DRAFT
Pribilof Island Golden King Crab 2023 Assessment

CPT Jan 2023

2020 Assessment Recap

Ben Daly presented

- Status quo Tier 5 assessment (total catch)
- Tier 4 assessment (RE model / slope survey)

CPT Recommended Tier 5 assessment

- Issues with lack of direct MMB estimates for early slope survey
- Lack of documentation surrounding RE model

SAFE Report

CPT Report May 2020

Response to Comments, 2020

CPT: "*Continue to explore the existence of 2004 survey size composition data.*"

We were unable to recover new 2004 survey data.

CPT: "*Improve CV calculations for 2002 and 2004 MMB estimates.*"

CVs were computed using variance of the multiplication of two random variables.

CPT: "*Explore a simplified GMACS model.*"

We were unable to explore a GMACS model during this reporting period, but are gathering data for future efforts.

Response to Comments, 2020

SSC: "*For the next full assessment, the SSC requests the authors provide three assessment alternatives:*

- *The current Tier 5 assessment methodology*.
- *A Tier 4 assessment. A key issue with the Tier 4 approach will be selecting an appropriate BMSY proxy and determining whether the estimates of biomass are sufficiently reliable to warrant a Tier 4 status for the stock…*
- *A Tier 5 methodology that uses Tier 4 methods for calculating the OFL/ABC. This approach would use the historical EBS slope survey estimates (based on a reference period) and use F=M for OFL calculation (or perhaps a different F value)…"*

We present all three options in this document and appendices.

Response to Comments, 2020

SSC: "*The SSC notes that assessing trends in catch is not currently possible because of confidential data. The SSC recommends that the authors consider rescaling catch across years (e.g., min/max or z-score) such that relative catch trends could potentially be displayed without violating confidentiality rules.*"

We were advised by ADF&G staff not to do so as catch numbers could be reasonably approximated given the trend and known values of non-confidential seasons.

Response to Comments, 2020

SSC: "*For the assessment alternatives using a survey reference period, the SSC recommends the authors and CPT provide a rationale for the preferred reference period, and clearly specify the objective associated with the chosen period (e.g., target the current productivity regime or the range of potential productivity).*"

For tier 4 calculations in Appendix A, we chose to use all the survey years available for two reasons:

- 1) survey data is limited to only 4-6 years over a 14 year time period, and
- 2) this is the best available fishery independent data to capture the range of potential productivity of the stock.

Response to Comments, 2020

- **SSC:** "*The SSC supports the CPT recommendation to evaluate EBS slope survey variance for the early survey years (2002 and 2004) and to continue investigating whether additional length and sex composition data are available for 2004*"

We were unable to recover additional biological data for 2002 and 2004, but variance in MMB proxies are now computed as suggested by the CPT.

Response to Comments, 2020

- **SSC:** "*The SSC supports continued efforts by ADF&G to coordinate with industry to conduct a pot survey, and reiterates its past recommendation to explore VAST model fits to the EBS slope survey data, recognizing that this method may not be successful given the spatial characteristics of the survey.*"

We were unable to explore VAST model fits during this reporting period.

Response to Comments, 2020

- **SSC:** *"The SSC recommends the authors and CPT consider whether the Aleutians Islands estimate of M (0.21) is appropriate for the PIGKC stock (M=0.18)."*

We acknowledge that a species-specific estimate of natural mortality is likely appropriate and both values of *M* are considered in Tier 4 calculations (Appendix A).

Tier 5 Approach

$$\mathrm{OFL} = (1 + R)RET + BM_{NC} + BM_{GF}$$

R = average of the estimated ratio of bycatch mortality to retained catch in the directed fishery during 2001-2010

RET = average annual retained catch in the directed crab fishery during 1993-1998

BM_{NC} = estimated average bycatch mortality in non-directed crab fisheries during 1994–1998 (snow/grooved Tanner)

BM_{GF} = estimated average bycatch mortality in groundfish fisheries during 1992/93-1998/99.

Changes to Tier 5 Approach

Updated crab bycatch timeseries (Daly, May CPT 2021)

Bycatch (t) = CPUE (crab/pot) x Effort (fishery) x Avg Wt (t)

Use average weight for group (sublegal, female, legal) in timeseries when no crab are caught in count pots

$$Wt = A \times CL^{B}$$

	A	B	Source
Male	0.0002712	3.168	ADF&G (fishery)
Female	0.0014240	2.781	FMP

Table 9

Year	Crab Season	$RET_{1993-1998}$	$R_{2001-2010}$	$BM_{NC,1994-1998}$	$BM_{GF,92/93-98/99}$
1993	1993/94	30.6			8.84
1994	1994/95	CF		0.61	7.97
1995	1995/96	155.09		9.05	2.71
1996	1996/97	149.24		3.65	1.73
1997	1997/98	81.31		2.34	0.71
1998	1998/99	CF		20.30	1.07
1999	1999/00				3.53
2000	2000/01				
2001	2001/02		0.058		
2002	2002/03		0.086		
2003	2003/04		CF		
2004	2004/05		CF		
2005	2005/06		CF		
2006	2006/07				
2007	2007/08				
2008	2008/09				
2009	2009/10				
2010	2010/11		CF		
	N	6	6	5	7
	Mean	78.80	0.063	7.19	3.79
	SE	24.84	0.005	3.57	1.25
	CV	0.32	0.08	0.50	0.33

Tier 5 Reference Points

$$\mathrm{OFL} = (1 + R)RET + BM_{NC} + BM_{GF}$$

94.7 t = (1 + 0.063) 78.80 t + 7.19 t + 3.79 t

$$\mathrm{ABC} = (1 - 0.25)\ \mathrm{OFL}$$ (75% buffer)

71.1 t = (1 – 0.25) 94.7 t

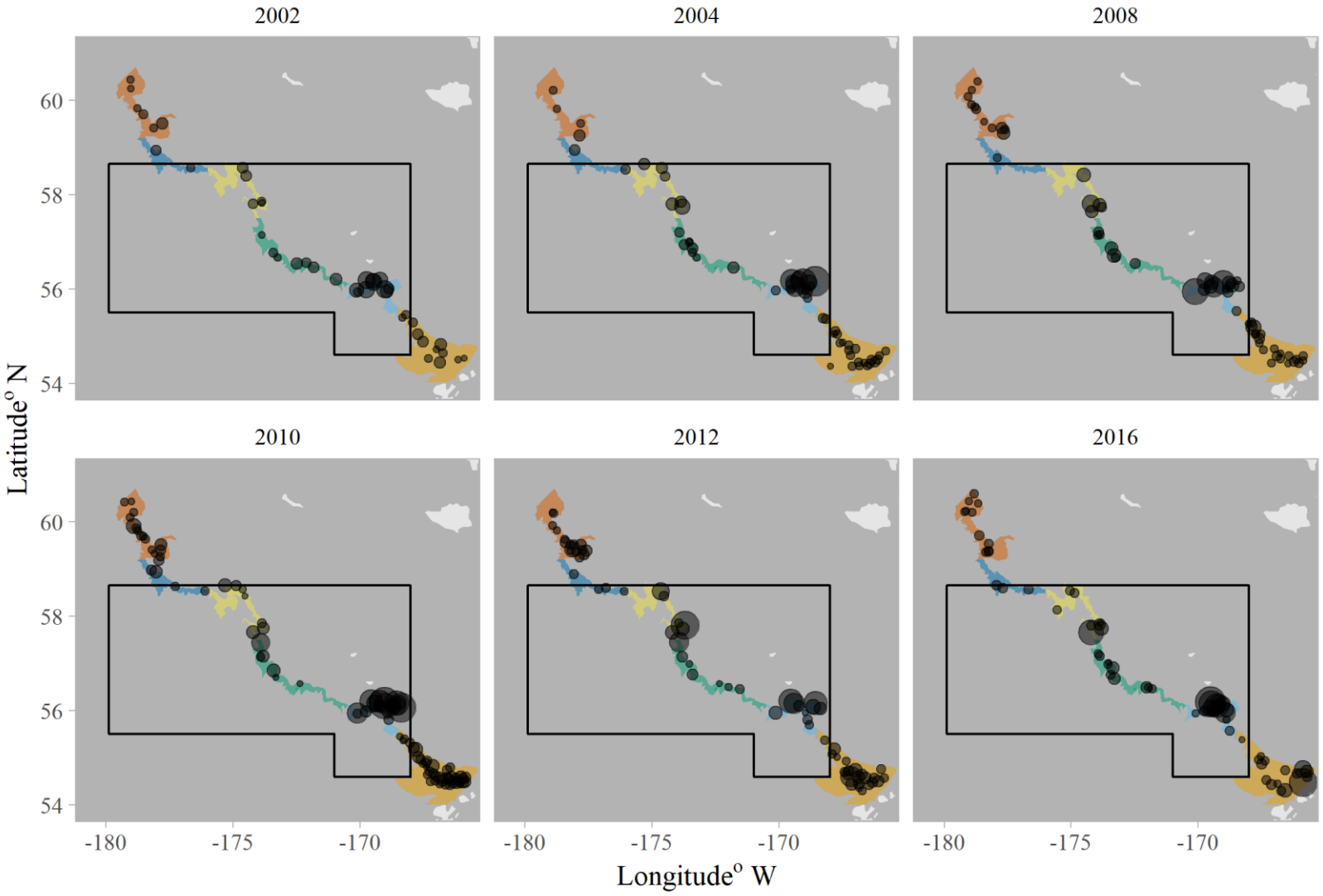
Tier 4 Approach (Appendix A)

The Tier 4 OFL is calculated using the F_{OFL} control rule (SAFE Intro):

$$F_{OFL} = \begin{cases} 0, & \frac{MMB}{B_{MSY}} \geq 0.25 \\ M\left(\frac{MMB}{B_{MSY}} - \alpha\right)(1-\alpha)^{-1}, & 0.25 < \frac{MMB}{B_{MSY}} < 1 \\ M, & MMB > B_{MSY} \end{cases}$$

- M = 0.18 yr^{-1} or 0.21 yr^{-1}
- MMB and B_{MSY} are estimated from NMFS-AFSC Slope Survey

NMFS-AFSC Slope Survey

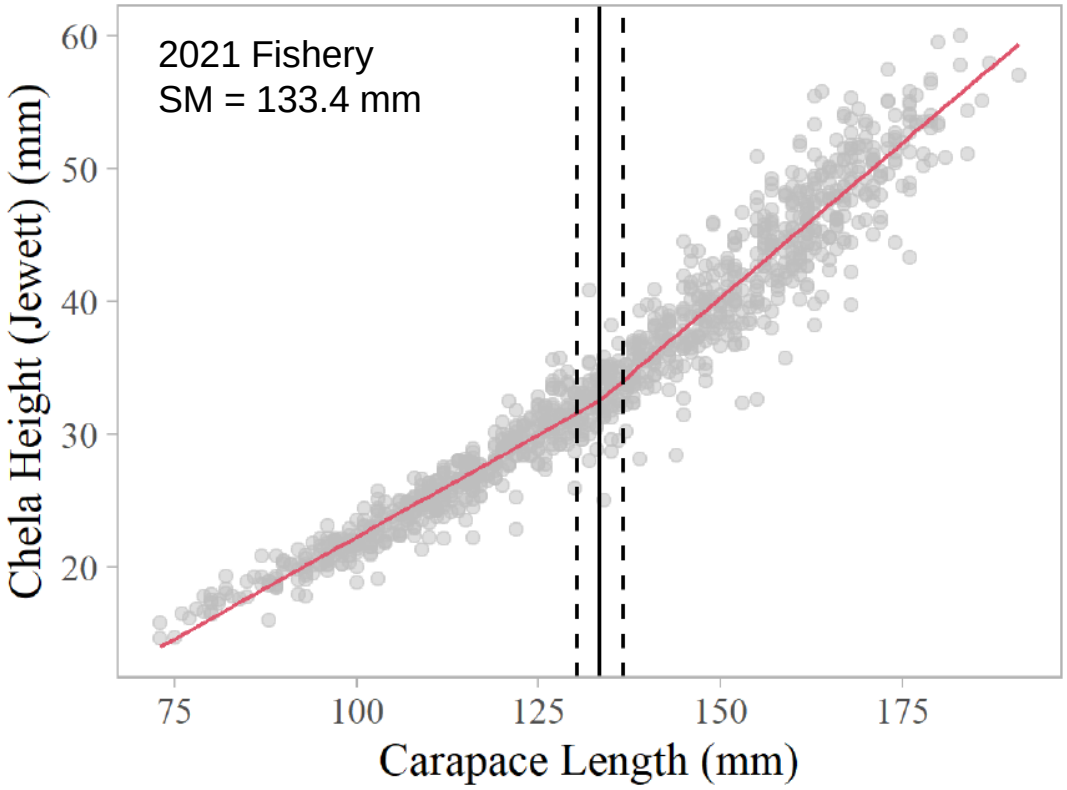


2020 SAFE Report

MMB

Male maturity = CL ≥ 107 mm (Somerton and Otto 1986)

But FYI



Slope Survey Observed MMB

Survey	Total Biomass (t)	MMB (t)[a]	CV	$r_{2008-2016}$
2002	715	314	0.29	
2004	1,085	476	0.39	
2008	972	551	0.31	0.57
2010	1,661	652	0.26	0.39
2012	1,213	368	0.34	0.30
2016	1,504	741	0.32	0.49
			Mean	0.44
			Var	0.01

[a]Estimates for 2002 and 2004 based on mean ratio from 2008-2016.

Random Effects Model

R package *rema* (Sullivan et al. 2022)

- Consensus version of RE models used by GPT for various Tier 4/5 assessments
- Extension of version used for PIGKC in 2020

Observation Model

$$\ln(B_t) = \ln(\hat{B}_t) + \varepsilon_t \qquad \varepsilon_t \sim N(0, \sigma^2_{\ln(B_t)})$$

Process Model

$$\ln(\hat{B}_t) = \ln(\hat{B}_{t-1}) + \eta_{t-1} \qquad \eta_{t-1} \sim N(0, \sigma^2_{PE})$$

More documentation (Sullivan et al. 2022)

PIGKC *rema* scenarios

23.0: MMB and CV 2002-2016. MMB estimates and associated CV were computed using the mean ratio of MMB:total biomass from 2008-2016.

23.0a: Same as 23.0, but with CV = 0.4 for 2002.

23.1: MMB and CV 2008-2016.

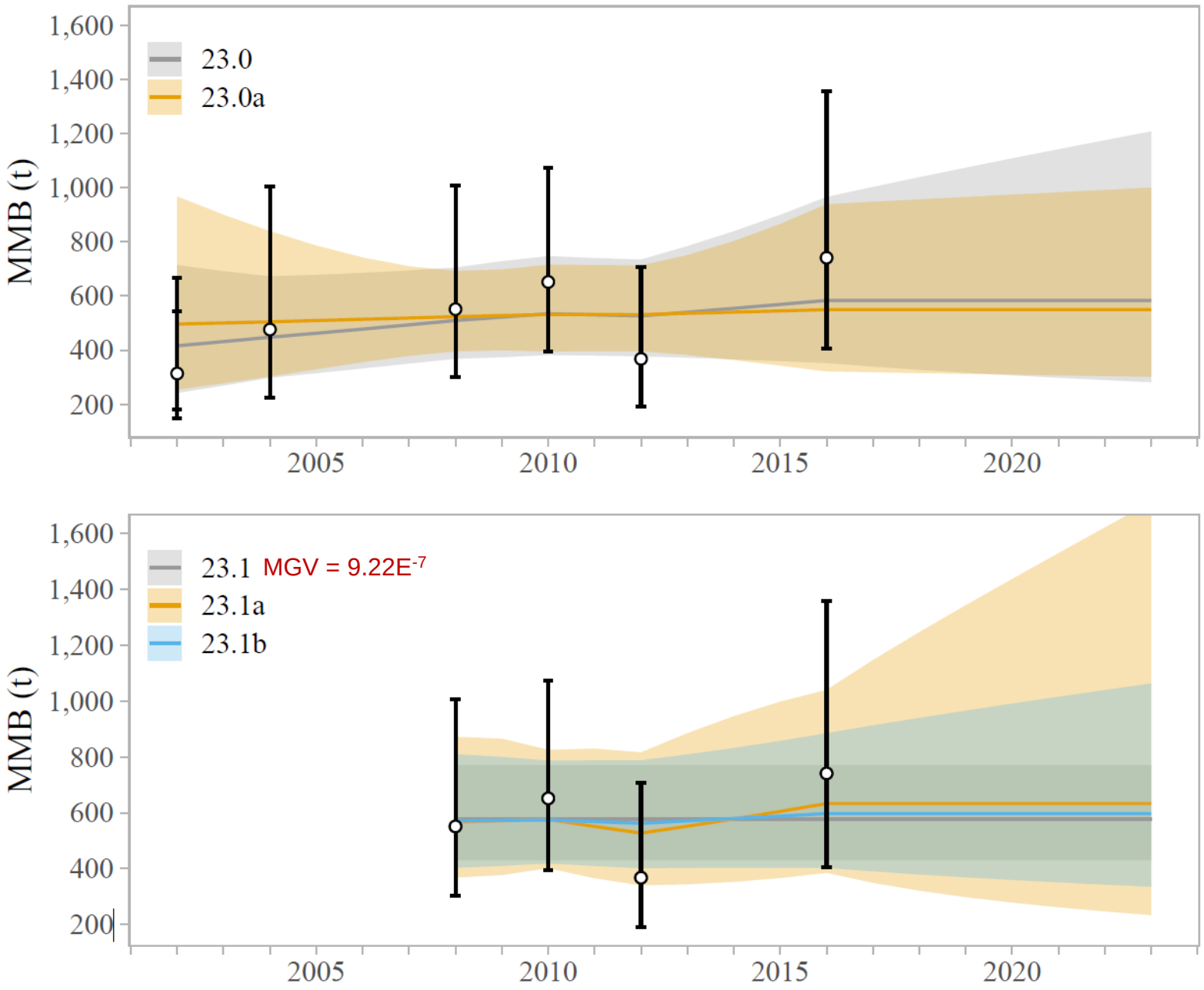
23.1a: Same as 23.1, but adding a squared penalty term to the likelihood to prevent process error from going to zero.

$$NLL = NLL + (\ln \sigma_{pe} + 1.5)^2$$

23.1b: Same as 23.1, but adding a prior to $\ln \sigma_{pe}$.

- $N(-2.3, 1)$ – based on estimate from, 23.0
- $N(-1.3, 1)$
- $N(-3.3, 1)$

Fig 4

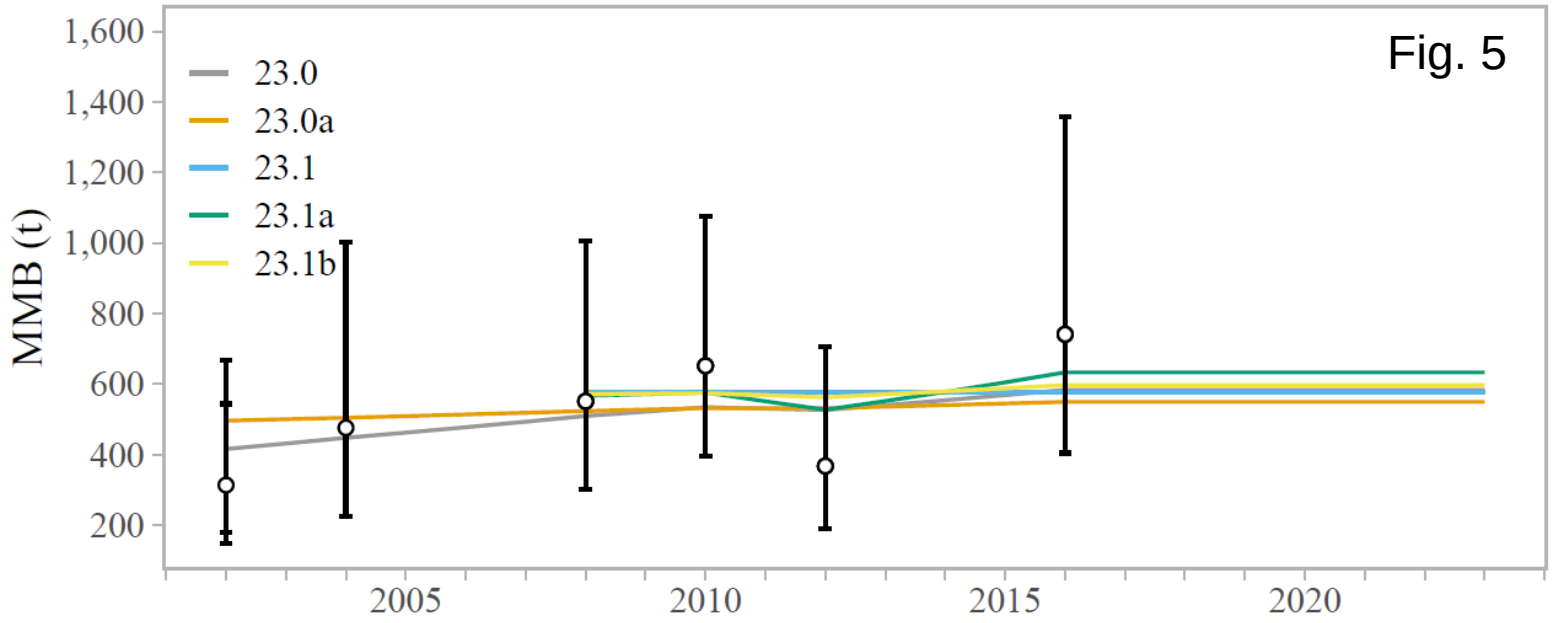

MMB (t)
1,600
1,400
1,200
1,000
800
600
400
200
2005
2010
2015
2020
23.0
23.0a
23.1 MGV = 9.22E-7
23.1a
23.1b

Model Estimates (Append A, Table 2)

Model	NLL	σ_{pe}	SE
23.0	2.55	0.101	0.10
23.0a	2.37	0.052	0.16
23.1	1.21	8.117e-06	2.54e-04
23.1a	1.68	0.166	0.10
23.1b	2.27	0.081	0.07

23.1b Priors & Est.
(Append A, Table 3)

μ	ln σ_{pe}	SE
-1.3	-1.85	0.77
-2.3	-2.51	0.86
-3.3	-3.35	0.96



Tier 4 Reference Points

B_{MSY} = Mean $\hat{B}_t$ 2002 - 2016 or 2008 – 2016
$\text{MMB}_{proj} = \text{MMB}e^{-0.625M}$

M = 0.18 yr^{-1}

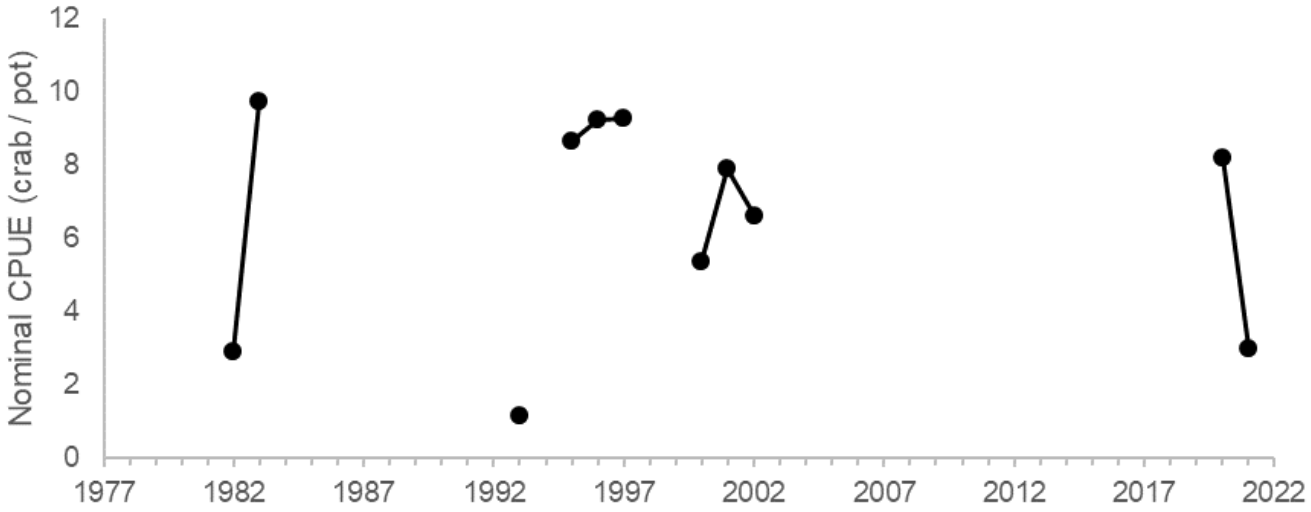
Model	B_{MSY} (t)	MMB (t)	MMB_{proj} (t)	$\text{MMB}_{proj}/B_{MSY}$	F_{OFL}	OFL (t)
23.0	507	584	521	1.03	0.18	85.9
23.0a	524	550	491	0.94	0.17	75.7
23.1	576	576	515	0.89	0.16	75.6
23.1a	573	633	566	0.99	0.18	91.9
23.1b	576	597	534	0.93	0.17	81.3

M = 0.21 yr^{-1}

Model	B_{MSY} (t)	MMB (t)	MMB_{proj} (t)	$\text{MMB}_{proj}/B_{MSY}$	F_{OFL}	OFL (t)
23.0	507	584	512	1.01	0.21	96.9
23.0a	524	550	482	0.92	0.19	83.9
23.1	576	576	506	0.88	0.18	83.8
23.1a	573	633	555	0.97	0.20	101.8
23.1b	576	597	524	0.91	0.19	90.1

Using a CPUE Index

- *rema* has option to fit to additional CPUE index with estimation of additional scaling parameter *q* (Sullivan et al. 2022)
- Sporadic participation in PIGKC may confound standardization of CPUE
  - Vessels have participated in only 2/15 seasons on average, max 7/15
  - Little basis for comparison among vessels



Other Issues

- Unknown gear efficiency for slope survey and mature male GKC (i.e., are biomass estimates accurate? Is that a good basis for B_{MSY}?)

- Still not making direct estimates of observed MMB for 2 of 6 survey years

- Slope survey is possibly discontinued, at least will not happen with any regularity in the near future

Tier 4/5 Approach (Appendix B)

Following the 2010 GOA spiny dogfish assessment

$$F_{\mathrm{OFL}} = M; \quad \mathrm{OFL} = B \times M$$

B = Average observed slope survey MMB from 2002 – 2016
M = 0.18 yr^{-1} or 0.21 yr^{-1}
ABC = 25% buffer

Append. B, Table 2

M	B (t)	OFL (t)	ABC (t)
0.18	517.0	93.1	69.8
0.21	517.0	108.6	81.4

Overall Specifications

Tier	*M*	OFL	ABC
5		94.7	71.1
4 (23.0)	0.18	85.9	64.4
4/5	0.18	93.1	69.8
4 (23.0)	0.21	96.9	72.7
4/5	0.21	108.6	81.4

CPT Decisions

1) Which Tier options do we want to see in May?

2) *If Tier 4 or 4/5,* which *M* do we consider?

3) *If Tier 4*, which scenarios? Do we want to see one with a CPUE index?

Author Recommendation: CPT recommend Tier 5 specifications in May