



**NOAA
FISHERIES**

**Alaska Fisheries
Science Center**

Stock assessment models at Alaska Fisheries Science Center Theme I – Part I

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Theme I, Part 1 Outline

- Tier system, targets and non-targets
- Approaches for data-limited stocks
 - Tier 6 example: Sharks
 - Tier 5 example: Shortraker rockfish
 - Tier 4 (crab) example:
- Control rules, uncertainty
- Retrospective working group

Definitions

- **MSY: Maximum Sustainable Yield**
 - Largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions
- **ABC: Acceptable Biological Catch**
 - Scientific advice on what the maximum quota should be.
- **OFL: Overfishing Level**
 - The level of catch when fishing at $F_{MSY/OFL}$
- **F_{ABC} / F_{OFL} : Fishing mortality rate used to set ABC / OFL**
 - Either from estimated MSY (Tier 1) or proxy (other tiers)
- **TAC: Total Allowable Catch**
 - Species-specific annually determined catch, based on MSY, OY

How do we choose our level of harvest/risk

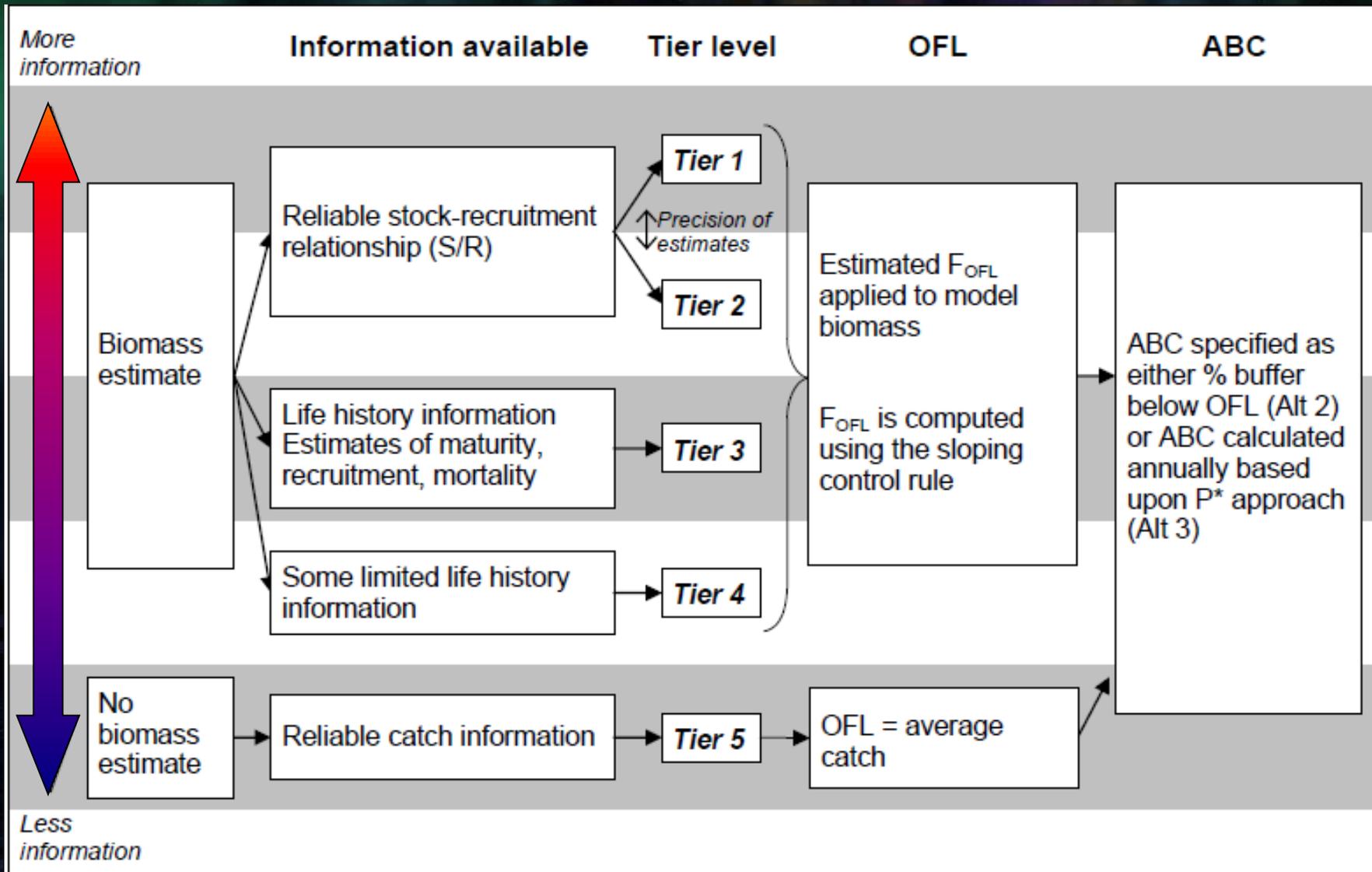
- **Target fisheries:**
 - Some stocks we have high data quality and low uncertainty
 - Harvest rates are based on the productivity of the stock
- **Incidental catch fisheries:**
 - We know less, so targeted fishing is not allowed
 - Limits are still imposed, and are sometimes linked to stock productivity

Groundfish tier system

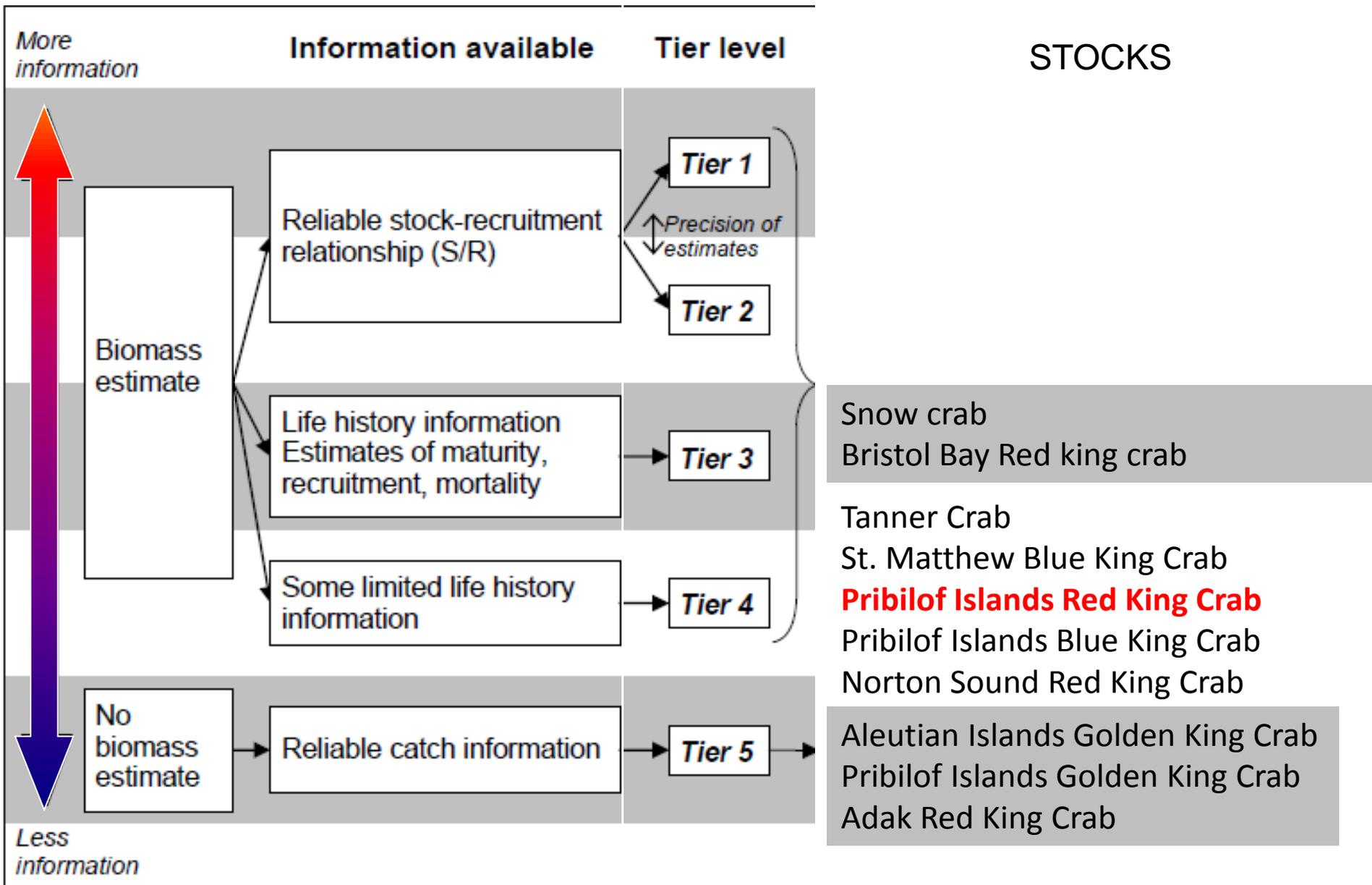
Data quality

- Tier 1: Bering Sea Pollock
 - Reliable stock recruitment relationship
 - Quota is buffered from OFL by sci. uncertainty
- Tier 2: Pacific ocean perch pre-1996
- Tier 3: Pacific Cod, Sablefish, Rockfish
 - Reliable estimates of spawners, age-structured model
 - Quota is buffered from OFL and **control rule**
- Tier 4: Some Flatfish, GOA Sharpchin
- Tier 5: Shortraker rockfish
 - OFL based on survey biomass estimates and natural mortality, 25% buffer
- Tier 6: Sharks, other species
 - OFL usually based on historical catch

Crab tier system

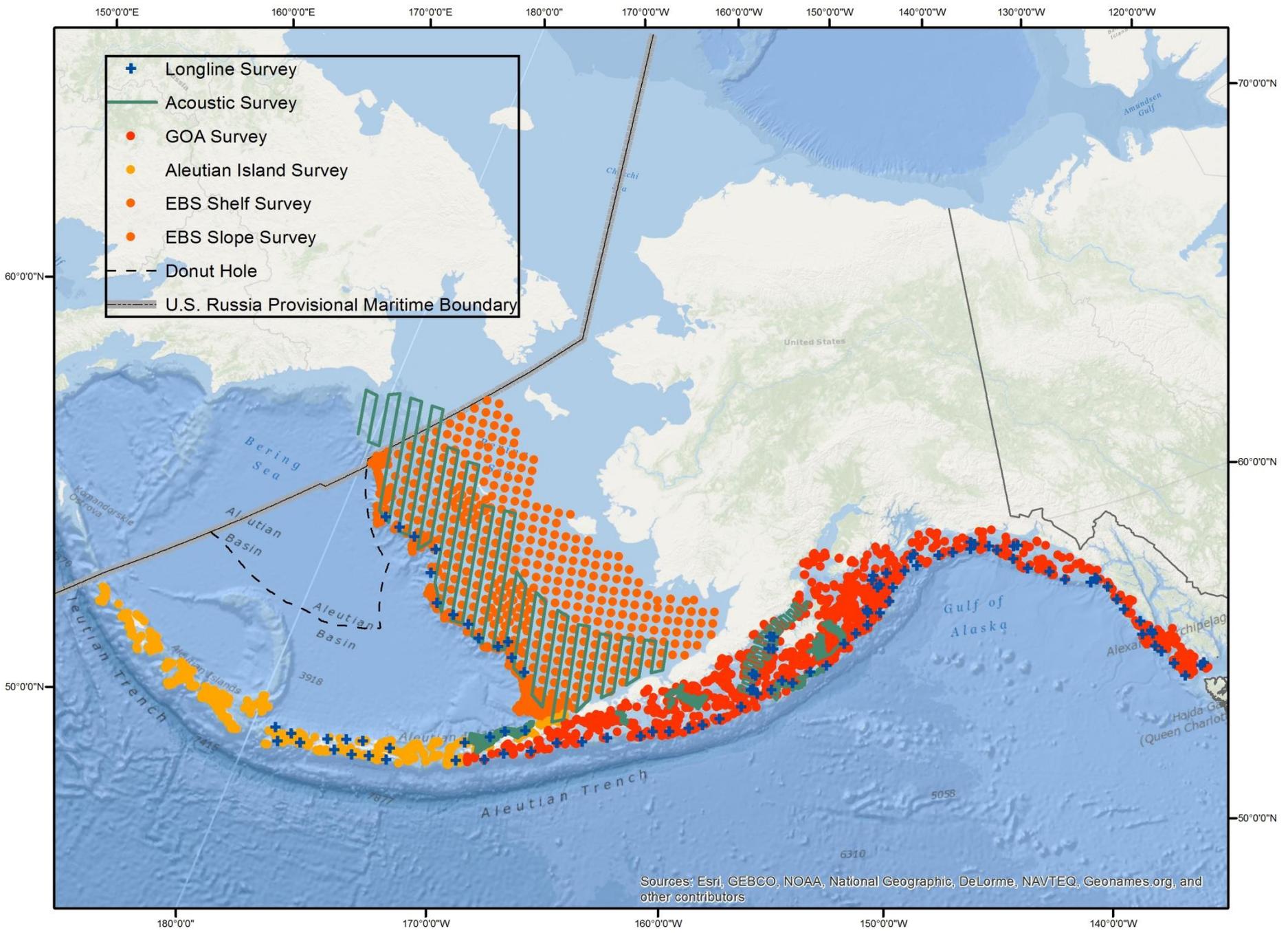


Current Crab Management Tier system



Different data, different models

- **Goal:** If it's important and possible, age-structured model
- **Challenges:** Crab, Pacific cod, shortraker rockfish, thornyhead rockfish
- Non-targeted, or low abundance stocks, could probably be elevated in tier, but aren't because:
 - Aging capacity
 - Assessment scientist capacity
- Data-limited approaches used



Data-limited in Alaska

- Data-limited is a relative term
- Species that are transient and semi-pelagic (spiny dogfish) or cryptic (octopus)
- We have 2 surveys, a stock assessment, and estimates of ABC and OFL for an **ecosystem component** (grenadiers)!

Approaches

- Catch-only (Tier 6)
- Survey biomass based (Tier 5)
 - “Reliable” estimates of B and M
- Hybrid (mixture of T6 and T5 methods)
- Ecosystem Tier 5 (octopus)

Example: GOA Sharks

Spiny Dogfish



Salmon



Pacific sleeper



Blue, basking,
great white, etc.

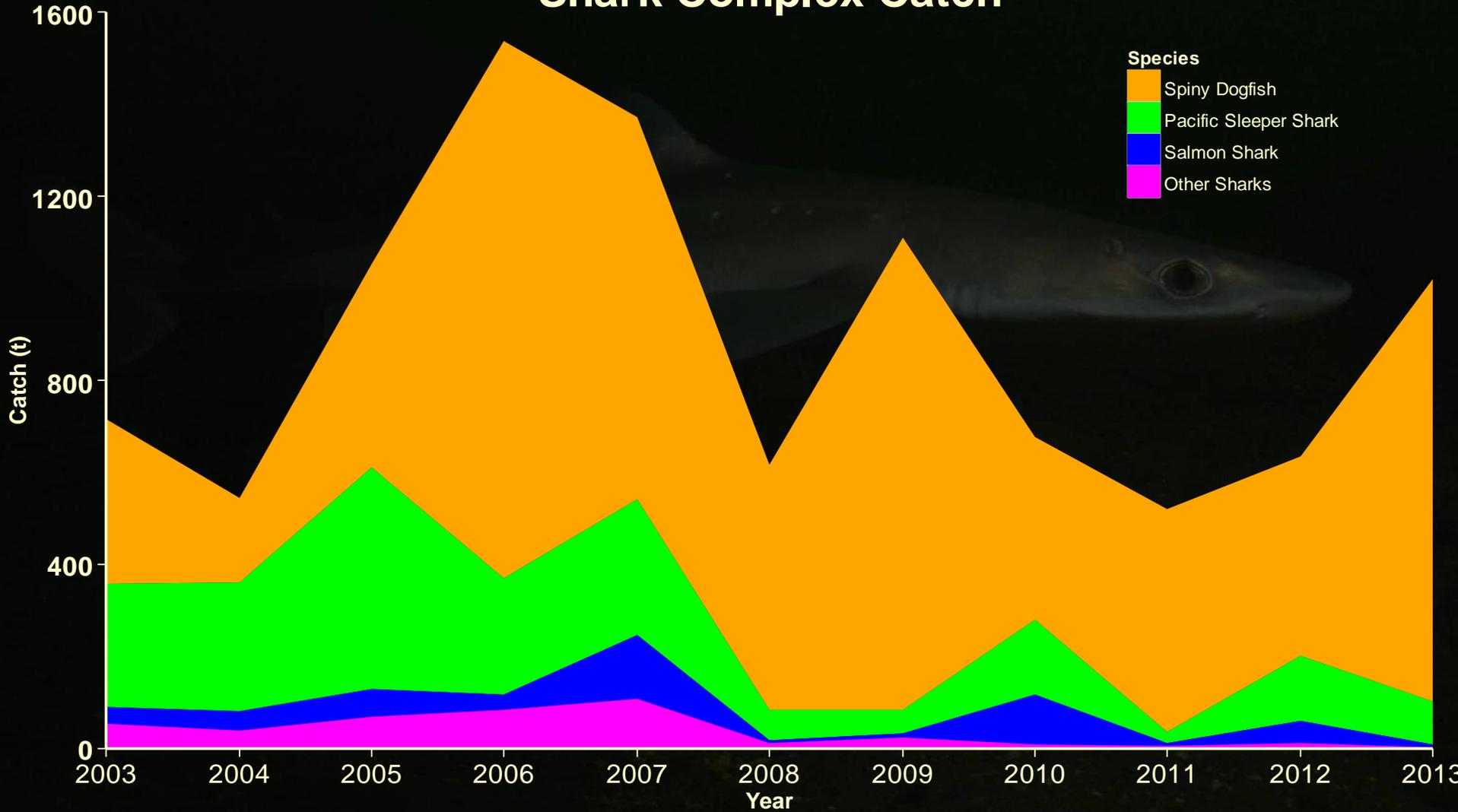


Data Sources

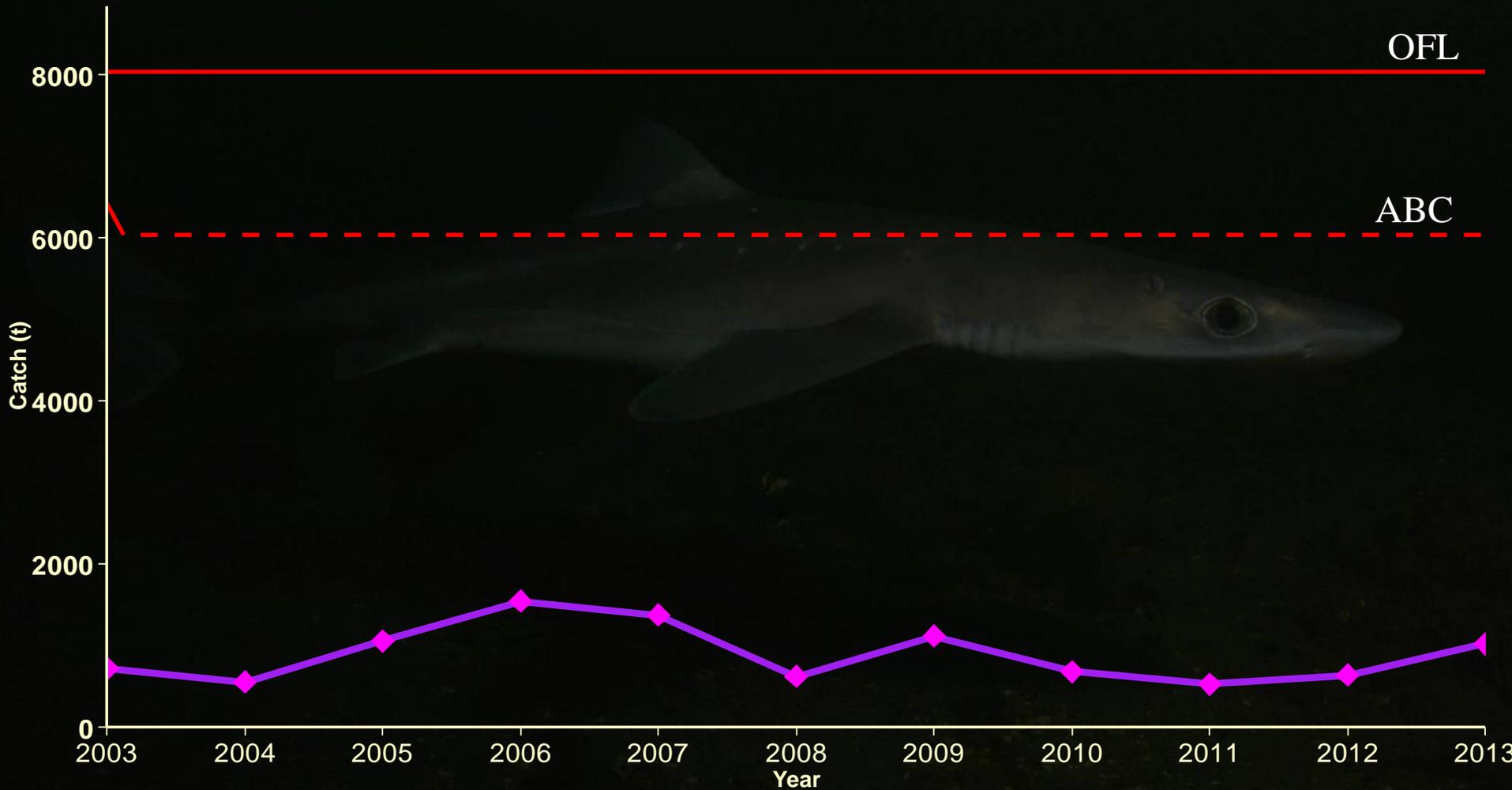
- Commercial catch
 - Historical catch (1997 – 2007) used for:
 - Pacific sleeper shark
 - Salmon shark
 - Other/unidentified sharks
 - GOA Biennial Trawl Survey
 - Used for spiny dogfish ABC/OFL
 - Other data sources
 - AFSC longline survey
 - IPHC longline survey
- 

GOA Shark Catch

Shark Complex Catch

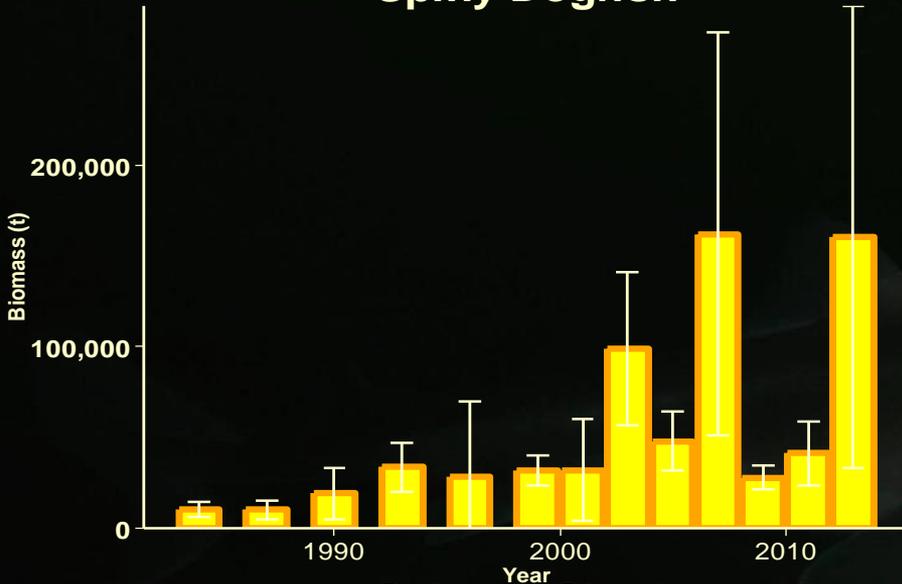


GOA Shark Complex Catch

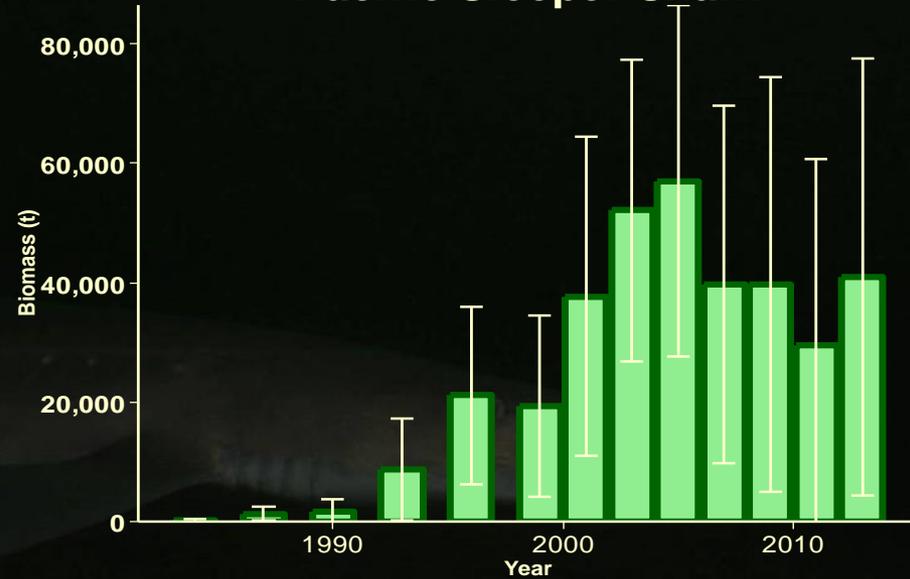


GOA Bottom Trawl Biomass

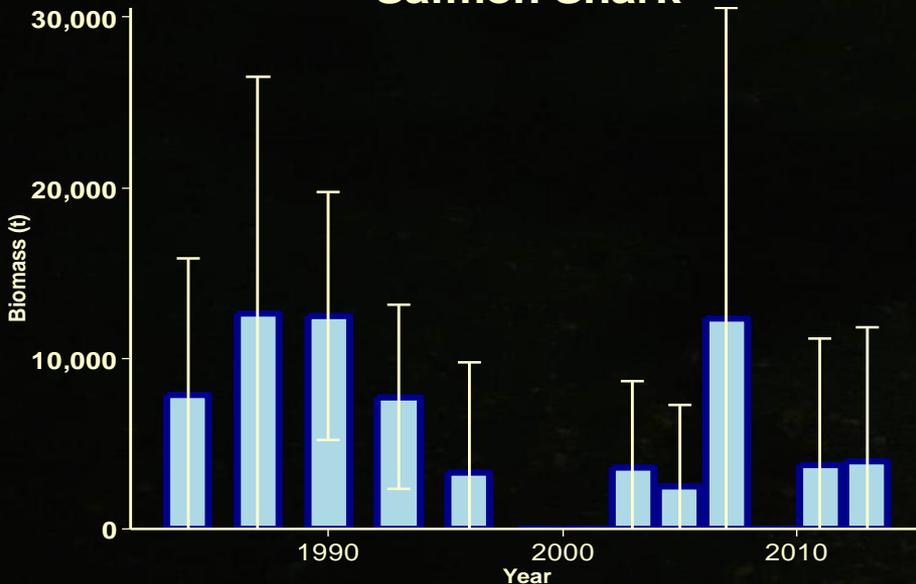
Spiny Dogfish



Pacific Sleeper Shark



Salmon Shark



Biomass is not estimated for other or unidentified sharks

OFL calculation

- Spiny dogfish component is calculated using an average trawl survey biomass, multiplied by natural mortality
- The rest of the complex uses tier 6 methods of the average catch over a fixed period
- These are added together for the complex and $ABC = 0.75 * OFL$

GOA Shortraker Rockfish



www.foxnews.com/us/2013/07/09/alaska-rockfish-believed-to-have-been-200-years-old-doesnt-look-day-o

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Alaska rockfish believed to have been 200 years old doesn't look a day over 64

Published July 09, 2013 / FoxNews.com



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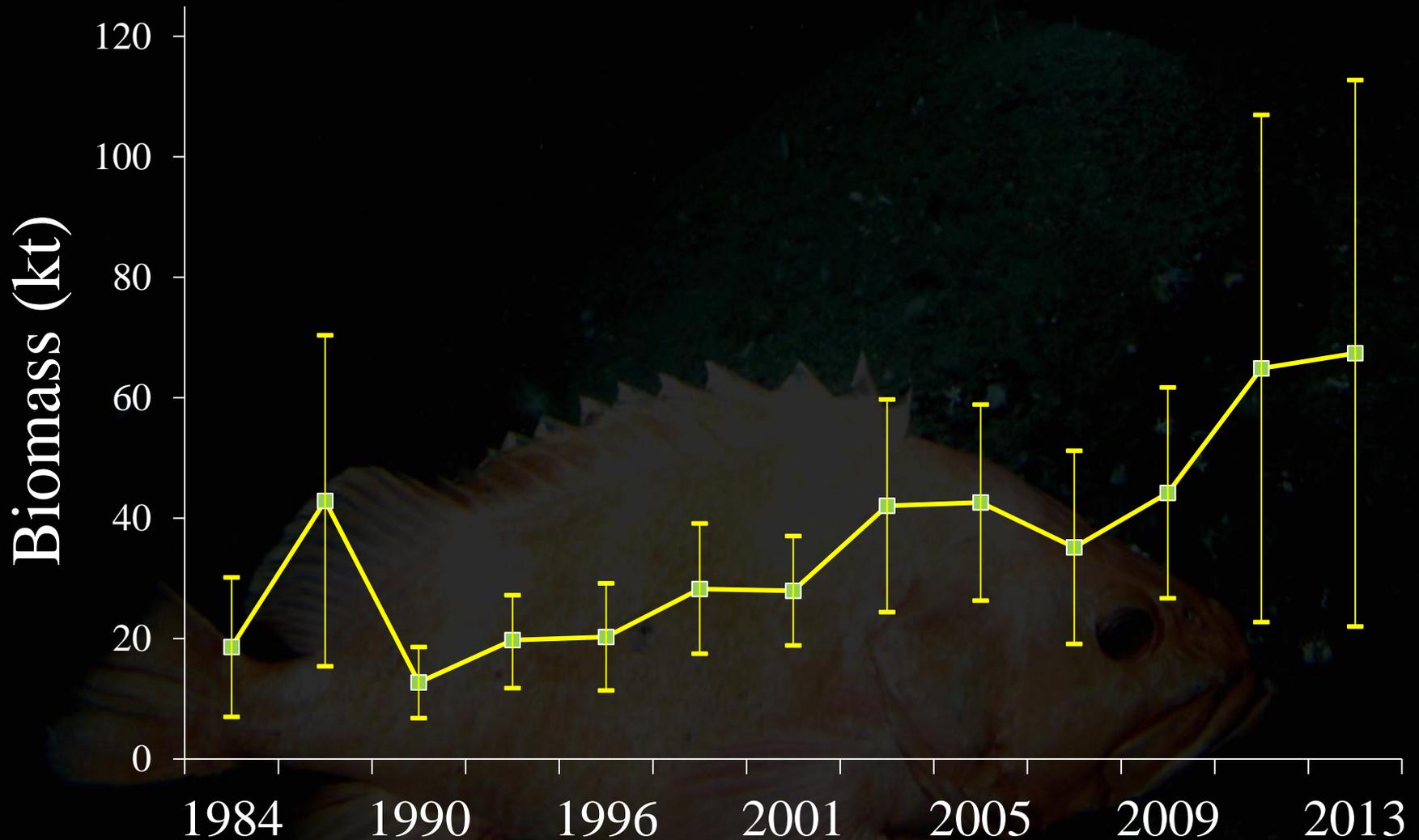
The rockfish [caught recently](#) in the vicinity of Juneau, Alaska,

GOA Shortraker Rockfish



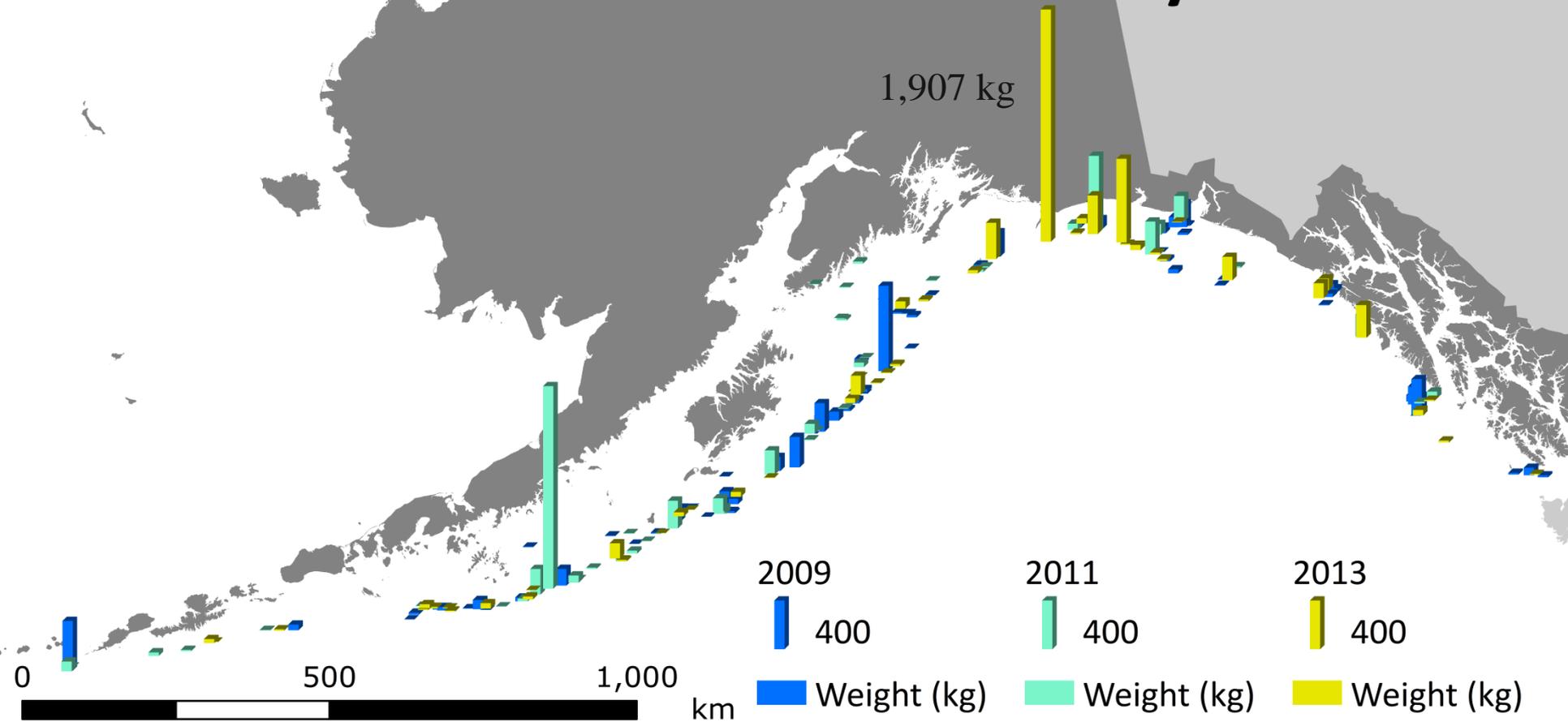
- Tier 5 species
 - Large, (probably) old, and valuable
- Attempts have been made to production age
- Lots of data, multiple surveys
- No little ones (estimating recruitment and length-based would be difficult)

Shortraker Trawl Survey Biomass

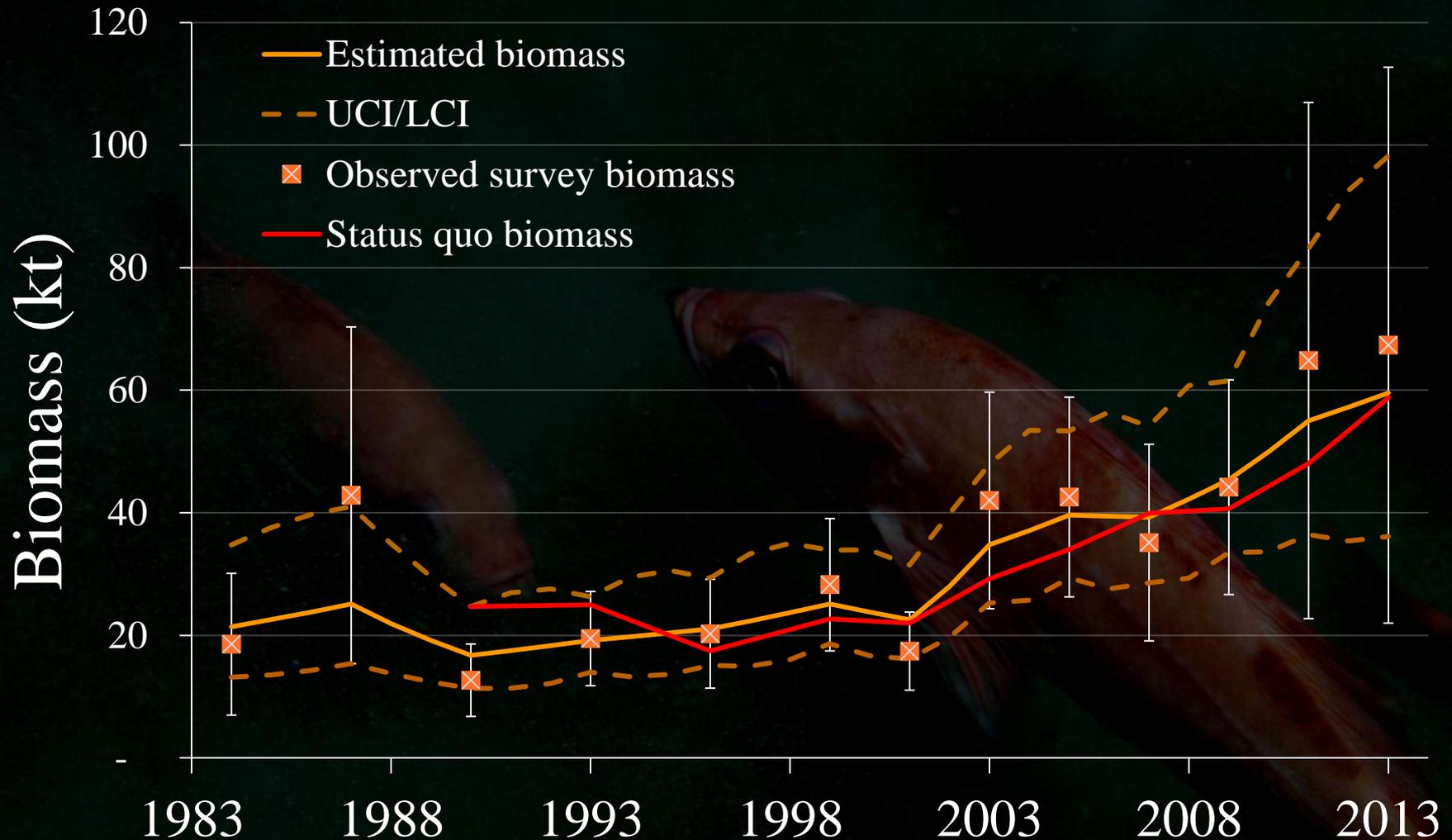


Shortraker Survey

Most Recent Trawl Surveys

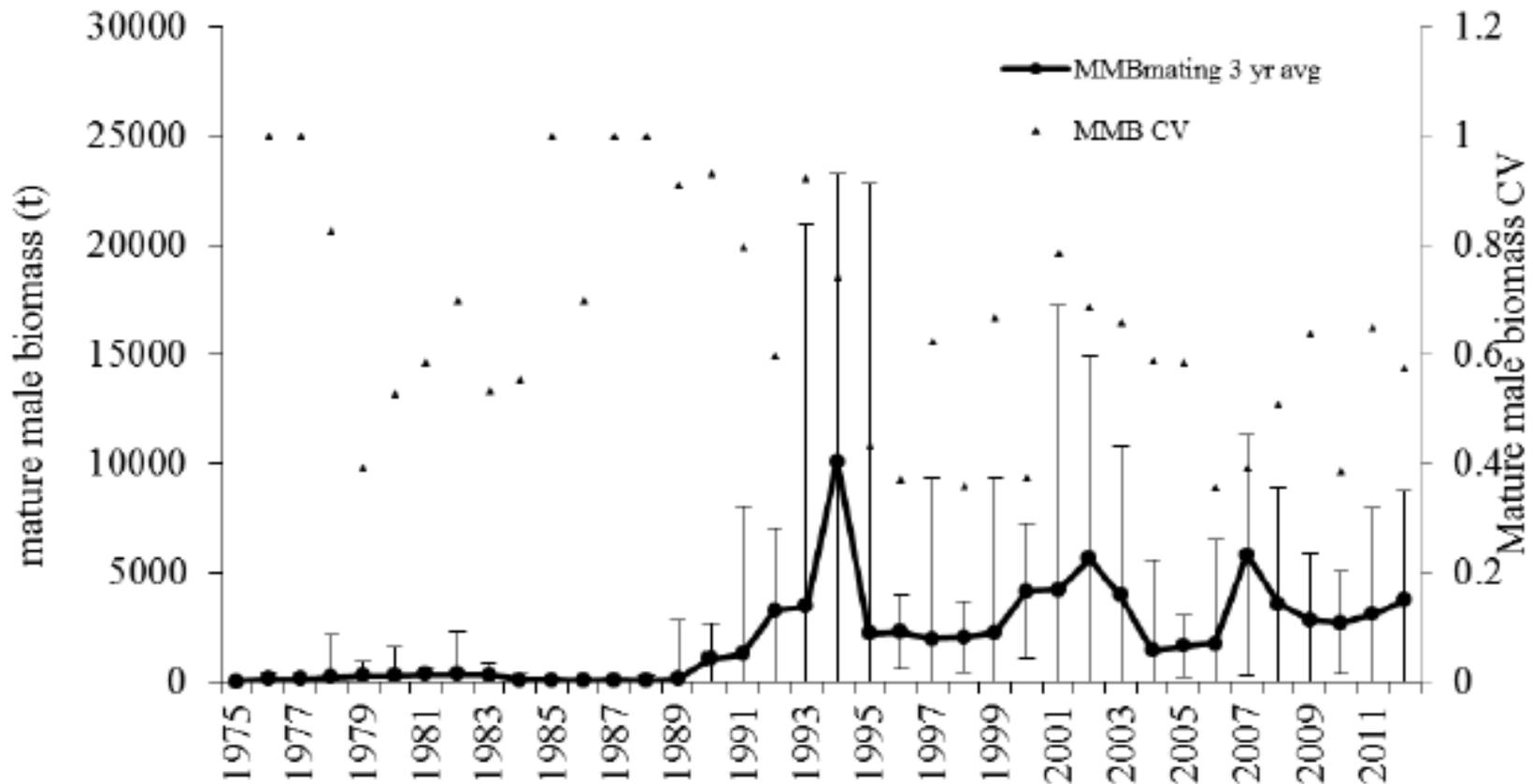


Fitting Total Trawl Survey Biomass via Random Effects Model



Crab example

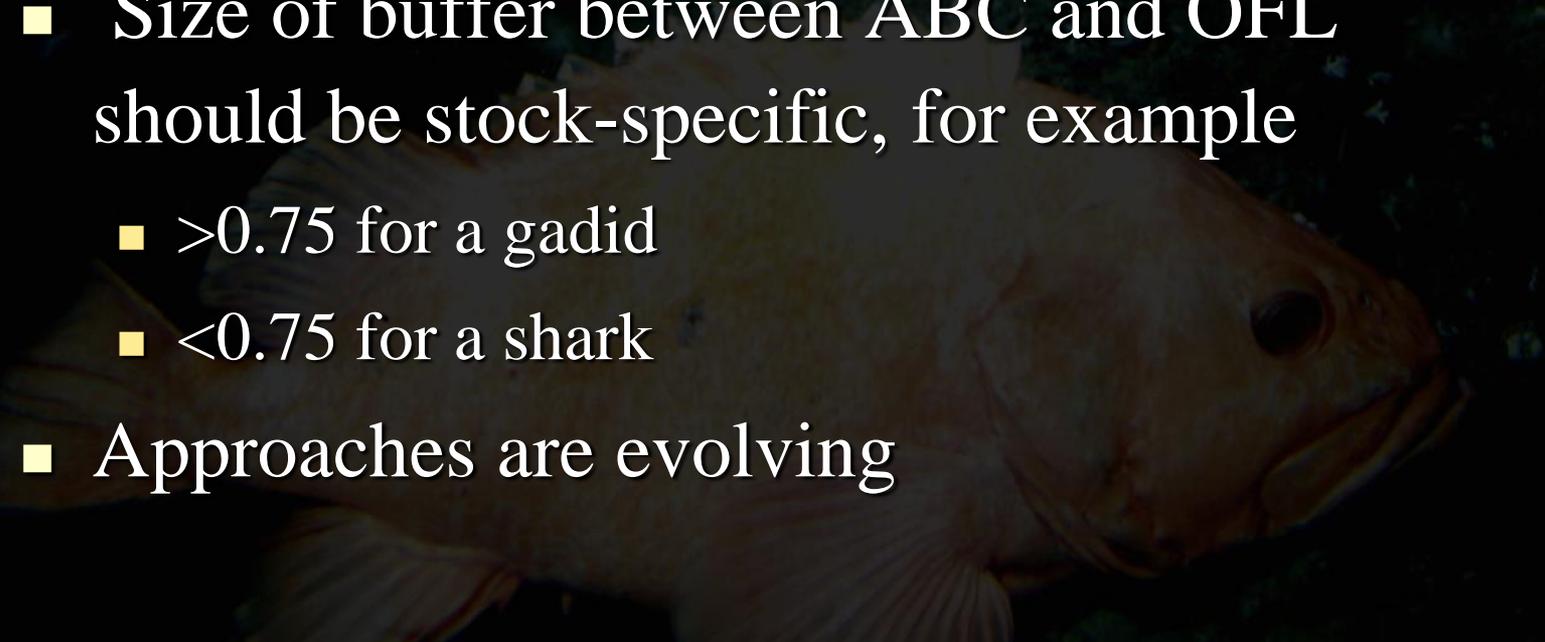
- Pribolof Island Red King Crab (Tier 4)



Crab example

- Pribolof Island Red King Crab (Tier 4)
- 3-year average of mature male survey biomass
- $F_{msy} = M = 0.18$
- $P^* = 0.49$ with survey uncertainty of last year survey of 0.62 and background uncertainty of 0.40

Criticisms of lower tiers

- Assumption of survey biomass being an estimate of “absolute exploitable biomass”
 - Assumption that M is a good proxy for F_{msy}
 - Size of buffer between ABC and OFL should be stock-specific, for example
 - >0.75 for a gadid
 - <0.75 for a shark
 - Approaches are evolving
- 

Single species management

Catch \leq TAC \leq ACL=ABC $<$ OFL

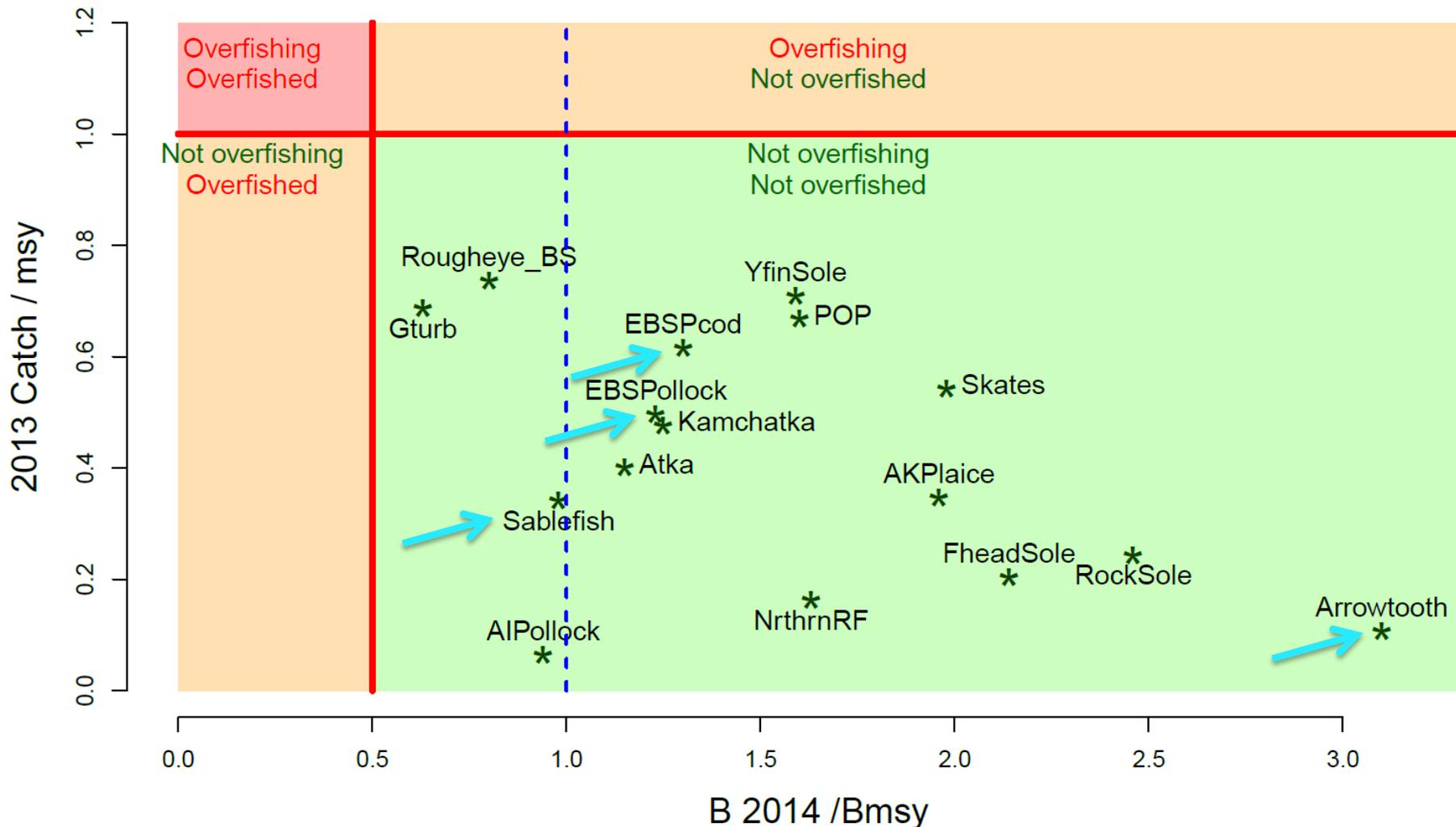
OFL ~ Catch at F_{MSY}

Buffers/Control rules

- Groundfish data limited stocks have a fixed buffer at $0.75 \times \text{OFL}$
- Crab stocks use a probability-only approach with a P^* of 0.49
 - Buffers have been set at about 10%
- Tier 3 stocks have a buffer that is the difference between F_{35} and F_{40}
- Tiers 3 and higher have a control rule that lowers the harvest rate when below our target reference point

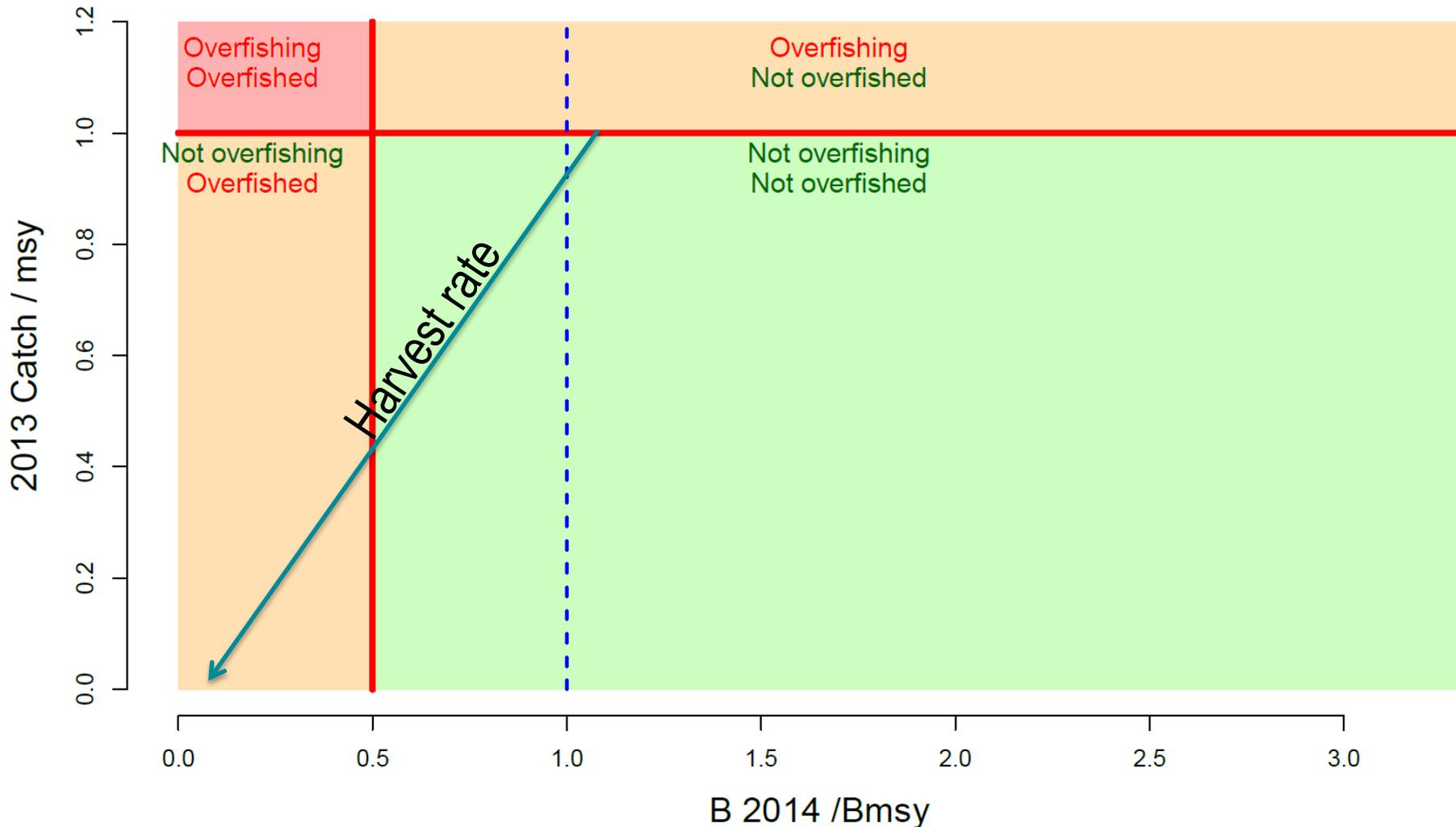
Stock status (How are we doing?)

Bering Sea and Aleutian Islands

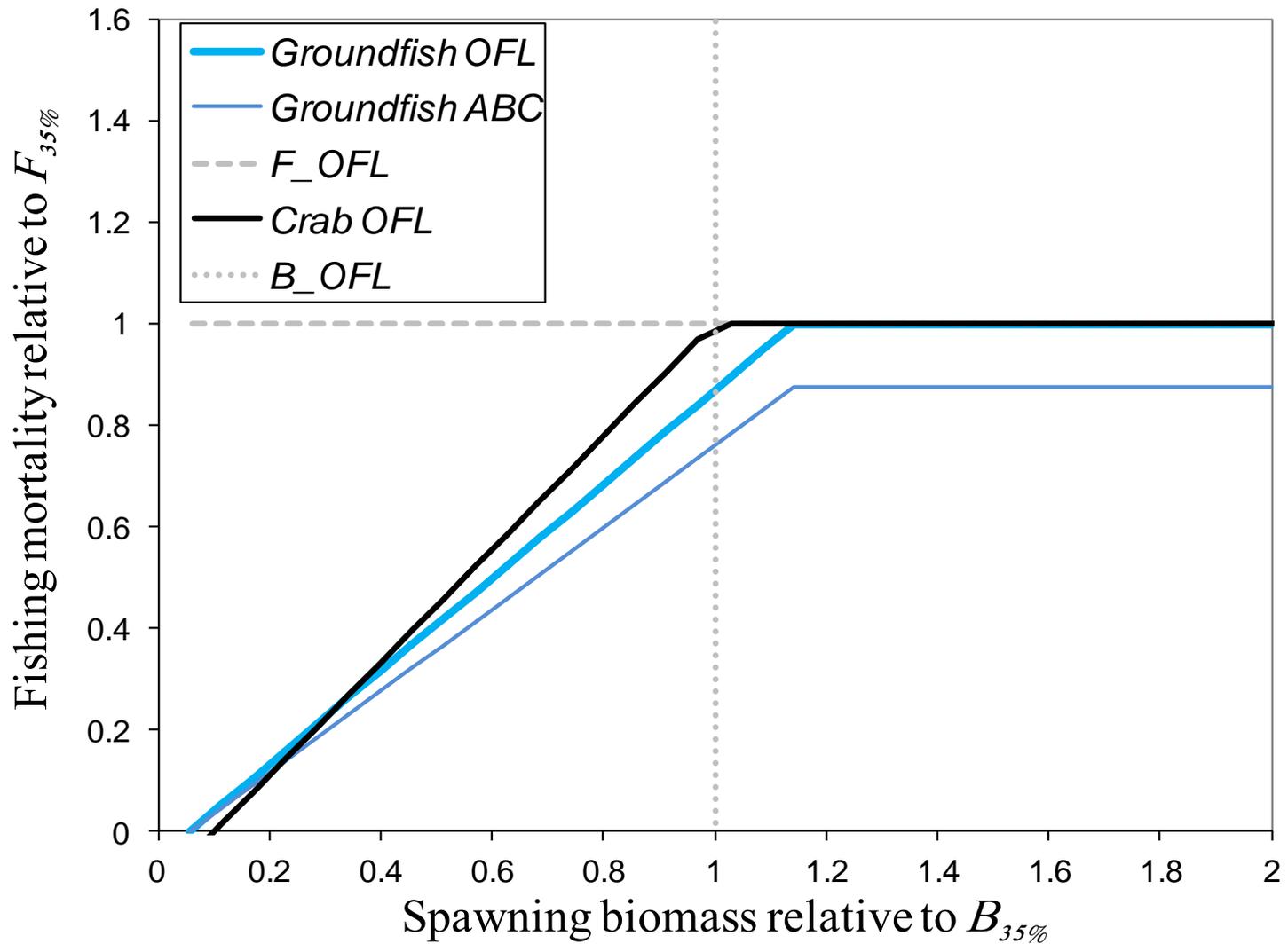


Stock status (catch control rule)

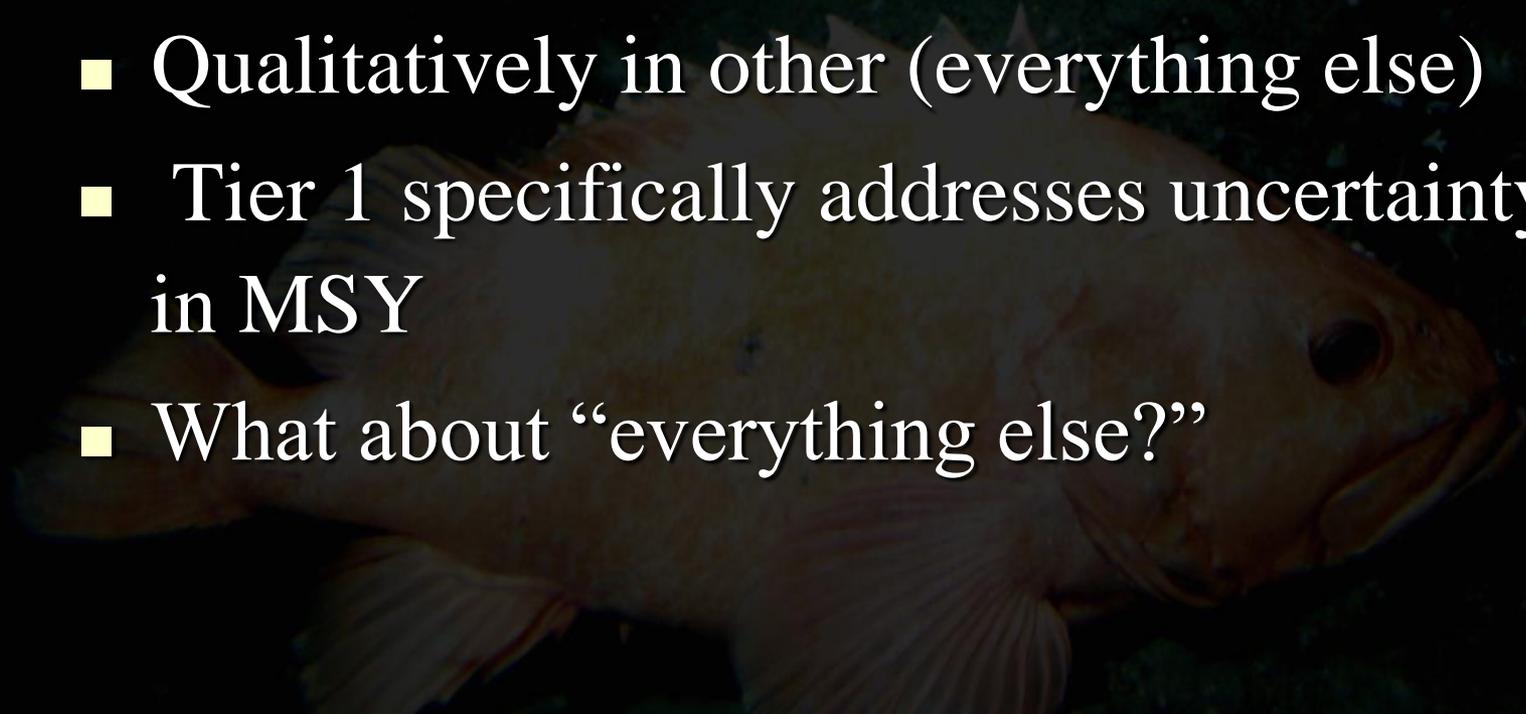
Bering Sea and Aleutian Islands



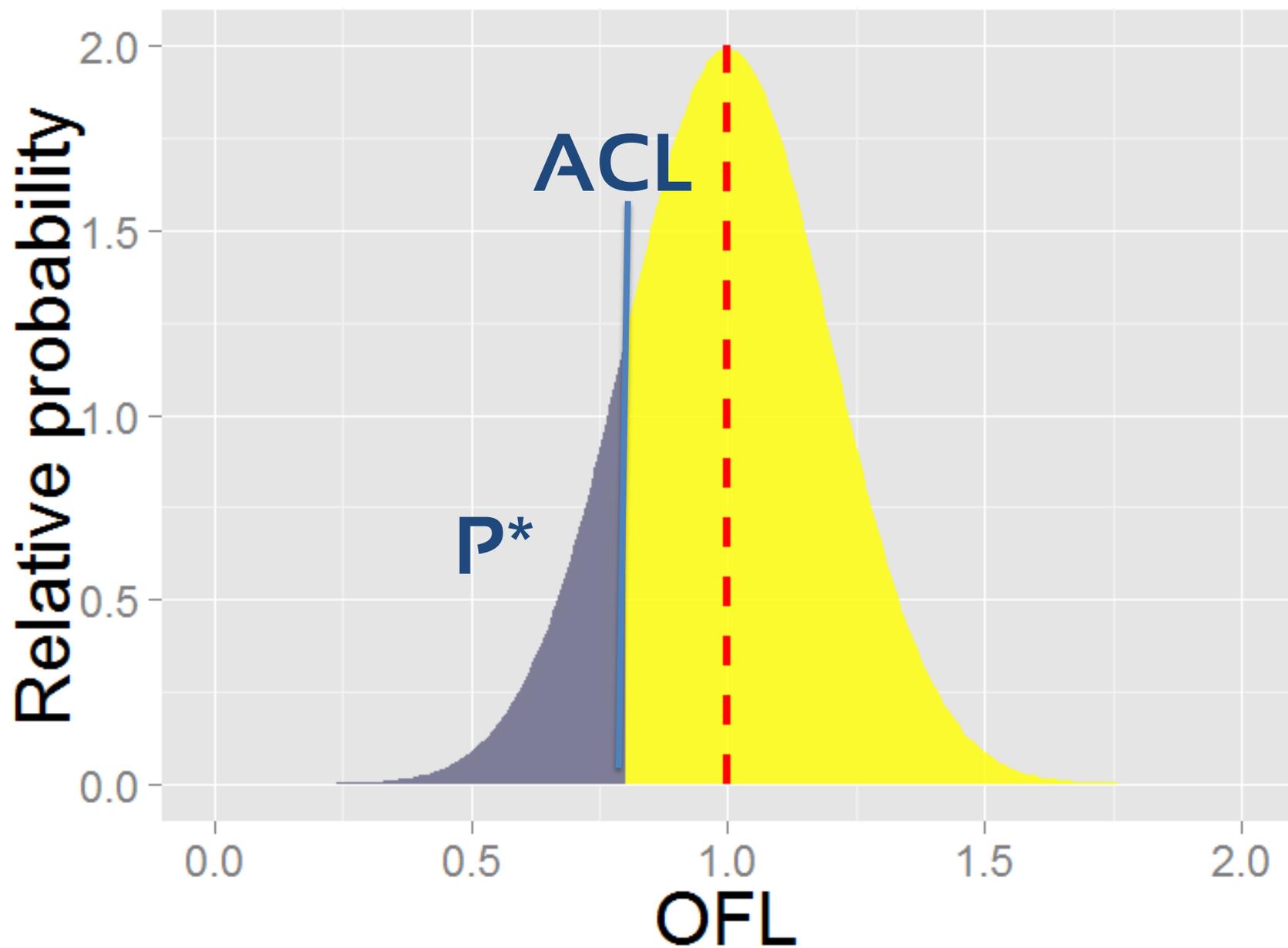
Stock status (catch control rule)



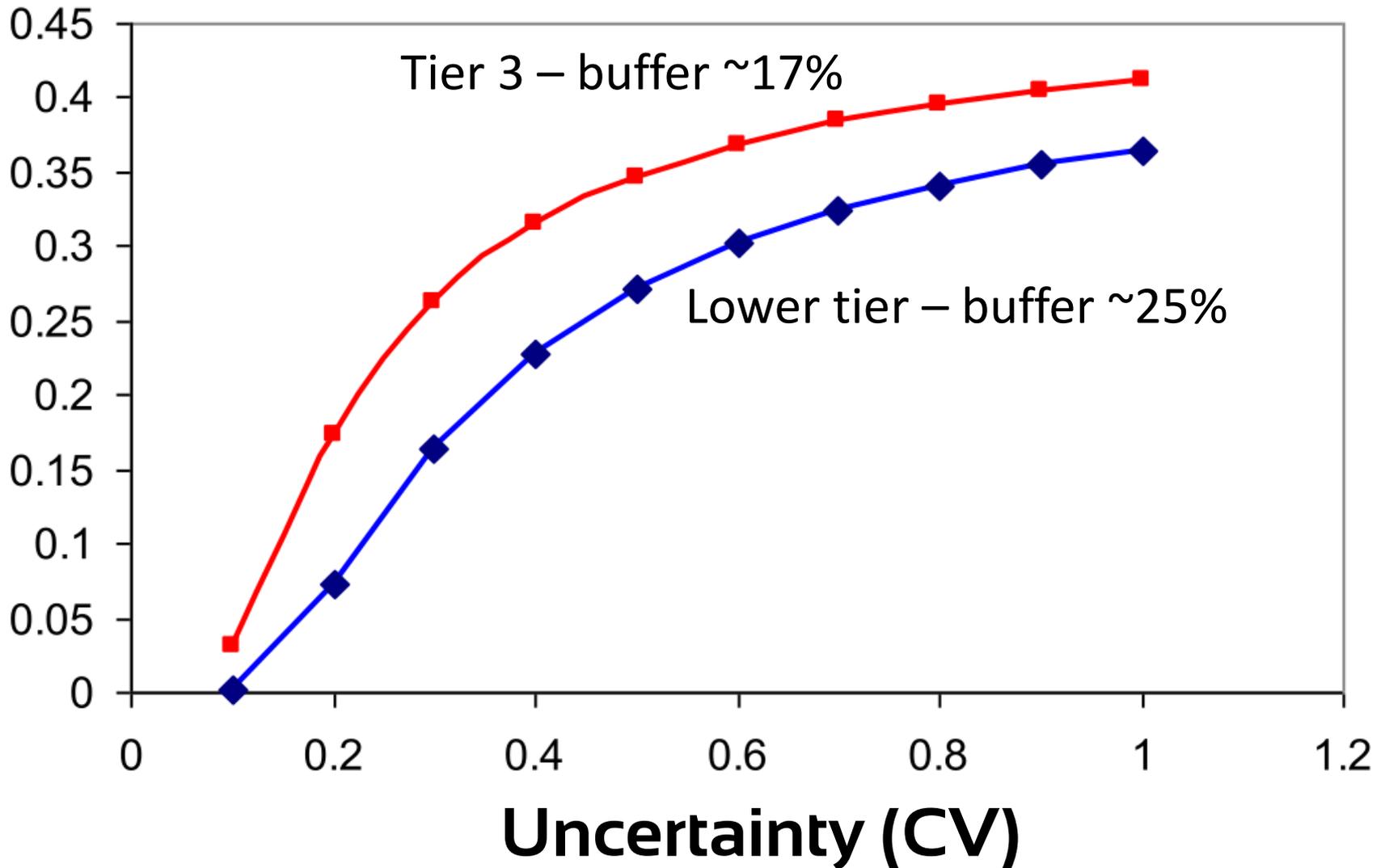
Are ACLs determined with scientific uncertainty?

- Yes!
 - Quantitatively in some cases (Tier 1 and crab)
 - Qualitatively in other (everything else)
 - Tier 1 specifically addresses uncertainty in MSY
 - What about “everything else?”
- 

P^* approach = Probability $ACL > OFL$



Implied buffers in other tiers (AK Groundfish)



Buffers/uncertainty

Tier	ABC Buffer	Direct link to uncertainty	Average buffer
1 (groundfish)	Harmonic mean of MSY	Yes	~5%
3 and 4 (groundfish)	Ratio of $F_{40}/F_{35} \times$ OFL	No	~17%
5 and 6 (groundfish)	0.75 * OFL	No	25%
Crab (Tiers 3-4)	$P^* = 0.49 +$ SSC/DFG	Yes	~10%
Crab (Tier 5)	$\leq 0.9 \times$ OFL	No	10%

Science, Service, Stewardship



Report of the Retrospective Investigations Group

Round 2: The compilation

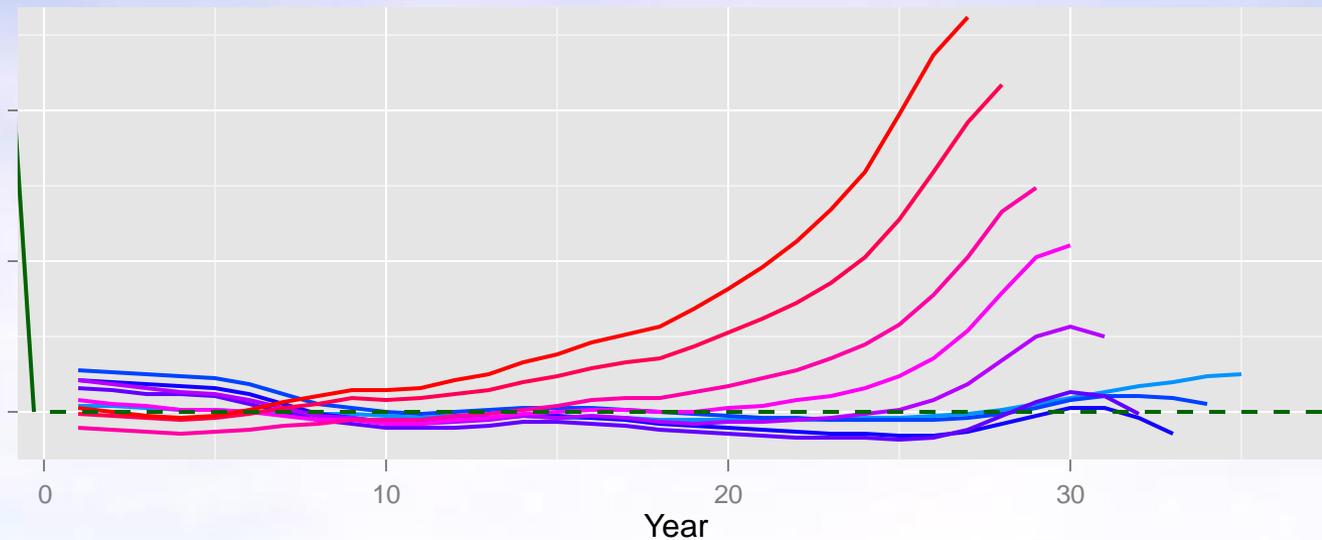
Dana Hanselman, Bill Clark, and Mike Sigler

Groundfish Plan Team meeting
Seattle, WA
September 2013

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Introduction I

A retrospective pattern is a systematic inconsistency among a series of estimates of population size ... based on increasing periods of data (Mohn 1999).



Introduction II

2012:

Discussed retrospectives, showed examples,
requested retrospectives from all authors

2013:

Compiled retrospectives of SSB for 20 AFSC
stocks

Computed statistics, plotted, compared,
examined potential causes

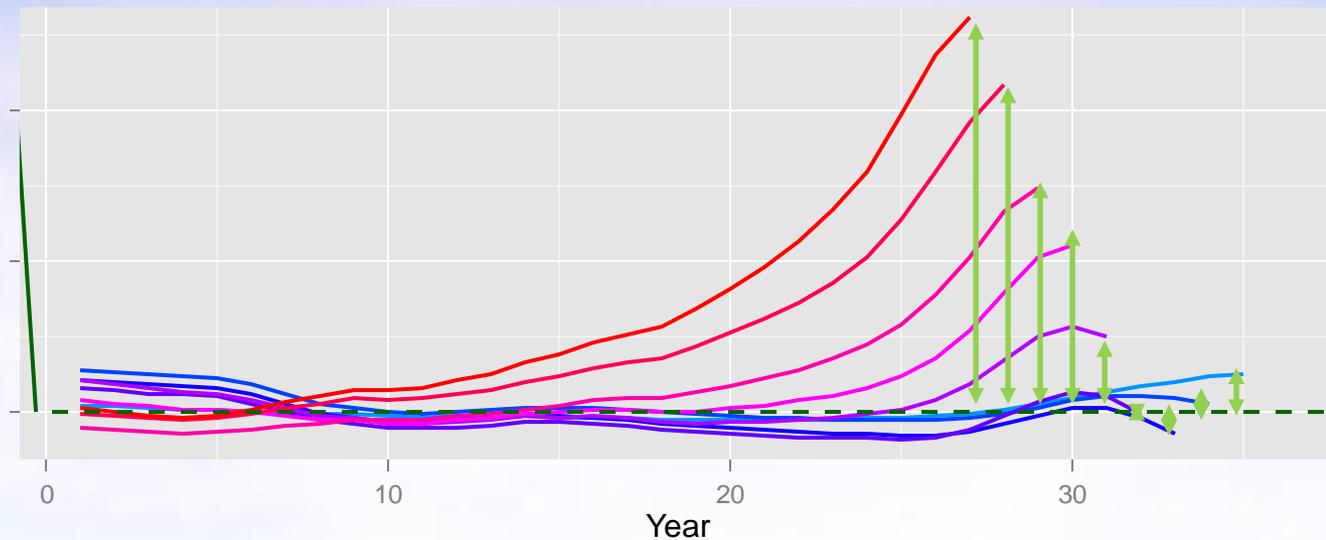
Recommendations for future work

The contestants

Stock ID	Common name	Mean	Survey	M	Recruit.	Average
		Survey	Time			
		CV	Series CV		CV	F
GOA_NR	GOA Northern rockfish	0.426	0.638	0.060	0.974	0.027
BSAI_POP	BSAI Pacific ocean perch	0.250	0.538	0.062	0.655	0.031
GOA_ATF	GOA Arrowtooth flounder	0.089	0.286	0.275	0.333	0.009
BSAI_GT	BSAI Greenland turbot	0.181	0.437	0.112	1.844	0.124
GOA_REBS	GOA RE/BS rockfish	0.176	0.146	0.030	0.668	0.024
GOA_DUSKY	GOA Dusky rockfish	0.397	0.538	0.070	0.924	0.053
BSAI_PCOD	BSAI Pacific cod	0.085	0.330	0.340	0.669	0.191
GOA_PCOD	GOA Pacific cod	0.177	0.364	0.340	0.430	0.228
BSAI_ATKA	BSAI Atka mackerel	0.249	0.375	0.300	0.609	0.167
GOA_POP	GOA Pacific ocean perch	0.250	0.432	0.060	0.680	0.102
BSAI_YFS	BSAI Yellowfin sole	0.089	0.202	0.120	0.502	0.079
BSAI_NRS	BSAI Northern rock sole	0.090	0.481	0.150	0.553	0.022
BSAI_NR	BSAI Northern rockfish	0.302	0.327	0.041	0.648	0.086
AI_POLL	AI Walleye pollock	0.345	0.767	0.180	2.130	0.076
BSAI_POLL	EBS walleye pollock	0.110	0.342	0.300	0.629	0.211
BSAI_BSRE	BSAI BS/RE rockfish	0.278	0.898	0.033	1.419	0.047
SABLE	Alaska sablefish	0.131	0.090	0.100	1.031	0.080
GOA_POLL	GOA Walleye pollock	0.176	0.973	0.300	1.212	0.141
BSAI_FHS	BSAI Flathead sole	0.111	0.276	0.200	0.516	0.066
BSAI_APL	BSAI Alaska plaice	0.114	0.160	0.130	0.418	0.045

The stats: Mohn's revised ρ

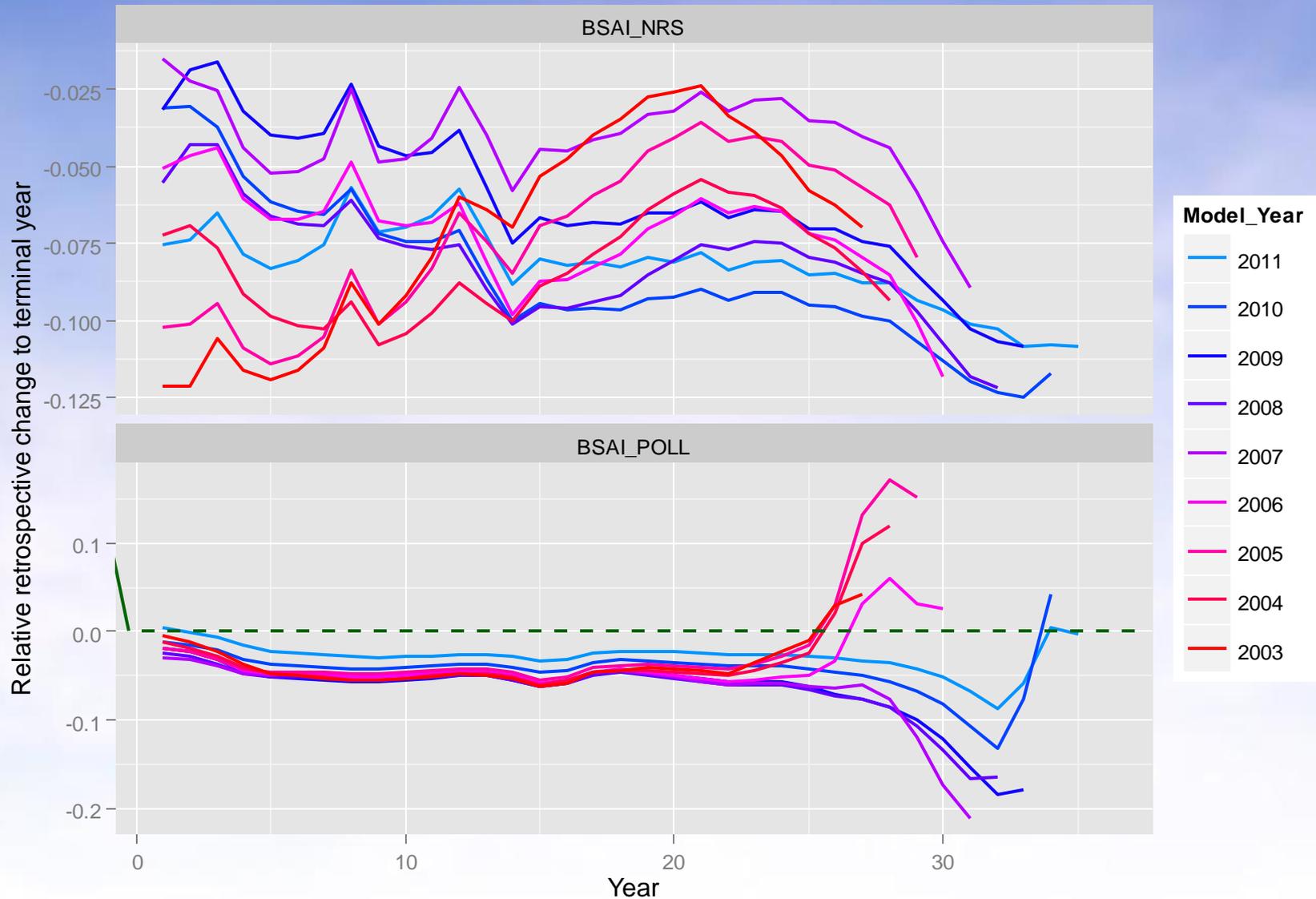
The average of the relative deviations of the **terminal year** to the reference model as data is removed.



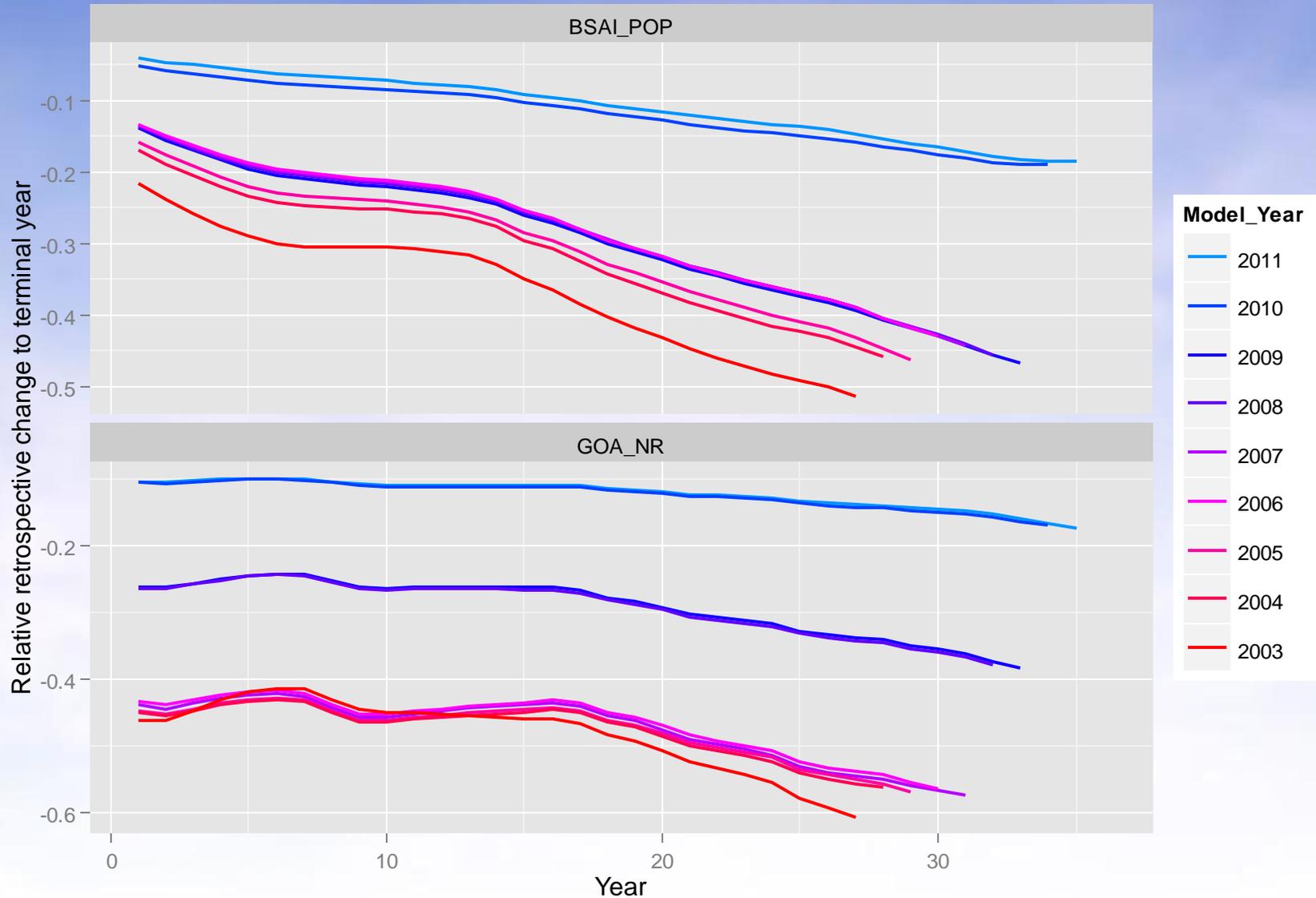
The rankings

stock	Mohn's revised ρ	Wood's Hole ρ	RMSE	H ϕ	Rank
GOA_NR	-0.443	-0.357	0.521	1.241	1
BSAI_POP	-0.401	-0.26	0.352	1.541	2
GOA_ATF	0.383	0.343	0.312	1.117	3
BSAI_GT	0.418	0.19	0.220	2.196	4
GOA_REBS	0.342	0.253	0.239	1.351	5
GOA_DUSKY	-0.304	-0.221	0.283	1.373	6
BSAI_PCOD	0.335	0.175	0.189	1.912	7
GOA_PCOD	0.422	0.068	0.128	6.191	8
BSAI_ATKA	0.255	0.14	0.179	1.824	9
GOA_POP	0.115	0.127	0.165	0.908	10
BSAI_YFS	-0.131	-0.065	0.099	2.014	11
BSAI_NRS	-0.101	-0.072	0.080	1.398	12
BSAI_NR	-0.083	-0.053	0.095	1.553	13
AI_POLL	0.086	0.048	0.058	1.801	14
BSAI_POLL	-0.019	-0.043	0.061	0.450	15
BSAI_BSRE	0.028	0.036	0.058	0.778	16
SABLE	0.089	0.016	0.043	5.404	17
GOA_POLL	0.037	0.023	0.052	1.636	18
BSAI_FHS	0.007	0.042	0.057	0.157	19
BSAI_APL	0.018	-0.006	0.015	-3.093	20

No retro/good retro



Denied Optimal Harvest stocks



DOH and OOPS

Stock	Denied Optimal Harvest (DOH)			Occasional Overage Potential Stock (OOPS)				
	<u>GOA NR</u>	<u>BSAI POP</u>	<u>G DUSKY</u>	<u>G PCOD</u>	<u>BSAI GT</u>	<u>GOA ATF</u>	<u>G REBS</u>	<u>BS PCOD</u>
Mohn's rev. ρ	-0.44	-0.40	-0.30	0.42	0.42	0.38	0.34	0.33
Wood's Hole ρ	-0.36	-0.26	-0.22	0.07	0.19	0.34	0.25	0.18
RMSE	0.52	0.35	0.28	0.13	0.22	0.31	0.24	0.19
H ϕ	1.24	1.54	1.37	6.19	2.20	1.12	1.35	1.91
Rank	1	2	6	8	4	3	5	7
Survey Selex	Asymp.	Asymp.	Asymp.	Dome	Dome	Asymp.	Dome	Dome
Software	AMAK	AMAK	AMAK	SS	SS	AMAK	AMAK	SS
Parameters	145	143	99	239	129	138	139	184
F_devs	51	53	35	-	-	51	35	-
Rec_devs	81	50	51	48	72	63	56	38
Eff. Param.	13	40	13	191	57	24	48	146

Retrospective predispositions

Stock statistic	Retrospective statistic	<i>r</i>	p-value
Mean.Survey.CV	Wood's hole ρ	-0.512	0.021
M	Mohn's revised ρ	0.486	0.030
Mean.Survey.CV	Mohn's revised ρ	-0.473	0.035
Mean.Survey.CV	RMSE	0.464	0.039
Average.F	Mohn's revised ρ	0.434	0.056
Average.F	Hanselman's ϕ	0.392	0.087
M	Wood's hole ρ	0.374	0.104
Average.F	RMSE	-0.300	0.198
Survey.Time.Series.CV	Wood's hole ρ	-0.284	0.225
Survey.Time.Series.CV	Mohn's revised ρ	-0.283	0.227
Average.F	Wood's hole ρ	0.215	0.363
M	Hanselman's ϕ	0.206	0.383

Conclusions

- Retrospective patterns are most likely related to:
 - Survey CV
 - Natural mortality
- Bias may be related to:
 - Selectivity shape
 - Model complexity
- Other things to examine:
 - Catchability and M estimation
 - Influence of prior distributions
 - Ratio of F/F_{ABC}
 - Number of peels, length of model time series
 - MSE/Sims to look at applying corrections, e.g., $1/(1+\rho)$

Recommendations I

- Always check for the presence of a retrospective pattern
- If a model exhibits a retrospective pattern, explore why
- Communicate this source of uncertainty
- There is currently not an accepted level beyond which an assessment is deemed to exhibit an **important** retrospective pattern.
- A strong retrospective might be used as a reason to choose one model over another, or to recommend an ABC higher or lower than would have otherwise been

Summary

- Data-limited methods could be improved
 - But we have data and we are at least dealing with lesser stocks
 - Capacity limits detailed attention to every stock/complex
- Link to scientific uncertainty could be improved
- Retrospective working group identifying “assessments of concern”



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Stock assessment models at Alaska Fisheries Science Center Theme I – Part II

Jim Ianelli

Alaska Fisheries Science Center
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