether method assumptions are met or violated
2. How sensitive catch recommendations are to data inputs
3. Information quality used in interpretation of results

   For example:

   - Is index of abundance more reliable than annual mean length observations?
4. Management strategy evaluation: exclude methods that do not meet minimum performance criteria (discussed in next section)

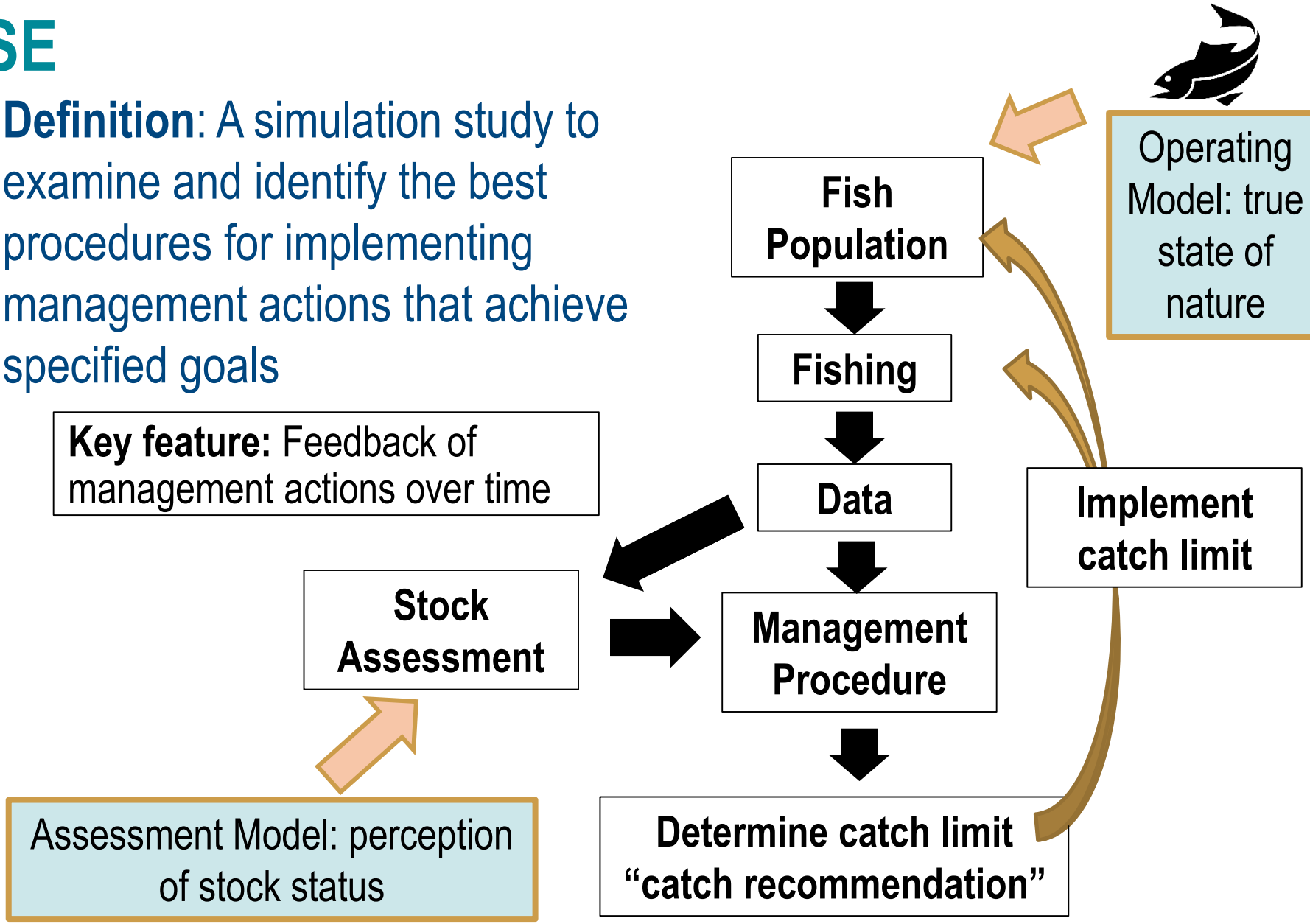
(2) MSE in DLMtool application

- ***Identify which methods are robust to uncertainty and bias in input parameters for a given "stock-type" and fishery***
  - Example
    - Create "deep-water grouper-like" stock by specifying a range of plausible life history parameters
    - Capture the potential biases and quality of data for the stock and fleet examined
- Eliminate methods which display pathological behavior

MSE

Definition: A simulation study to examine and identify the best procedures for implementing management actions that achieve specified goals

Key feature: Feedback of management actions over time



Operating model

- Age-structured model
- Conditioned on:
  - Fishing effort for representative fleet
  - Depletion estimate (input as a range) in terminal year of historical period (2014 for SEDAR49)
- Single fishery
- **Data-limited application
- Technical aspects detailed in SEDAR49-AW10

Parameterizing the operating models

- Operating model parameters and justifications detailed in Working Papers for each species (SEDAR49-AW01-06,08-09)
- Modifications include:

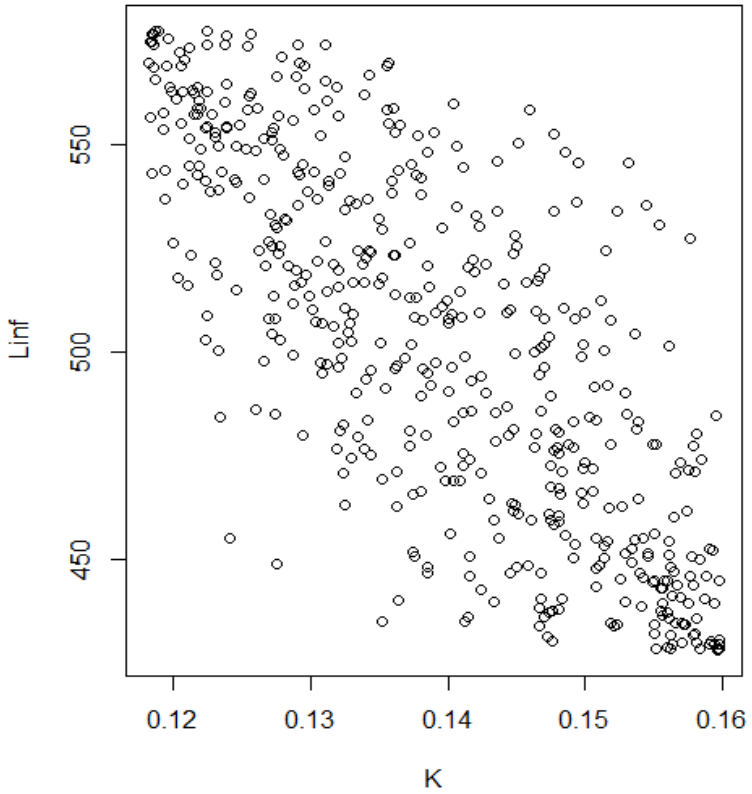
Observation model parameter	Original	Updated
Cobs	(CV, CV)	(CV, 2CV)
Iobs	(max annual CV, max annual CV)	(min annual CV, max annual CV)
CALcv	(max annual CV, max annual CV)	(min annual CV, max annual CV)

  - Depletion updated using recent mean length data

Depletion (Bnow/Bunfished)	Original	Updated Base
Red Drum	c(0.05, 0.55)	c(0.42, 0.59)
Snowy Grouper	c(0.05, 0.30)	c(0.15, 0.40)
Almaco Jack	c(0.10, 0.13)	c(0.07, 0.32)

Correlation of life history parameters

- DLMtool draws values for user specified inputs from uniform distributions of von Bertalanffy parameters K, Linf and t0
- Correlated uniform draws for the parameters using multivariate probability distributions (after Schumann 2009)
  - Implemented using copula theory



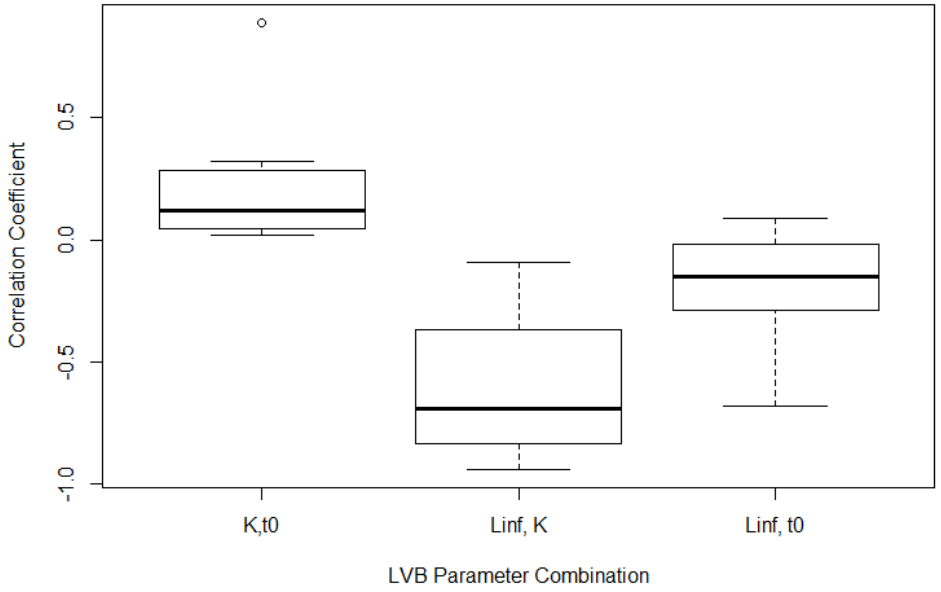
Specified correlation = -0.76

Correlation coefficients

- Based on meta-analysis of parameters from literature review (SEDAR49-AW07)
  - Paucity of estimates for reef fish
  - Tropical emperor (*Lethrinus mahsena*)

Picture by Randall, J.E., fishbase.org

	Linf,K	K,t0	Linf,t0
Value (Mean)	-0.58	0.24	-0.19
Range (Mean ± SD)	(-0.87, -0.29)	(-0.07, 0.55)	(-0.43, 0.04)



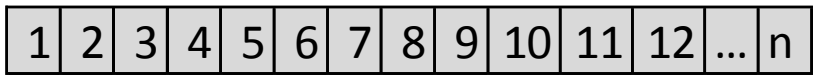
Historical versus Simulation (Test) Period

Historical Period:

- Simulate population dynamics and fleet dynamics for representative fleet
- Conditioned to reach specified depletion level in terminal year

Year 1:
Start at onset of fishery

Terminal year (n):
Last year of historical data

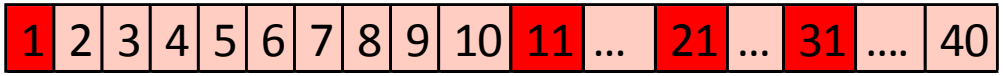


Simulation Period:

- Assessment interval of 10 years
  - An assessment is conducted in Years 1, 11, 21, and 31 (dark red)
- Every year of simulation period, new data is collected

Year 1:
First year of simulation period

Year 40:
Last year of simulation period



Performance metrics

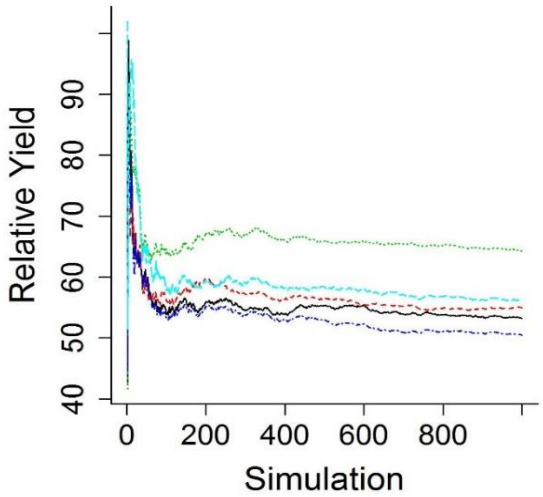
1. Probability of not overfishing (PNOF)
2. Probability of the biomass remaining above half BMSY (B50):
3. Average annual variability in yield to remain within 15% (VY15):
   - Criteria of > 50% chosen for each

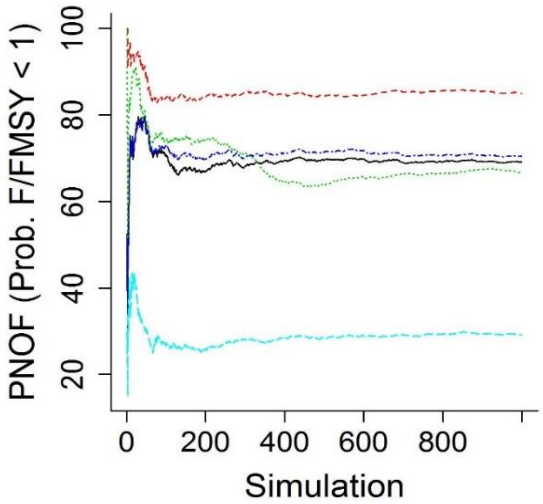
- Long-term yield (LTY)
- Short-term yield (STY)
- Probability of reducing the stock below 20%BMSY (Bbelow20)

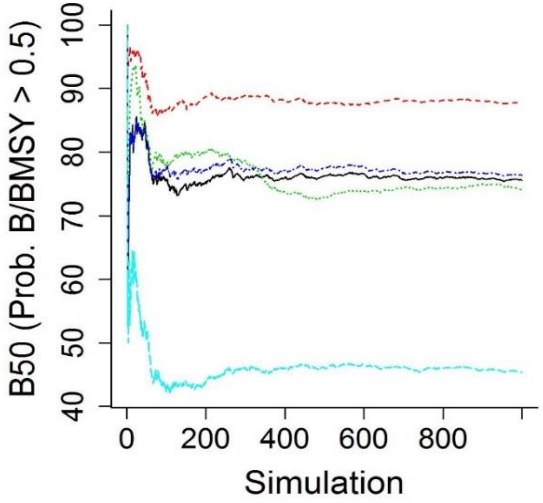
Method convergence in MSE

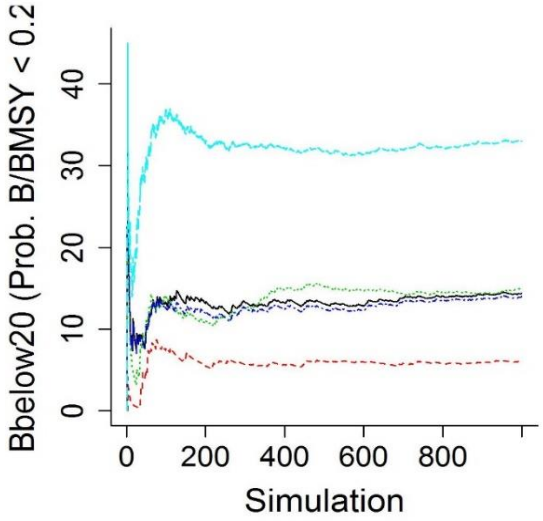
Have performance metrics stabilized or are more simulations needed?

All metrics converge to within 0.05% for all species and methods presented by 1,000 simulations









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Extra slides

Performance metrics: PNOF example

- For each method:

$$PNOF = \frac{\sum simulations\ where\ \frac{F}{FMSY} < 1}{Total\ simulations\ * NProyears} \times 100$$

N Projection Years = 4

N simulations = 5

	ProYear1	ProYear2	ProYear3	ProYear4
Sim1	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	F/FMSY>1
Sim2	**F/FMSY<1**	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**
Sim3	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	F/FMSY>1
Sim4	F/FMSY>1	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**
Sim5	**F/FMSY<1**	F/FMSY>1	**F/FMSY<1**	F/FMSY>1

In simple example, **11 simulations** have F/FMSY<1

$$PNOF = \frac{\sum simulations\ where \frac{F}{FMSY} < 1}{Total\ simulations * NProyears} \times 100 = \frac{11}{5 * 4} \times 100 = 55\%$$

Performance metrics: B50 example

- For each method:

$$B50 = \frac{\sum simulations\ where\ \frac{B}{BMSY} > 0.5}{Total\ simulations * NProyears} \times 100$$

N Projection Year = 4

N simulations = 5

	ProYear1	ProYear2	ProYear3	ProYear4
Sim1	**B/BMSY>0.5**	**B/BMSY>0.5**	**B/BMSY>0.5**	**B/BMSY>0.5**
Sim2	**B/BMSY>0.5**	B/BMSY<0.5	**B/BMSY>0.5**	B/BMSY<0.5
Sim3	**B/BMSY>0.5**	B/BMSY<0.5	**B/BMSY>0.5**	B/BMSY<0.5
Sim4	**B/BMSY>0.5**	**B/BMSY>0.5**	B/BMSY<0.5	**B/BMSY>0.5**
Sim5	B/BMSY<0.5	**B/BMSY>0.5**	**B/BMSY>0.5**	**B/BMSY>0.5**

In simple example, **14 simulations** have B/BMSY>0.5

$$B50 = \frac{\sum simulations\ where \frac{B}{BMSY} > 0.5}{Total\ simulations * NProyears} \times 100 = \frac{14}{5 * 4} \times 100 = 70\%$$

Performance metrics: VY15 example

- For each method:

$$\text{AAVY} = \frac{Catch_{y,t} - Catch_{y,t+1}}{(Catch_{y,t+1})^2}$$

N simulations = 5

	Combined Across Years
Sim1	**AAVY<15%**
Sim2	**AAVY<15%**
Sim3	**AAVY<15%**
Sim4	AAVY>15%
Sim5	**AAVY<15%**

In simple example, **4 simulations** have AAVY<15%

$$VY15 < 15\% = \frac{\sum simulations\ where\ AAVY < 0.15}{Total\ simulations} \times 100 = \frac{4}{5} \times 100 = \mathbf{80\%}$$

Performance metrics: LTY example

- For each method:

$$LTY = \frac{\sum simulations\ where \frac{Catch}{RefY} > 0.5\ in\ last\ 5\ years}{Total\ simulations\ * NProyears} \times 100$$

RefY = highest long-term yield (mean over last 5 years of projection) obtained from fixed F strategy

N Projection Year = 10 but *only use last 5 years*

N simulations = 5

	ProYear6	ProYear7	ProYear8	ProYear9	ProYear10
Sim1	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**
Sim2	Catch/RefY < 0.5	Catch/RefY < 0.5	**Catch/RefY > 0.5**	Catch/RefY < 0.5	Catch/RefY < 0.5
Sim3	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	**Catch/RefY > 0.5**	Catch/RefY < 0.5
Sim4	Catch/RefY < 0.5	Catch/RefY < 0.5	Catch/RefY < 0.5	Catch/RefY < 0.5	**Catch/RefY > 0.5**
Sim5	Catch/RefY < 0.5	Catch/RefY < 0.5	Catch/RefY < 0.5	**Catch/RefY > 0.5**	Catch/RefY < 0.5

In simple example, **12 simulations** have Catch/RefY > 0.5

$$LTY = \frac{\sum simulations\ where \frac{Catch}{RefY} > 0.5}{Total\ simulations * NProyears} \times 100 = \frac{12}{5 * 5} \times 100 = 48\%$$