Development of a Stock Synthesis Model for Skates in the Gulf of Alaska

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GOA Plan Team Meeting

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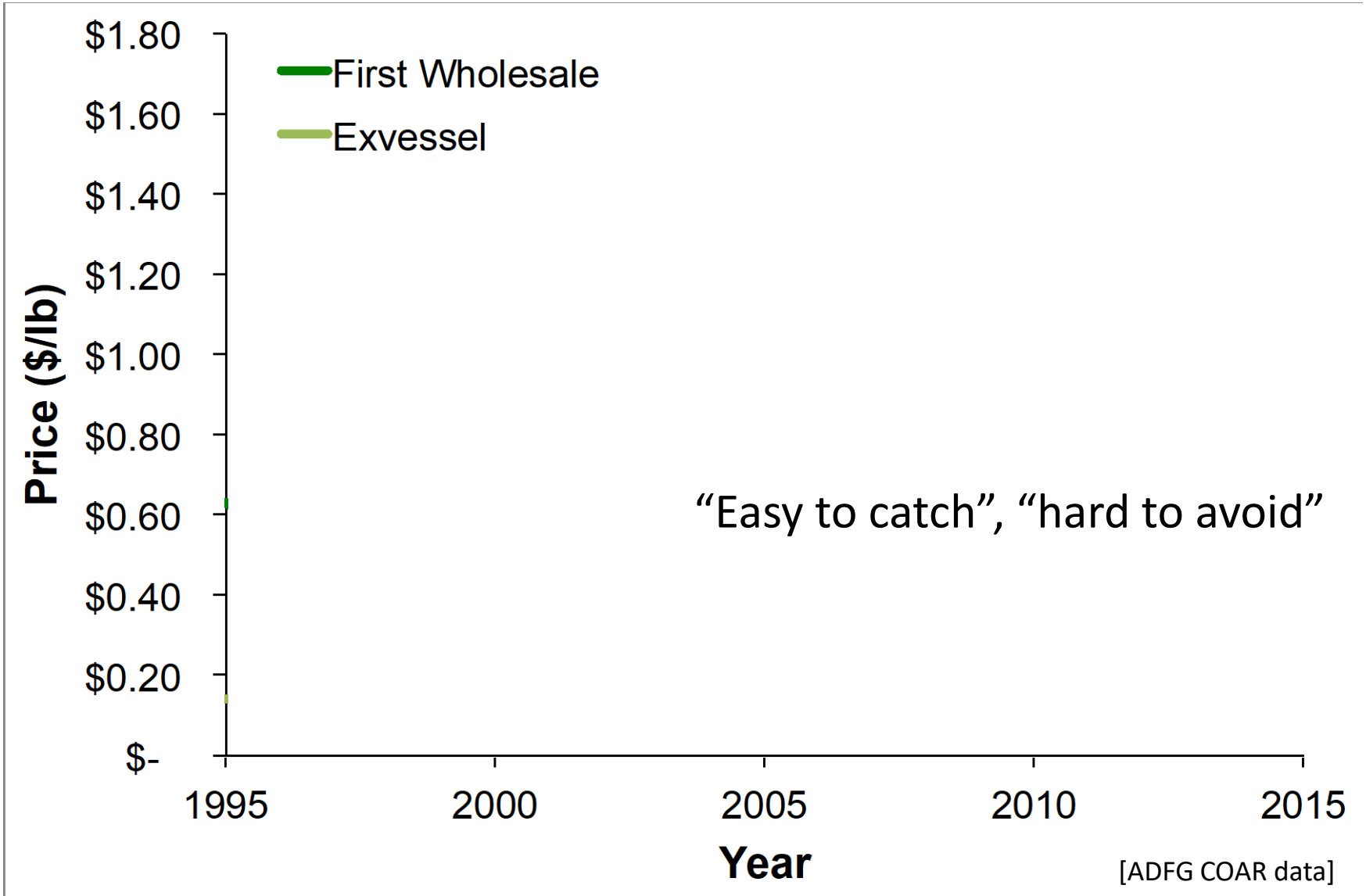
Farrugia et al. 2017. In prep, *Fisheries Research*

PhD Goal & Objectives

Is skate fishing sustainable and profitable in the GOA?

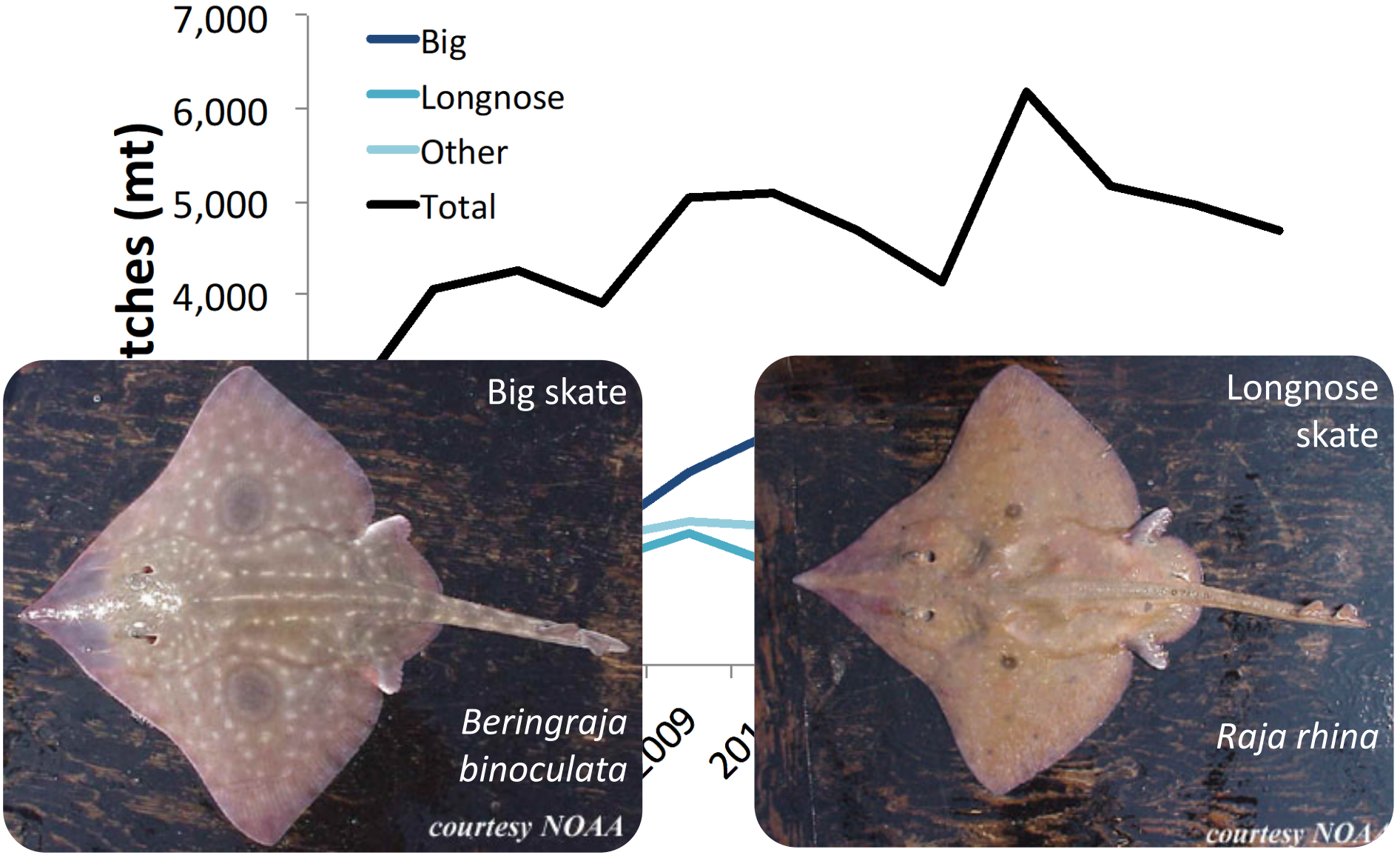
- Chapter 3: Bioeconomic Model
  - Determine most viable harvest strategy of skate fishery
- Chapter 2: Stock Assessment
  - Population dynamics model
- Chapter 1: Ecology
  - Movement patterns and habitat use

Demand for Fishing Opportunities

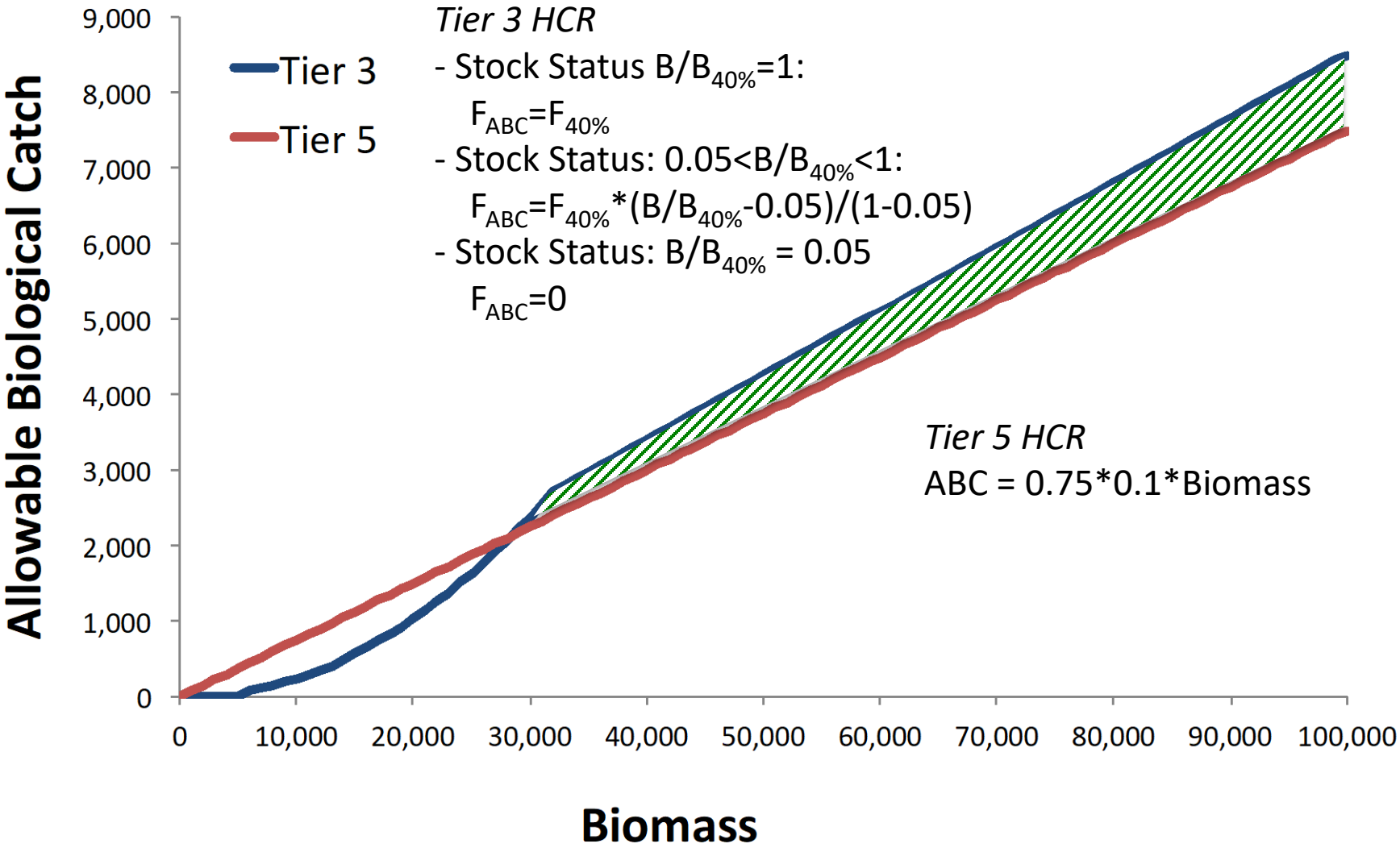


[ADFG COAR data]

GOA-Wide Skate Catches



Benefits of a Stock Assessment



Opportunity and Challenge

- Skates from Alaska: desirable product likely to stay in demand [Farrugia et al, 2015]
  - Revenue for harvesters and processors

- Data limited, tier 5 species [Ormseth, 2015]
  - No formal stock assessment
  - Managed using limited biological and population information

T. Farrugia

Chapter Objective

- How much skate biomass can be harvested each year?
  - Gather/compile data on skates
  - Develop a population dynamics model to be used in formal stock assessments for each species

Methods - Parameterization

- Stock Synthesis v 3.24 [Punt and Maunder, 2013]
  - Flexible, powerful ADMB-based software
  - Useful for data-limited stocks
- Single, GOA-wide population per species [Farrugia et al., 2016]
- Age-structured, 1-sex, 1 growth pattern (von Bert.)
- Beverton-Holt SR model
- Growth and mat parameters from lit. [Ebert et al 2008, Gburski et al 2007]
- Size selectivity modeled as double-normal [Ormseth, 2013] for fisheries and surveys
- 2 fleets (TWL/LGL), 2 surveys (NMFSTWL/IPHCLGL)
- Data from NMFS, AFSC, IPHC

Parameters and Data Sources

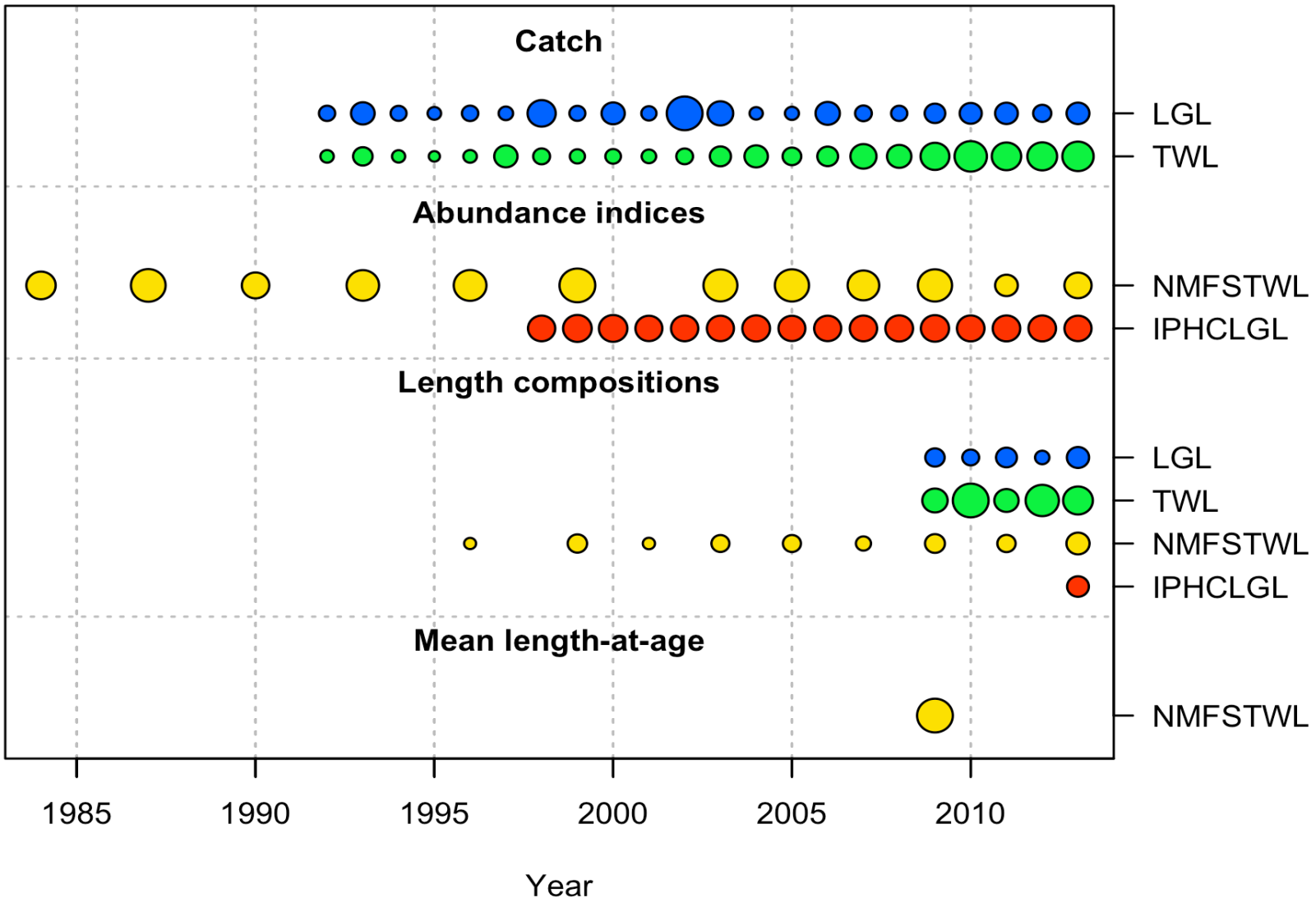
Parameter	Starting value in model	Source
Natural mortality	0.1*	Ormseth, 2015
First age at maturity (yr)	10*	Gburski, 2007; Ebert, 2008
Min length (cm)	30*	Gburski, 2007
Max length (cm)	247.5*	Gburski, 2007
Von Bert K	0.08*	Gburski, 2007
Weight-length scale	$5x10^{-o}$	Farrugia unpublished data
Weight-length exponent	3.1064	Farrugia unpublished data
Maturity curve inflection	148.6	Ebert, 2008
Maturity curve slope	-0.548	Ebert, 2008
Beverton-Holt R0	10*	Gertseva, 2007 (US west coast longnose stock assessment)
Beverton-Holt steepness	0.21*	Gertseva, 2007 (US west coast longnose stock assessment)
Stock-recruitment sigmaR	0.3	Gertseva, 2007 (US west coast longnose stock assessment)
Catchability	1	Ormseth, 2016 (BSAI Alaska skate stock assessment)

* These parameter values were allowed to be estimated within the model.

Methods - Examining Assumptions

- "Preferred" model chosen based on:
  - Highest likelihood
  - Most reasonable life history outputs
- Sensitivity analyses examine influence of individual parameters on model outputs
  - Selectivity curve shape: asymptotic vs. dome
  - Additional discard mortality
  - Recruitment deviation σ_R
  - Catchability parameter

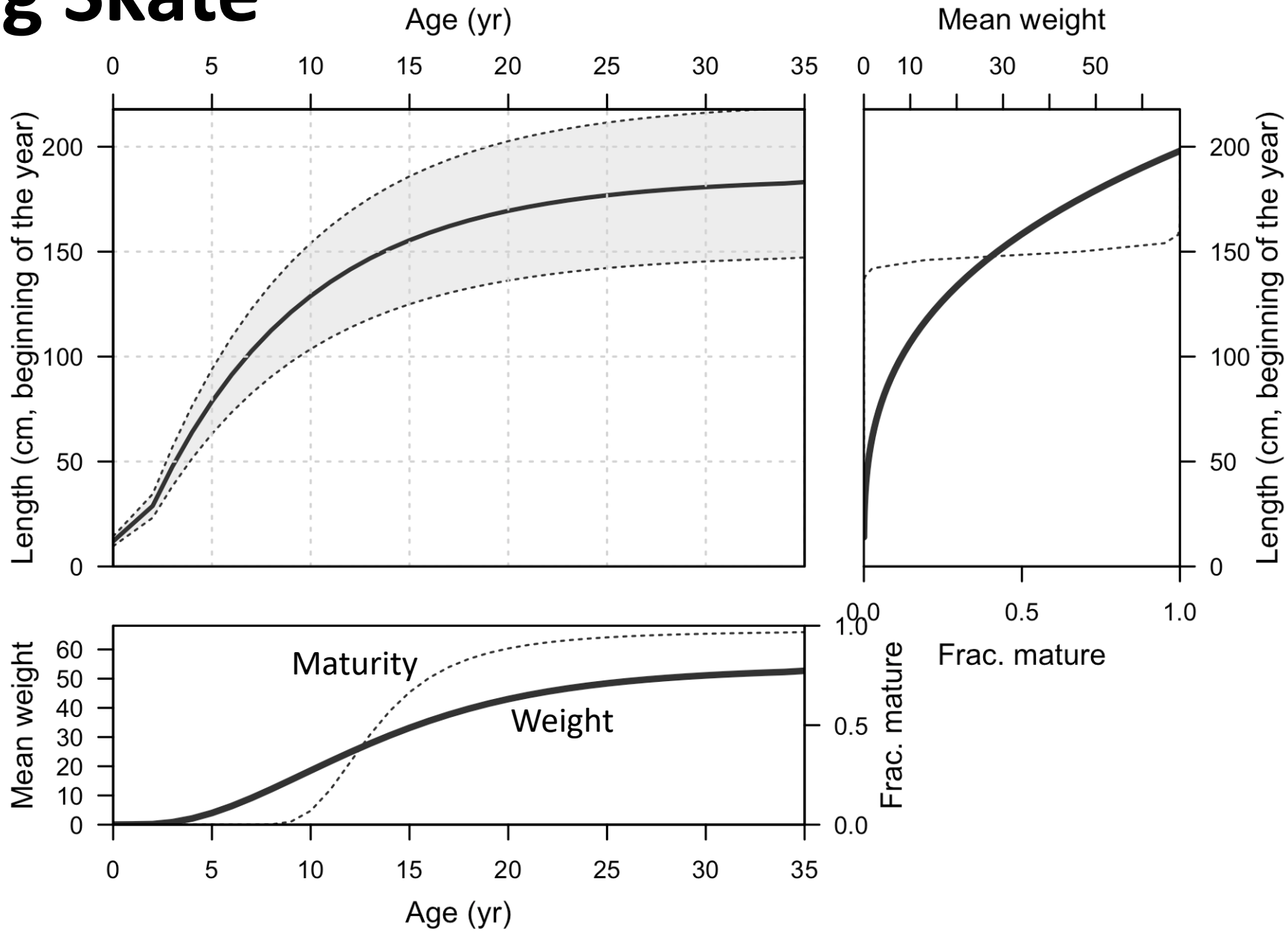
Data Availability



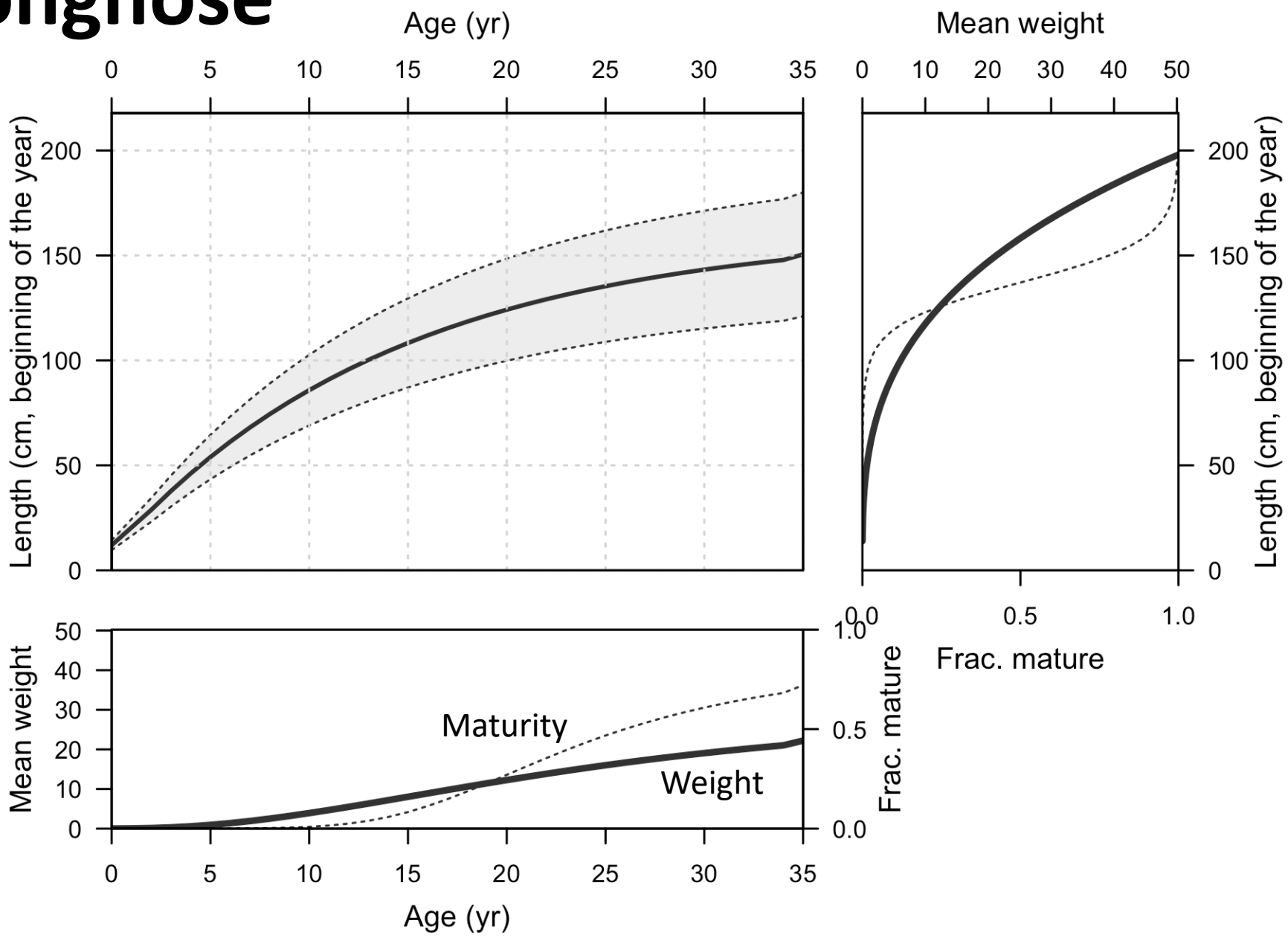
Results

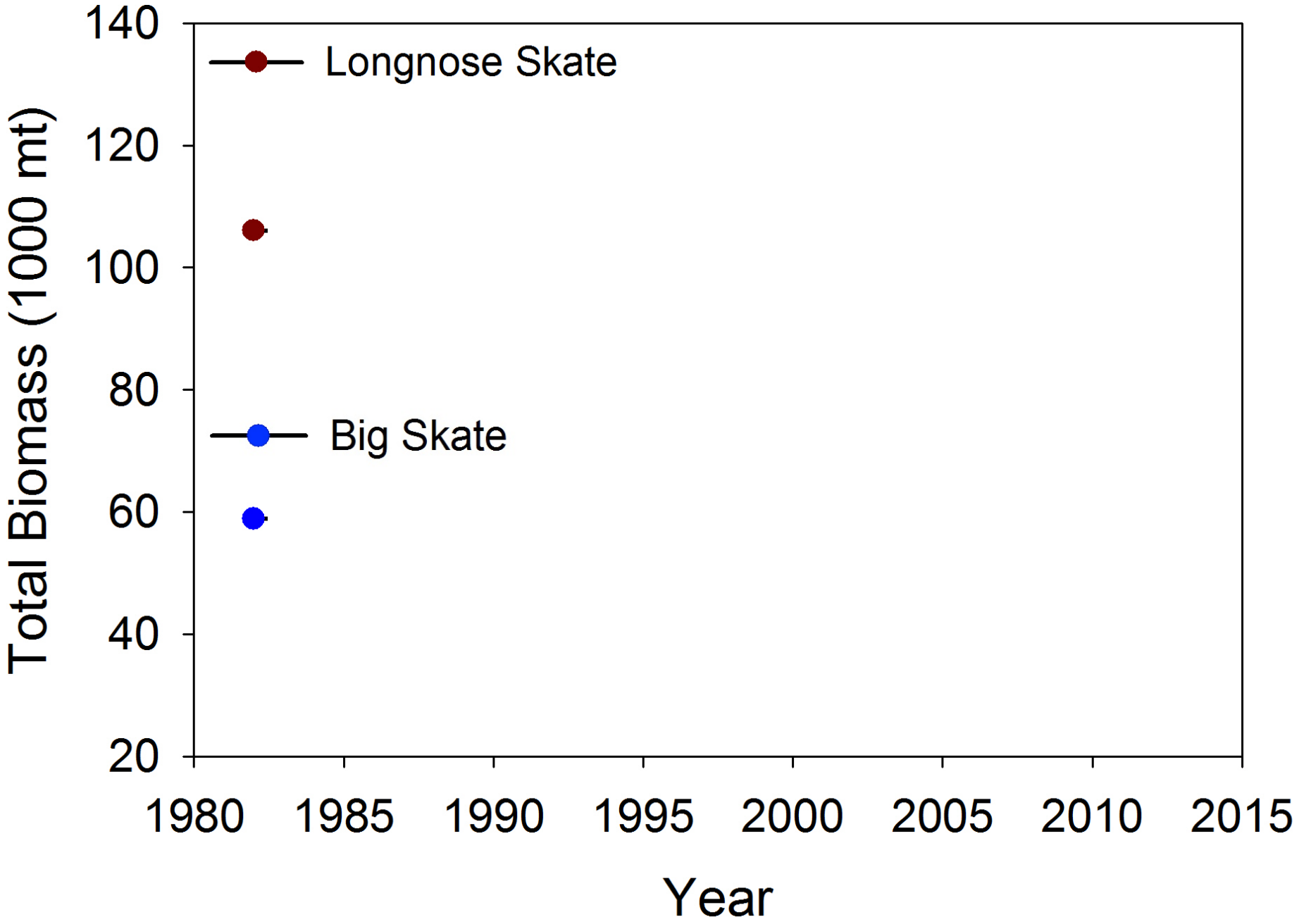
- Successfully produced models for both species
- Life history parameters output consistent with observations
  - Natural mortality ~0.25 for both species [Thompson, 2006]
  - Max length: 185 cm TL for big skates, 162 cm TL for longnose skates [Gburski et al. 2007]
  - von Bert. growth rate (K): 0.13 for big skates, 0.07 for longnose skates [Gburski et al. 2007]

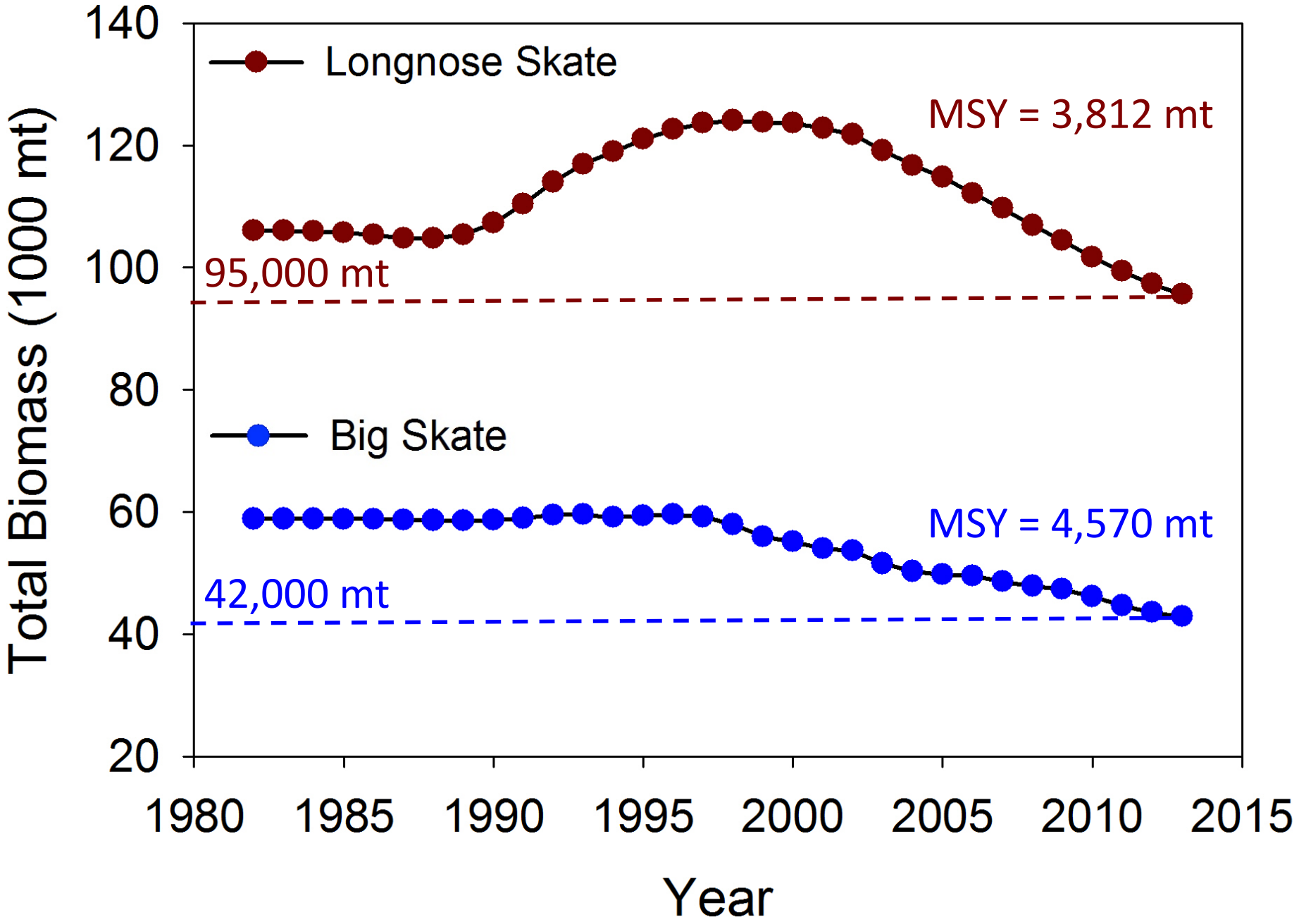
Big Skate

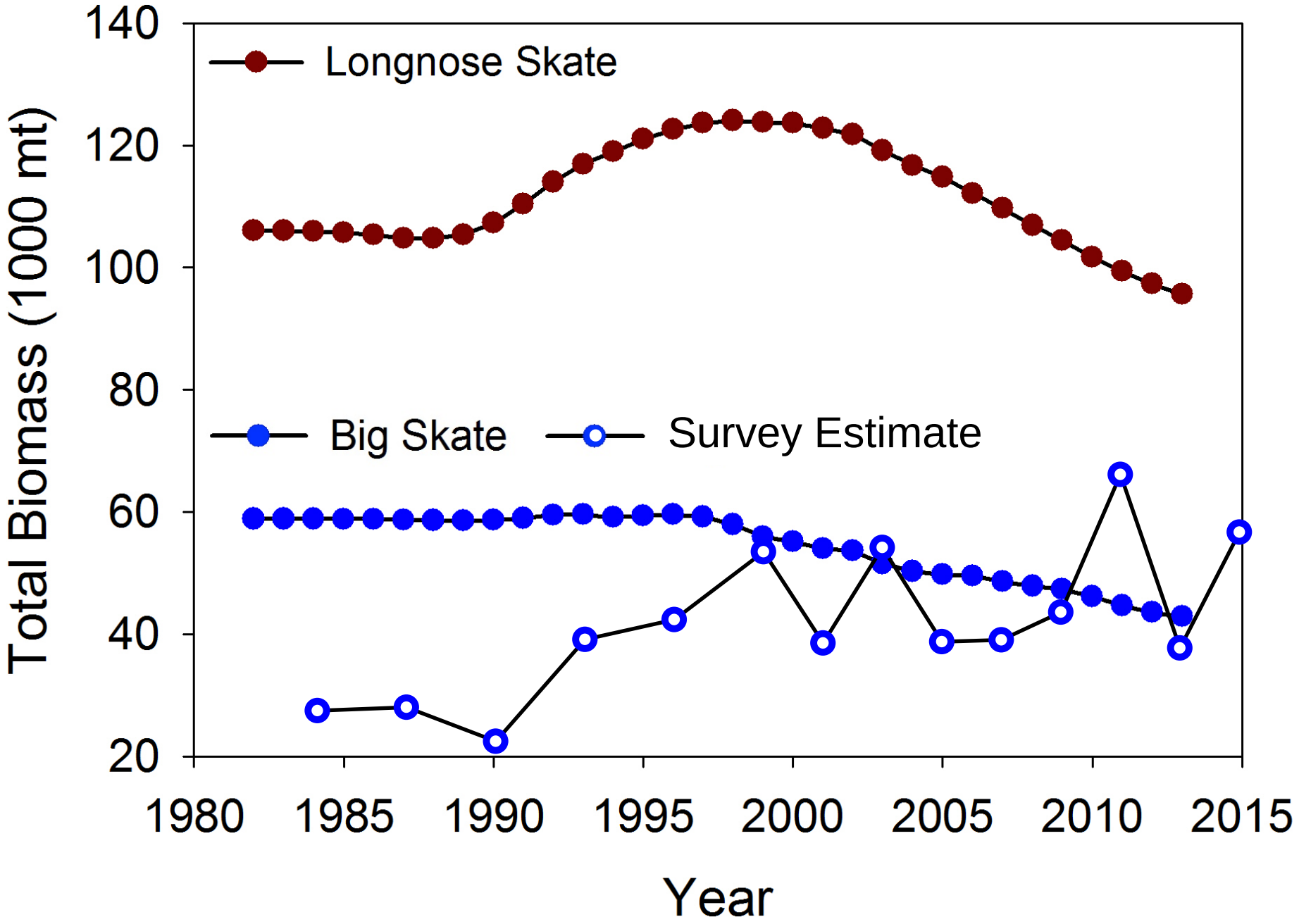

Age (yr)
0
5
10
15
20
25
30
35
Length (cm, beginning of the year)
0
50
100
150
200
Mean weight
0
10
30
50
Length (cm, beginning of the year)
0
50
100
150
200
0.0
0.5
1.0
Frac. mature
Mean weight
0
10
20
30
40
50
60
Maturity
Weight
Frac. mature
0.0
0.5
1.0
0
5
10
15
20
25
30
35
Age (yr)

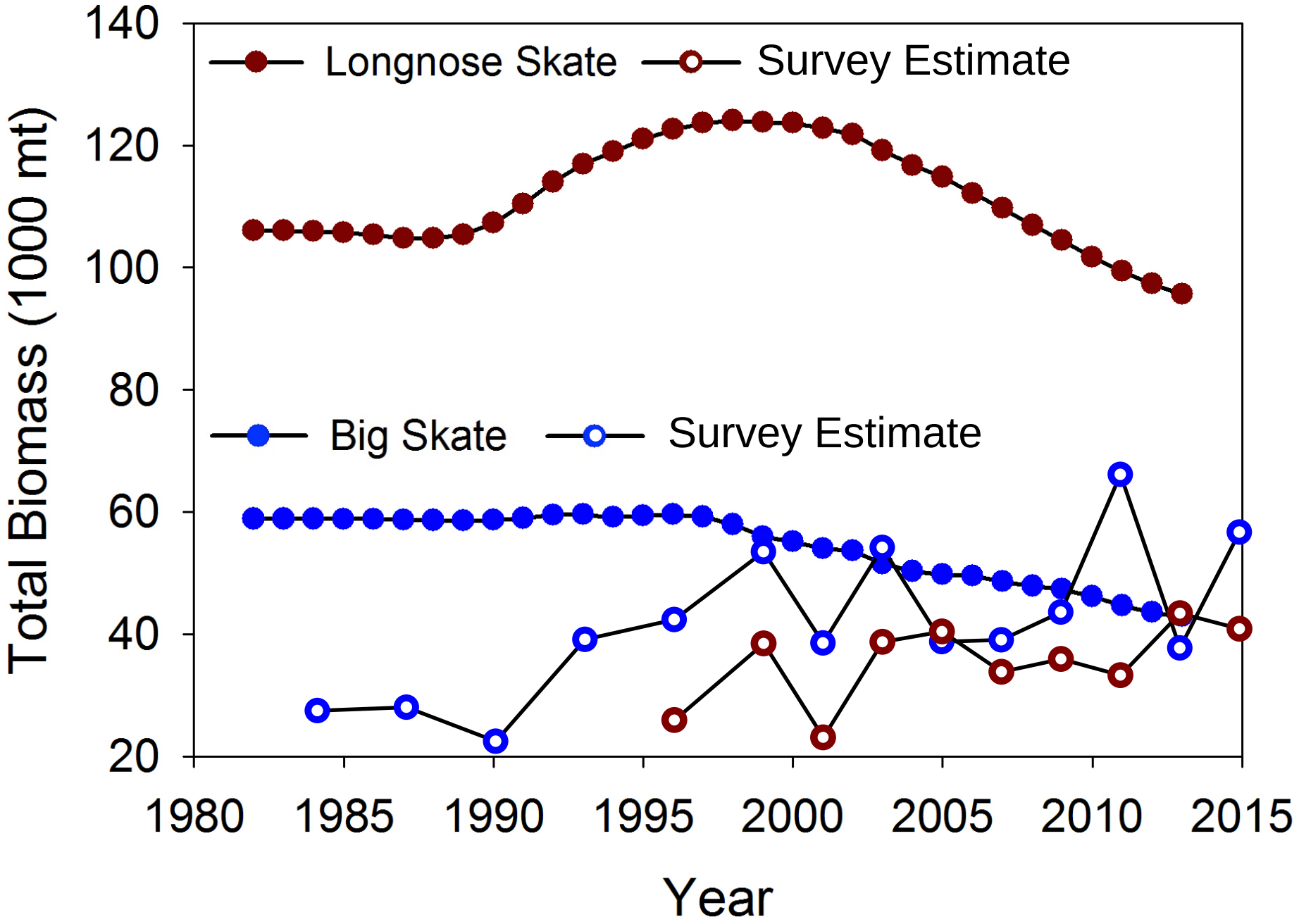
Longnose


Age (yr)
0
5
10
15
20
25
30
35
Length (cm, beginning of the year)
200
150
100
50
0
Mean weight
0
10
20
30
40
50
Length (cm, beginning of the year)
200
150
100
50
0
0.0
0.5
1.0
Frac. mature
Mean weight
50
40
30
20
10
0
Maturity
Weight
Frac. mature
1.0
0.5
0.0
0
5
10
15
20
25
30
35
Age (yr)


Longnose Skate
Big Skate
Total Biomass (1000 mt)
140
120
100
80
60
40
20
1980
1985
1990
1995
2000
2005
2010
2015
Year


Longnose Skate
MSY = 3,812 mt
95,000 mt
Big Skate
MSY = 4,570 mt
42,000 mt
Total Biomass (1000 mt)
Year
140
120
100
80
60
40
20
1980
1985
1990
1995
2000
2005
2010
2015

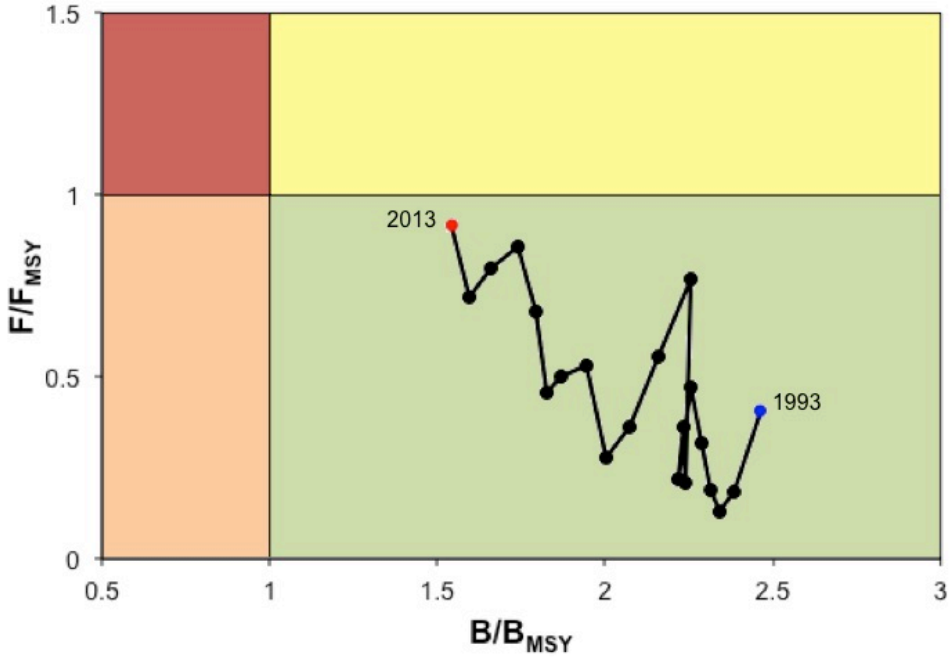

Longnose Skate
Big Skate
Survey Estimate
Total Biomass (1000 mt)
140
120
100
80
60
40
20
1980
1985
1990
1995
2000
2005
2010
2015
Year


Longnose Skate
Survey Estimate
Big Skate
Survey Estimate
Total Biomass (1000 mt)
140
120
100
80
60
40
20
1980
1985
1990
1995
2000
2005
2010
2015
Year

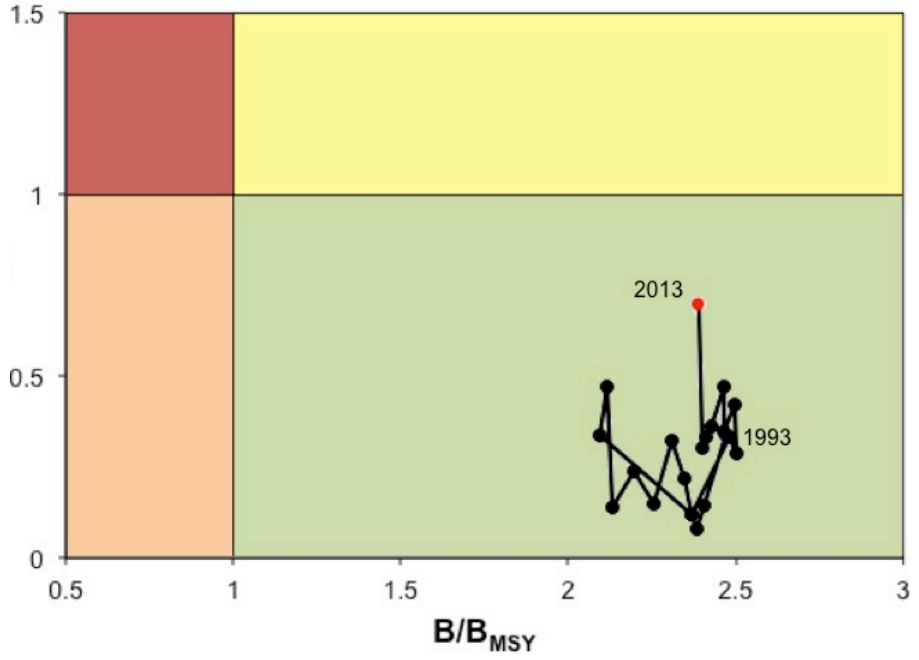
Biological Reference Points

- Biomass ratio = current biomass/B_{MSY}

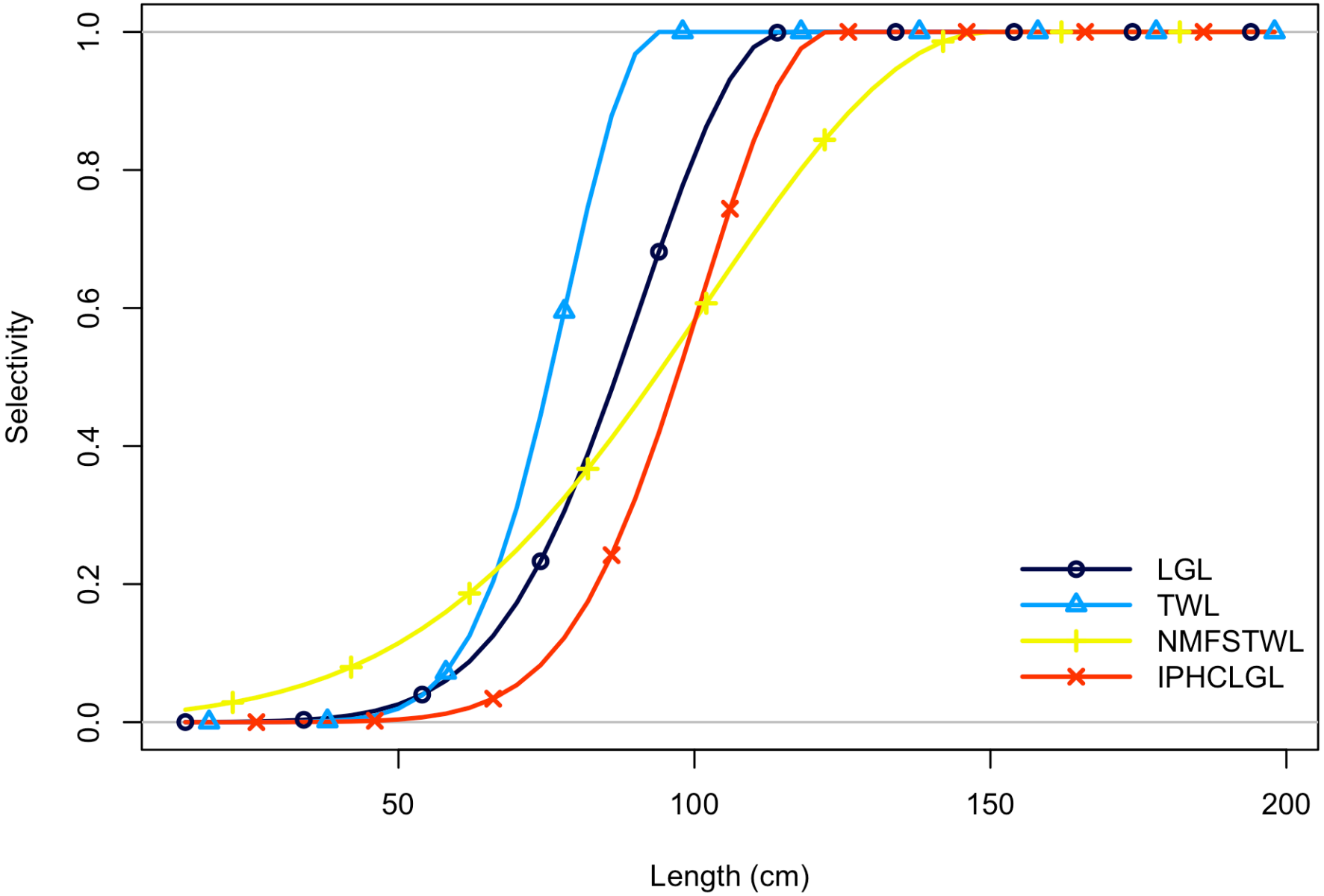
Big skate > 1



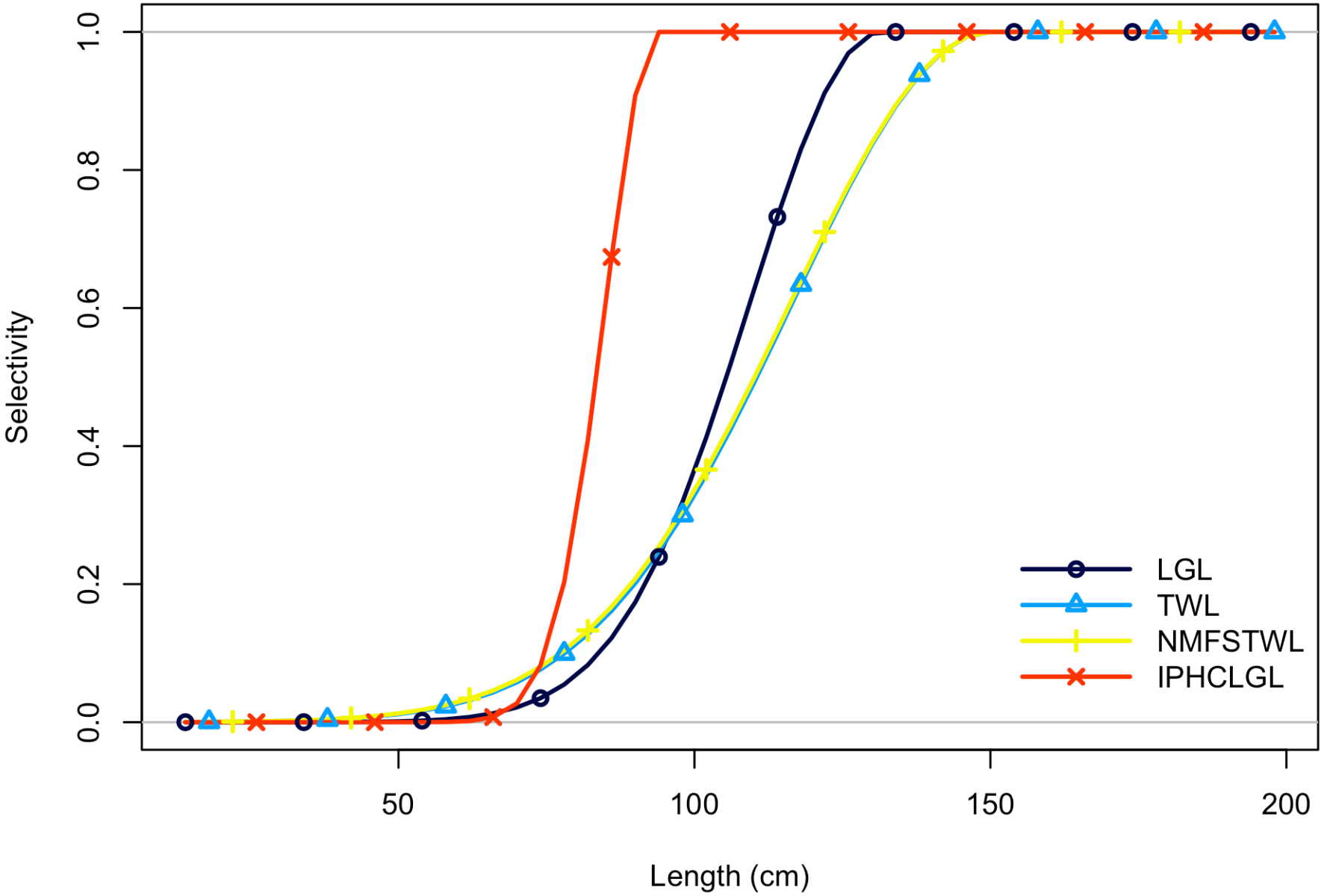
Longnose skate > 2



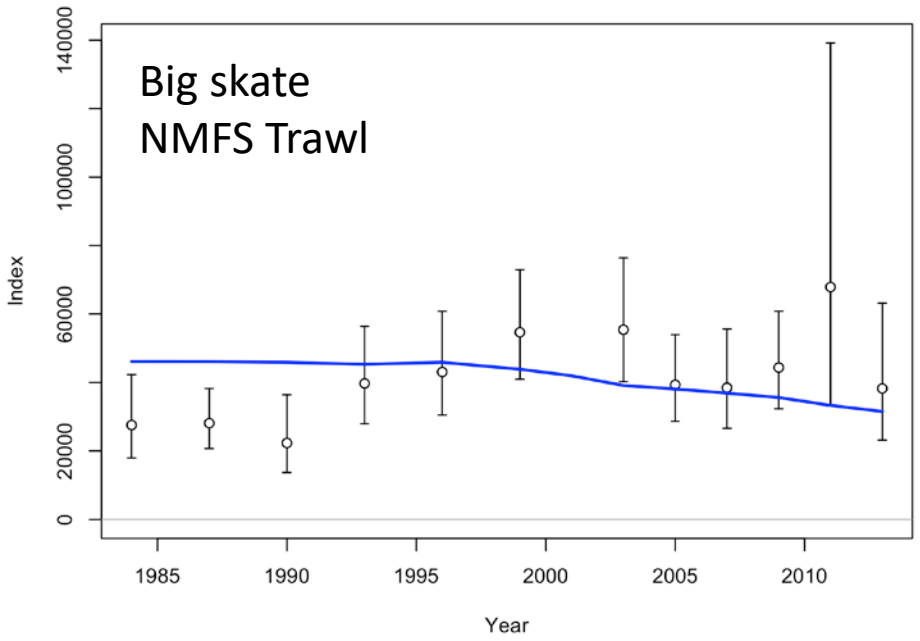
Selectivity of Big Skates at Length for Fleets

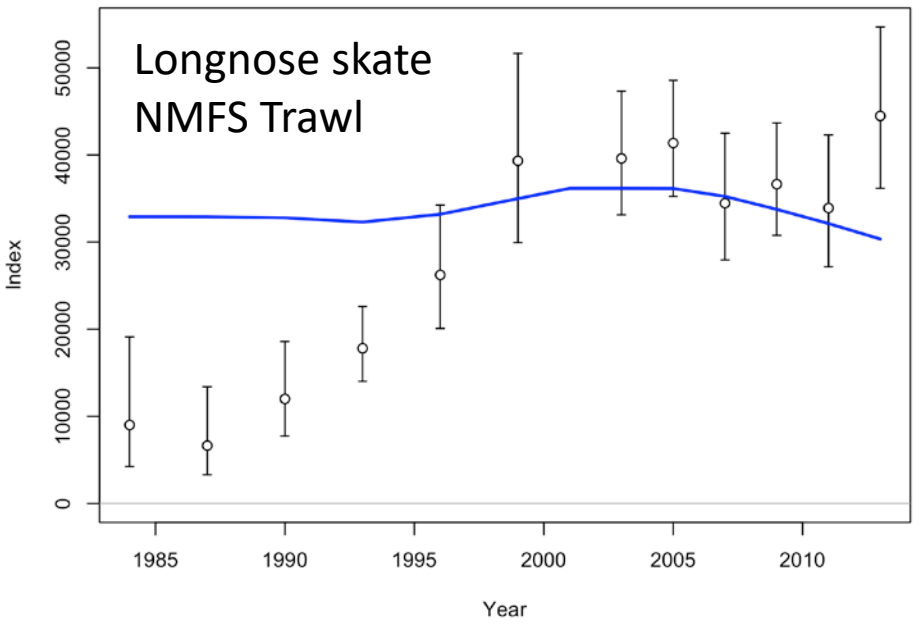


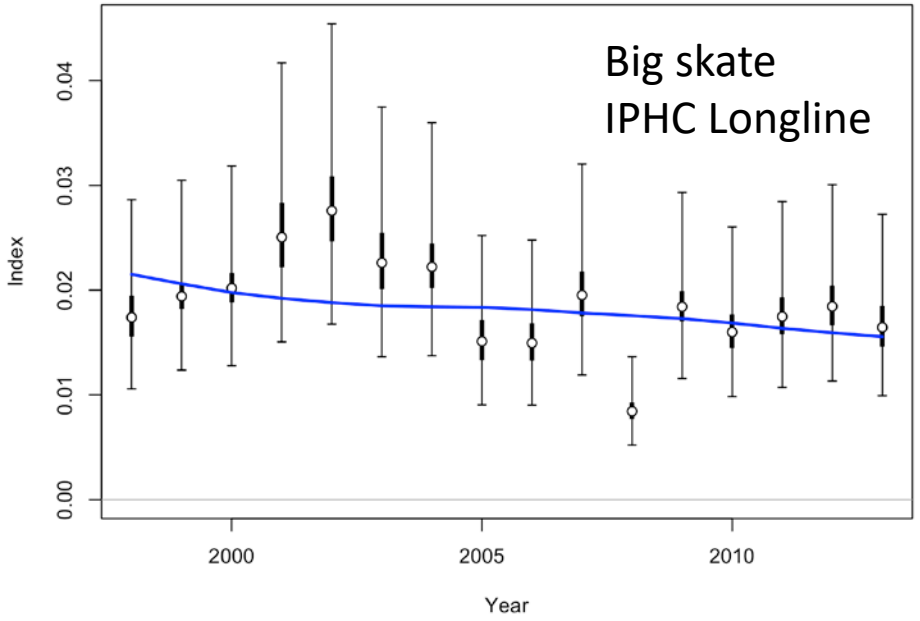
Selectivity of Longnose Skates at Length for Fleets

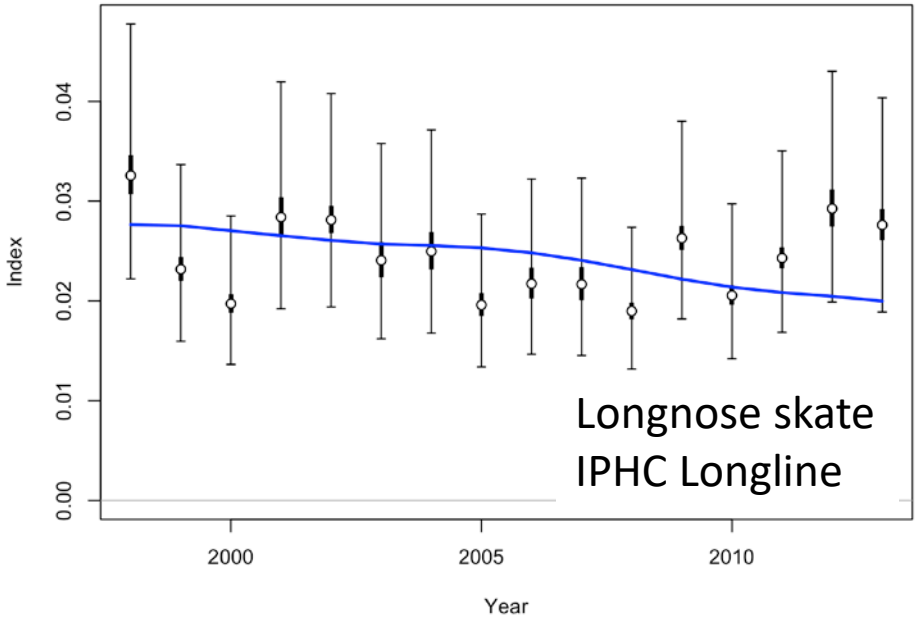


Fit to index data (±95% uncertainty interval)

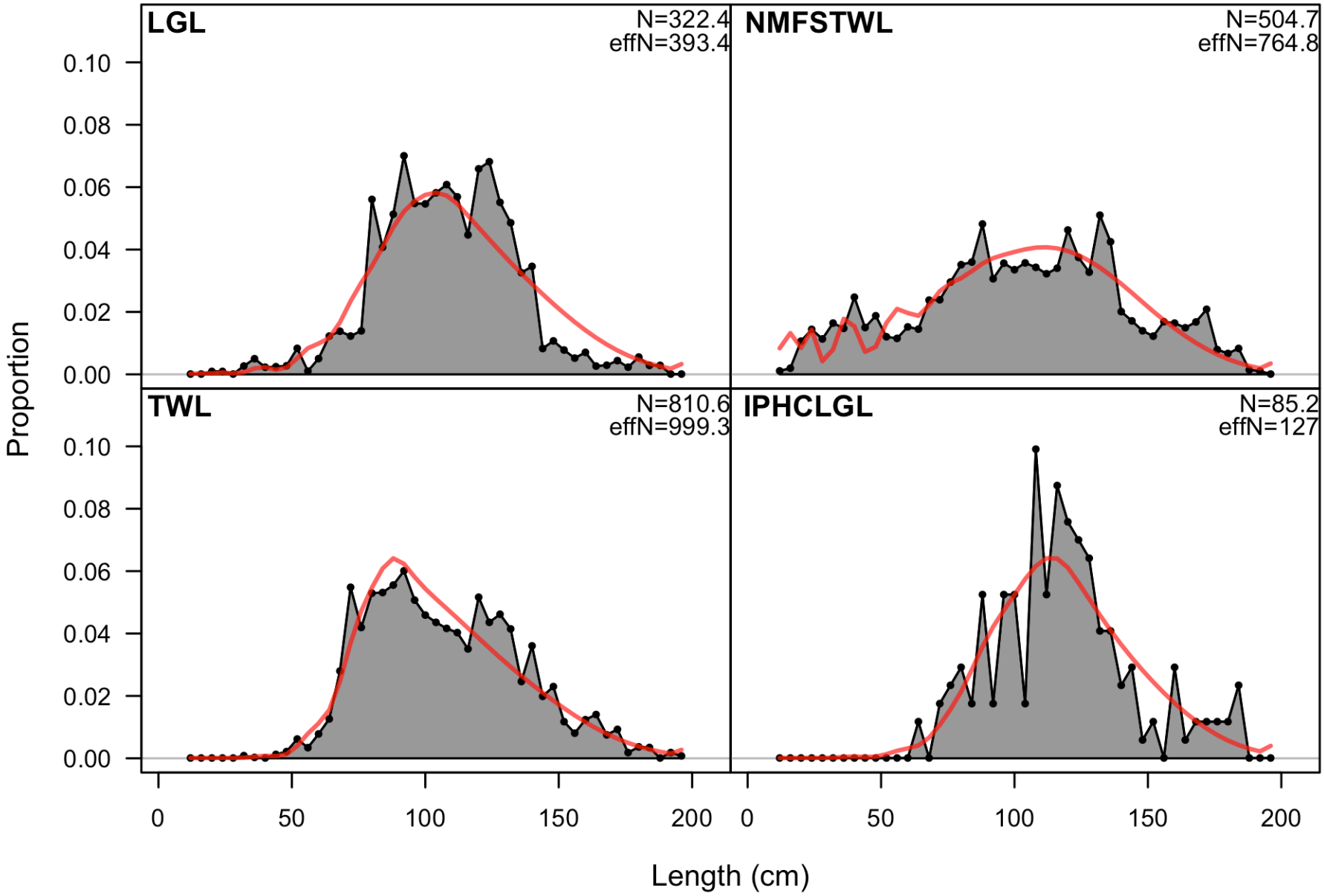




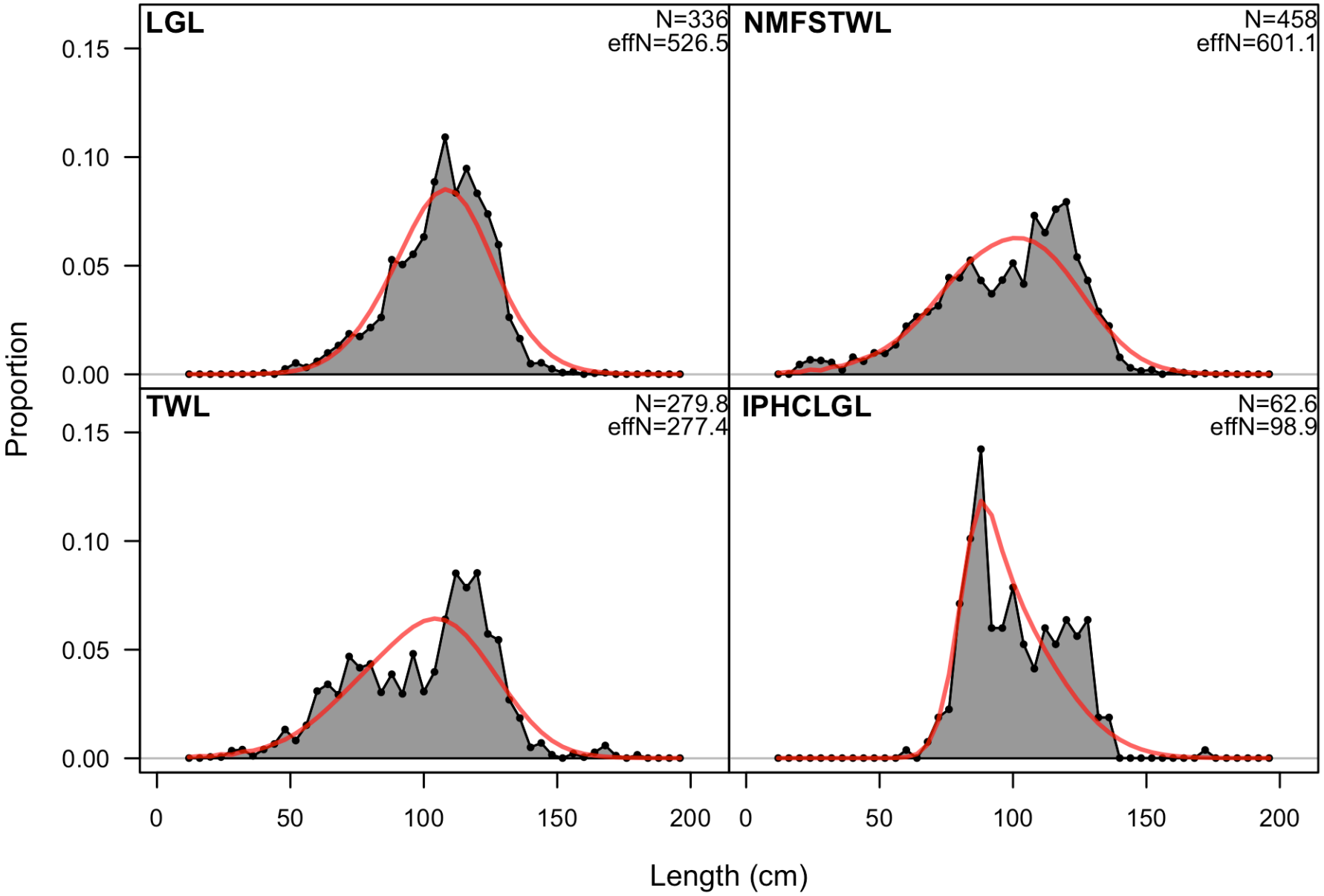




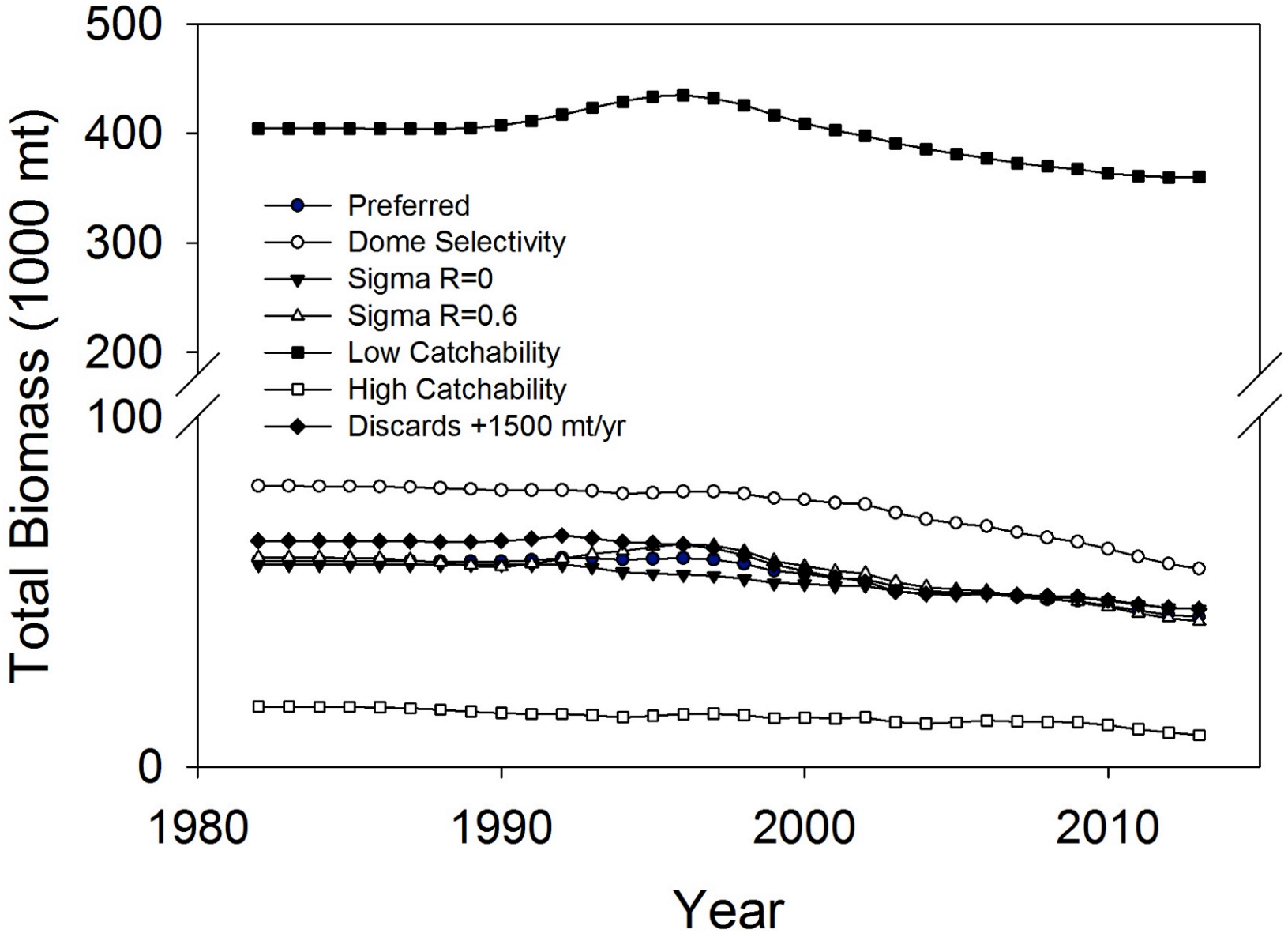
Length Compositions for Retained Big Skates



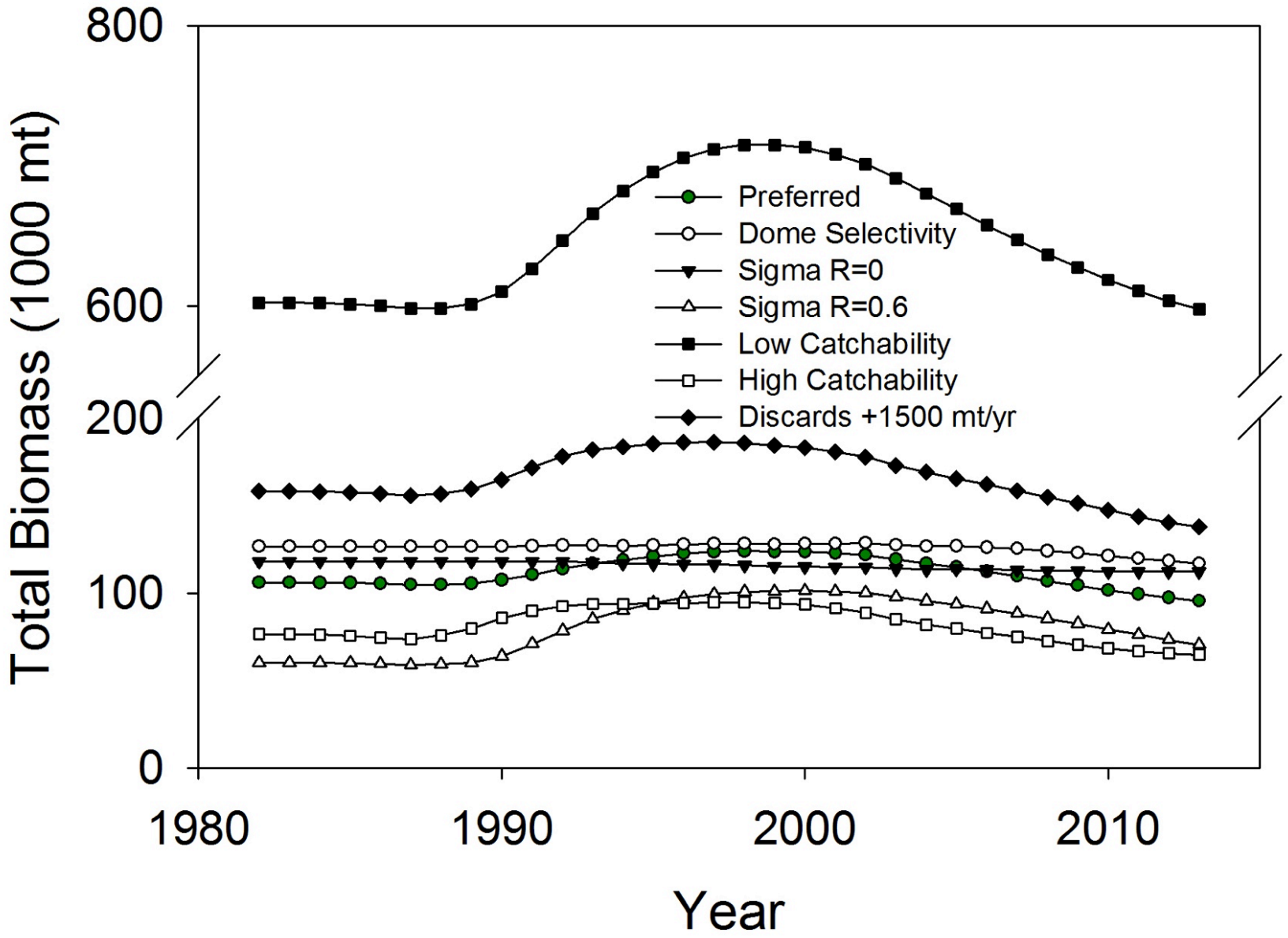
Length Compositions for Retained Longnose Skates

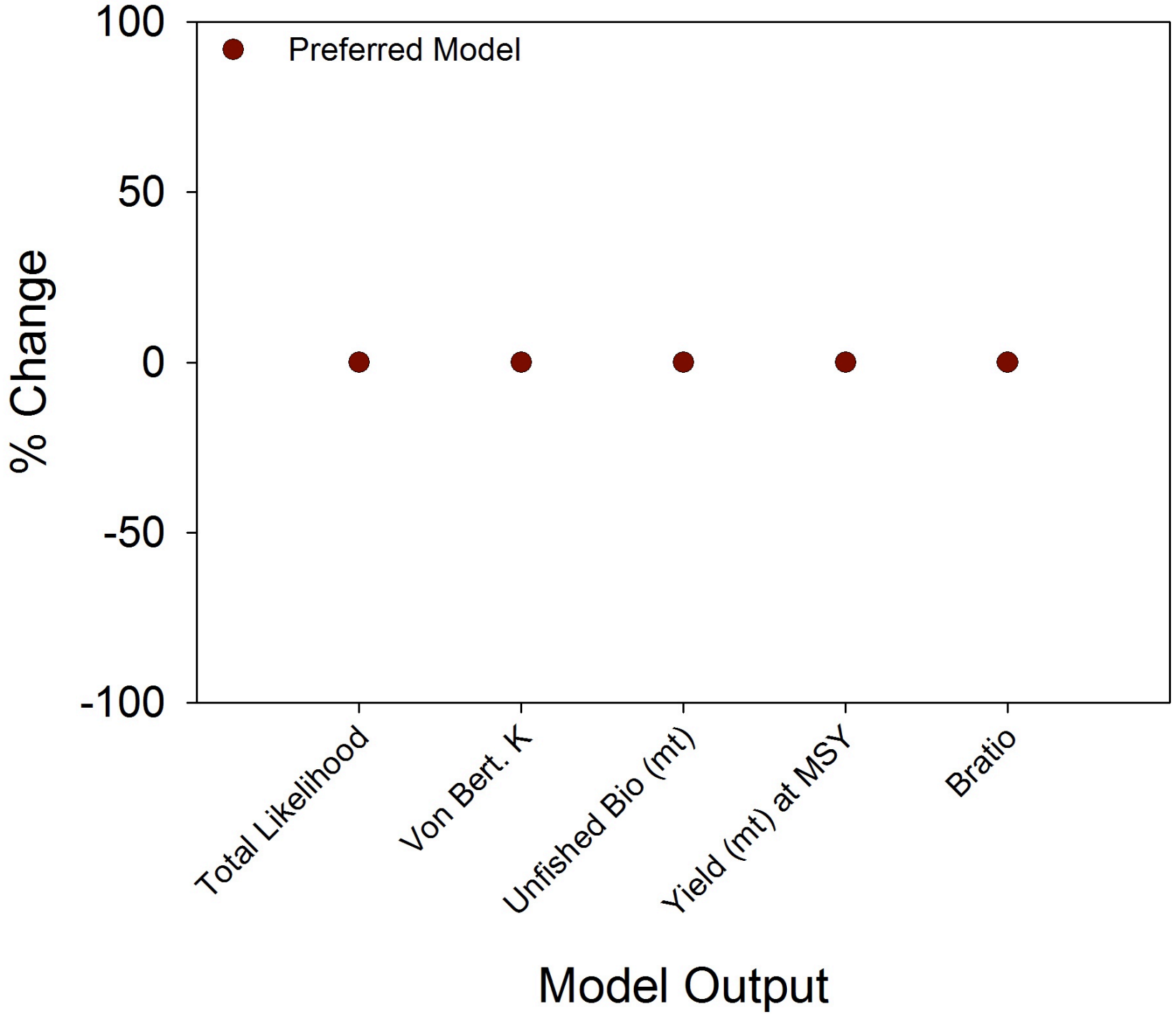


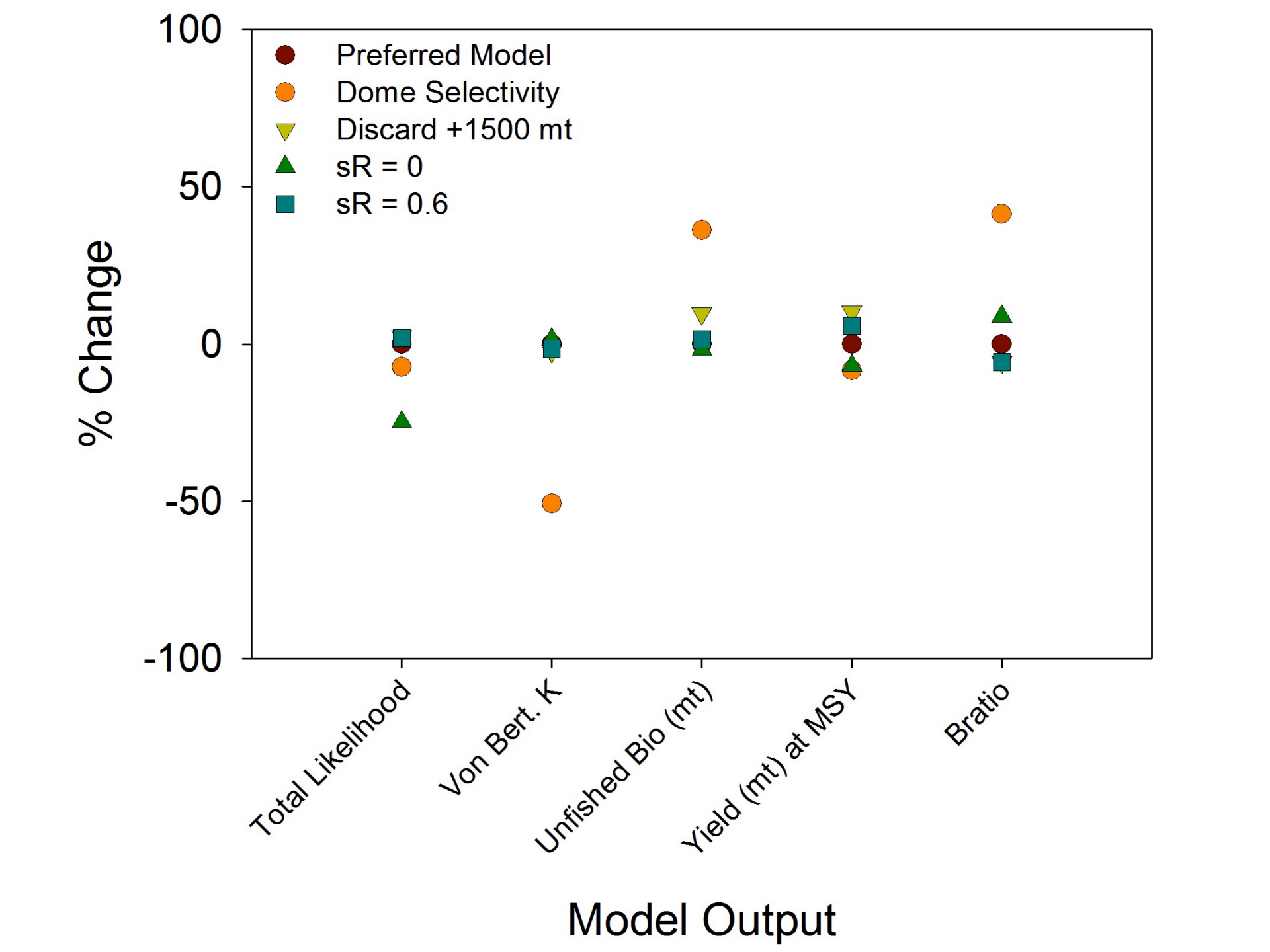
Big Skate Models Comparison

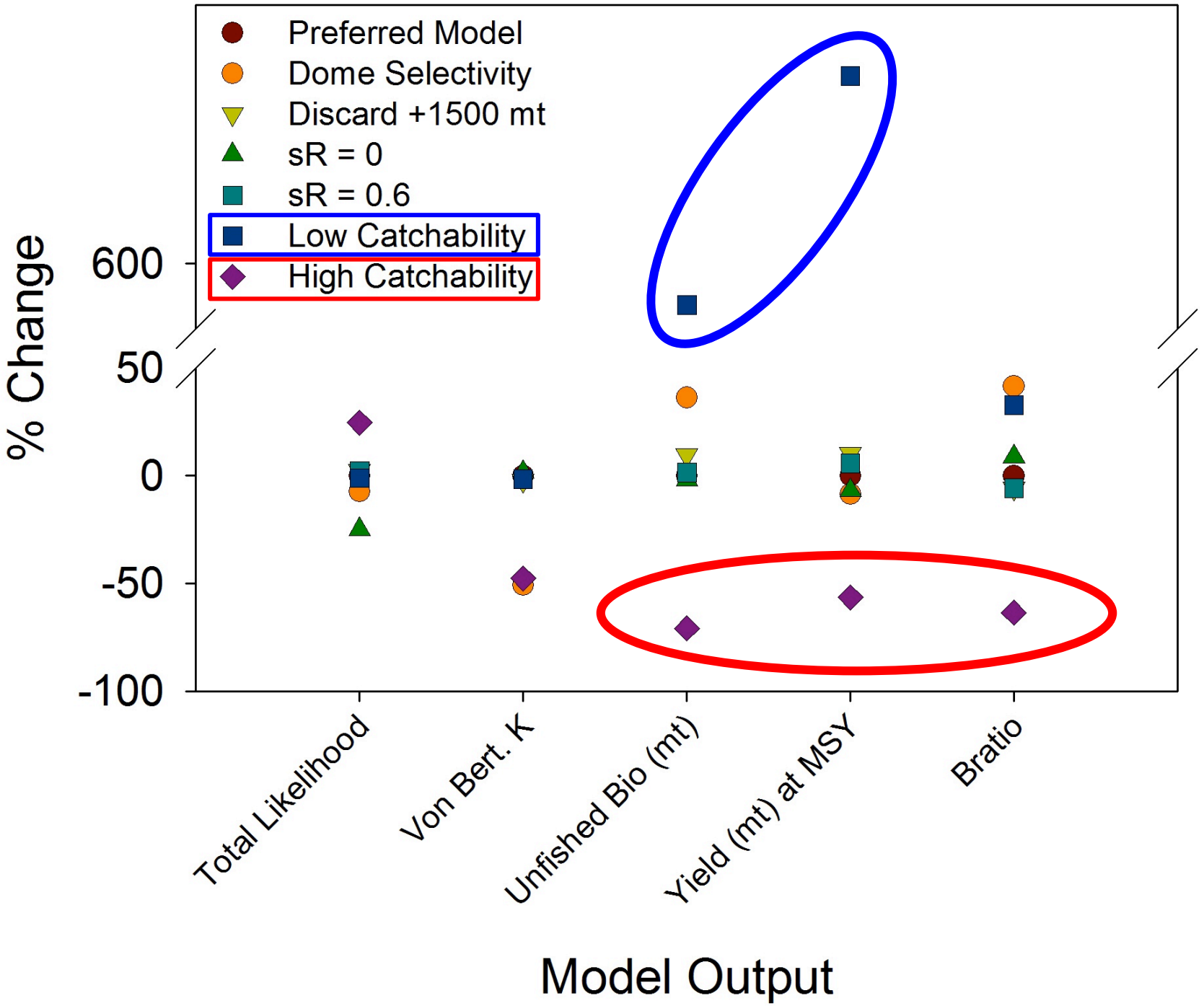


Longnose Models Comparison

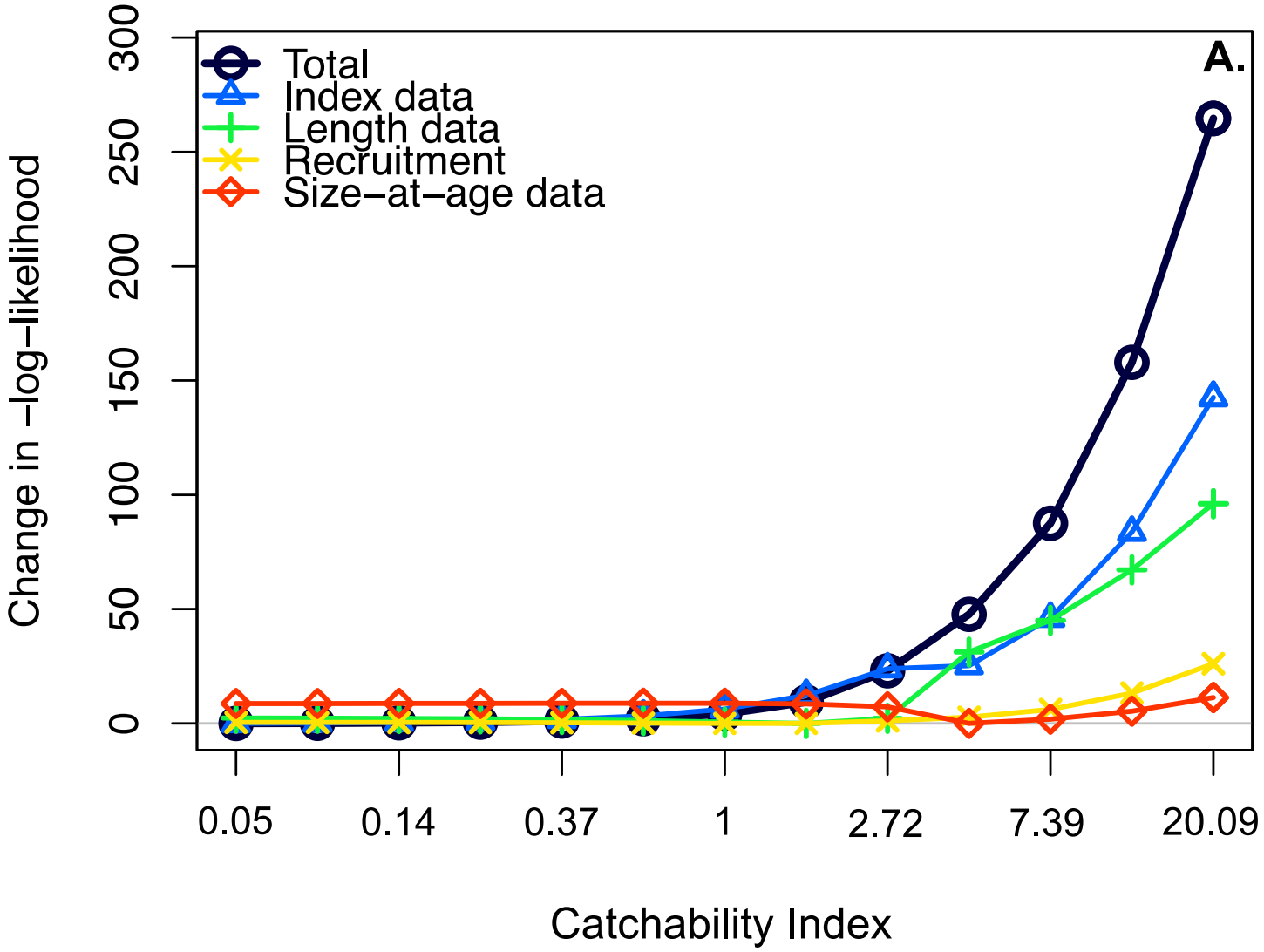



Preferred Model
100
50
0
-50
-100
% Change
Total Likelihood
Von Bert. K
Unfished Bio (mt)
Yield (mt) at MSY
Bratio
Model Output

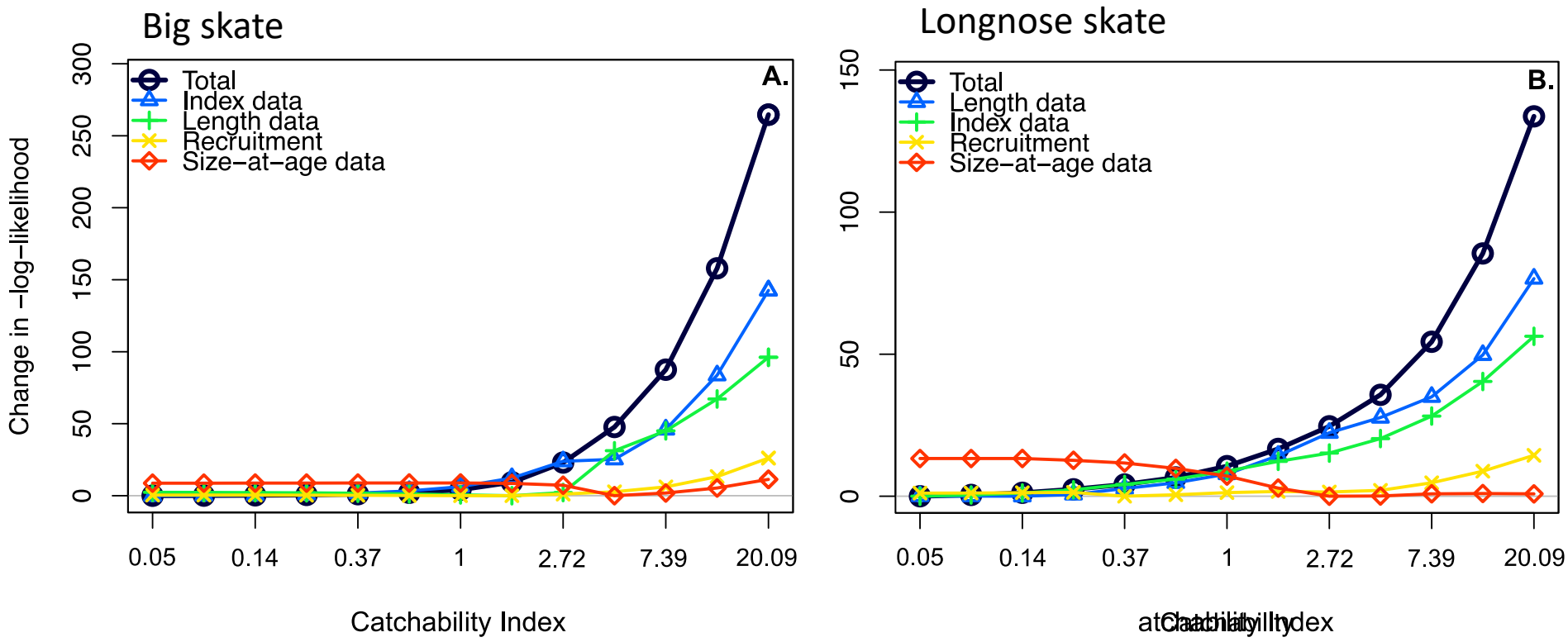

Preferred Model
Dome Selectivity
Discard +1500 mt
sR = 0
sR = 0.6
100
50
0
-50
-100
% Change
Total Likelihood
Von Bert. K
Unfished Bio (mt)
Yield (mt) at MSY
Bratio
Model Output


Preferred Model
Dome Selectivity
Discard +1500 mt
sR = 0
sR = 0.6
Low Catchability
High Catchability
% Change
600
50
0
-50
-100
Total Likelihood
Von Bert. K
Unfished Bio (mt)
Yield (mt) at MSY
Bratio
Model Output

Catchability Likelihood Profile



Catchability Likelihood Profile



SS3 model results vs. current specifications

Big skate (*Beringraja binoculata*)		
Quantity	Current Specs (RE biomass model & Tier 5)	Farrugia SS3 model
M (natural mortality)	0.1	0.256
Biomass (t)	50,857	42,894
OFL/MSY (t)	5,086	4,570

Longnose skate (*Raja rhina*)		
Quantity	Current Specs (RE biomass model & Tier 5)	Farrugia SS3 model
M (natural mortality)	0.1	0.246
Biomass (t)	42,737	95,607
OFL/MSY (t)	4,274	3,812

Conclusions

- Available data not optimal, but sufficient to develop simple stock assessments
  - Crucial to management and development of fishery
- Next steps:
  - Share the model data and files with AFSC
  - Extend time series
    - Integrate changes in observer coverage after 2013
  - Survey index not matching model estimate
  - Catchability parameter
  - Reproductive biology
    - Fecundity, recruitment
  - Discard rate and mortality

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- Julie Bonney (AGDB)
- Torie Baker (MAP)
- Quentin Fong (MAP)
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- Ginny Eckert (UAF, MESAS)
- Terry Quinn (UAF)
- Jackie Knue (DEC)
- Lara Horstmann (UAF)
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- Cathy Tide (NMFS)
- Chris Gburski (AFSC)
- Alex Oliveira (KSMSC)
- Mike Byerly, Chris Russ, Elisa Russ (ADFG)
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- Northern Gulf of Alaska Applied Research Award

Questions/Comments?