Coping with information gaps in stock productivity for rebuilding and achieving maximum sustainable yield

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ORIGINAL ARTICLE

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Coping with information gaps in stock productivity for rebuilding and achieving maximum sustainable yield for grouper–snapper fisheries

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Background

How do we delineate MSY-based reference points?

Often, productivity, namely stock-recruitment steepness, is uncertain.

Let’s create a simplified fishery system.

Then, let’s develop a framework for delineating reference points in the face of steepness uncertainty.

Decision

F_{MSY}

Need: Life history, Selectivity, Steepness

Effect

Fish stock

Catches

Desired outcome

MSY

B_{MSY}

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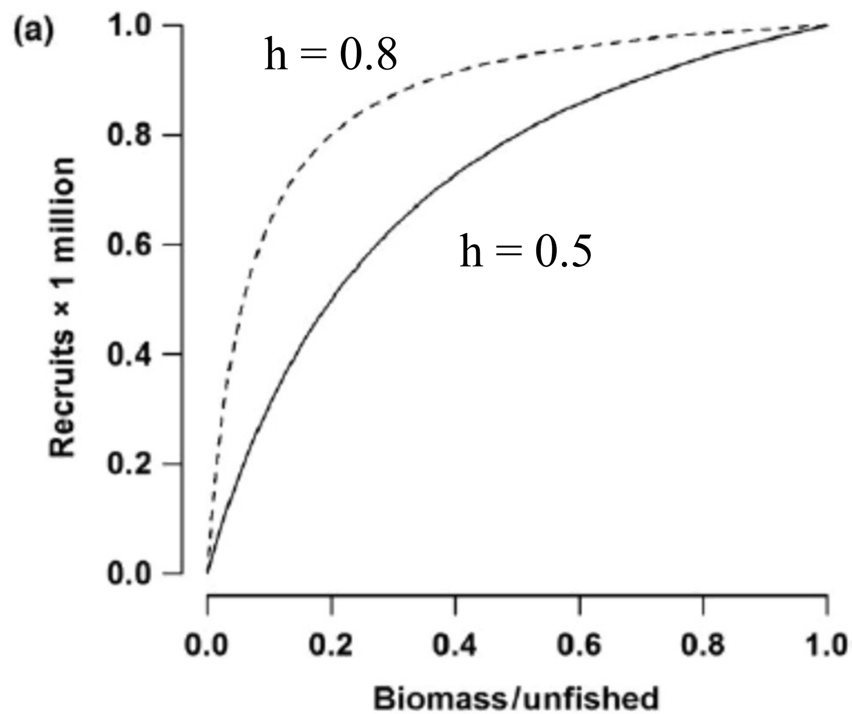

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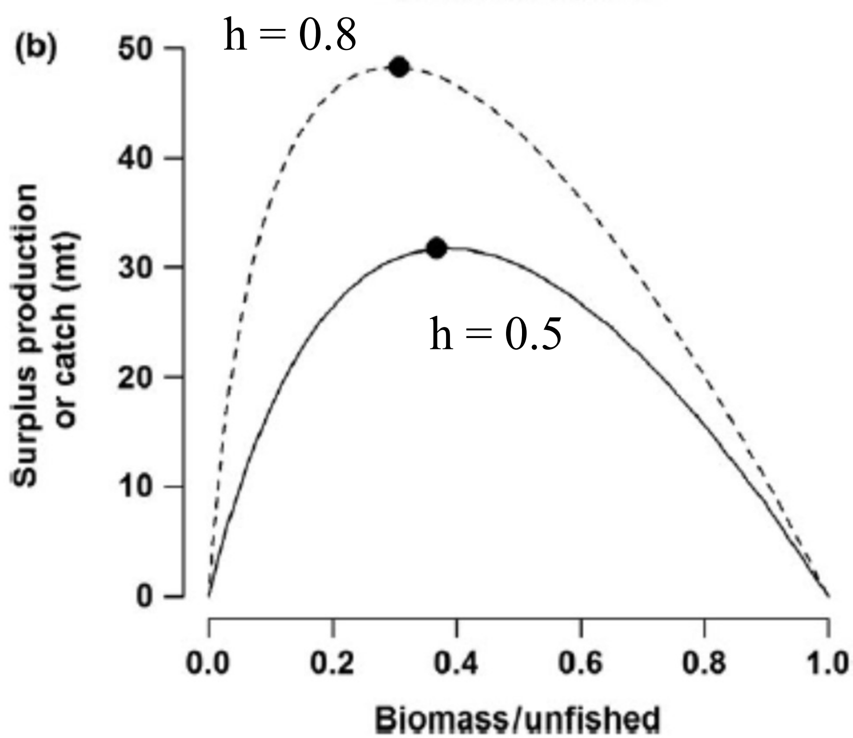

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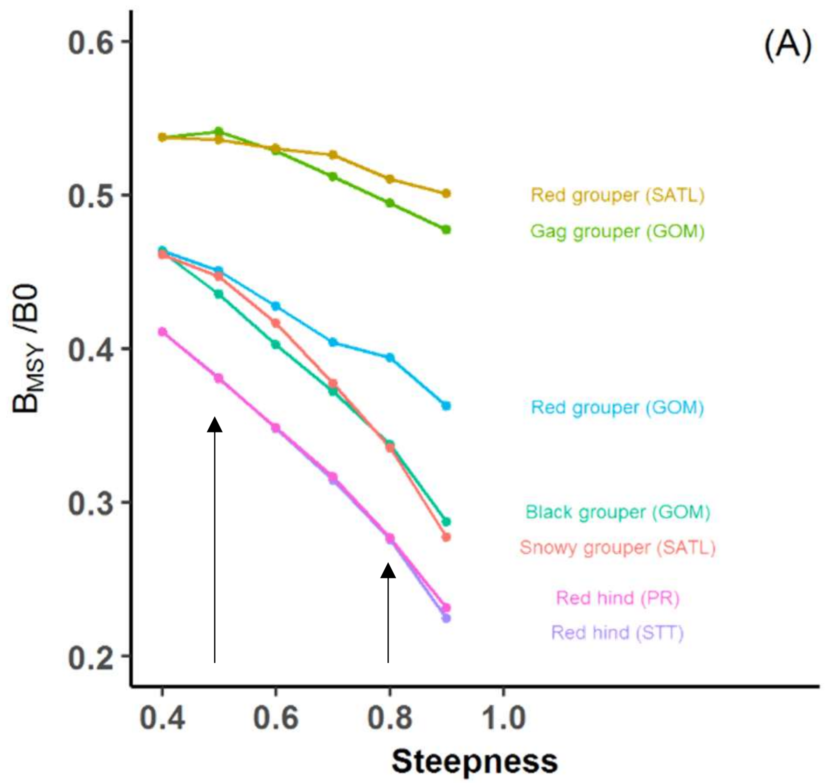

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Decision

F_{MSY}

Need: Life history, Selectivity, ~~Steepness~~

- US Fisheries, National Standard 1 Guidelines
- When sufficient information is lacking, proxies can be used for status determination criteria:

$\boldsymbol{F_{x\%SPR}}$ *MFMT for defining overfishing*

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Decision

$F_{x\%SPR}$

Need: Life history, Selectivity, ~~Steepness~~

Effect

Fish stock

Catches

Desired outcome

MSY → *Yield at* $F_{x\%SPR}$

B_{MSY} → *Biomass at* $F_{x\%SPR}$

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Decision

$F_{30\%SPR}$

Need: Life history, Selectivity, ~~Steepness~~

Simulation

Fish stock: life history, selectivity, steepness

Catches

How well do we achieve our desired outcome?

MSY ?

B_{MSY} ?

Problem!

We must assume a steepness value to perform the simulation!

What if we took a probabilistic approach to steepness uncertainty?

Decision

$F_{30\%SPR}$

Need: Life history, Selectivity, ~~Steepness~~

Simulation

Fish stock: life history, selectivity, steepness

Catches

How well do we achieve our desired outcome?

MSY ?

B_{MSY} ?

Can we identify F%spr proxy for Fmsy in the face of steepness uncertainty?

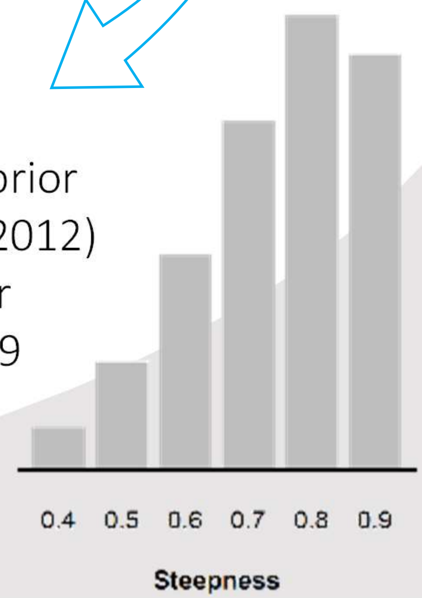
1 Simulations
Each, conditional on:

- Life history
- Selectivity
- Steepness value
- $F_{\%SPR}$ proxy for F_{MSY}

2 Summarize
Performance vs. Steepness

h=0.4	h=0.5	h=0.6	h=0.7	h=0.8	h=0.9
0.10	0.15	0.20	0.25	0.30	0.35
0.30	0.35	0.40	0.45	0.50	0.55
0.40	0.35	0.30	0.25	0.20	0.10
0.10	0.10	0.10	0.05	0	0
0.10	0.05	0	0	0	0

3 Define steepness prior
Shertzer & Conn (2012)
Demersal fish prior
Bull. Mar. Sci. 88:39

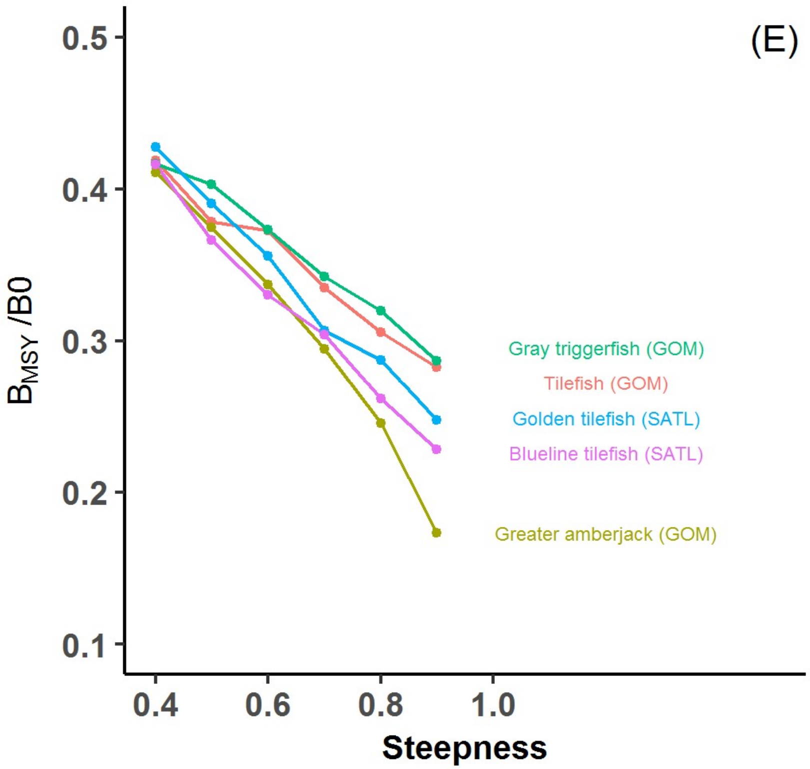


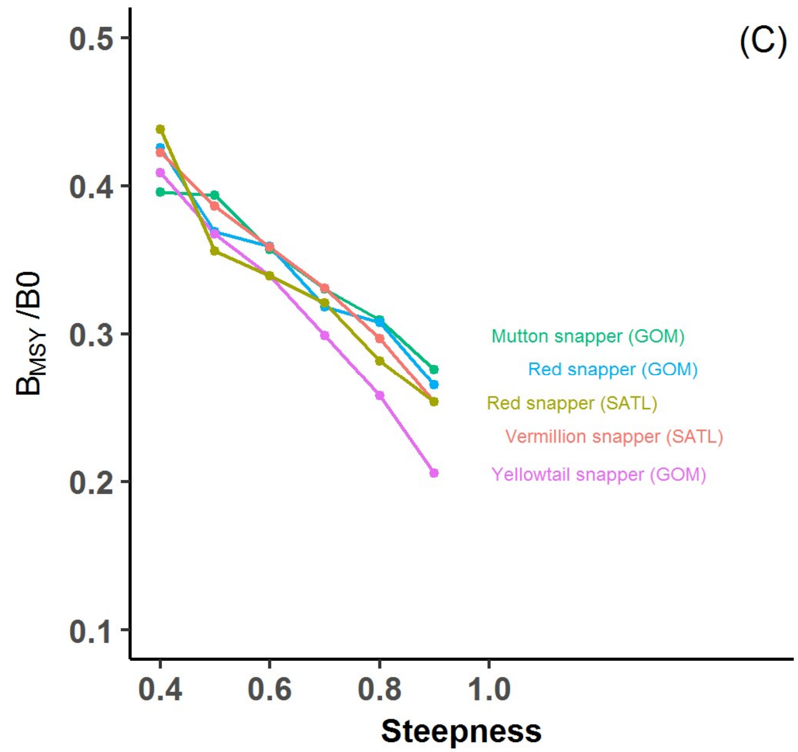
4 Marginalize performance according to probability rules

Results not conditional on any specific steepness, but reflect steepness uncertainty

Repeated analysis for 17 grouper – snapper life histories

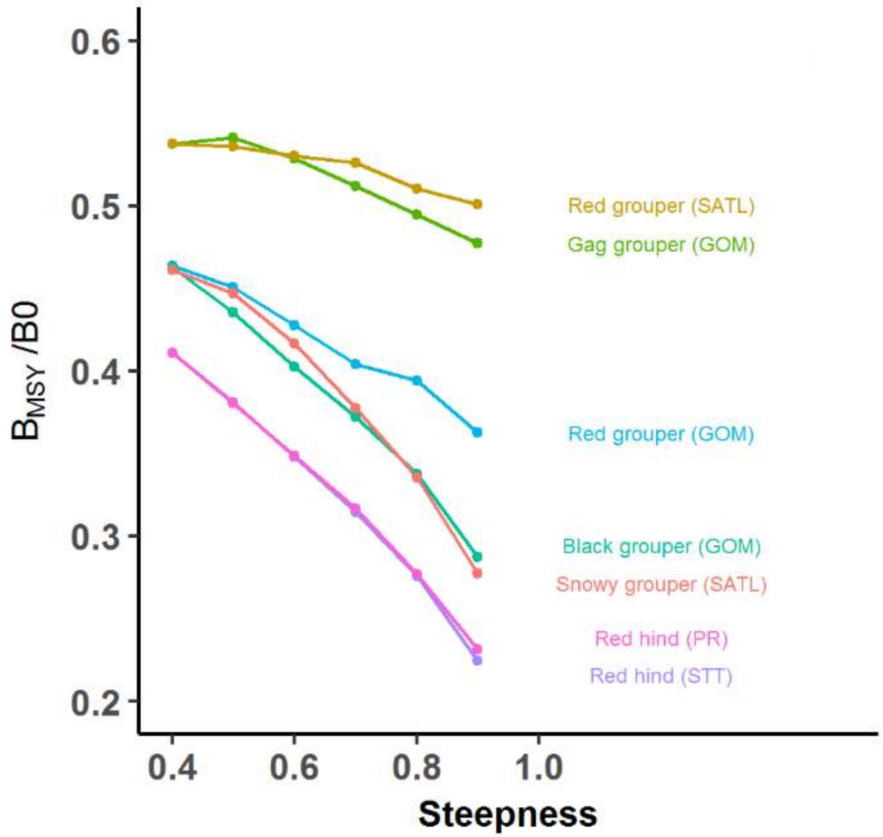
Snappers
Gonochoristic stocks





Repeated analysis for 17 grouper – snapper life histories

Groupers
Hermaphroditic stocks

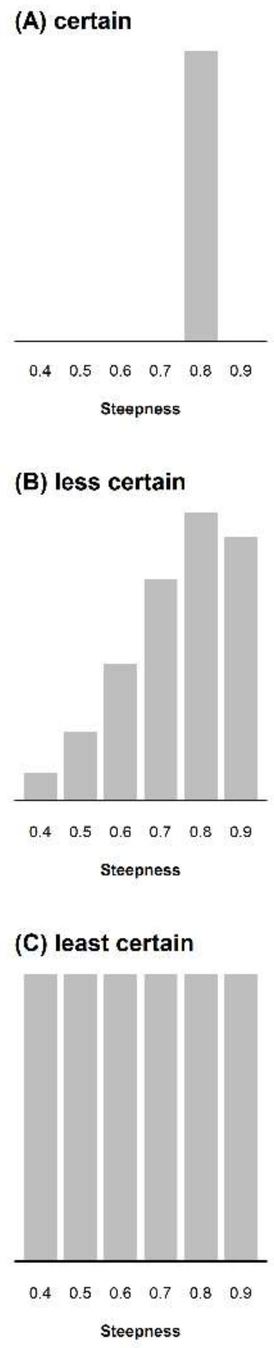


Stock selection:

- Have been subject to quantitative stock assessment
- Judged to have sufficient life history information for inclusion in analysis

Steepness Priors

Framework illustrated using three different priors, reflecting degree of certainty.



- Formalization of subjectivity
- Allows for exploration of effect of beliefs on management decisions
- Brings key uncertainties to the forefront of policy discussions
- Frames uncertainties that are consequential to management decisions.

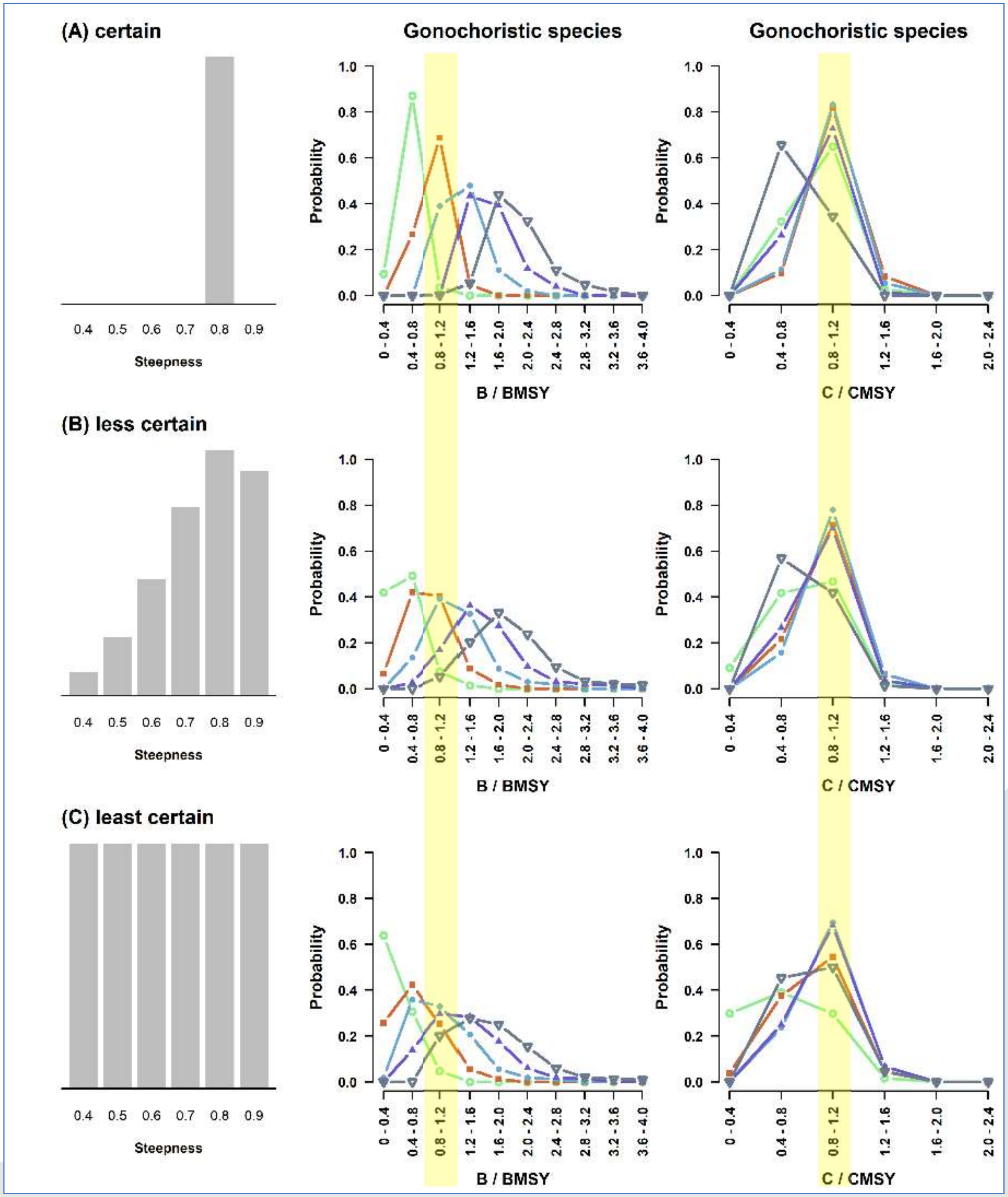
Snappers

*F*40%SPR

Has the greatest probability mass centered around long-term achievement of MSY,

While also maintaining biomass in proximity to *B*MSY

Alternative priors can be specified, reflecting degree of uncertainty used in integrating across states of nature.

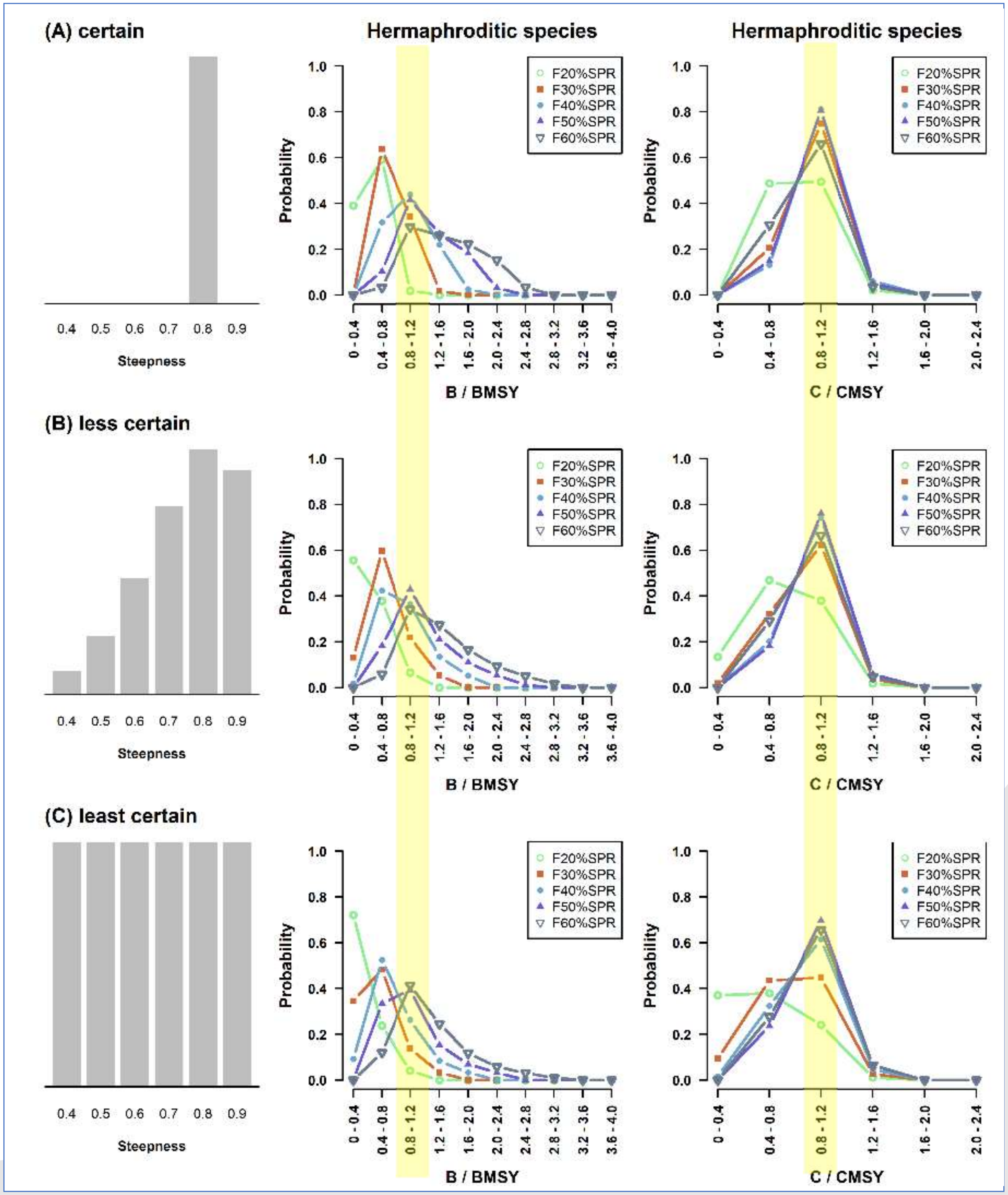


Groupers

*F*50%SPR

Has the greatest probability mass centered around long-term achievement of MSY,

While also maintaining biomass in proximity to *B*MSY



Apply this guidance

Decision-making framework

This paper highlights a methodology or framework.

A pathway for consistency in Fproxy specification

- Where knowledge exists, it can be formalized in a way that bring knowledge to forefront of policy discussions
- Allows for exploration of the effect of degree of belief on management decisions
- This paper emphasizes a process (framework), where inputs can be modified (e.g., life history and selectivity patterns), to produce products of interest (Fproxy)

Apply this guidance

Core guidance

F40%SPR for snappers, F50%SPR for groupers

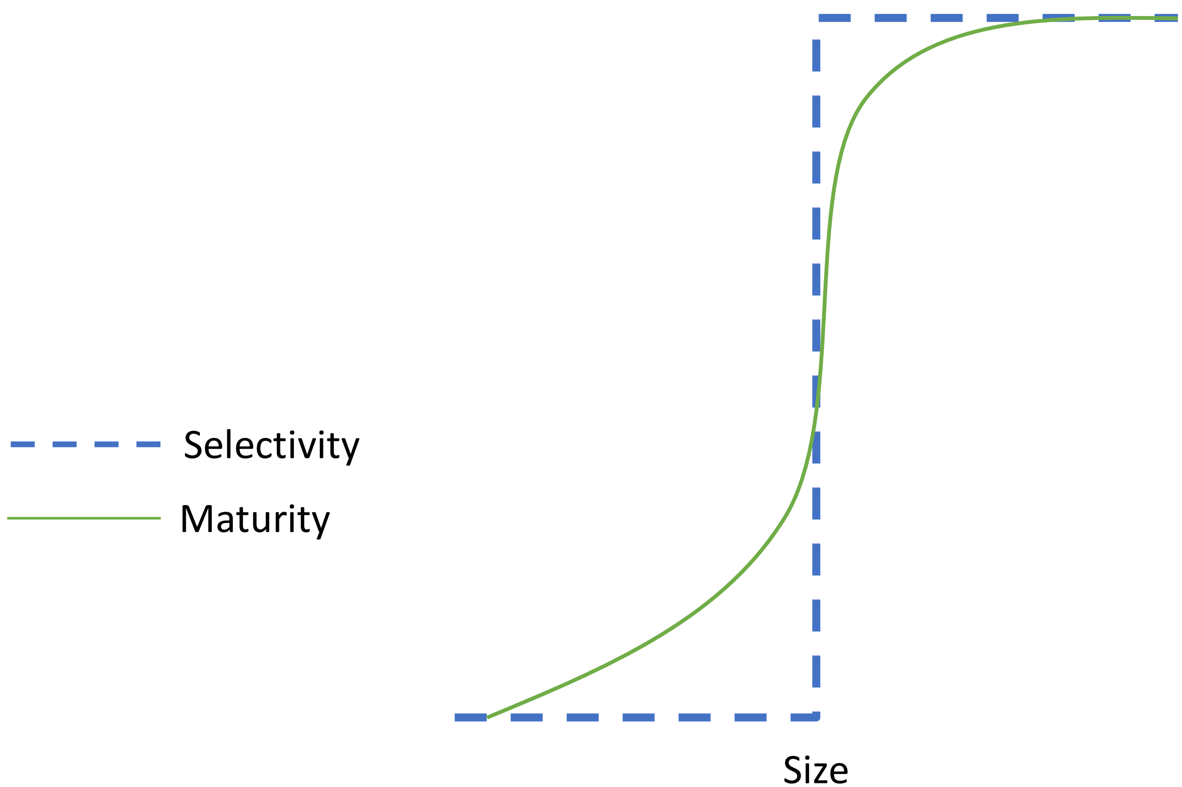
Most probable outcome for achieving MSY-level catches

- Clark (2002), F40%SPR should be close to optimum F, particularly when recruitment to the fishery coincides with maturity.
- Mace (1994) similarly suggests that F40%SPR be adopted as a target fishing mortality rate when the stock–recruitment relationship is unknown.
- Brooks et al. (2010) suggested that a SPR of 30% would only be appropriate for <u>very resilient stocks</u>

Apply this guidance

Selectivity

Selectivity at size at maturity is a reasonable assumption for several GOM fisheries



Common name	A50	L50	Federal commercial regulatory size limit
Gonochoristic assemblage			
Mutton snapper (GOM)	3	433 mm TL	406 mm TL
Red snapper (GOM)	2	315 mm TL	330 mm TL
Red snapper (SATL)	2	348 mm FL	–
Yellowtail snapper (SATL & GOM)	2	305 mm TL	305 mm TL (GOM)
Vermilion snapper (SATL)	1	211 mm TL	305 TL
Tilefish (GOM)	2	345 mm TL	–
Golden tilefish (SATL)	3	399 mm TL	–
Greater amberjack (GOM)	4	832 mm FL	914 mm FL
Grey triggerfish (GOM)	1	183 mm FL	356 mm FL
Blueline tilefish (SATL)	3	445 mm TL	–

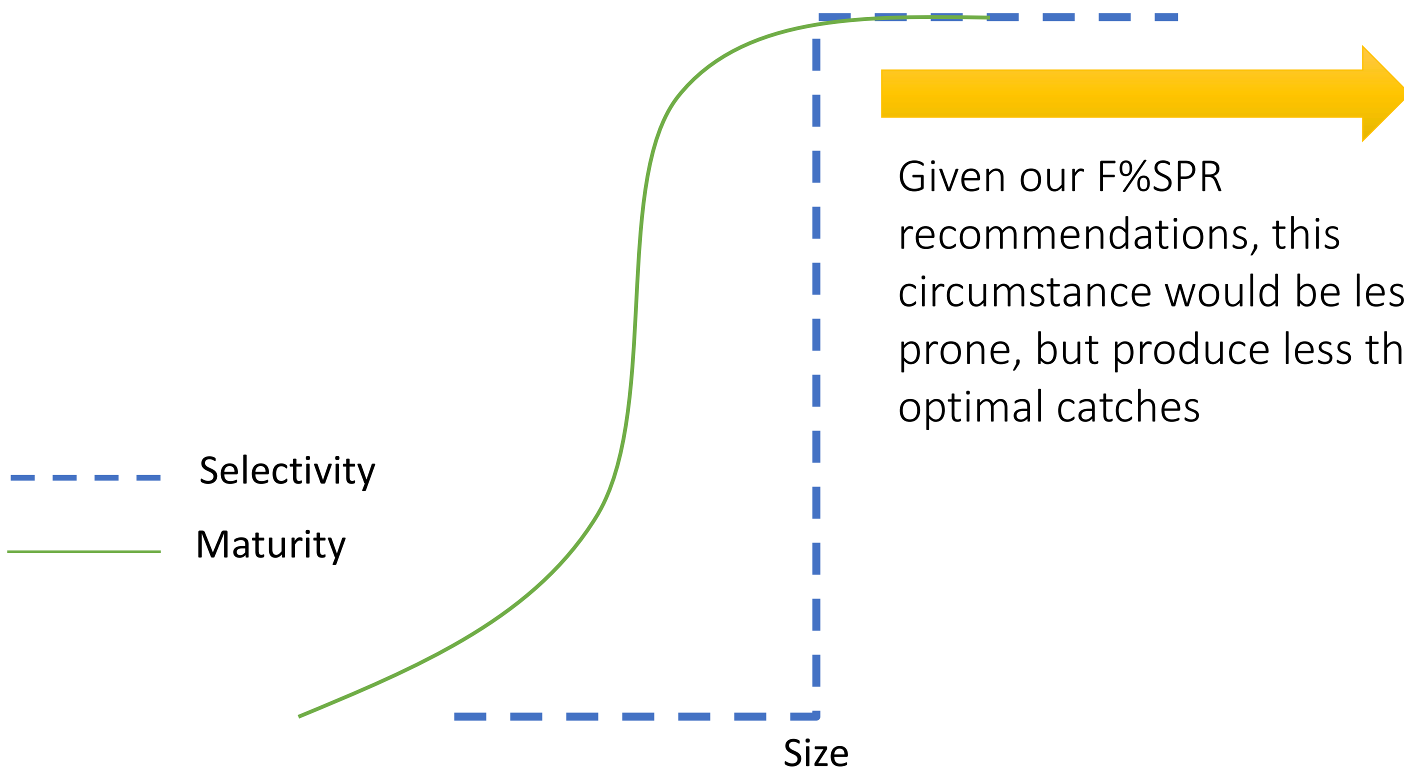
Hermaphroditic assemblage		**L50**	**Federal size limit**
Red grouper (GOM)	3	328 mm TL	457 mm TL
Red grouper (SATL)	3	459 mm TL	508 mm TL
Black grouper (GOM)	7	904 mm TL	610 mm TL
Gag grouper (GOM)	4	605 mm TL	559 mm TL
Snowy grouper (SATL)	5	557 mm TL	–
Red hind (STT)	3	251 mm FL	–
Red hind (PR)	3	232 mm FL	–

Gathered in 2019

Apply this guidance

Selectivity

What if current size limits are above size at maturity? How might we interpret the simulations in the paper?



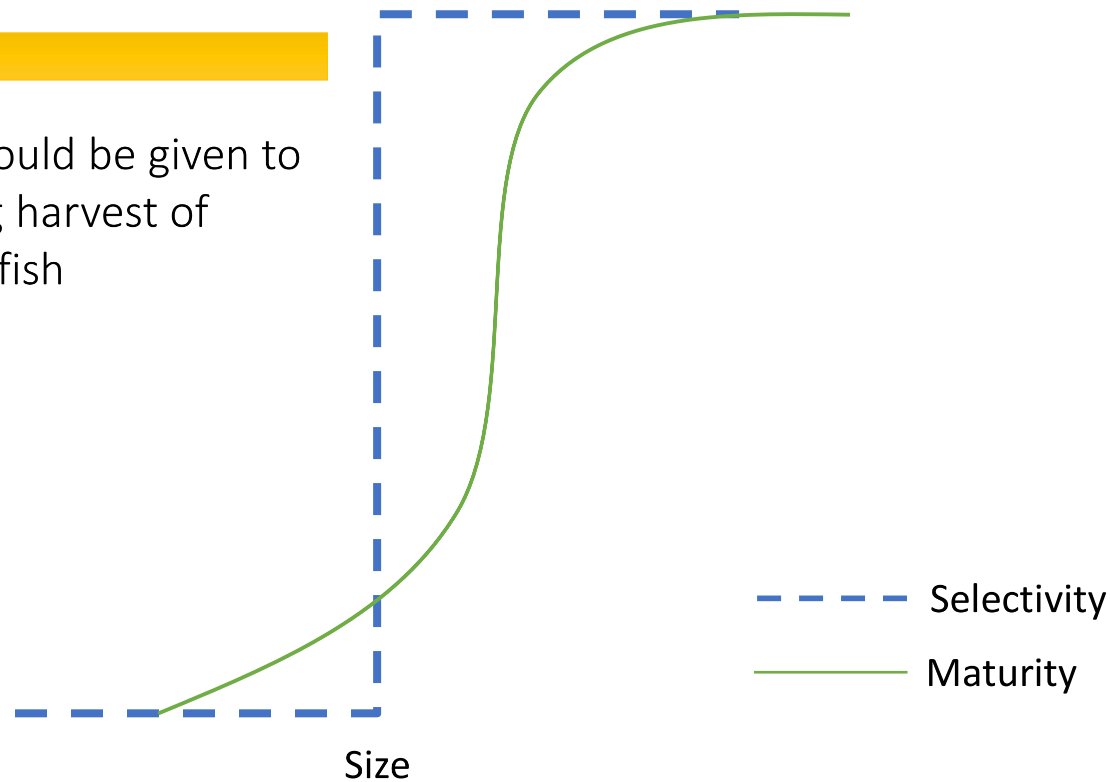
Given our F%SPR recommendations, this circumstance would be less risk prone, but produce less than optimal catches

Re-think this guidance

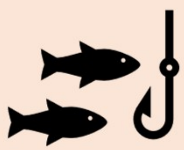
Selectivity

Consider in-depth analysis when (i) selectivity includes small fish, (ii) is complex, or (iii) prioritizing catch maximization

Priority should be given to addressing harvest of immature fish



Re-think this guidance



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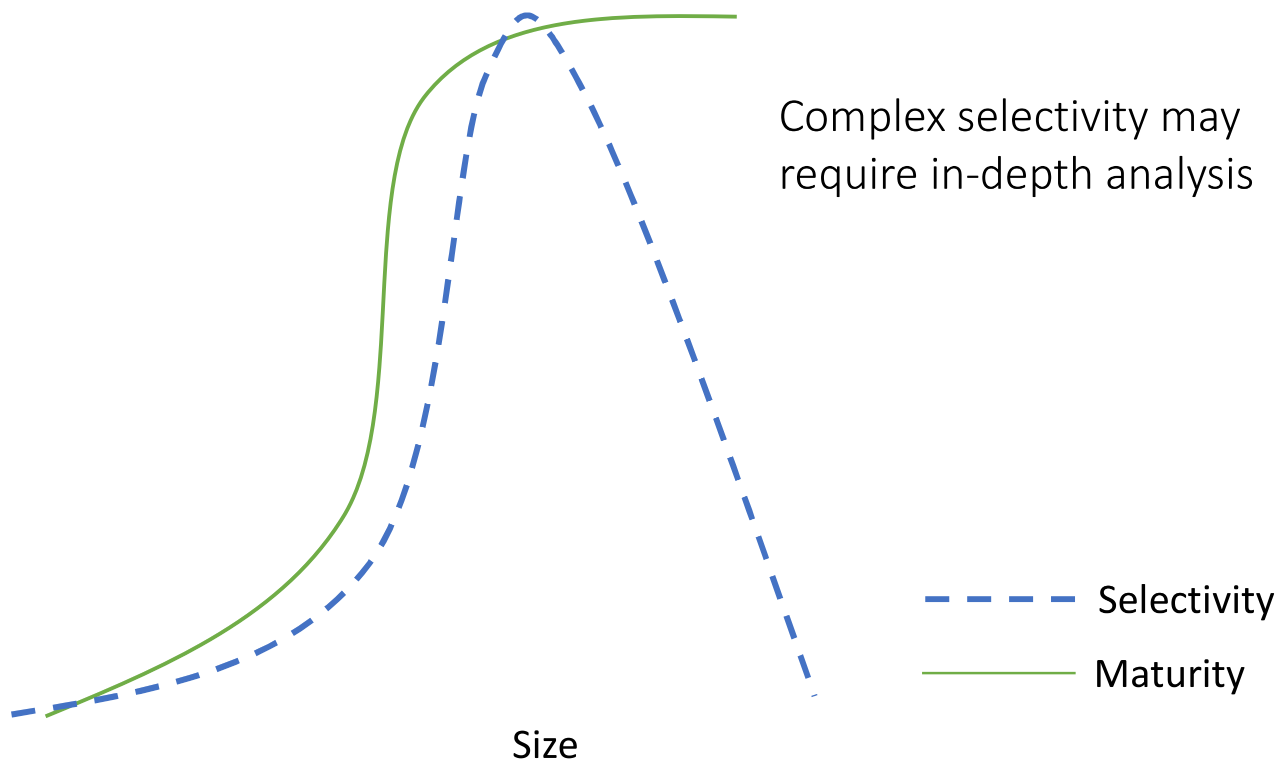
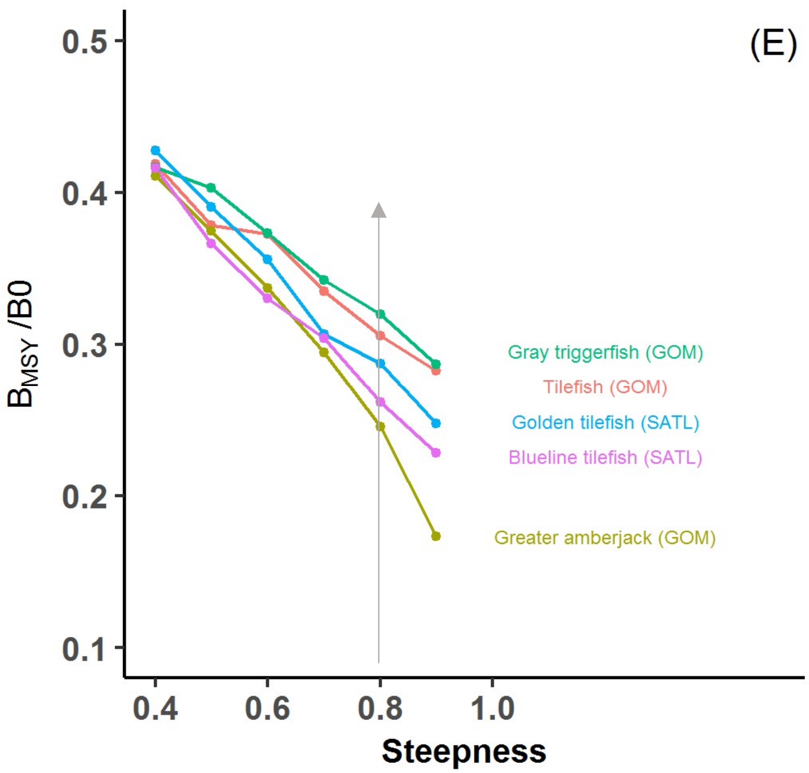


Re-think this guidance

Life history

Consider in-depth analysis for other species, updated life histories and those that differ from the species included in the study.

- Goethel et al. (2022) emphasized avoiding generalizing and emphasizing differences between stocks.
- Brooks et al. (2010) reinforced the importance of selecting a level of SPR based on life history characteristics.
- This study.



Re-think this guidance

Hermaphroditic species

Consider in-depth analysis based on total biomass (not female biomass) for hermaphroditic species.

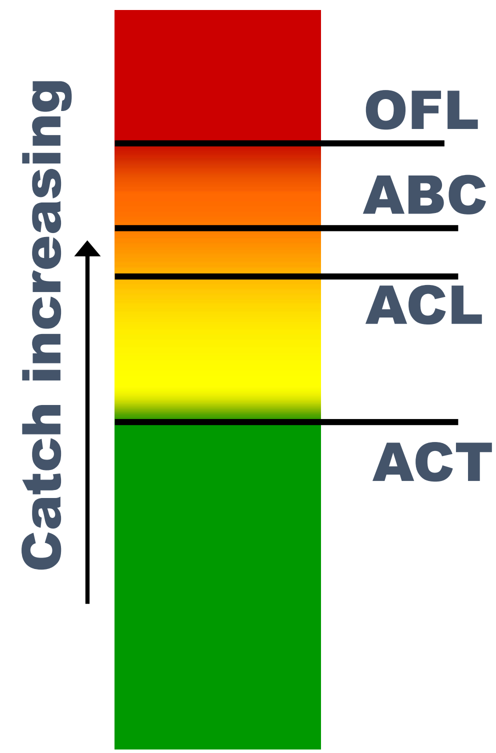
- Brooks et al. (2008) suggests reference points for hermaphroditic species should be calculated using total biomass, not female biomass.

Re-think this guidance

Scientific uncertainty

Consider in-depth analysis to address other key uncertainties in establishing reference points.

- F40%SPR may be too low under prevailing environmental conditions and where there is considerable uncertainty in life history parameters. (Brodziak, 2002; Cadrin, 2012; Dorn, 2002; Restrepo et al., 1998).
- Time-varying natural mortality, including episodic red tide events, may require consideration of precautionary catch limits (Harford et al. 2018).
- Updated steepness prior?



Apply this guidance

Decision-making framework

Framework and process

Core guidance

F40%SPR for snappers,

F50%SPR for groupers

Selectivity

At size at maturity

Re-think this guidance

Selectivity

When small fish in catch, complex, or catch optimize

Life history

Species-specific to avoid generalization

Hermaphroditic species

Total biomass

Scientific uncertainty

Address key uncertainties.

Conclusion and future directions

Guidance consistent with a variety of grouper-snapper species

Gonochoristic stocks
Snappers

$F_{40\%\ SPR}$

Hermaphroditic stocks
Groupers

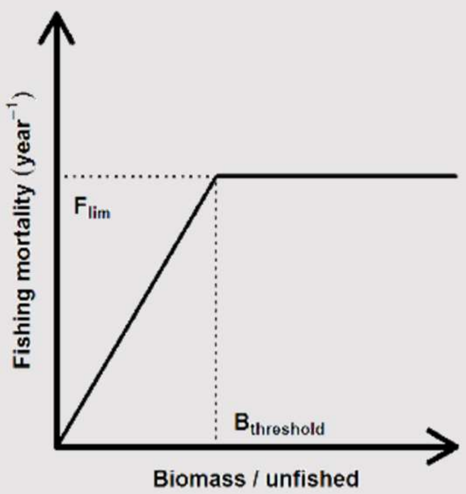
$F_{50\%\ SPR}$

Conclusion and future directions

Framework implores focus on process of reference point determination

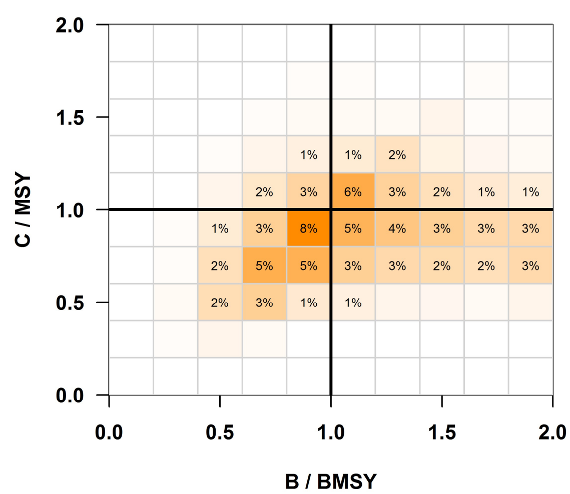
Could spur discussion on holistic performance the fishery system (e.g., MSE)

- Stock rebuilding
- Fmsy vs. Fproxy
- Data - limited

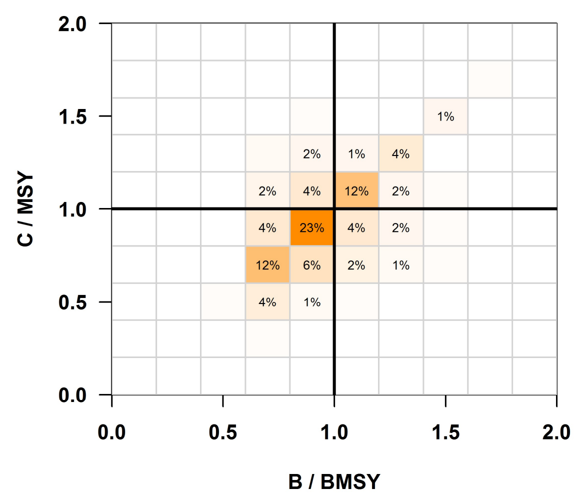


	F_{lim}	$B_{threshold}$
HCR1	$F_{30\%SPR}$	0.2
HCR2	$F_{40\%SPR}$	0.3
HCR3	$F_{50\%SPR}$	0.4
HCR4	$F_{60\%SPR}$	0.5

Harvest control rule



NS1 Rule



Conclusion and future directions

Consider a process for Fproxy specification ‘better practices’

Consider toolkit development to formalize those practices

Strengthen this type of analysis by incorporating:

Life history uncertainty

Stock-recruit function type (e.g., Ricker)

Estimation error of key quantities (e.g., Fproxies)

Imperfect information and implementation error

Put the process to the test

Avoid unanticipated problems via simulation testing (e.g., MSE)

References

- Shertzer, K. W., and P. B. Conn. 2012. Spawner-Recruit Relationships of Demersal Marine Fishes: Prior Distribution of Steepness. Bull. Mar. Sci. 88:39–50.
- Clark, W. G. 2002. F35% Revisited Ten Years Later. N. Am. J. Fish. Man. 22:251–257.
- Mace, P. M. 1994. Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. Can J Fish Aquat Sci. 51:110–122.
- Brooks, E. N., J. E. Powers, and E. Cortés. 2010. Analytical reference points for age-structured models: application to data-poor fisheries. ICES J. Mar. Sci. 67:165–175.
- Brooks, E. N., K. W. Shertzer, T. Gedamke, and D. S. Vaughan. 2008. Stock assessment of protogynous fish: evaluating measures of spawning biomass used to estimate biological reference points. Fish Bull. 106:12.
- Goethel, D. R., K. L. Omori, A. E. Punt, P. D. Lynch, A. M. Berger, C. L. de Moor, É. E. Plagányi, J. M. Cope, N. A. Dowling, R. McGarvey, A. L. Preece, J. T. Thorson, M. Chaloupka, S. Gaichas, E. Gilman, S. A. Hesp, C. Longo, N. Yao, and R. D. Methot. 2022. Oceans of plenty? Challenges, advancements, and future directions for the provision of evidence-based fisheries management advice. Reviews in Fish Biology and Fisheries.
- Brodziak, J. 2002. In Search of Optimal Harvest Rates for West Coast Groundfish. N. Am. J. Fish. Man. 22:258–271.
- Cadrin, S. X. 2012. Unintended consequences of MSY proxies for defining overfishing. International Council for the Exploration of the Sea, C.M. 2012/L:23, Copenhagen.
- Dorn, M. W. 2002. Advice on West Coast Rockfish Harvest Rates from Bayesian Meta-Analysis of Stock−Recruit Relationships. N. Am. J. Fish. Man. 22:280–300.
- Restrepo, V. R., G. G. Thompson, P. M. Mace, W. L. Gabriel, L. L. Low, A. D. MacCall, R. D. Methot, J. E. Powers, B. L. Taylor, P. R. Wade, and J. F. Witzig. 1998. Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson–Stevens Fishery Conservation and Management Act. NOAA Tech. Memo. NMFS-F/SPO-31, 54 p.
- Harford, W. J., A. Grüss, M. J. Schirripa, S. R. Sagarese, M. Bryan, and M. Karnauskas. 2018. Handle with Care: Establishing Catch Limits for Fish Stocks Experiencing Episodic Natural Mortality Events. Fisheries 43:463–471.

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