Estimating local limit reference points for highly migratory sea turtles

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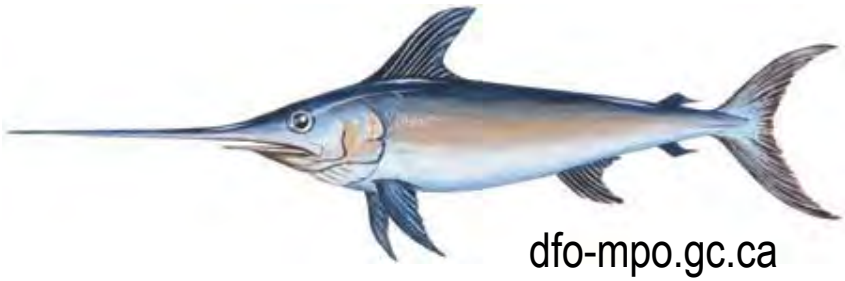
Silver Spring, MD

Motivation



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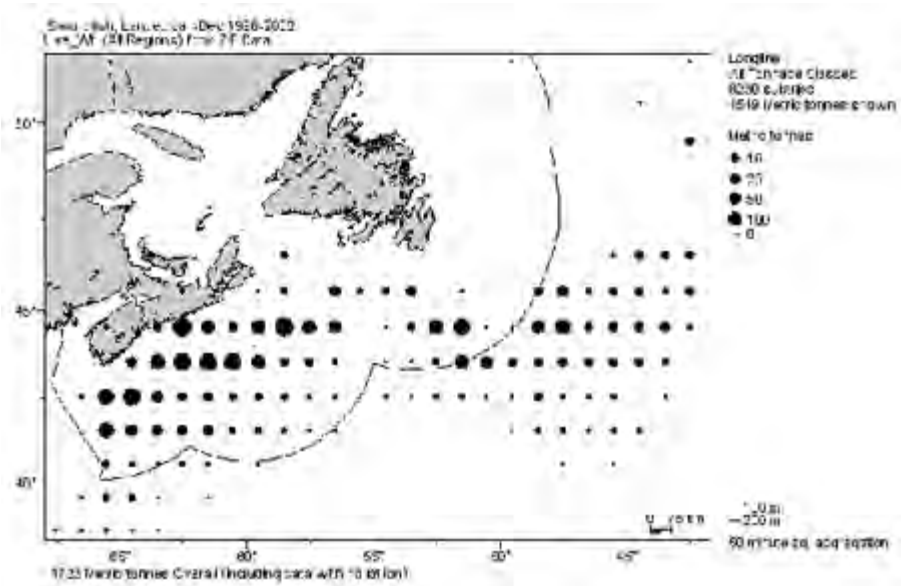

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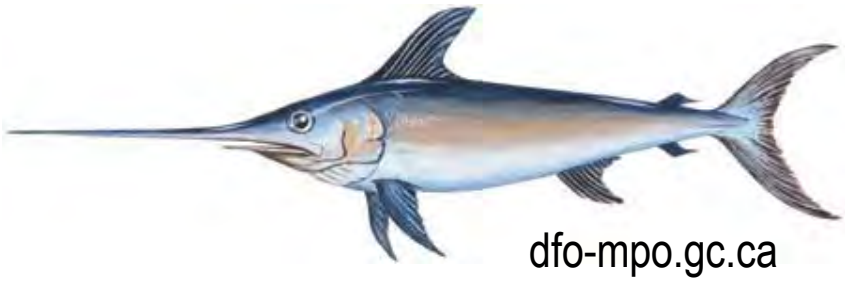

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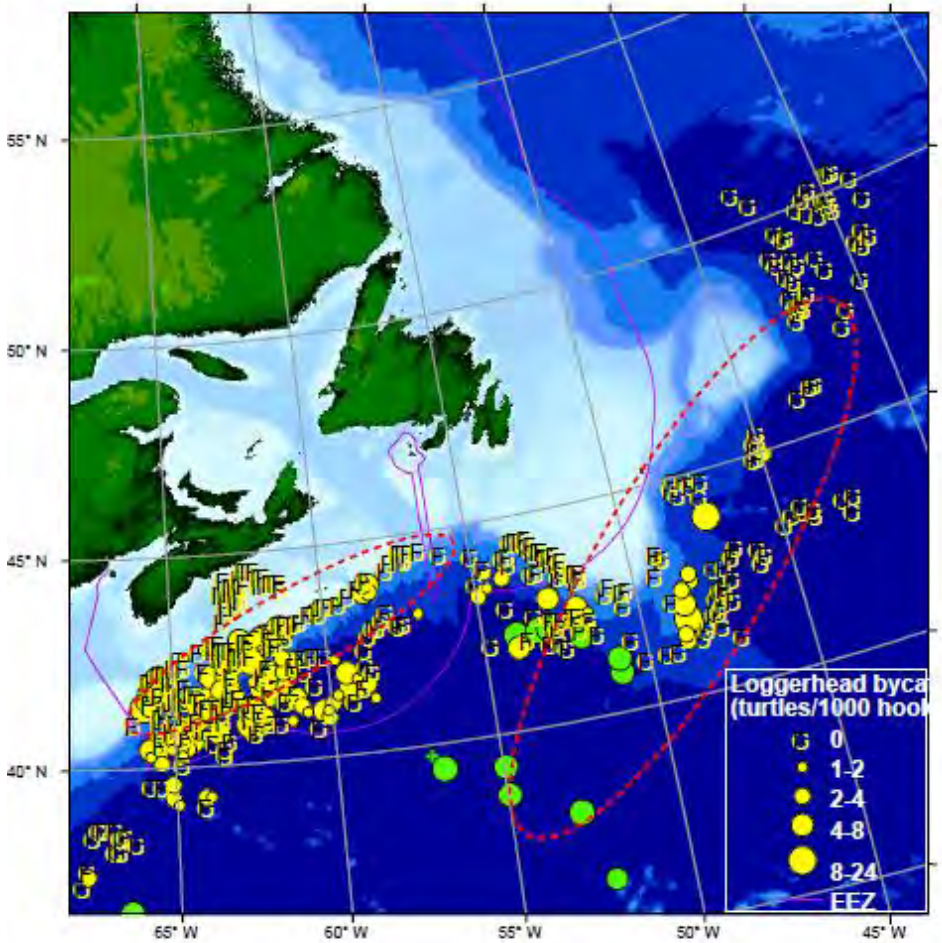
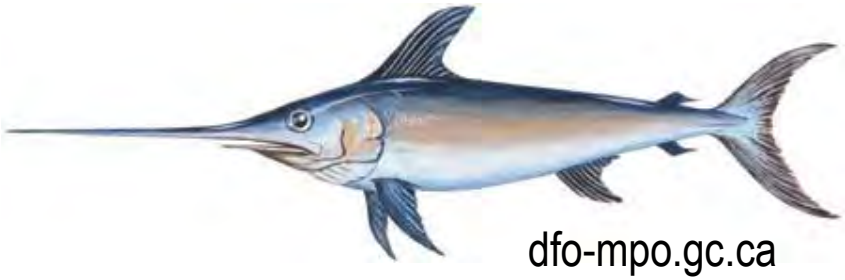


Loggerhead BPUE 2000-2009, DFO 2010

Motivation



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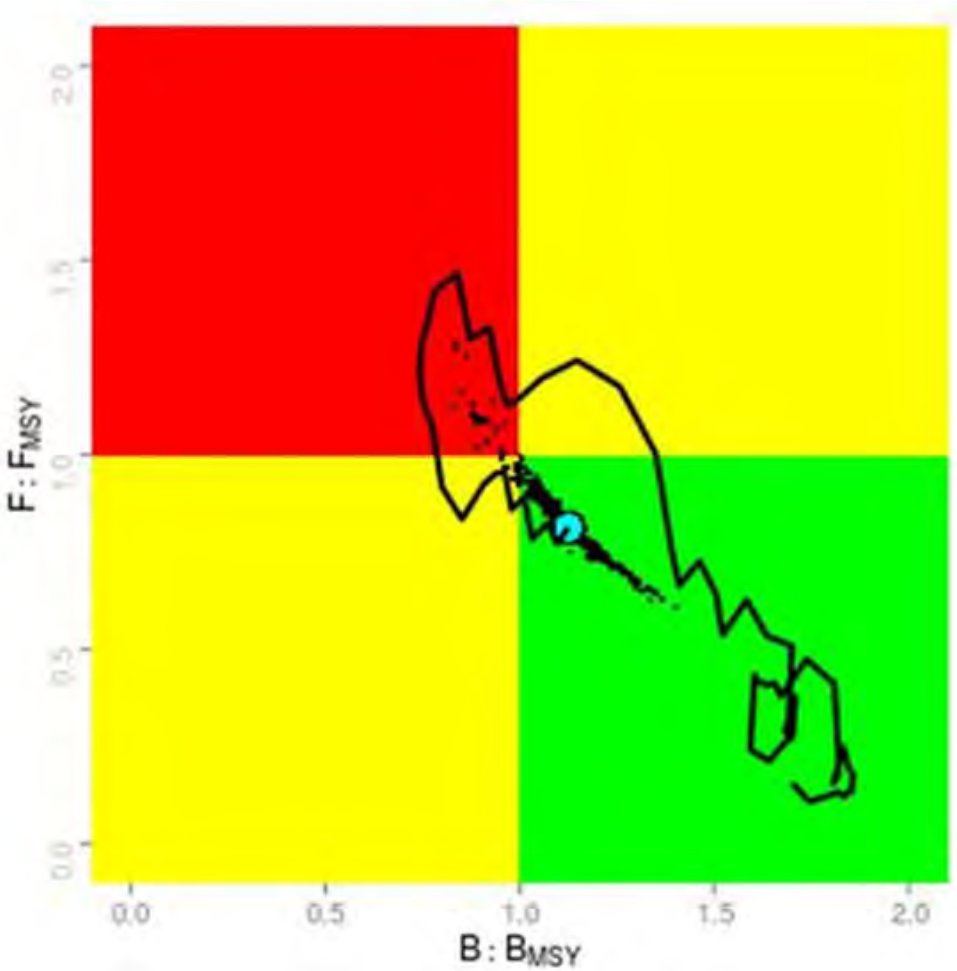
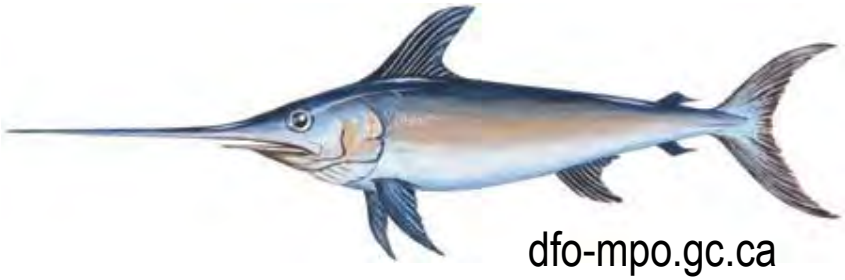
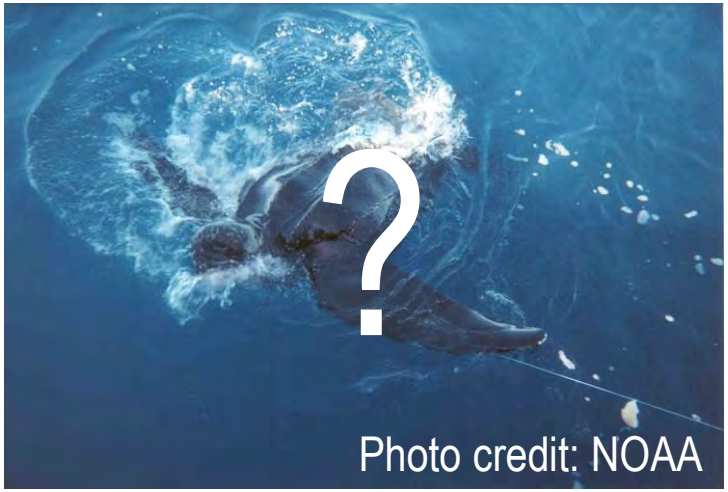


Kobe phase plot and trajectory for North Atlantic swordfish. ICCAT 2014

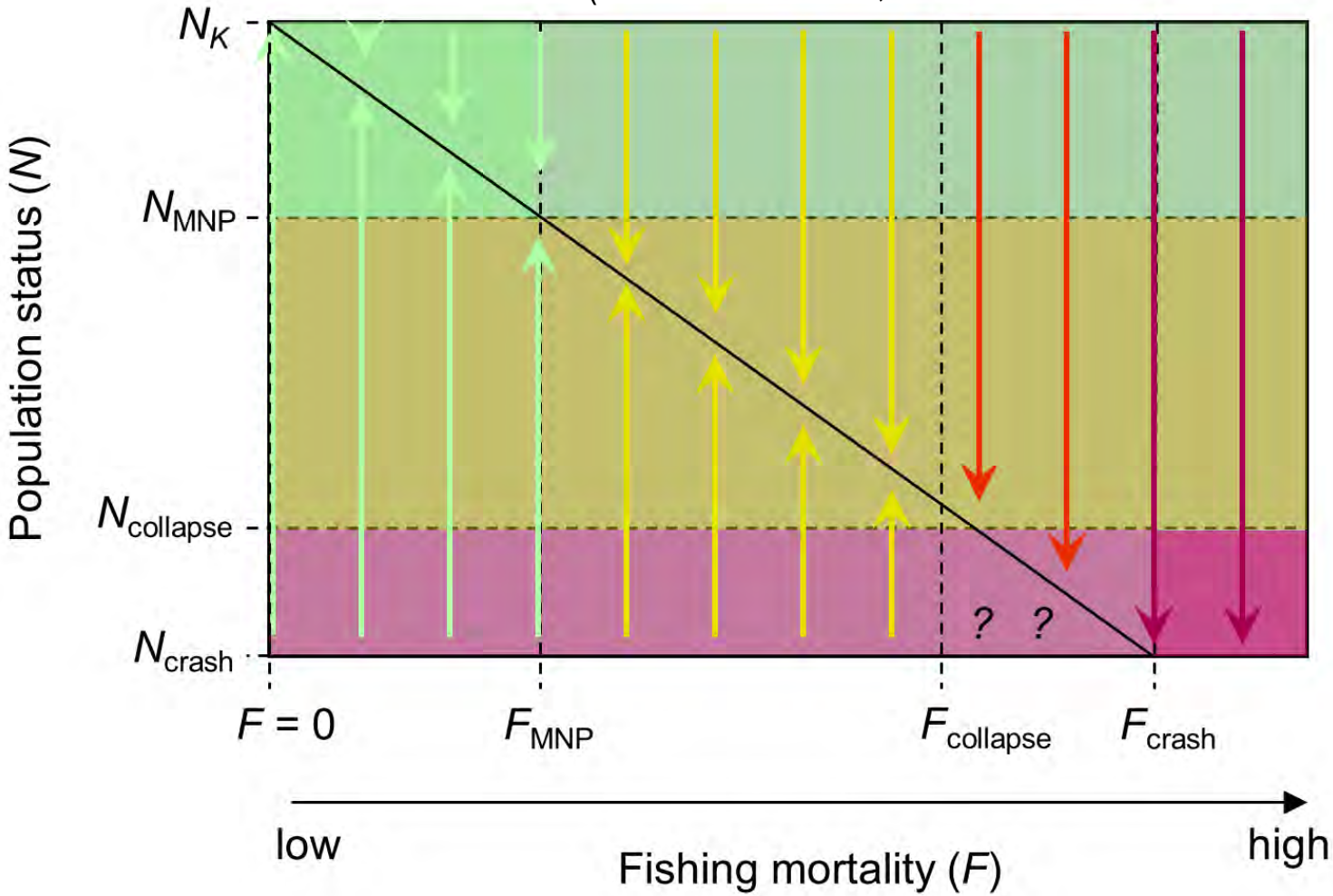
Motivation





Concept: Limit Reference Points (LRPs)

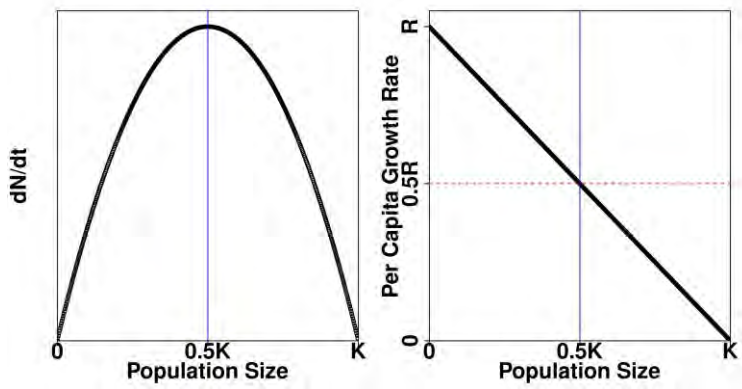
(Curtis et al 2015a, modified from Moore et al 2013)



Concept: LRP Estimators

$$PBR = 0.5 * R_{\max} * N_{\min} * F_r$$

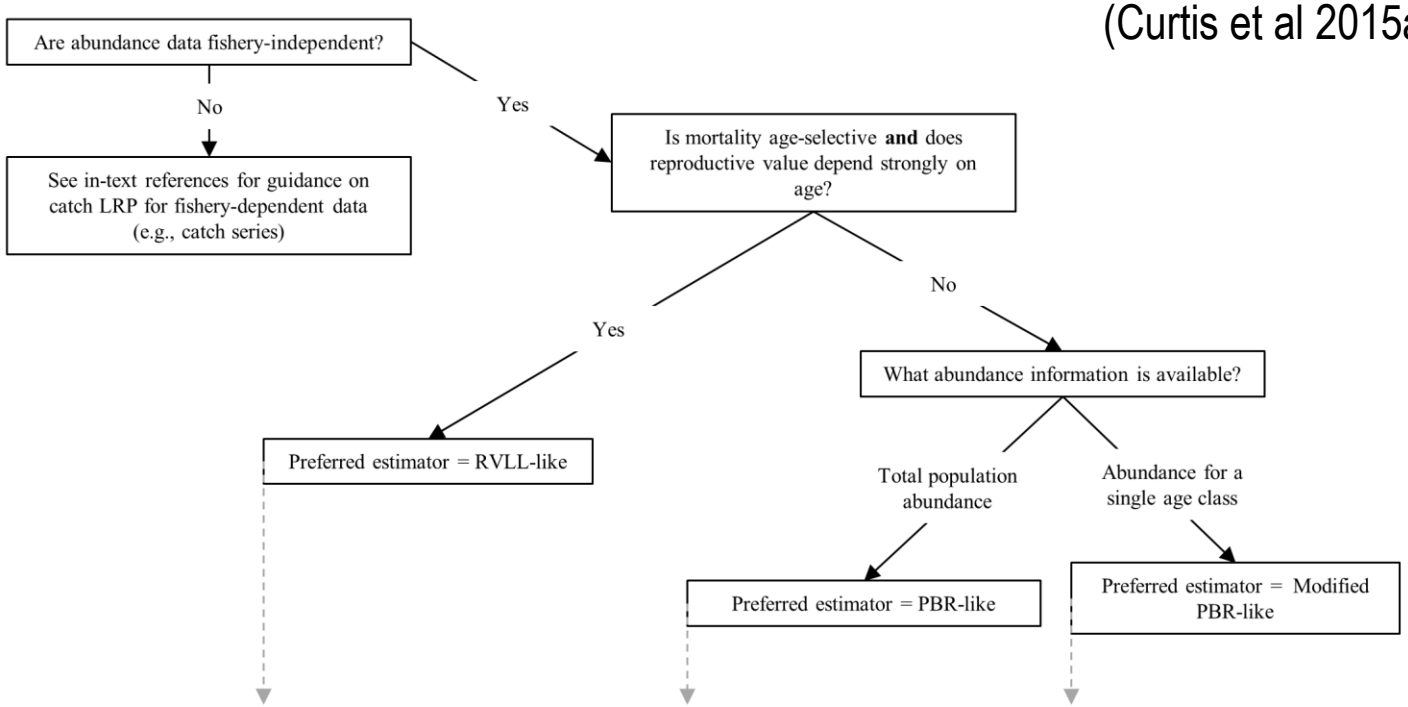
- 0.5 * R_{max} - growth rate at MNPL in logistic model;



- N_{min} – lower percentile of population estimate that ensures meeting management objectives
- F_r - recovery factor; 0.1 to 1; to account for potential biases; or ensure time to recovery not unduly extended

Concept: LRP Estimators

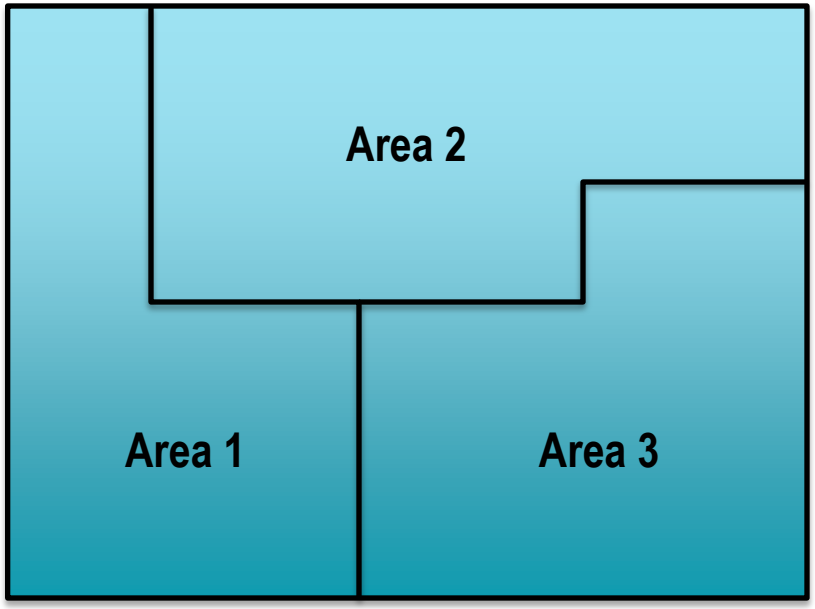
(Curtis et al 2015a)

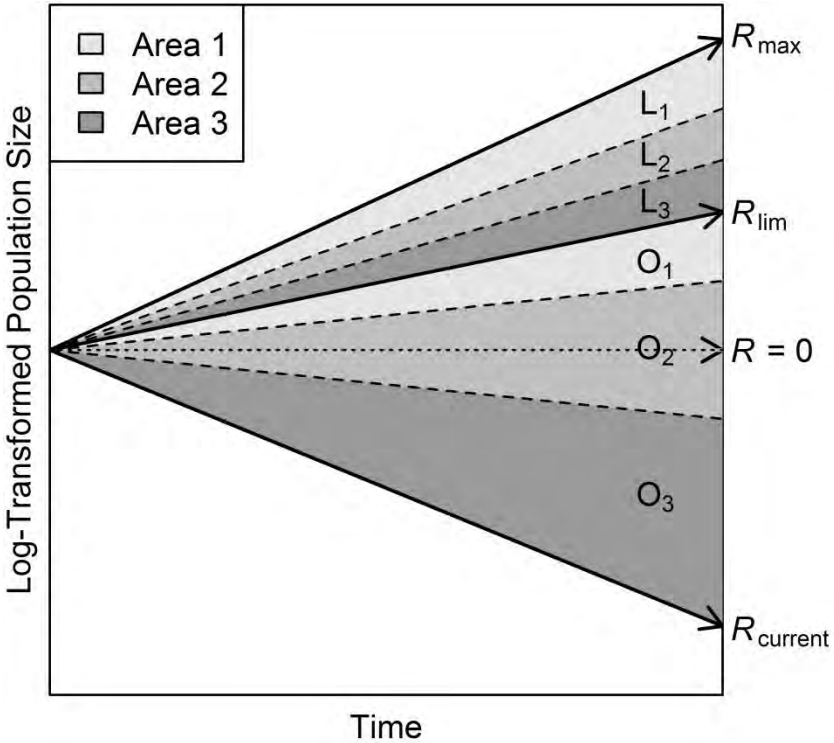


Catch LRP estimator (basic form):	$(b\ R_{max}\ N f)_{min}$	$(b\ R_{max}\ N f)_{min}$	$(b\ R_{max}\ g(\eta)\ f)_{min}$
Notes:	N = abundance scaled by reproductive value	N = total abundance across ages	η = abundance for an age class; $g(\eta)$ is a function to obtain total abundance from η
Indicator:	Removals scaled by reproductive value	Removals	Removals
Data requirements:	Life table data to construct a population transition matrix corresponding to optimal population-growth conditions; estimates of abundance for a particular age or stage class (e.g., reproductive adults); age- or stage-specific estimates of human-caused removals	Estimates of R_{max} (from life table or other methods), survey estimates of total population abundance, estimates of human-caused removals	Estimates of R_{max} (from life table or other methods), survey estimates of η, demographic parameters to convert η to N; estimates of human-caused removals

Concept: Local LRPs

- Proportional to local abundance





(Curtis et al 2015a)

Concept: LRPs

Strengths of reference points:

- Tie population impacts to population outcomes in probabilistic framework
- Comparability among species, regions
- Relevant to cumulative impacts from all sources
- Can explore sensitivity to different types of uncertainty or bias
- Easy to re-evaluate given new information, e.g. about life history
- If used to set limits, encourage transparent, a priori discussion and decisions about objectives and risk tolerances

Objectives: S&T Toolbox Funding Years 1/2

- Further development of reference point estimators (RVLL and PBR) and management strategy evaluation tools
- Case study(s) to demonstrate application of reference point estimation to sea turtles

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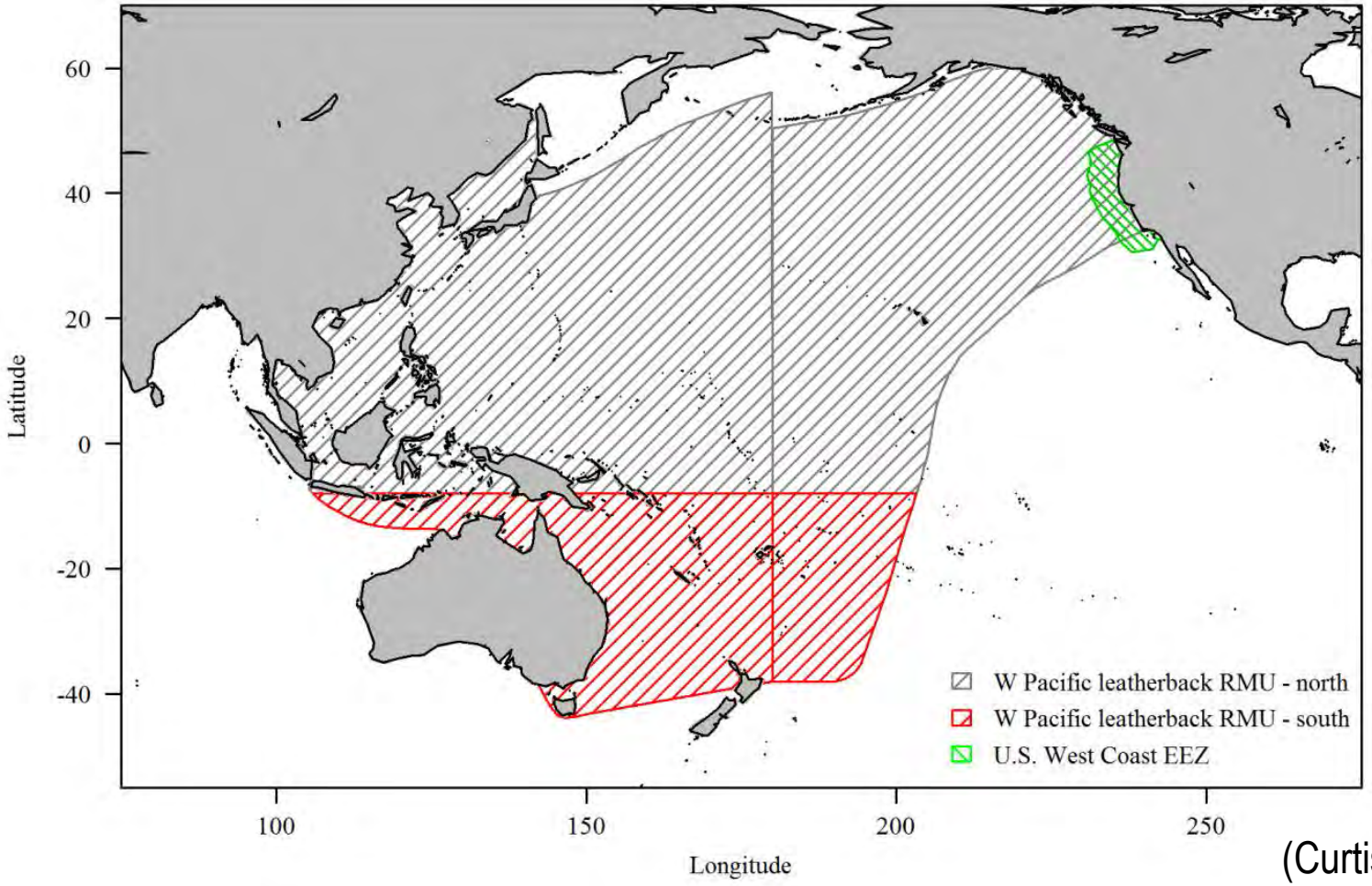
Methods

LRP estimation steps

1. Specify conservation objectives
   - population unit
   - population thresholds, risk tolerances, and time horizons
2. Choose LRP estimator
3. Estimate maximum potential population productivity
4. Estimate local abundance
5. Tune LRP estimator for uncertainty, defined risk tolerances

Methods: 1.a. Management Unit



(Curtis et al 2015b)

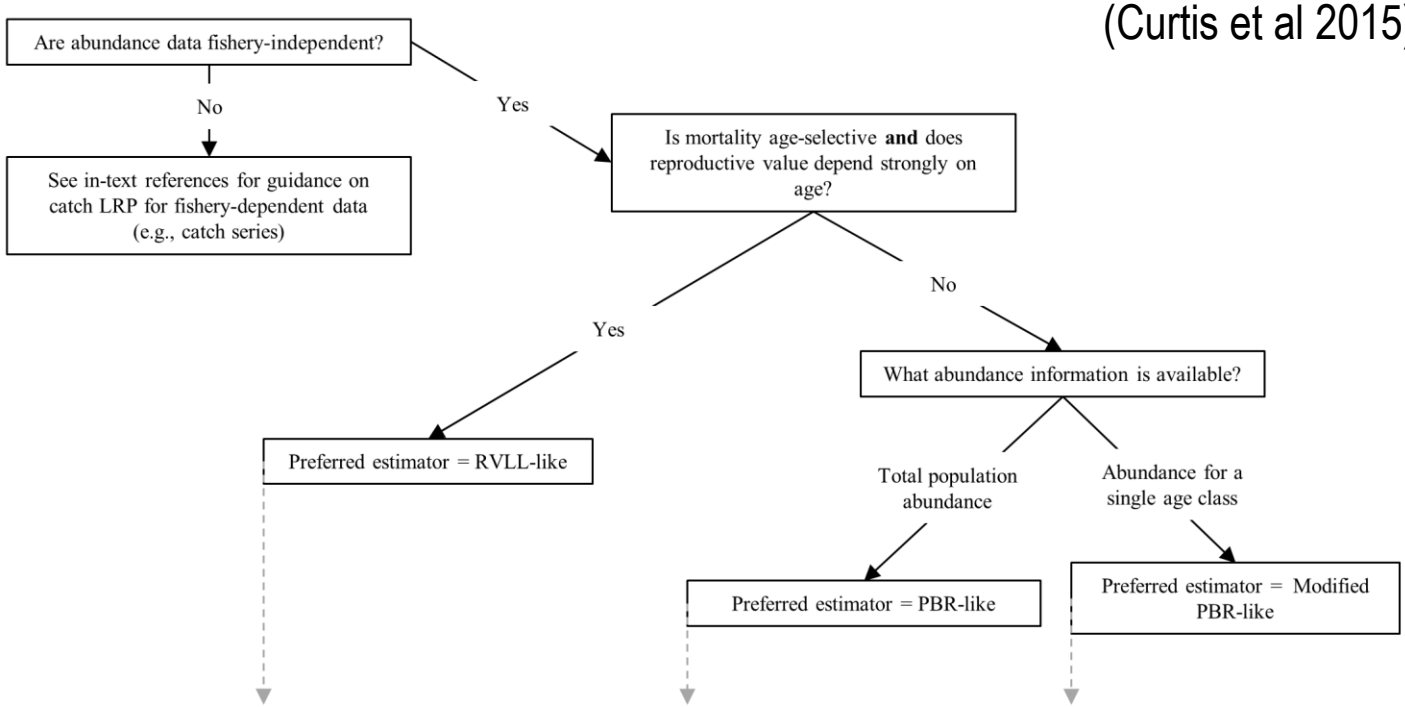
Methods: 1.b. Conservation objectives

1. Avoid exceeding F_{MNPL} (<5% risk)
2. Avoid exceeding $F_{collapse}$ (<2.5% risk)
3. Recover to productive state (MNPL)
   - Within percent time difference from unimpacted population (PBR under MMPA)
4. Maintain current # adults

Evaluation time horizon: two generations (40 years)

Methods: 2. Choose LRP Estimator

(Curtis et al 2015)



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Methods: 3. Estimate Productivity

$$PBR = [0.5 Rmax N_L f_a]_{min}$$

- R_{max} ~ U(0.04, 0.06), inferred from other populations

Methods: 4. Estimate Local Abundance

$$PBR = [0.5RmaxNL\ f_a]_{min}$$

$$\widehat{N}_{fem,USWCEEZ} = \frac{days\ in\ WCEEZ}{365} \times proportion\ using\ WCEEZ \times (\widehat{RI} - 1)\ \widehat{n}_{2014}$$

$$\widehat{N} = \frac{1}{proportion\ adults}\ \frac{1}{\widehat{PF}}\ \widehat{N}_{fem,USWCEEZ}$$

Methods: 5. Management Strategy Evaluation

Biological/Operating Model

(applied to entire population, age-structured "theta-logistic", non-selective bycatch mortality)

Observation Model

(sample nesting females)

Management Model

(estimate and apply LRP, only outcome uncertainty in discard mortality)

Additional parameters: 10% K starting population, all stages equally density-dep

Methods: 5. Management Strategy Evaluation

Tool development

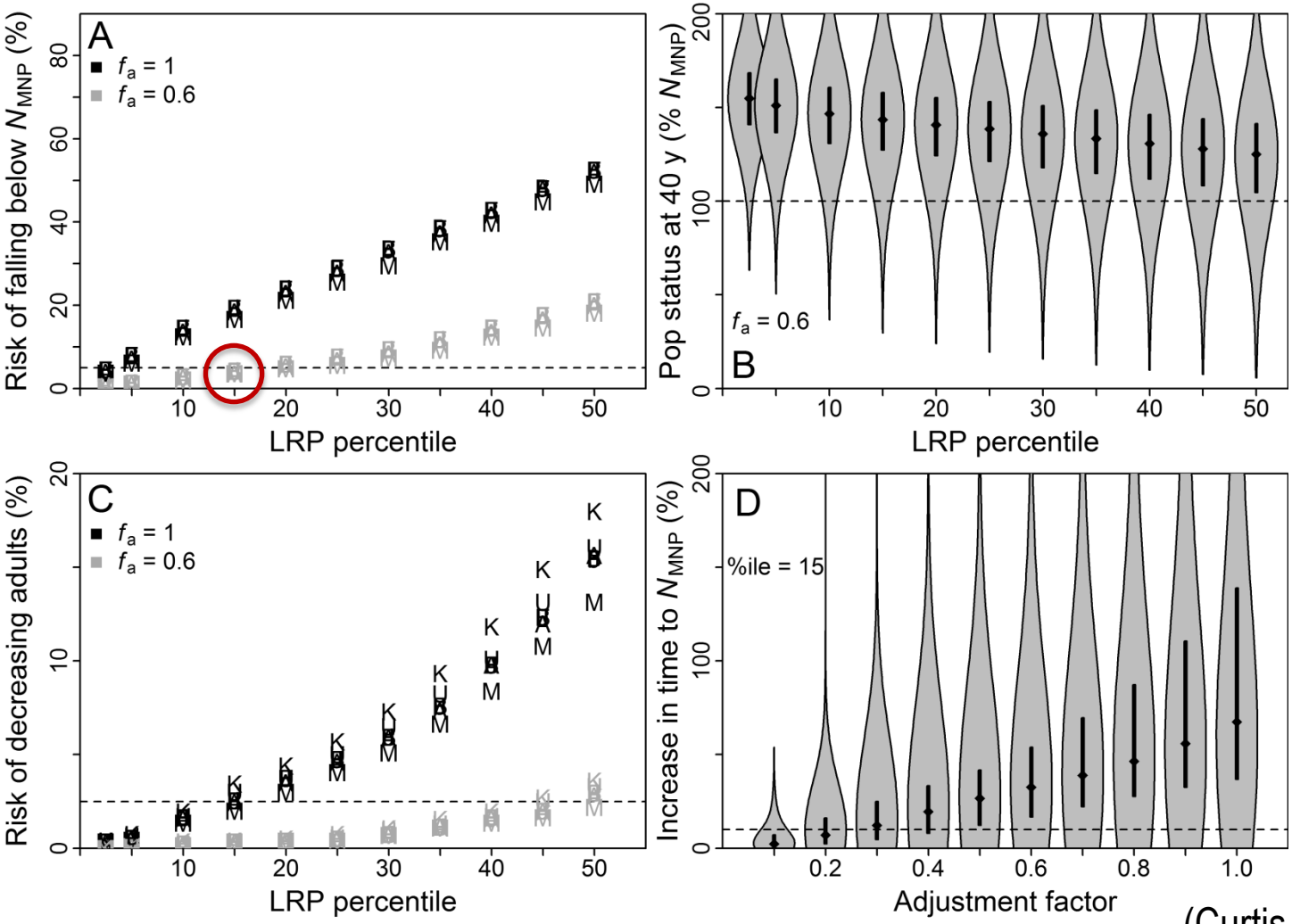
1. Systematic error in abundance estimation
2. Uncertainty in population productivity
3. Uncertainty in discard mortality
4. Mapping percentiles of final LRP distribution to risk

Methods: 5. Management Strategy Evaluation

Sensitivity Trials

- F: double F at constant R_{max}
- A: underestimate P_{adult}
- J: varying P_{juv} more steeply
- M: Underestimated AFR (True AFR=20, estimated AFR still 10)
- U: Pessimistic unstable starting age structure
- K: Currently at 20%K instead of 10%

Results: Hypothetical LRPs



(Curtis et al 2015b)

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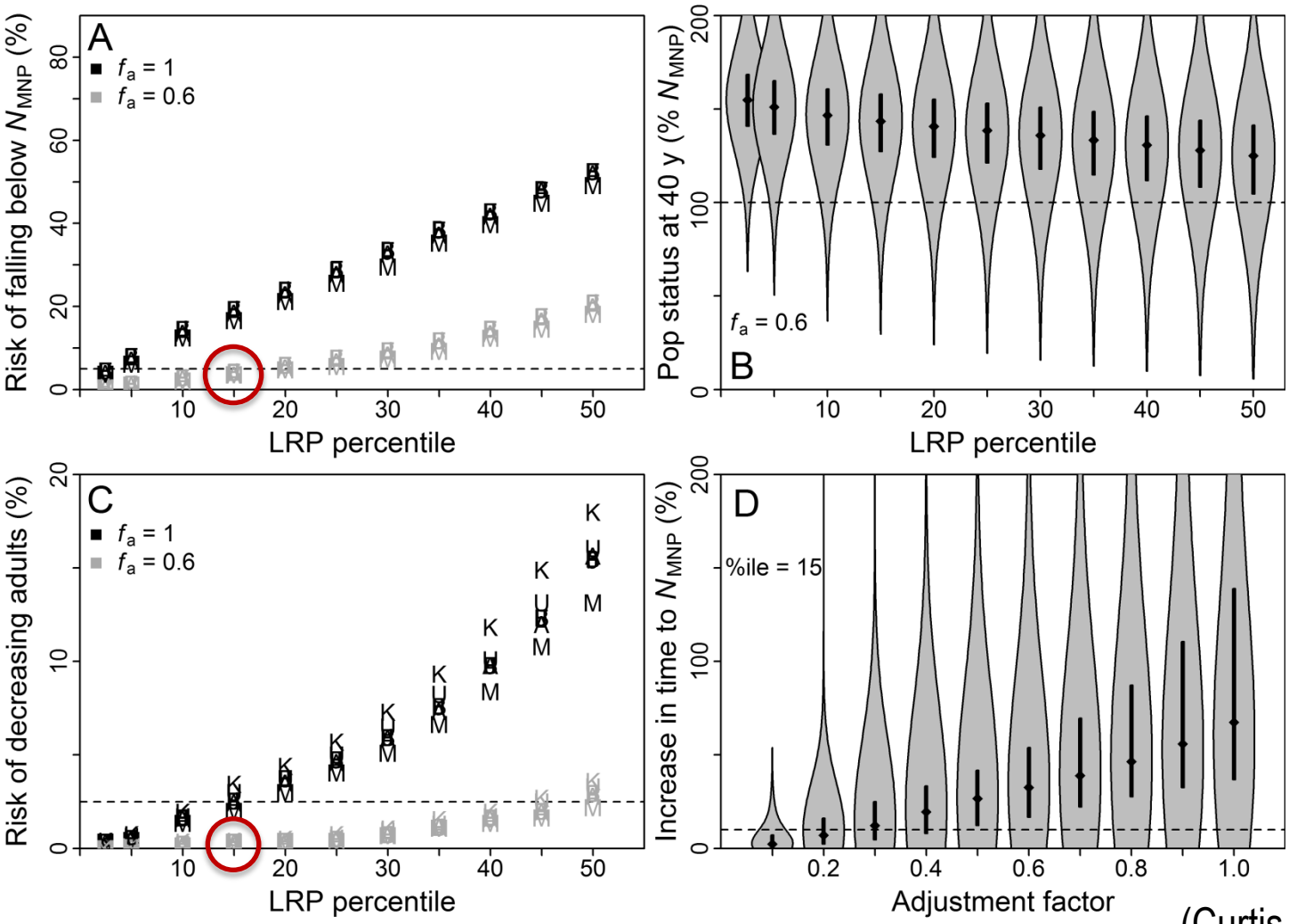

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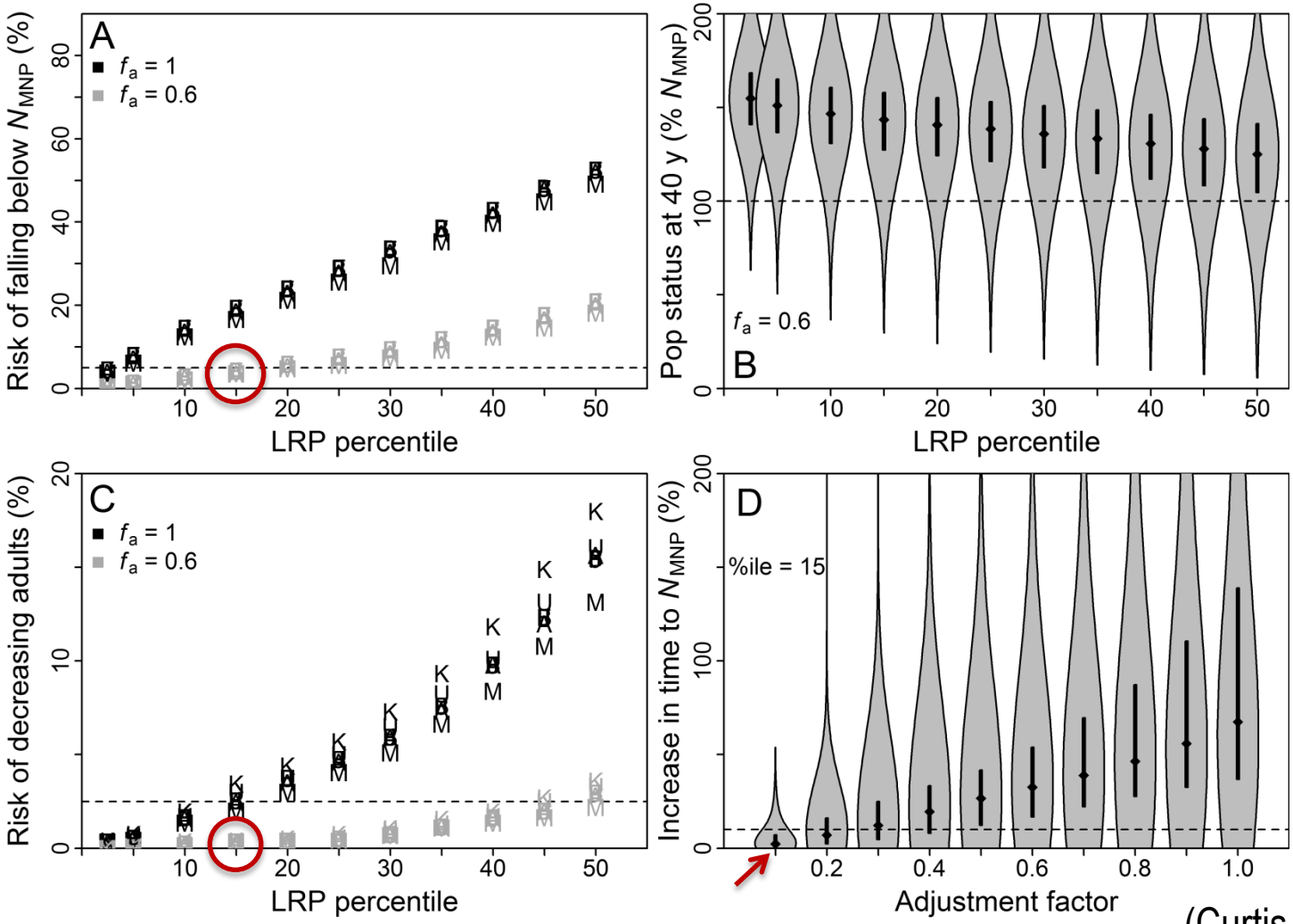

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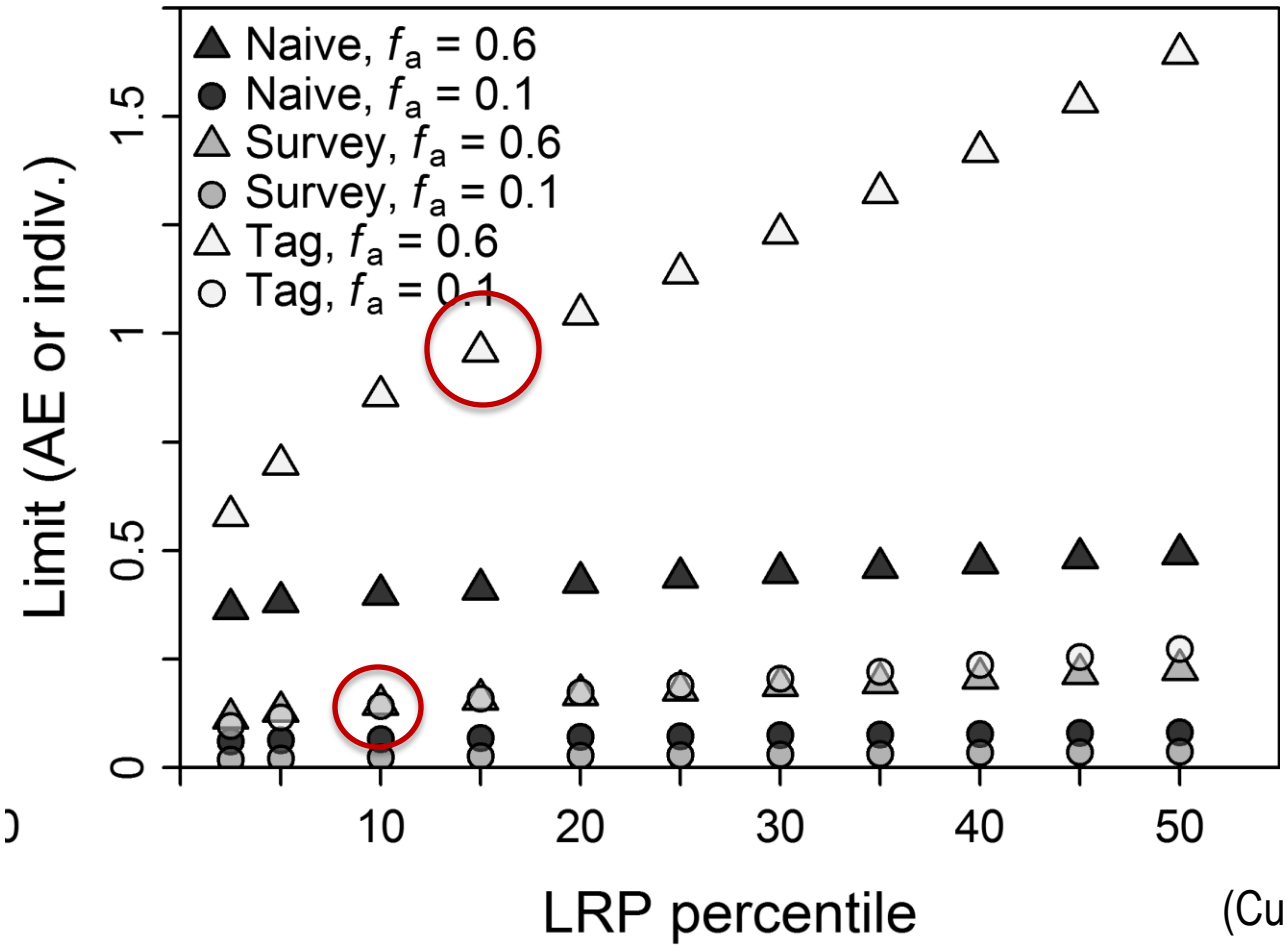
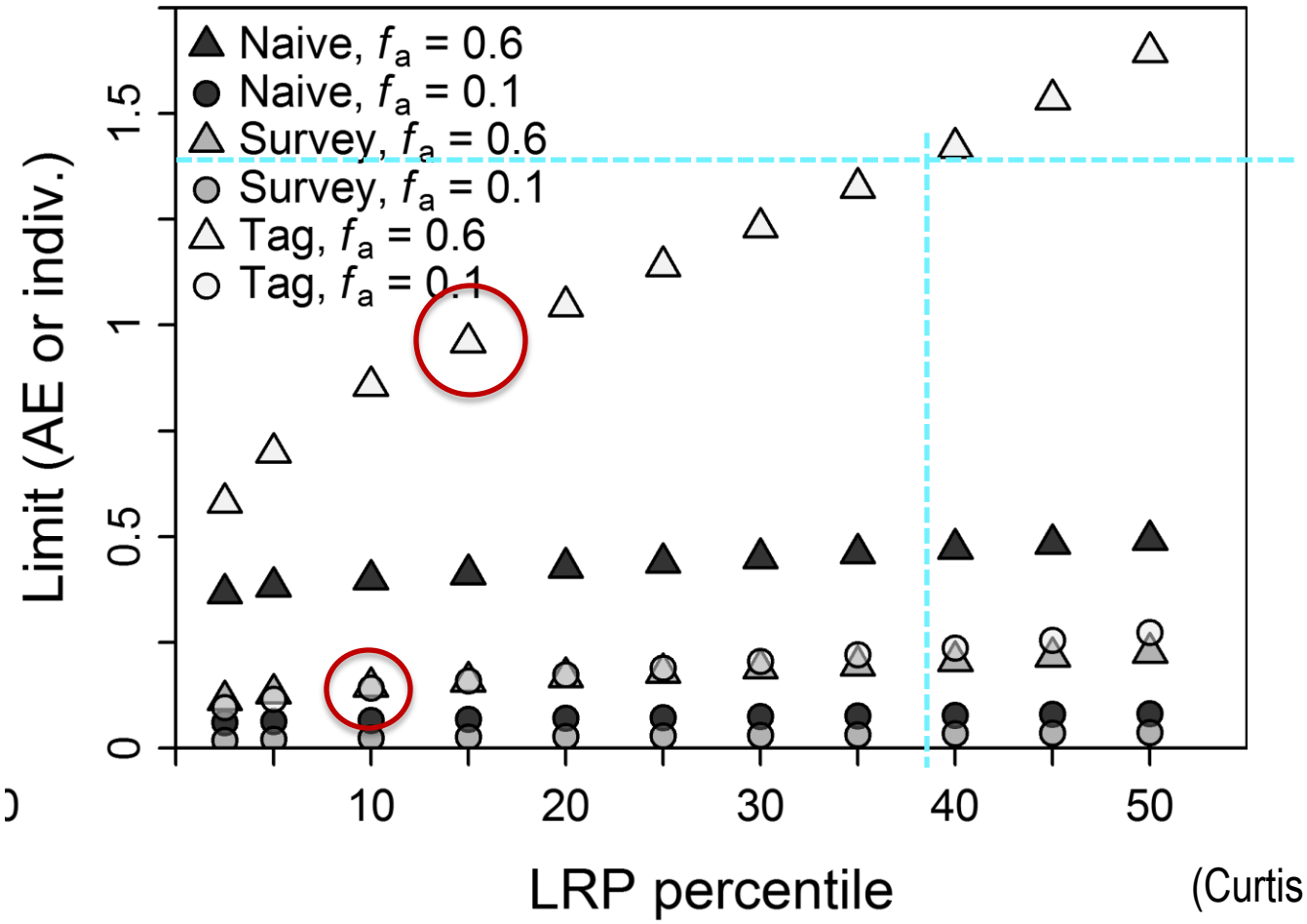


(Curtis et al 2015b)

Results: Risk Assessment



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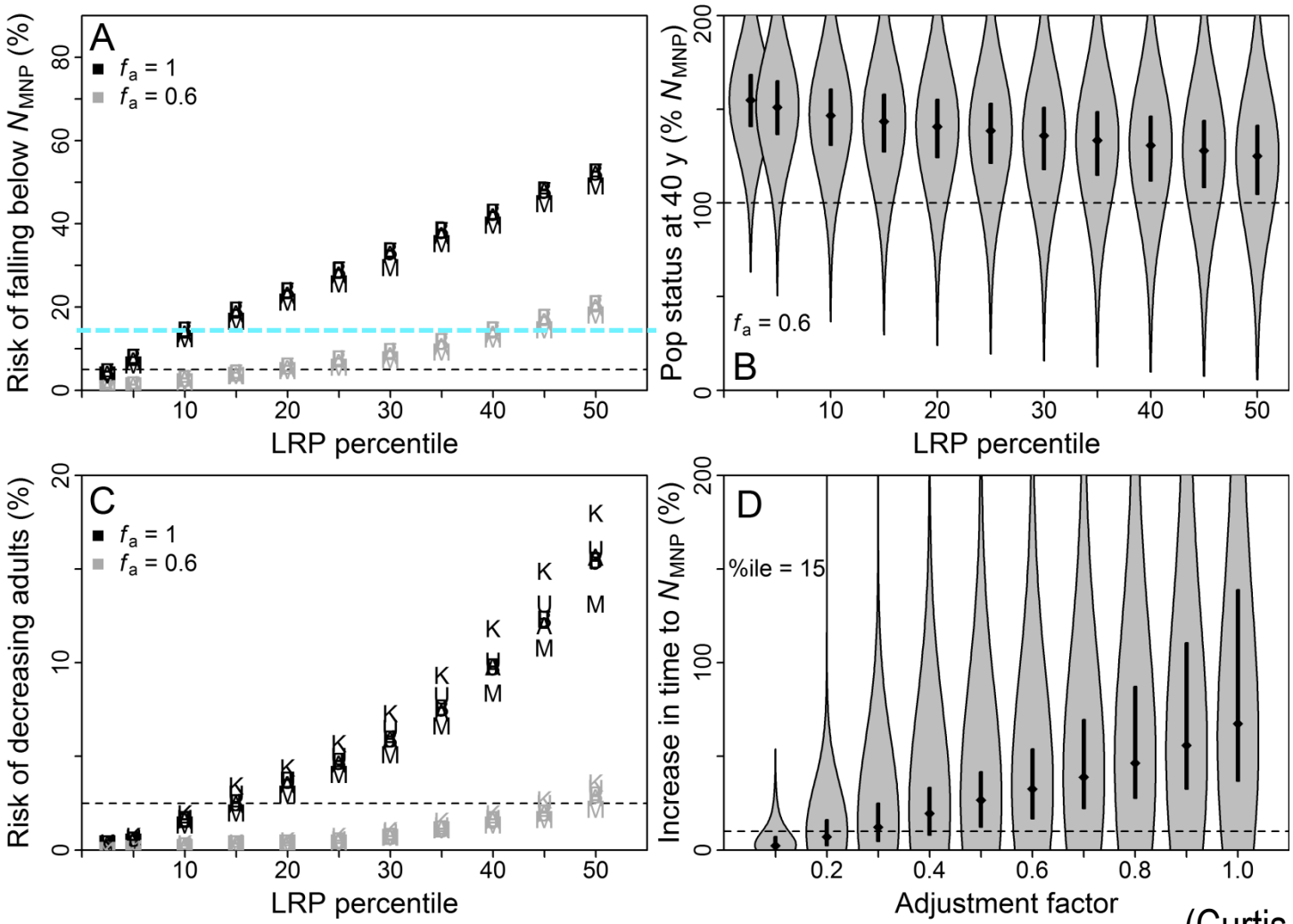
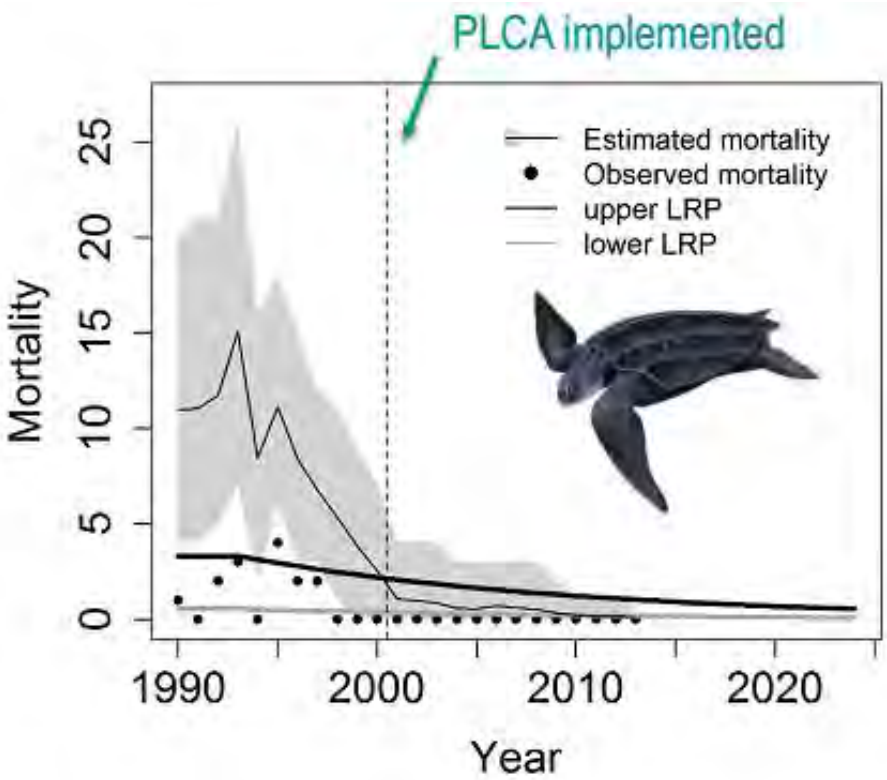


(Curtis et al 2015b)

Results: Risk Assessment II



(Moore and Curtis, in press)

Results

- Publication of case study in *PLoS ONE* with code for MSE
- Dialogue and collaboration with region (WCRO)
  - pre-publication
  - post-publication

Ongoing and Future Work

- Comparability among regions important feature of LRPs so conducting additional case study
- Further development of RVLL tool
- Continued/expanded dialogue

Potential Management Applications?

Leveling playing field for U.S. fishermen:

- Can add value to jeopardy analysis in conjunction with current approaches
- Can support ecosystem-based fisheries management under MSA
- Can facilitate comparison of impacts on PLMR in international fisheries to our own
- Can provide standard for sustainability certification

Potential Management Applications?

WORK IN PROGRESS!!!

Acknowledgments

NOAA OFFICE OF SCIENCE AND TECHNOLOGY
NATIONAL MARINE FISHERIES SERVICE

LENFEST OCEAN PROGRAM

&

A whole lot of help and advice from a whole lot of people