# Recommended harvest strategy for Aleutian Islands golden king crab

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**RC 3**

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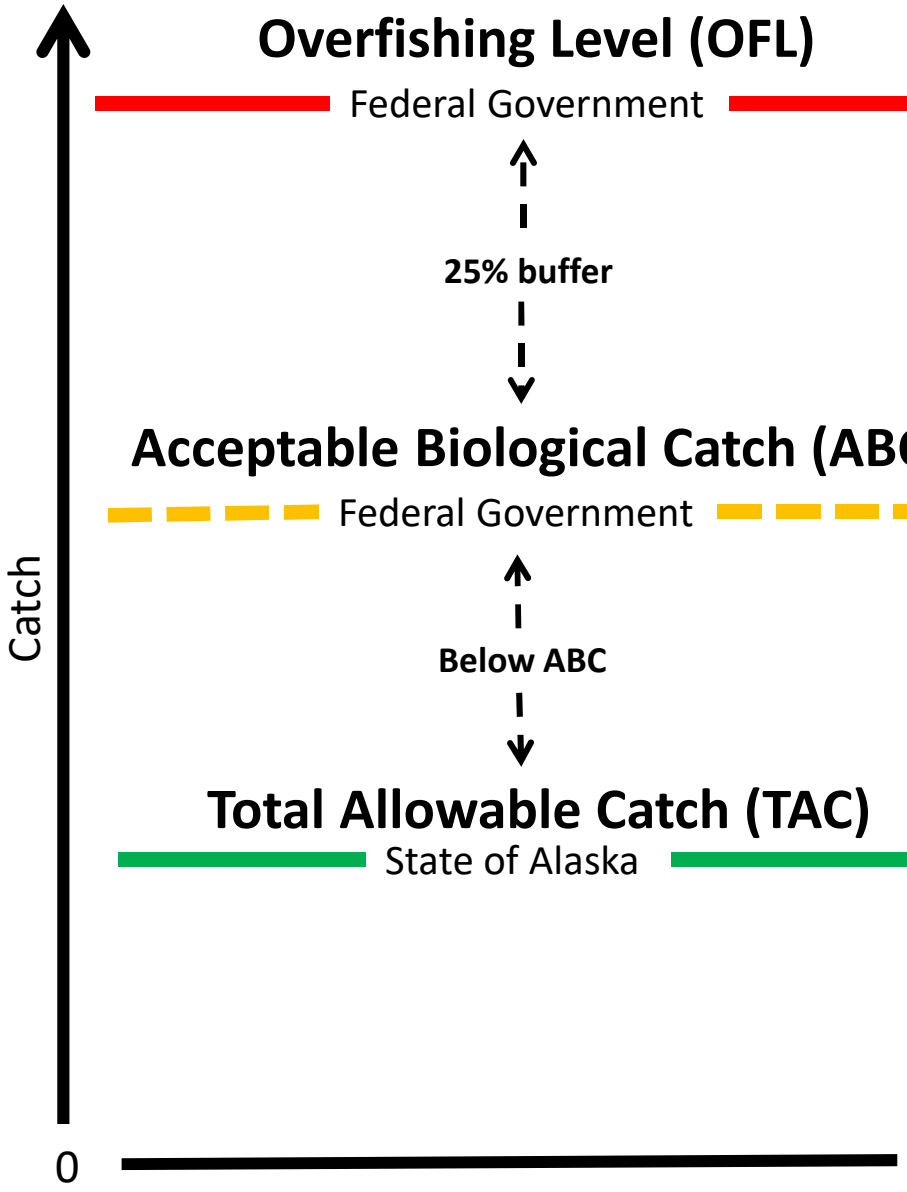
# State/Federal cooperative management regime

**Federal process:**

- NPFMC FMP: 10 BSAI crab stocks (including AIGKC)
- OFL (overfishing level): approximates MSY
- ABC (acceptable biological catch): below OFL to account for "*the scientific uncertainty in the estimate of OFL and any other specified scientific uncertainty*"

**State process:** harvest levels (TAC) and other management actions

- BOF Policy on King and Tanner Crab Resource Management, FMP, MSA national standards
- FMP Amendment 38: optimum yield ranges from 0 – <OFL
  - Sum of all sources of fishing mortality <ABC

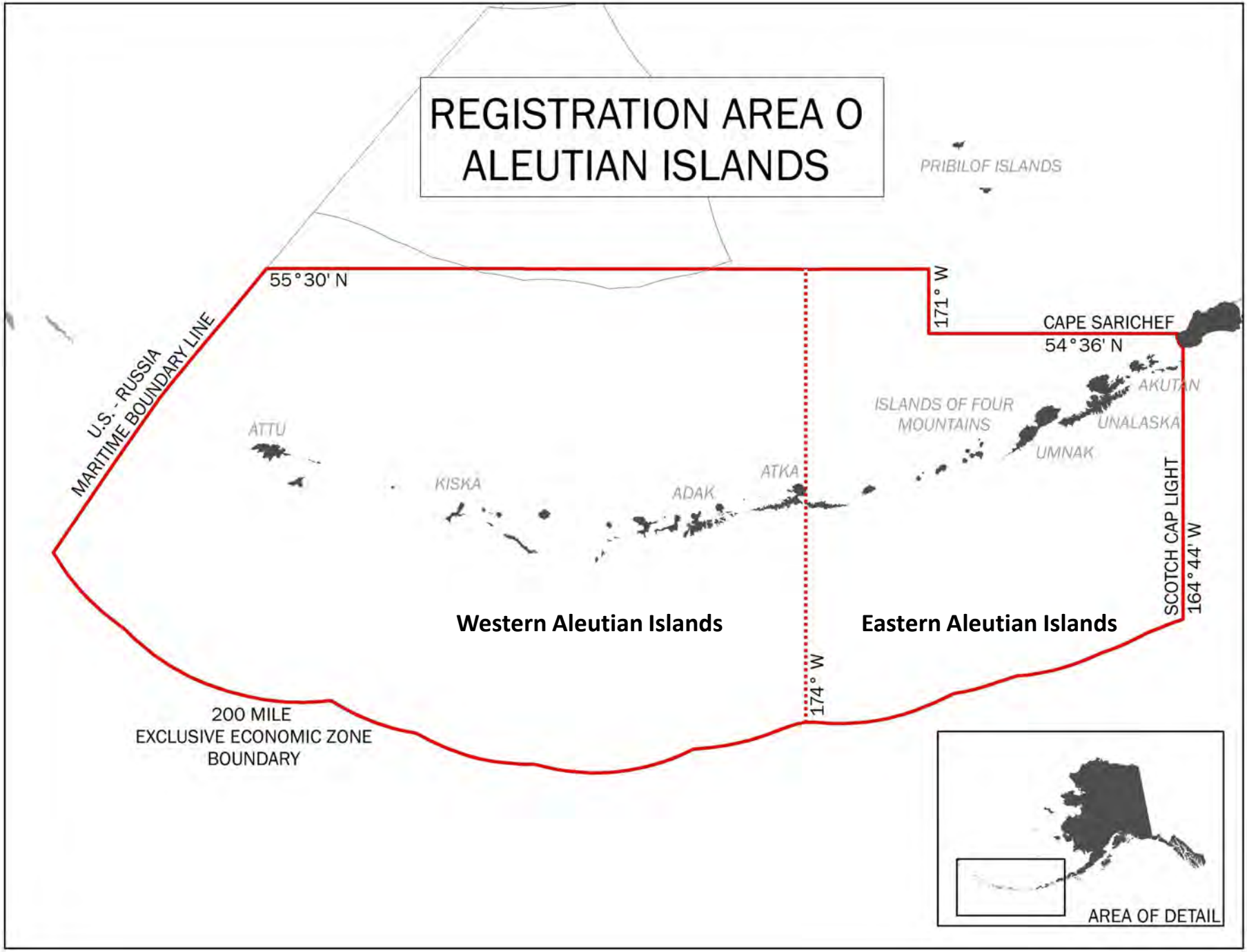



**OFL**: Level of fishing mortality that jeopardizes the capacity of a stock to produce the maximum sustained yield on a continuing basis.

**ABC:** Level of annual catch that accounts for scientific uncertainty and is set to prevent the OFL from being exceeded.

In practice ABC limits mortality of **ALL** male and female crabs regardless of size, from all sources of fishery mortality (i.e. retained catch, bycatch in directed and non-directed crab fisheries, and groundfish fisheries).

**TAC:** Annual catch target for the directed fishery, set to prevent exceeding the ABC for that stock. **Limits legal sized males**, but must consider all sources of mortality to ensure the ABC is not exceeded. Considers model uncertainty and other factors.


REGISTRATION AREA O
ALEUTIAN ISLANDS
PRIBILOF ISLANDS
55°30' N
171° W
CAPE SARICHEF
54°36' N
U.S. - RUSSIA
MARITIME BOUNDARY LINE
ATTU
KISKA
ADAK
ATKA
ISLANDS OF FOUR
MOUNTAINS
AKUTAN
UNALASKA
UMNAK
SCOTCH CAP LIGHT
164°44' W
Western Aleutian Islands
Eastern Aleutian Islands
174° W
200 MILE
EXCLUSIVE ECONOMIC ZONE
BOUNDARY
AREA OF DETAIL

# Current Fishery Management

- Size: 6.0 inches carapace width (152.4 mm)
- Sex: Male only
- Season: August 1 to April 30
- Managed east/west of 174° W longitude
- Gear: pots (longline)
- Harvest levels (total allowable catch; TAC) fixed in regulation
- Small fleet: 5 vessels
- Rationalized fishery

# ADF&G Harvest strategy

The annual TAC is set by state regulation, 5 AAC 34.612 (Harvest Levels for Golden King Crab in Registration Area O), as approved by the BOF in March 2012:

(a) Until the Aleutian Islands golden king crab stock assessment model and a state regulatory harvest strategy are established, the harvest levels for the Registration Area O golden king crab fishery are as follows:

(1) east of 174° W long. (EAG): 3.31 million pounds; and

(2) west of 174° W long. (WAG): 2.98 million pounds;

(b) The department may modify the harvest levels based on the best scientific information available and considering the reliability of estimates and performance measures, sources of uncertainty as necessary to avoid overfishing, and any other factors necessary to be consistent with sustained yield principles.

*Prior to 2018, the word “reduce” was used

# AIGKC stock assessment model

- In development for nearly 10 years, accepted in 2017 by NPFMC for annual OFL and ABC determination
- AIGKC considered 1 stock, managed as 2 areas: east (**EAG**) and west (**WAG**) of 174° W long.
  - OFL and ABC calculated for each management area separately, then combined for a single stock OFL and ABC
- Model-based abundance estimates now available
  - Abundance estimates allow TAC to be scaled to stock status: better conservation, maximizes economic and social benefits
  - No fishery-independent bottom trawl survey, no area-swept abundance estimates prior to model

# Objective/purpose

**Objective:** Develop a state harvest strategy that allows for abundance-based TAC calculations

*How can we balance the tradeoff between conservation and economic considerations?*

- Conducted 30-year **forecast simulations** to evaluate how thirteen different harvest policies affect stock sustainability and productivity by comparing conservation and economic criteria

# Forecast simulations

What the analysis is:

- A tool used to estimate relative differences in population sustainability and productivity under different harvest policies

What the analysis is not:

- A crystal ball that tells us exactly what will happen over the next 30 years

# Forecast simulations

- 2018 base model (scenario 18_0)
- Projected abundances for 30 years
  - *Evaluated **short term** (1-8 years) and **long term** (1-30 years) results*
- 500 random replicates
- Estimated:
  - Mature males biomass (MMB)
  - Mature male abundance (MMA)
  - Legal male biomass (LMB)
  - Overfishing level (OFL)
  - Acceptable biological catch (ABC)
  - Total catch (TOTC)
  - Retained catch (RETC)
  - Retained catch per unit effort (CPUE)
  - Number of annual recruits

<u>Then calculated probabilities of:</u>
exceeding conservation thresholds,
meeting economic goals, etc.

# Evaluating State HCRs

**Management criteria**: 2-tiered approach

**Conservation**

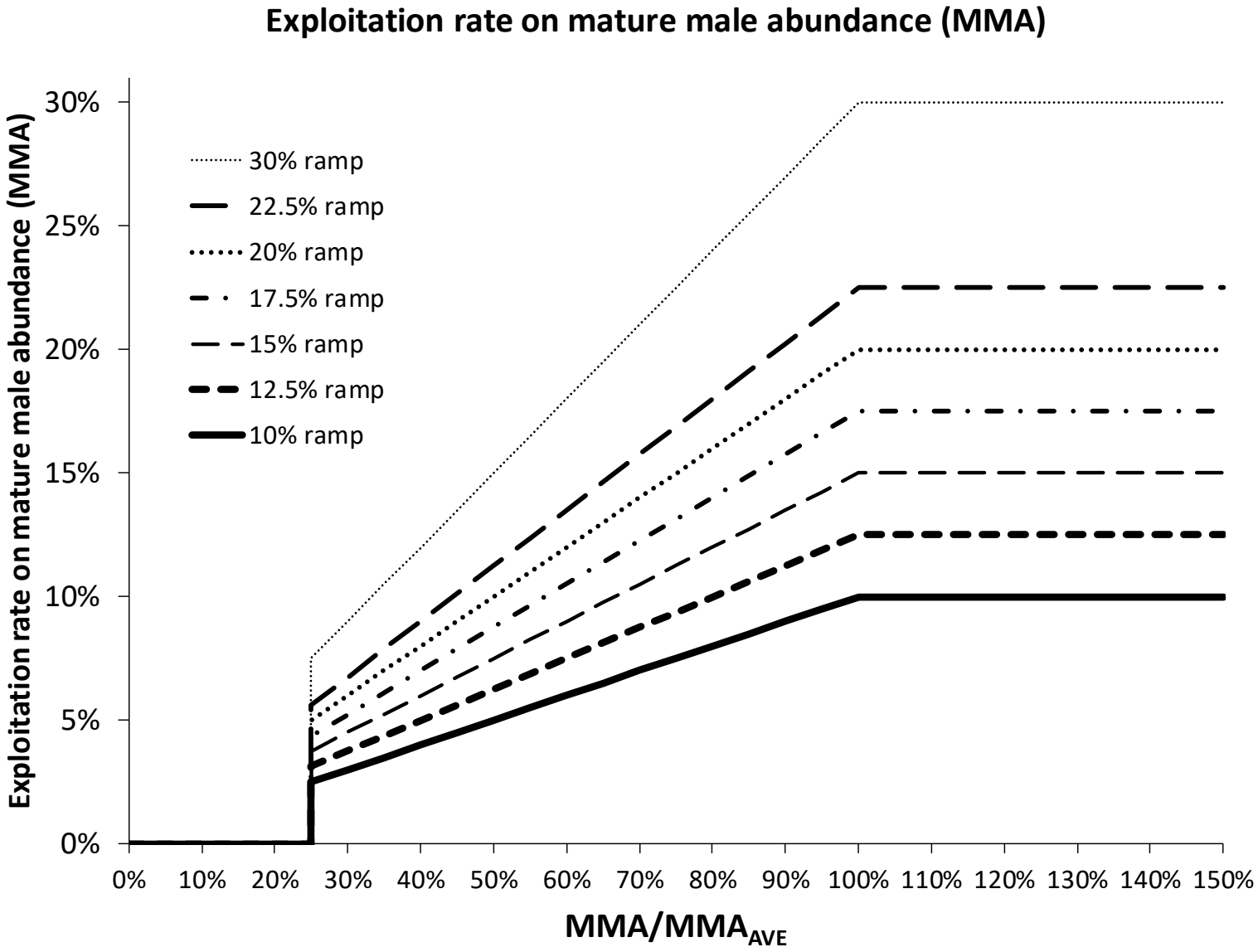
1. Overfished: probability that MMB < MSST
2. Overfishing: probability that RETC + bycatch_mort > OFL (and ABC)
3. Probability that MMB < $B_{MSY}$

**Economic**

1. Probability of fishery closure: MMB < 0.5MSST
2. Average retained catch (RETC)
3. Annual variability in retained catch
4. Probability that retained catch < historical mean catch
5. Probability that retained catch is within desired range
   - EAG: 4 mill lb ± 20%; WAG: 3 mill lb ± 20%
6. Mean CPUE
7. Probability that CPUE < historical mean CPUE
8. Relative fishing effort (RETC/CPUE)
9. Stock status: Probability that MMA < $MMA_{AVE}$
   - Indicator of where we are on the exploitation "ramp"

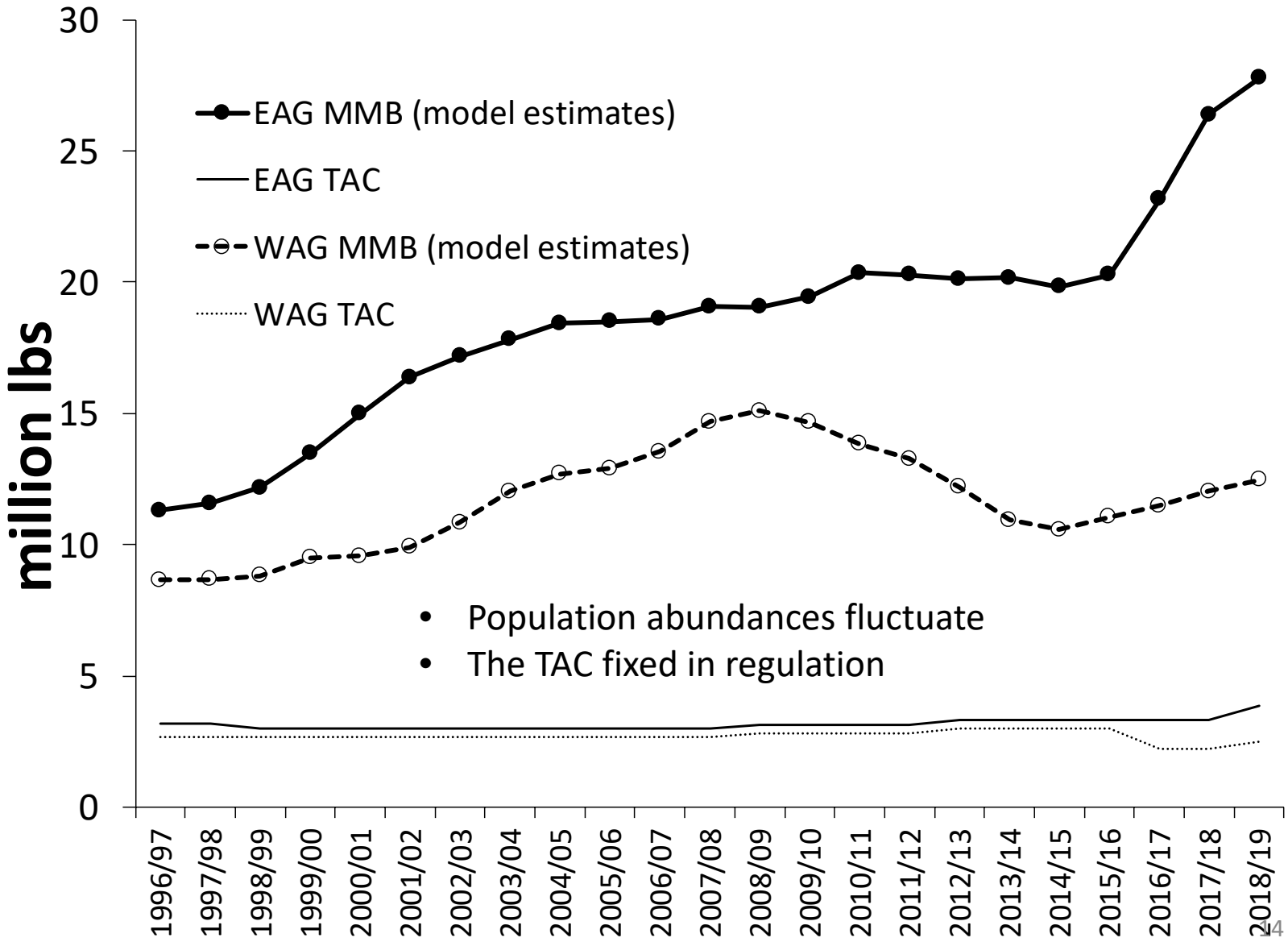
# Harvest Control Rules

| Policy | period for $MMA_{AVE}$ | Exploitation rate on MMA $MMA/MMA_{AVE}$%<100% | Max Exploitation rate on MMA $MMA/MMA_{AVE}$%≥100% | Exploitation rate cap on L abund |
|---|---|---|---|---|
| 0 | 1985-2017 | 0 | 0 | 0 |
| 1 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.10 | 0.1 | 0.25 |
| 2 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.125 | 0.125 | 0.25 |
| 3 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.15 | 0.15 | 0.25 |
| 4 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.20 | 0.2 | 0.25 |
| 5 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.30 | 0.3 | 0.25 |
| 6 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.10 | 0.1 | 0.3 |
| 7 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.125 | 0.125 | 0.3 |
| 8 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.15 | 0.15 | 0.3 |
| 9 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.20 | 0.2 | 0.3 |
| 10 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.30 | 0.3 | 0.3 |
| 11 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.175 | 0.175 | 0.25 |
| 12 | 1985-2017 | $MMA/MMA_{AVE}$ X 0.225 | 0.225 | 0.25 |
| 13 | 1985-2017 | EAG: 0.15, WAG: 0.23 | EAG: 0.15, WAG: 0.23 | none |

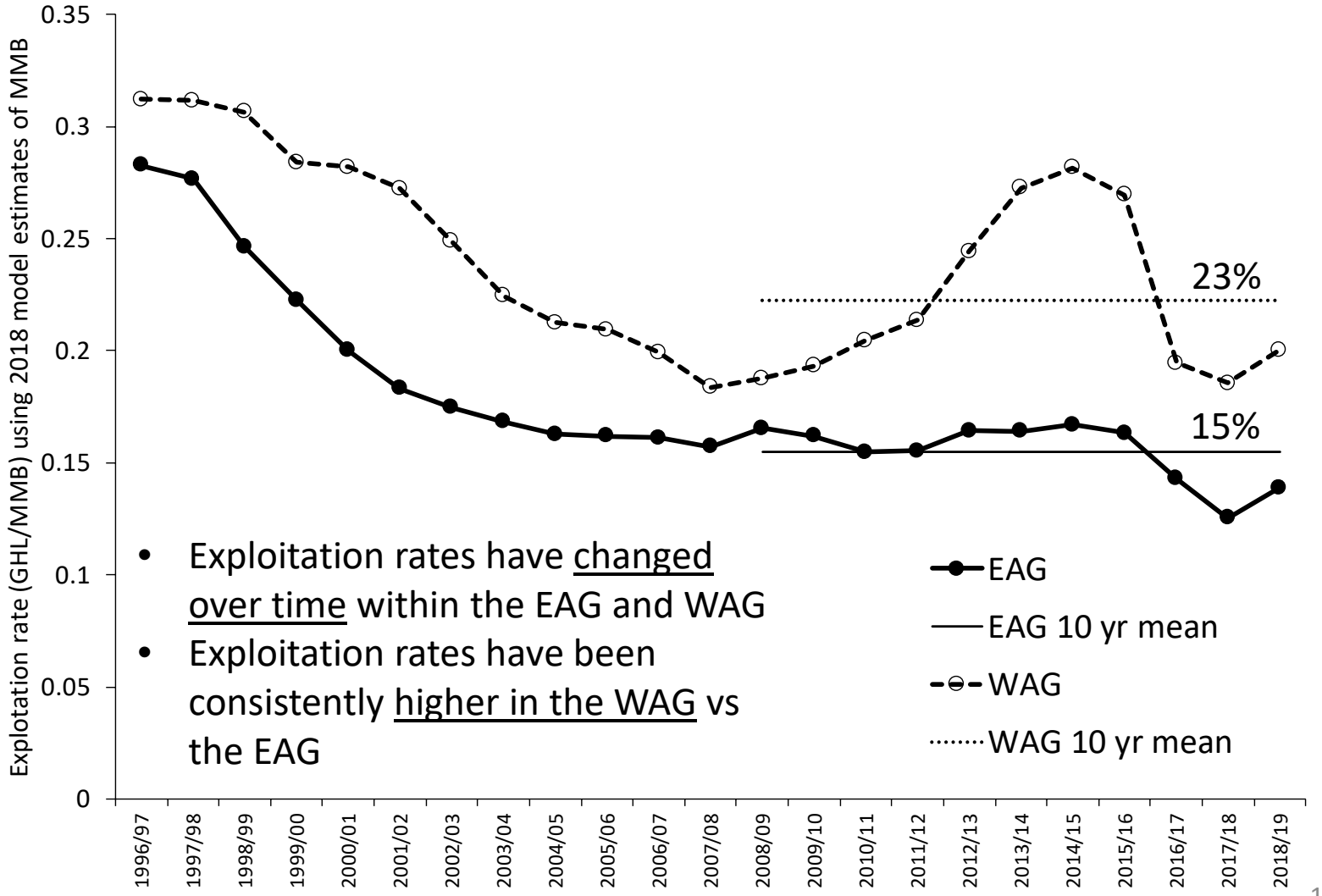



* Includes 25% and 30% exploitation “caps” on legal male abundance

# Historical TAC and MMB model estimates

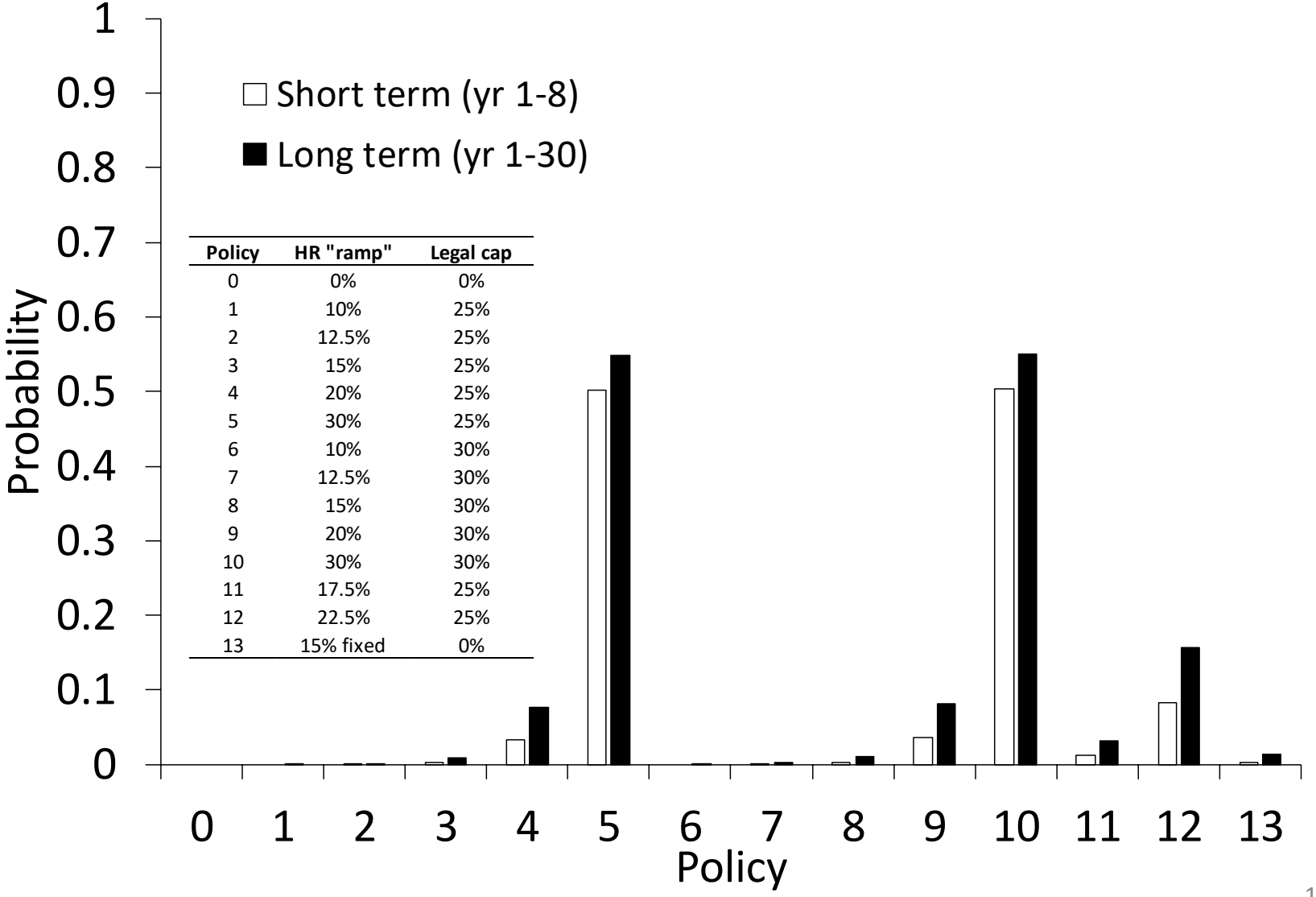


# Estimates of historical exploitation rates



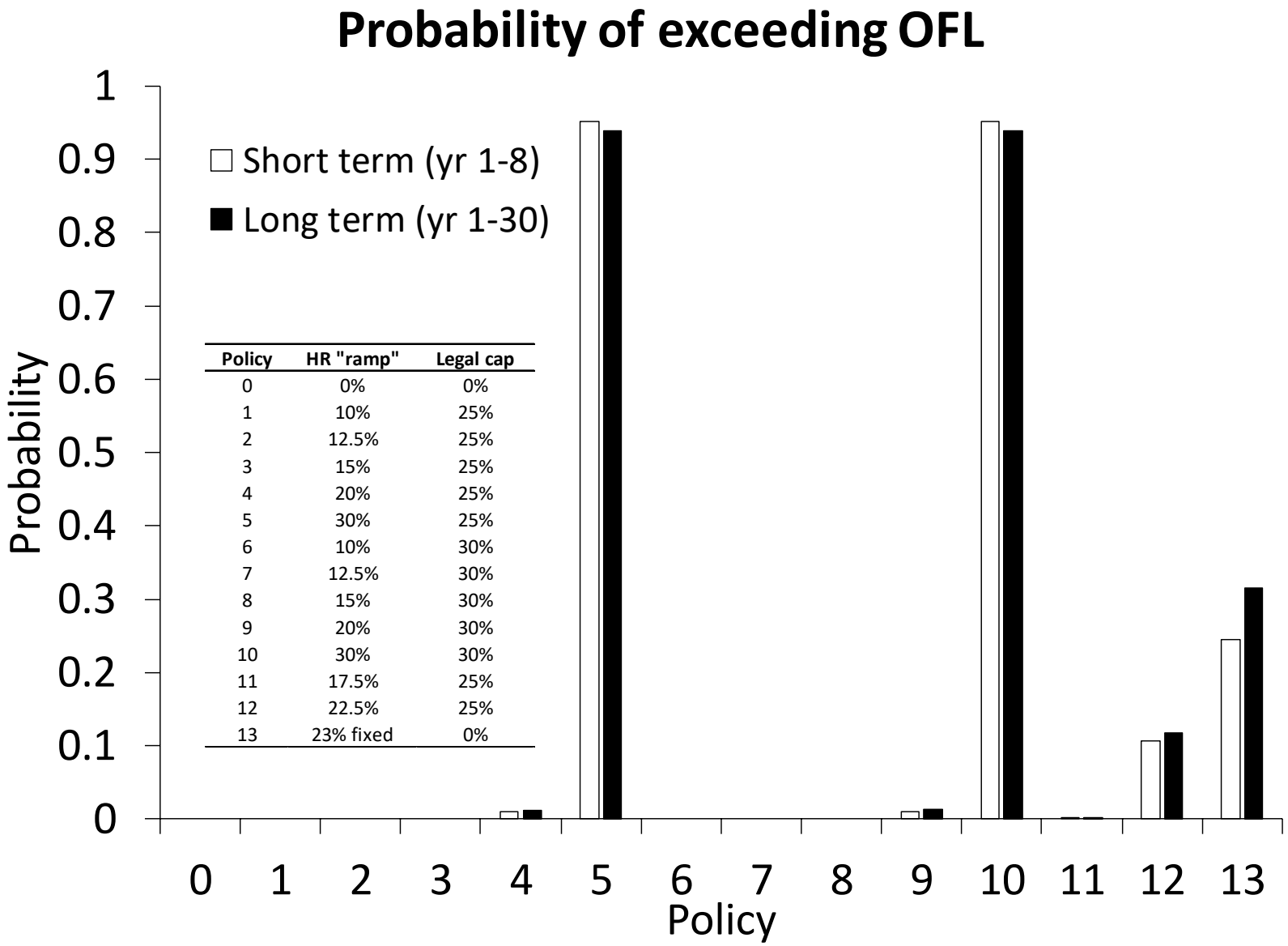
EAG

## Probability of exceeding OFL




| Policy | HR "ramp" | Legal cap |
|---|---|---|
| 0 | 0% | 0% |
| 1 | 10% | 25% |
| 2 | 12.5% | 25% |
| 3 | 15% | 25% |
| 4 | 20% | 25% |
| 5 | 30% | 25% |
| 6 | 10% | 30% |
| 7 | 12.5% | 30% |
| 8 | 15% | 30% |
| 9 | 20% | 30% |
| 10 | 30% | 30% |
| 11 | 17.5% | 25% |
| 12 | 22.5% | 25% |
| 13 | 15% fixed | 0% |

# WAG

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| 8 | 15% | 30% |
| 9 | 20% | 30% |
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| 12 | 22.5% | 25% |
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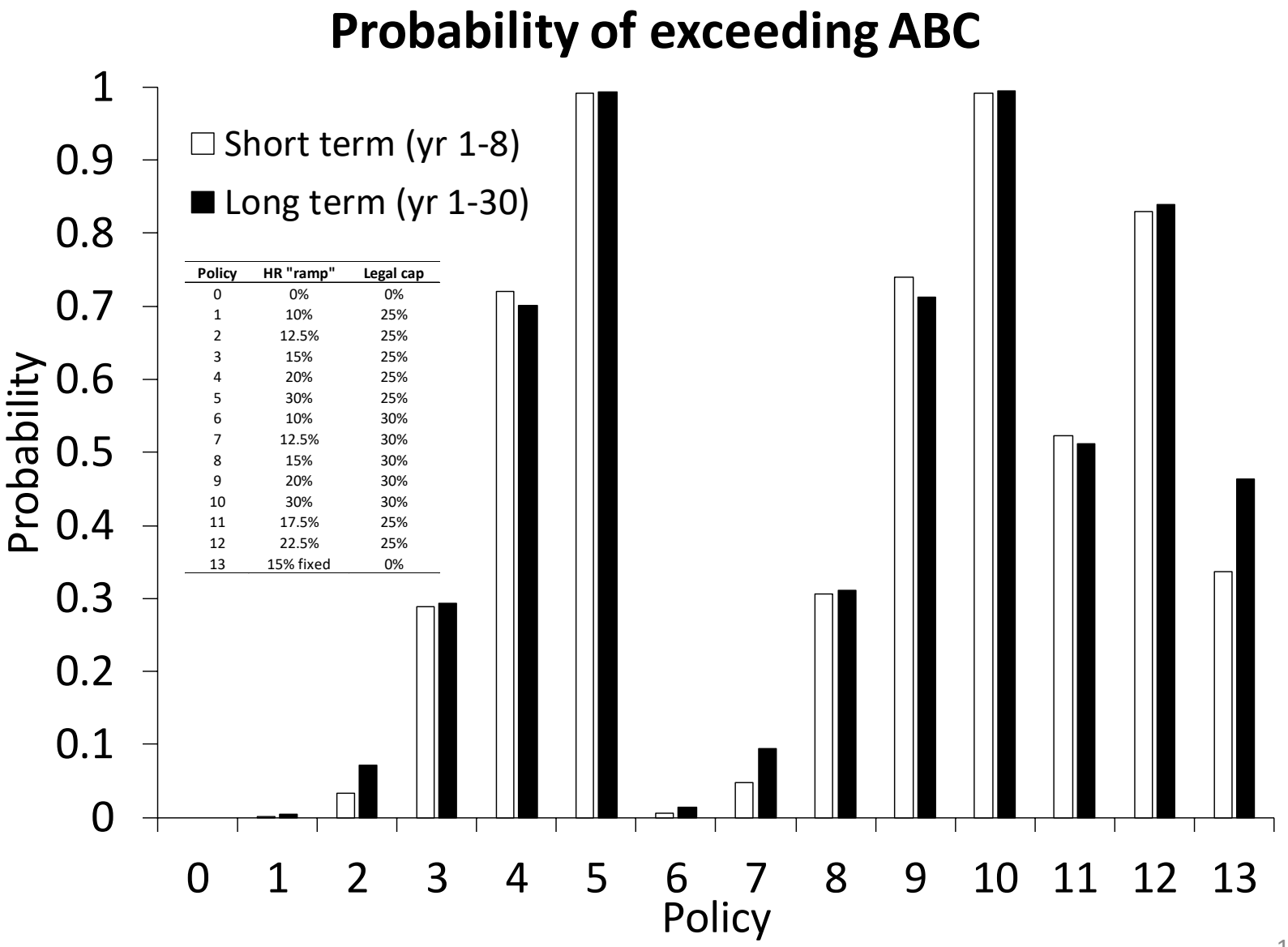
# EAG

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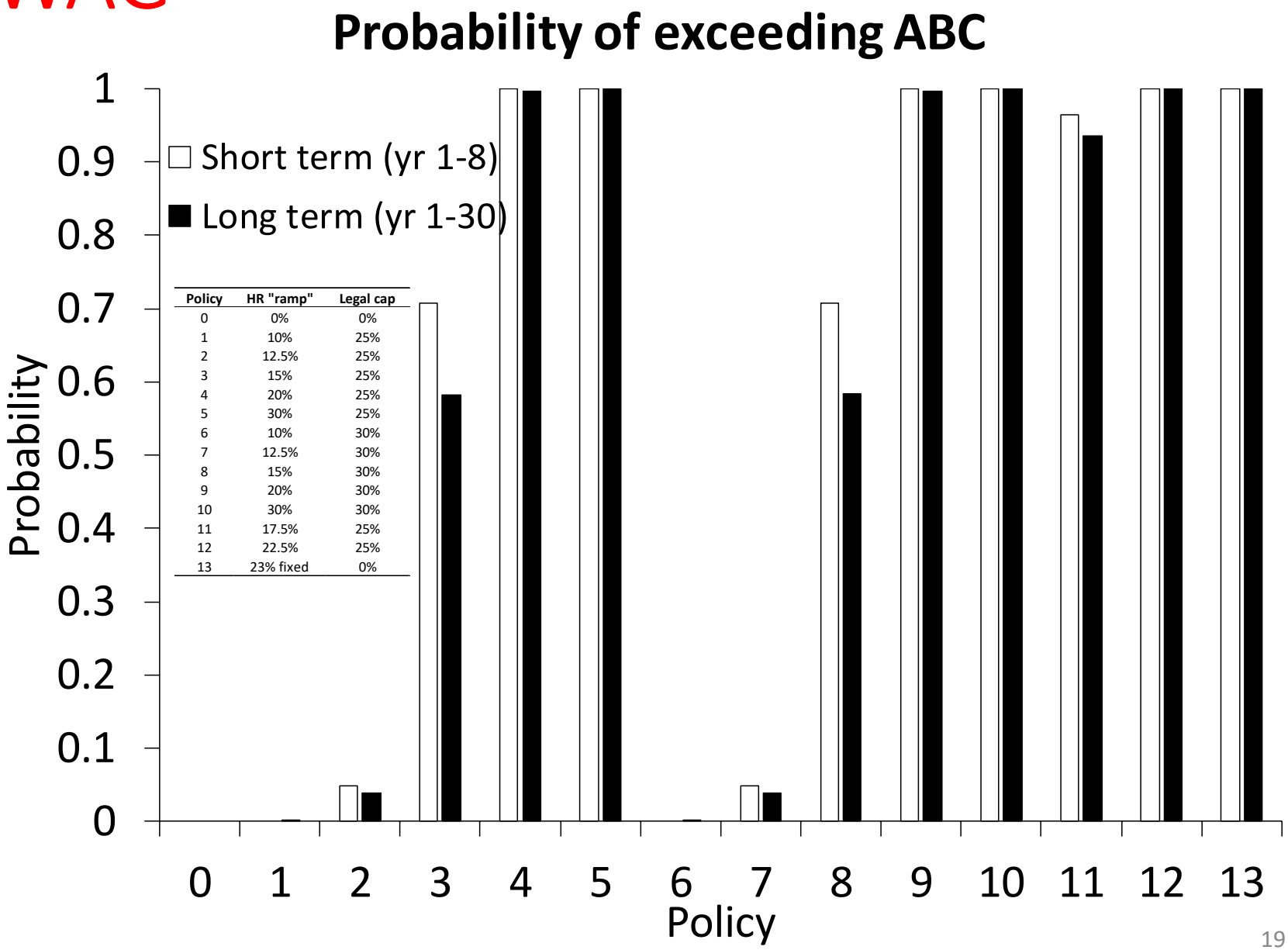
| 8 | 15% | 30% |
| 9 | 20% | 30% |
| 10 | 30% | 30% |
| 11 | 17.5% | 25% |
| 12 | 22.5% | 25% |
| 13 | 15% fixed | 0% |

WAG

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# EAG

| Policy | HR "ramp" | Legal cap |
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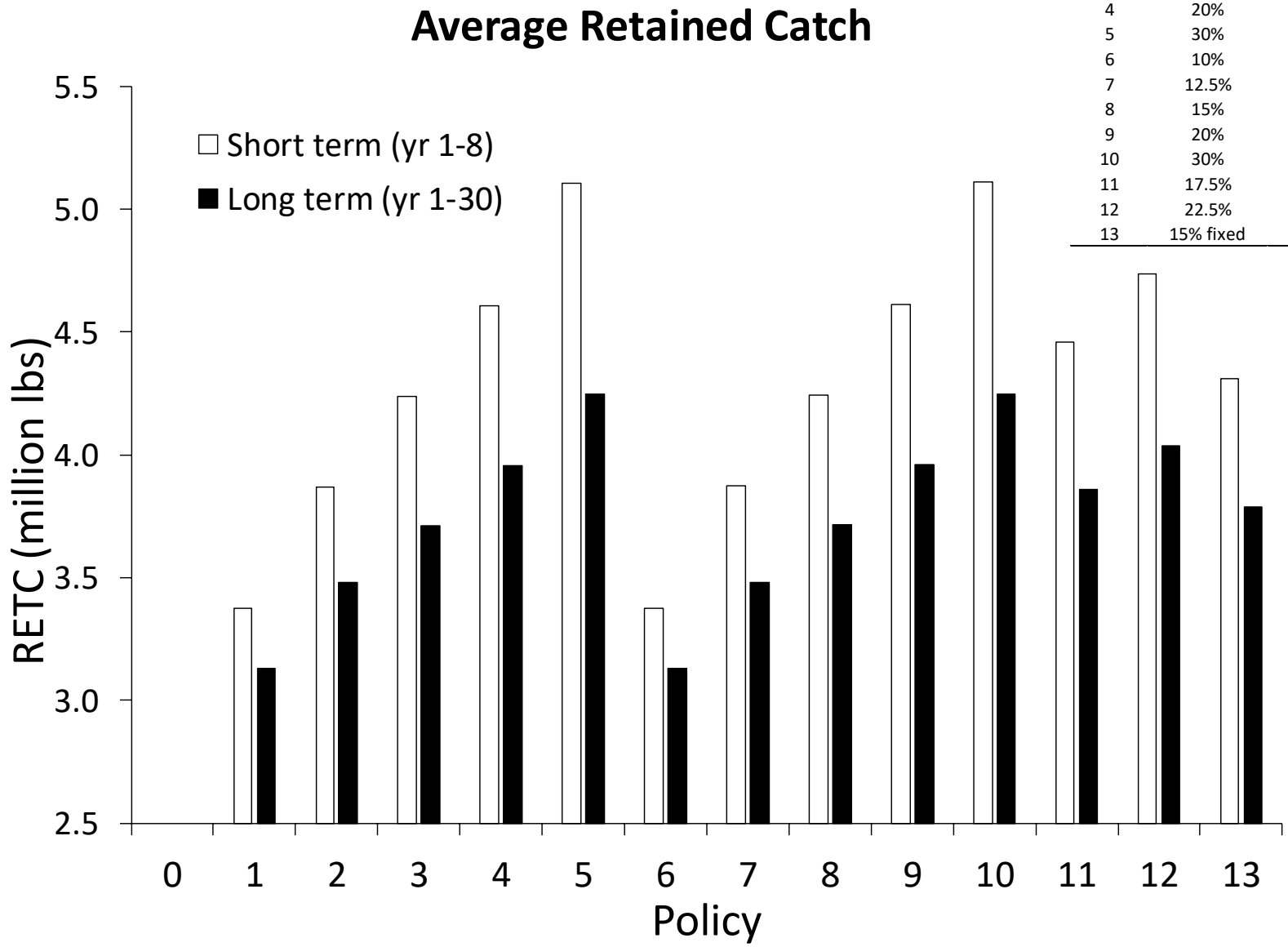

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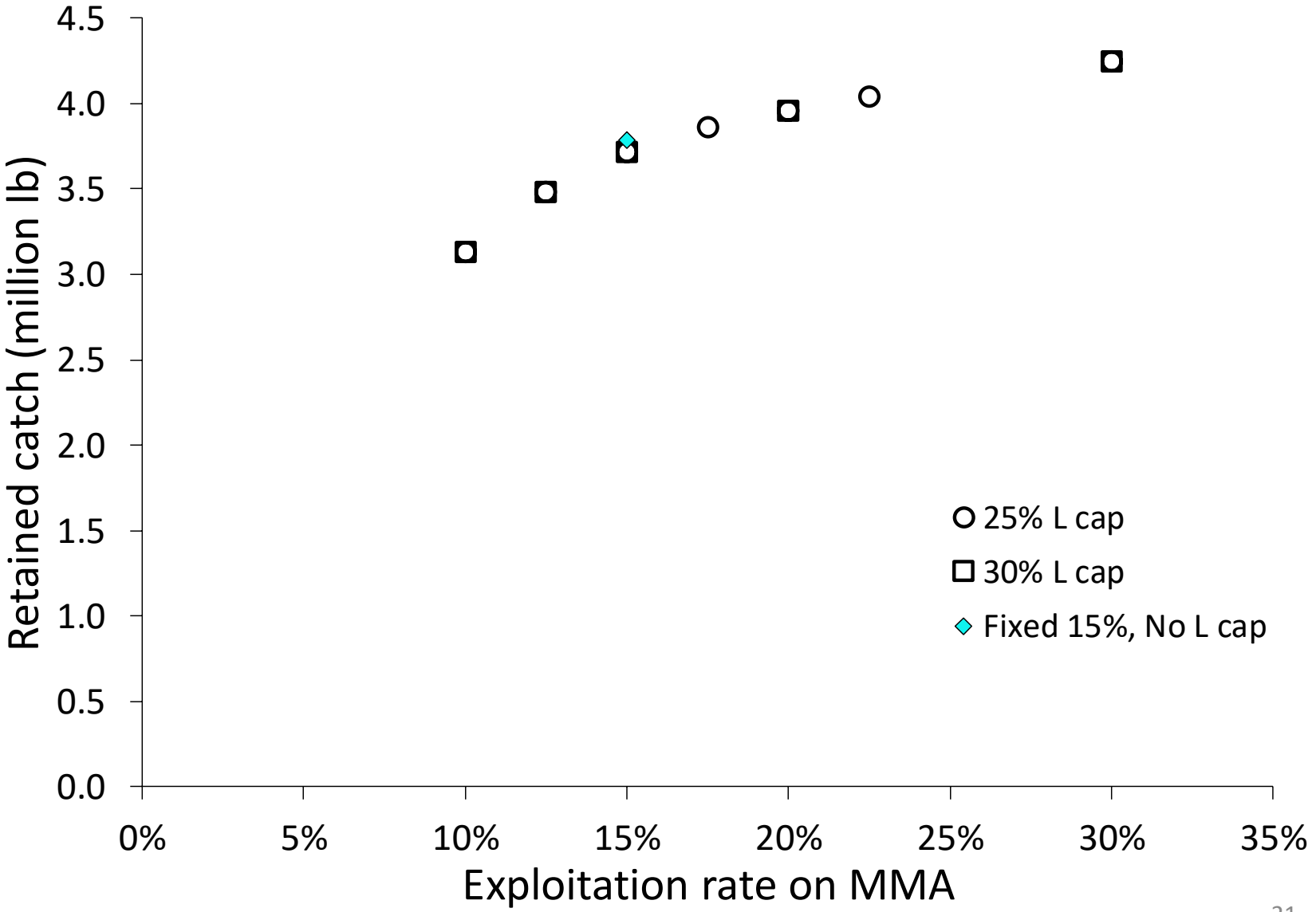
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Retained catch (million lb)
0%
5%
10%
15%
20%
25%
30%
35%
Exploitation rate on MMA
25% L cap
30% L cap
Fixed 15%, No L cap

WAG

| Policy | HR "ramp" | Legal cap |
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| 1 | 10% | 25% |
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| 6 | 10% | 30% |
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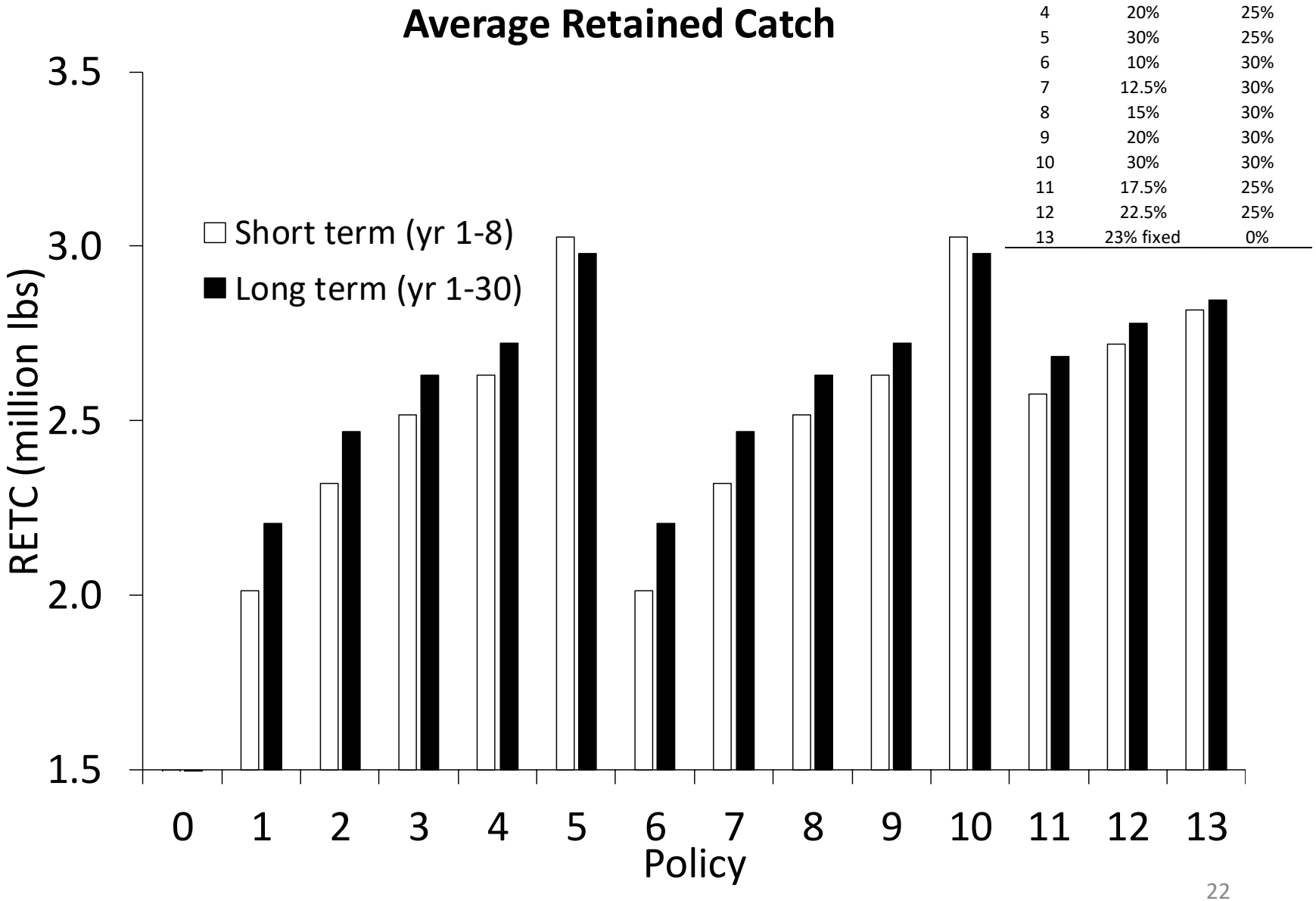

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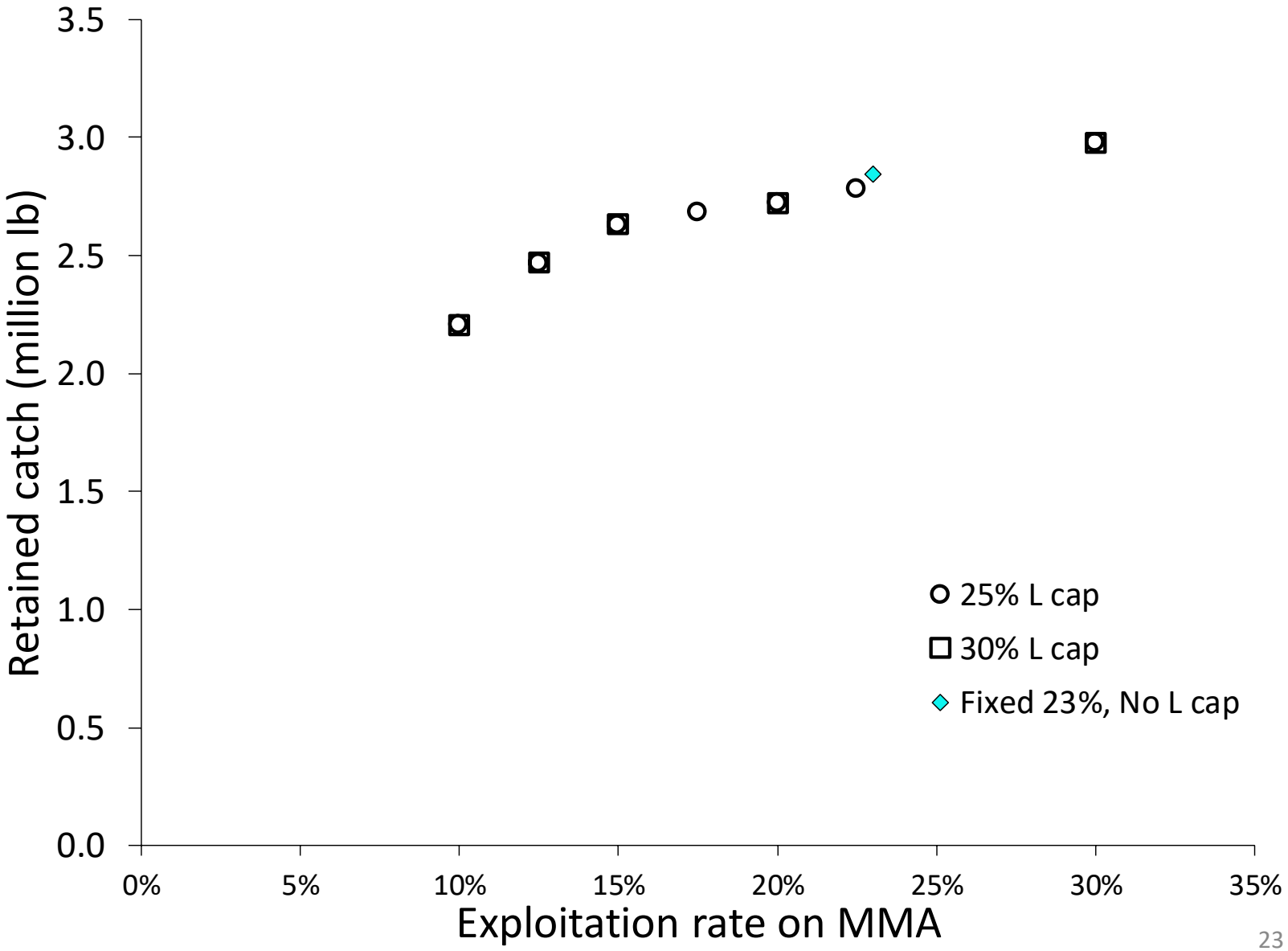
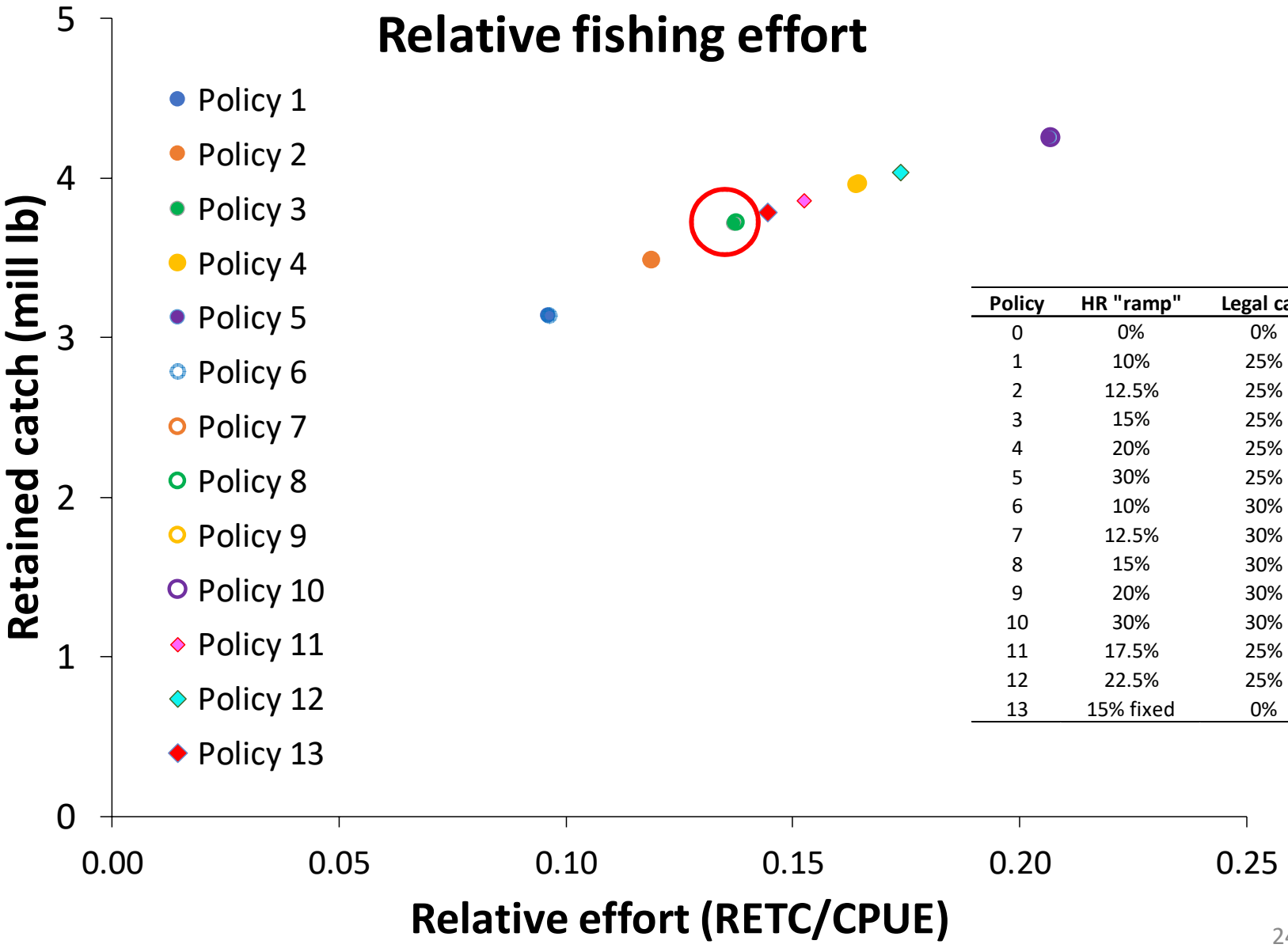

3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Retained catch (million lb)
0%
5%
10%
15%
20%
25%
30%
35%
Exploitation rate on MMA
25% L cap
30% L cap
Fixed 23%, No L cap

# EAG

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| 4 | 20% | 25% |
| 5 | 30% | 25% |
| 6 | 10% | 30% |
| 7 | 12.5% | 30% |
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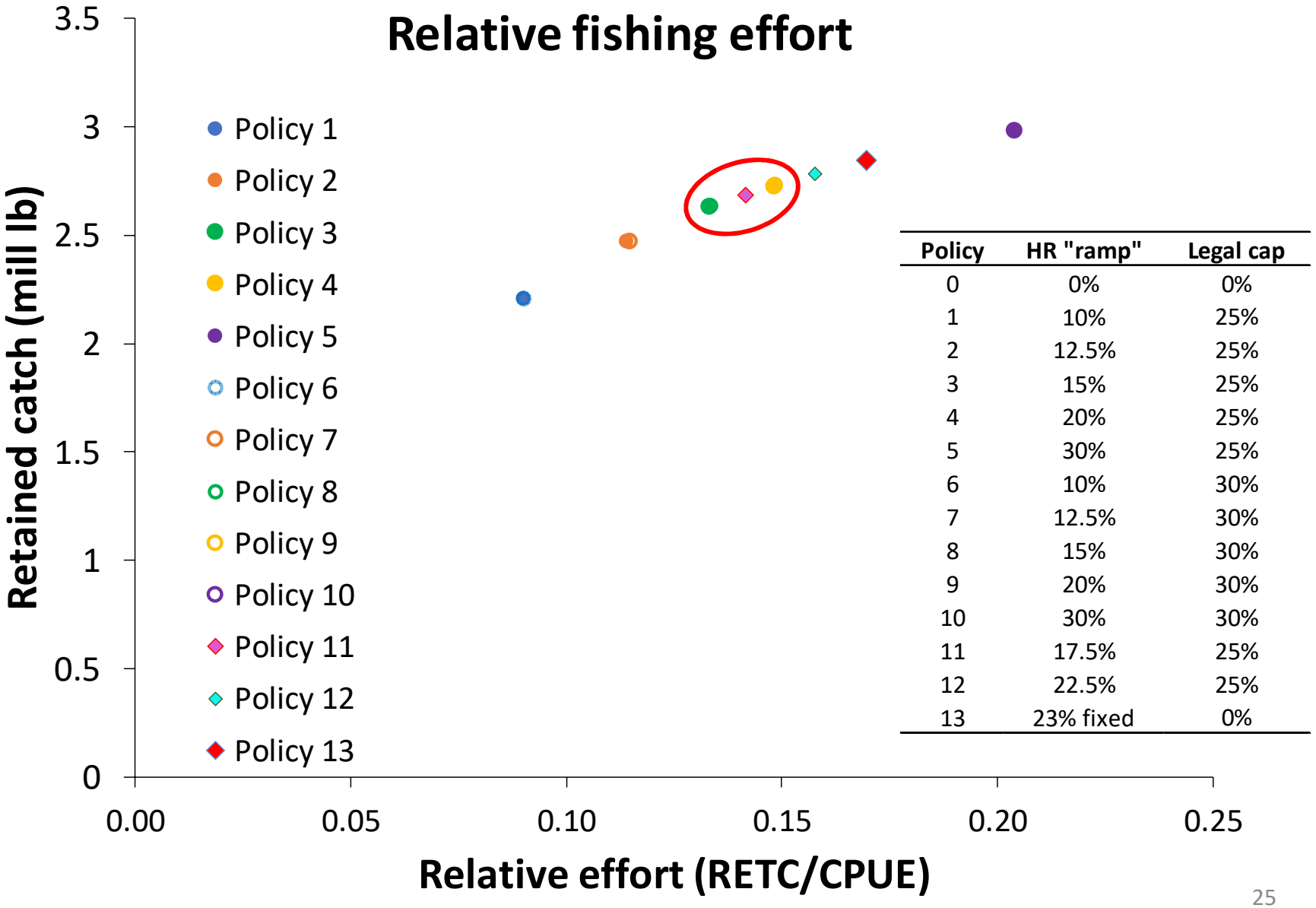
| 12 | 22.5% | 25% |
| 13 | 15% fixed | 0% |

# WAG

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| 4 | 20% | 25% |
| 5 | 30% | 25% |
| 6 | 10% | 30% |
| 7 | 12.5% | 30% |
| 8 | 15% | 30% |
| 9 | 20% | 30% |
| 10 | 30% | 30% |
| 11 | 17.5% | 25% |
| 12 | 22.5% | 25% |
| 13 | 23% fixed | 0% |

# Decision Matrix

Distill the conservation and economic risk metrics into a single decision table based on policy ranks

| **Conservation** | |
|---|---|
| Metric | Unit |
| Overfished | Probability |
| Severely overfished | Probability |
| Overfishing (OFL) | Probability |
| Overfishing (ABC) | Probability |
| Below $B_{MSY}$ | Probability |

| **Catch** | |
|---|---|
| Metric | Unit |
| Retained catch | Mill lb |

| **Catch Stability** | |
|---|---|
| Metric | Unit |
| Fishery closures | Probability |
| Annual catch var | Proportion |
| Relative TAC (1) | Probability |
| Relative TAC (2) | Probability |
| CPUE (1) | crab $pot^{-1}$ |
| CPUE (2) | Probability |
| Relative effort | RETC $CPUE^{-1}$ |
| Stock status | Probability |

# EAG: Decision Matrix

| SHORT TERM (year 1-8) | | | | Conservation | Catch | Catch Stability |
|---|---|---|---|---|---|---|
| Policy | Description | HR "ramp" | L cap | | | |
| 0 | No fishing | 0% | 0% | | | |
| 1 | 10% ramp, 25% L cap | 10% | 25% | 1 | 13 | 1 |
| 2 | 12.5% ramp, 25% L cap | 12.5% | 25% | 3 | 11 | 2 |
| 3 | 15% ramp, 25% L cap | 15% | 25% | 5 | 9 | 6 |
| 4 | 20% ramp, 25% L cap | 20% | 25% | 9 | 5 | 9 |
| 5 | 30% ramp, 25% L cap | 30% | 25% | 12 | 2 | 12 |
| 6 | 10% ramp, 30% L cap | 10% | 30% | 2 | 12 | 3 |
| 7 | 12.5% ramp, 30% L cap | 12.5% | 30% | 4 | 10 | 4 |
| 8 | 15% ramp, 30% L cap | 15% | 30% | 6 | 8 | 7 |
| 9 | 20% ramp, 30% L cap | 20% | 30% | 10 | 4 | 10 |
| 10 | 30% ramp, 30% L cap | 30% | 30% | 13 | 1 | 13 |
| 11 | 17.5% ramp, 25% L cap | 17.5% | 25% | 8 | 6 | 8 |
| 12 | 22.5% ramp, 25% L cap | 22.5% | 25% | 11 | 3 | 11 |
| 13 | 15% fixed, No L cap | 15% | 0% | 7 | 7 | 5 |
| **LONG TERM (year 1-30)** | | | | **Conservation** | **Catch** | **Catch Stability** |
| Policy | Description | HR "ramp" | L cap | | | |
| 0 | No fishing | 0% | 0% | | | |
| 1 | 10% ramp, 25% L cap | 10% | 25% | 1 | 13 | 1 |
| 2 | 12.5% ramp, 25% L cap | 12.5% | 25% | 3 | 11 | 2 |
| 3 | 15% ramp, 25% L cap | 15% | 25% | 5 | 9 | 6 |
| 4 | 20% ramp, 25% L cap | 20% | 25% | 9 | 5 | 9 |
| 5 | 30% ramp, 25% L cap | 30% | 25% | 12 | 2 | 12 |
| 6 | 10% ramp, 30% L cap | 10% | 30% | 2 | 12 | 3 |
| 7 | 12.5% ramp, 30% L cap | 12.5% | 30% | 4 | 10 | 5 |
| 8 | 15% ramp, 30% L cap | 15% | 30% | 6 | 8 | 7 |
| 9 | 20% ramp, 30% L cap | 20% | 30% | 10 | 4 | 10 |
| 10 | 30% ramp, 30% L cap | 30% | 30% | 13 | 1 | 13 |
| 11 | 17.5% ramp, 25% L cap | 17.5% | 25% | 8 | 6 | 8 |
| 12 | 22.5% ramp, 25% L cap | 22.5% | 25% | 11 | 3 | 11 |
| 13 | 15% fixed, No L cap | 15% | 0% | 7 | 7 | 4 |

# WAG: Decision Matrix

| SHORT TERM (year 1-8) | | | | Conservation | Catch | Catch Stability |
|---|---|---|---|---|---|---|
| Policy | Description | HR "ramp" | L cap | | | |
| 0 | No fishing | 0% | 0% | | | |
| 1 | 10% ramp, 25% L cap | 10% | 25% | 1.5 | 13 | 1 |
| 2 | 12.5% ramp, 25% L cap | 12.5% | 25% | 3.5 | 11 | 3.5 |
| 3 | 15% ramp, 25% L cap | 15% | 25% | 5 | 9 | 5 |
| 4 | 20% ramp, 25% L cap | 20% | 25% | 8 | 6 | 8 |
| 5 | 30% ramp, 25% L cap | 30% | 25% | 12.5 | 1 | 13 |
| 6 | 10% ramp, 30% L cap | 10% | 30% | 1.5 | 12 | 2 |
| 7 | 12.5% ramp, 30% L cap | 12.5% | 30% | 3.5 | 10 | 3.5 |
| 8 | 15% ramp, 30% L cap | 15% | 30% | 6 | 8 | 6 |
| 9 | 20% ramp, 30% L cap | 20% | 30% | 9 | 5 | 9 |
| 10 | 30% ramp, 30% L cap | 30% | 30% | 12.5 | 2 | 12 |
| 11 | 17.5% ramp, 25% L cap | 17.5% | 25% | 7 | 7 | 7 |
| 12 | 22.5% ramp, 25% L cap | 22.5% | 25% | 10 | 4 | 10.5 |
| 13 | 23% fixed, No L cap | 23% | 0% | 11 | 3 | 10.5 |
| **LONG TERM (year 1-30)** | | | | **Conservation** | **Catch** | **Catch Stability** |
| Policy | Description | HR "ramp" | L cap | | | |
| 0 | No fishing | 0% | 0% | | | |
| 1 | 10% ramp, 25% L cap | 10% | 25% | 1.5 | 13 | 1 |
| 2 | 12.5% ramp, 25% L cap | 12.5% | 25% | 3 | 11 | 3 |
| 3 | 15% ramp, 25% L cap | 15% | 25% | 5 | 9 | 5 |
| 4 | 20% ramp, 25% L cap | 20% | 25% | 8 | 6 | 6 |
| 5 | 30% ramp, 25% L cap | 30% | 25% | 13 | 2 | 12 |
| 6 | 10% ramp, 30% L cap | 10% | 30% | 1.5 | 12 | 2 |
| 7 | 12.5% ramp, 30% L cap | 12.5% | 30% | 4 | 10 | 7 |
| 8 | 15% ramp, 30% L cap | 15% | 30% | 6 | 8 | 8 |
| 9 | 20% ramp, 30% L cap | 20% | 30% | 9 | 5 | 10 |
| 10 | 30% ramp, 30% L cap | 30% | 30% | 12 | 1 | 13 |
| 11 | 17.5% ramp, 25% L cap | 17.5% | 25% | 7 | 7 | 4 |
| 12 | 22.5% ramp, 25% L cap | 22.5% | 25% | 10 | 4 | 11 |
| 13 | 23% fixed, No L cap | 23% | 0% | 11 | 3 | 9 |

# Summary: EAG

- The 30% and 22.5% ramps (both L caps) are aggressive with moderate/high probability of exceeding OFL
  - Moderate probability to being overfished (i.e., MMB<MSST) under some recruitment scenarios
- The 17.5% and 20% ramps (25% L cap) and 15% fixed (No L cap) have moderate/high probability of exceeding ABC
- The 10% and 12.5% ramps are "safe" (low probability of exceeding conservation thresholds) but may not optimize yield
- **The 15% ramp (with either the 25% or 30% legal cap)** is likely the best trade-off between meeting conservation objectives and optimizing yield
  - Moderate levels of conservation risk
  - Simulations predict TACs around 3.7 mill lbs with moderate annual variability (~10-12%) without high increases in fishery effort relative to the 10% and 12.5% ramps
  - Approximates historic exploitations rates

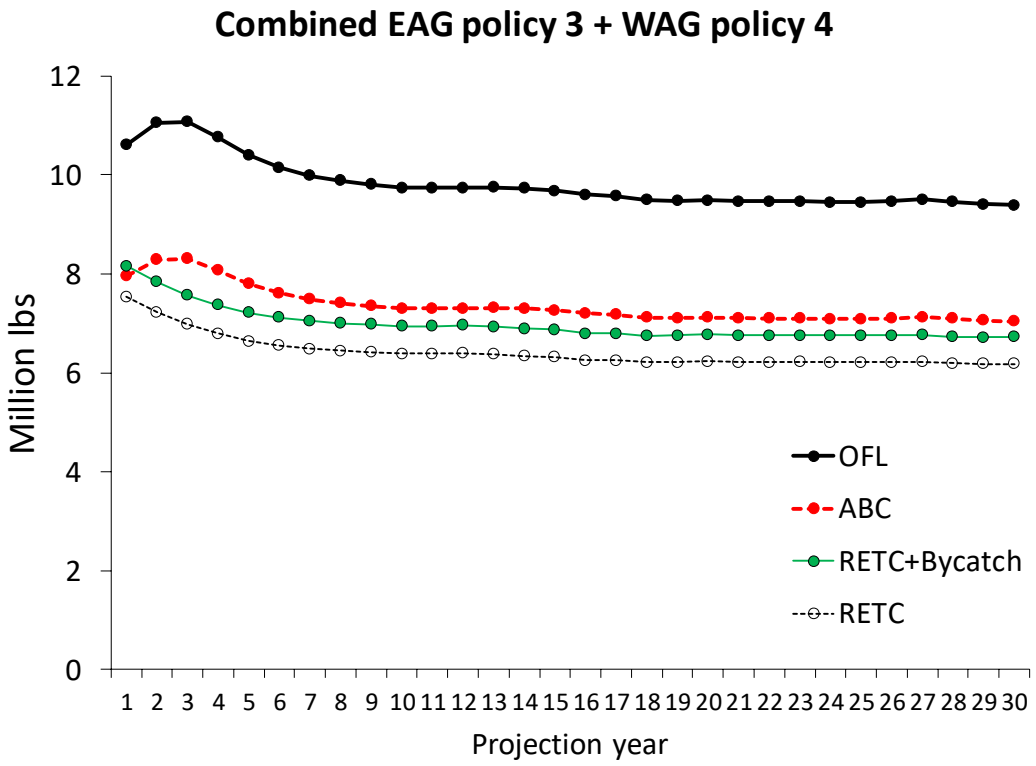
# Summary: WAG

- The 30% and 22.5% ramps (both L caps) and the 23% fixed rate is aggressive with moderate/high probability of exceeding OFL
  - Moderate probability to being overfished (i.e., MMB<MSST) under some recruitment scenarios
- All policies with 15% ramps or higher have high probabilities of exceeding the ABC
- The 10% and 12.5% ramps are "safe" but may not optimize yield
- **The 15%, 17.5%, and 20% ramps (with either legal cap)** likely the best trade-off between meeting conservation objectives and optimizing yield
  - Increasing conservation risk within the 15%-20% range
  - Predicted TACs are similar (2.6-2.7 mill lb)
  - Annual catch variation is similar
  - TACs will likely flirt with area-specific ABC
    - Simulation results are sensitive to how bycatch mortality is estimated
  - Relative fishing effort has to increase dramatically for modest catch increase

# Recommendation

**EAG**: 15% ramp with a 25% legal cap

**WAG**: 15%, 17.5%, or 20% ramp with a 25% legal cap



# Thank you