A Simulation Approach to Assess Lower Bounds (Population threshold Reference points)

Approach:

Investigate the Efficiency and Efficacy of Lower Pop. Thresholds to Protect Stocks

The investigation focused on finding answers to the following questions for specific lower bounds:

- **How quickly would spawning biomass increase to S_{MSY}?**
- **How many additional management actions (AMAs) would occur?**
- **What would be the long-term, average escapement?**
- **What would be the long-term, average harvest?**

Investigative Tool: Simulation

Current information was used to build simulations:

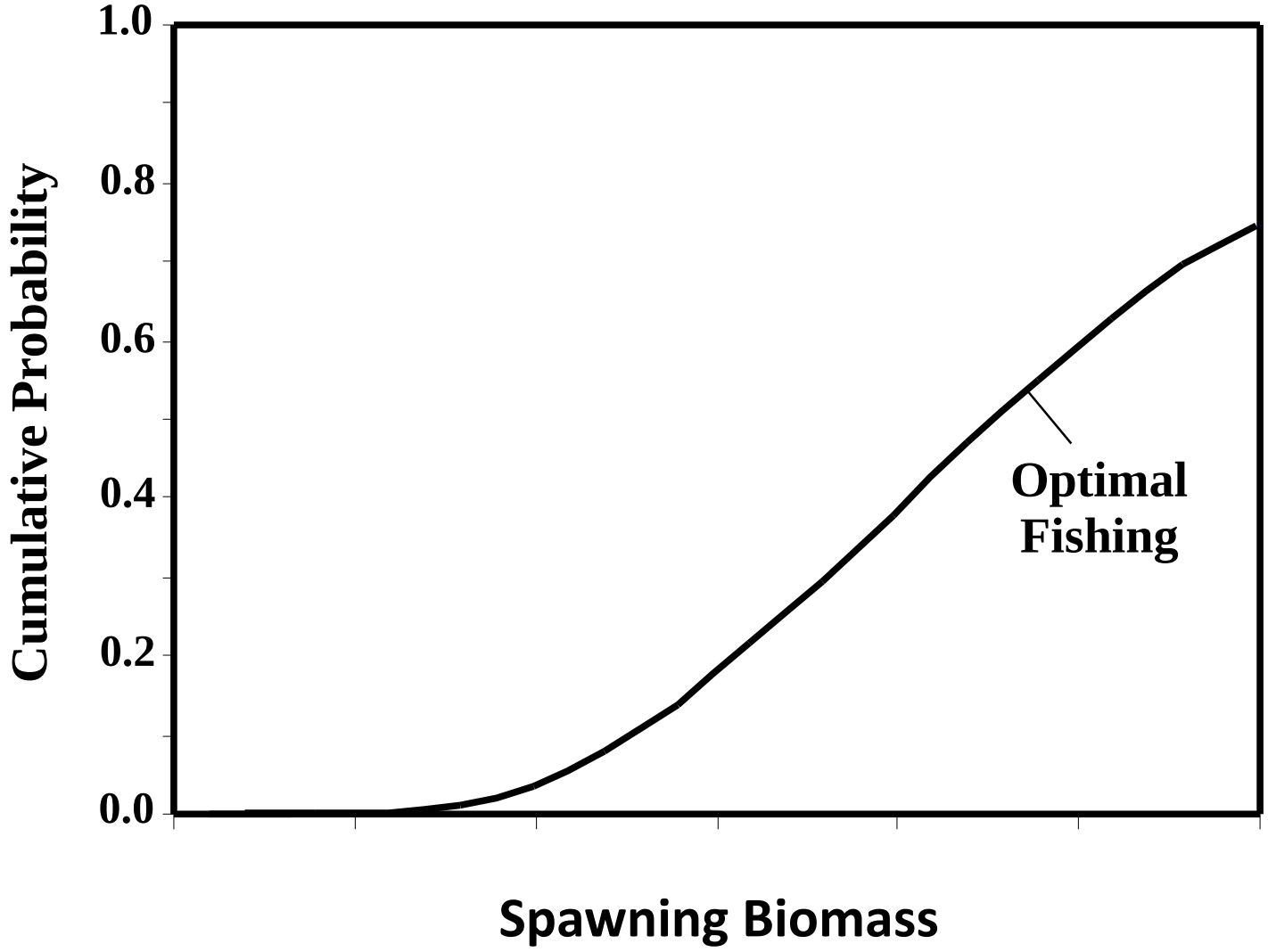
- **Estimated stock-recruit relationships with observed variation in predictions, process error (with autocorrelation)**
- **Constant harvest rates**
- **Age structured model with constant selectivity, survival by age and maturation.**

You're a Fisheries Manager and Spawning Biomass have been low….

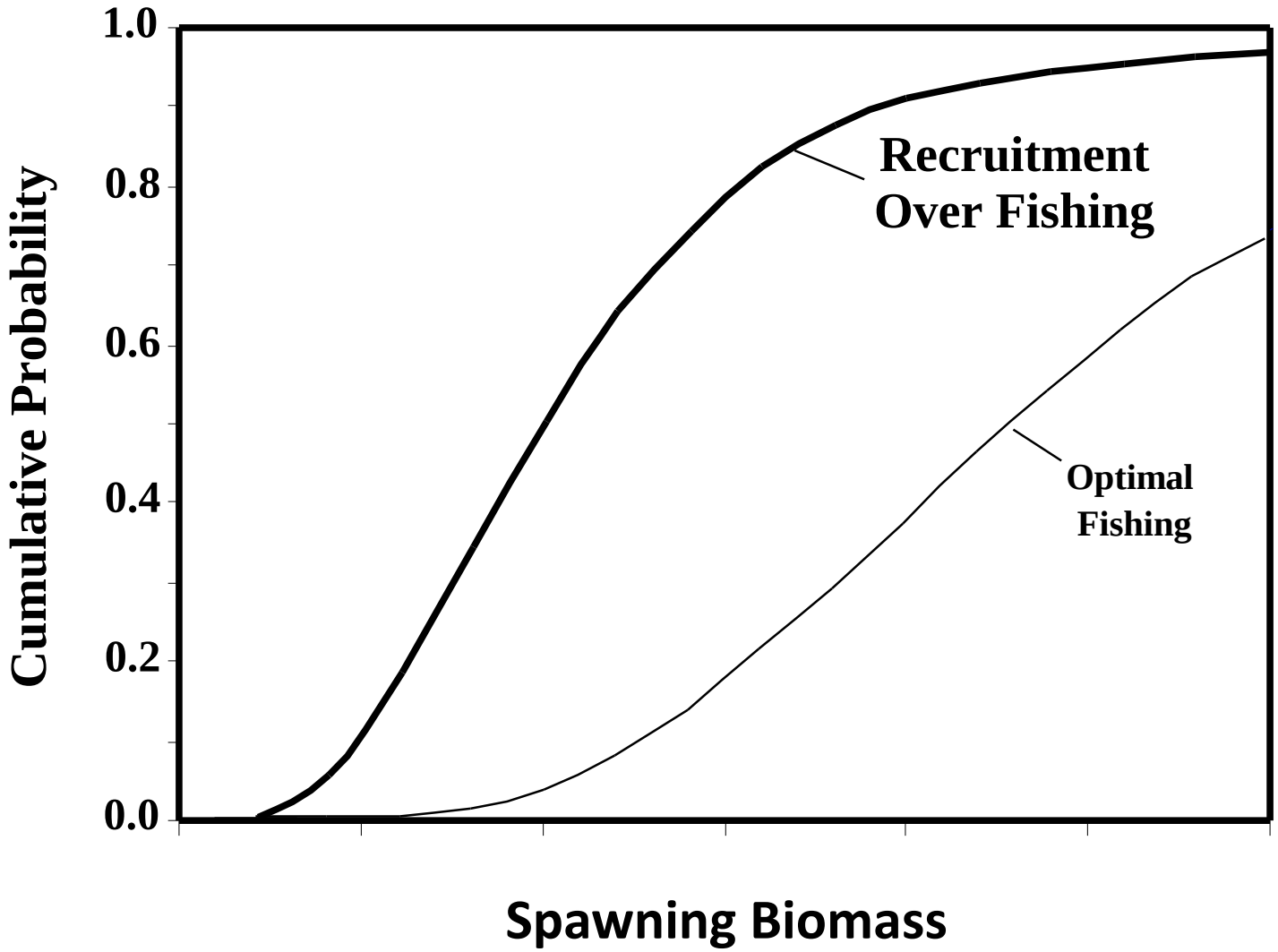
Risk for the fisheries manager is the probability of making the wrong decision:

- **Unnecessarily Restricting Fisheries when fishing is optimal; or**
- **Not Protecting Stocks when they are overfished.**

Management Action is NOT Needed

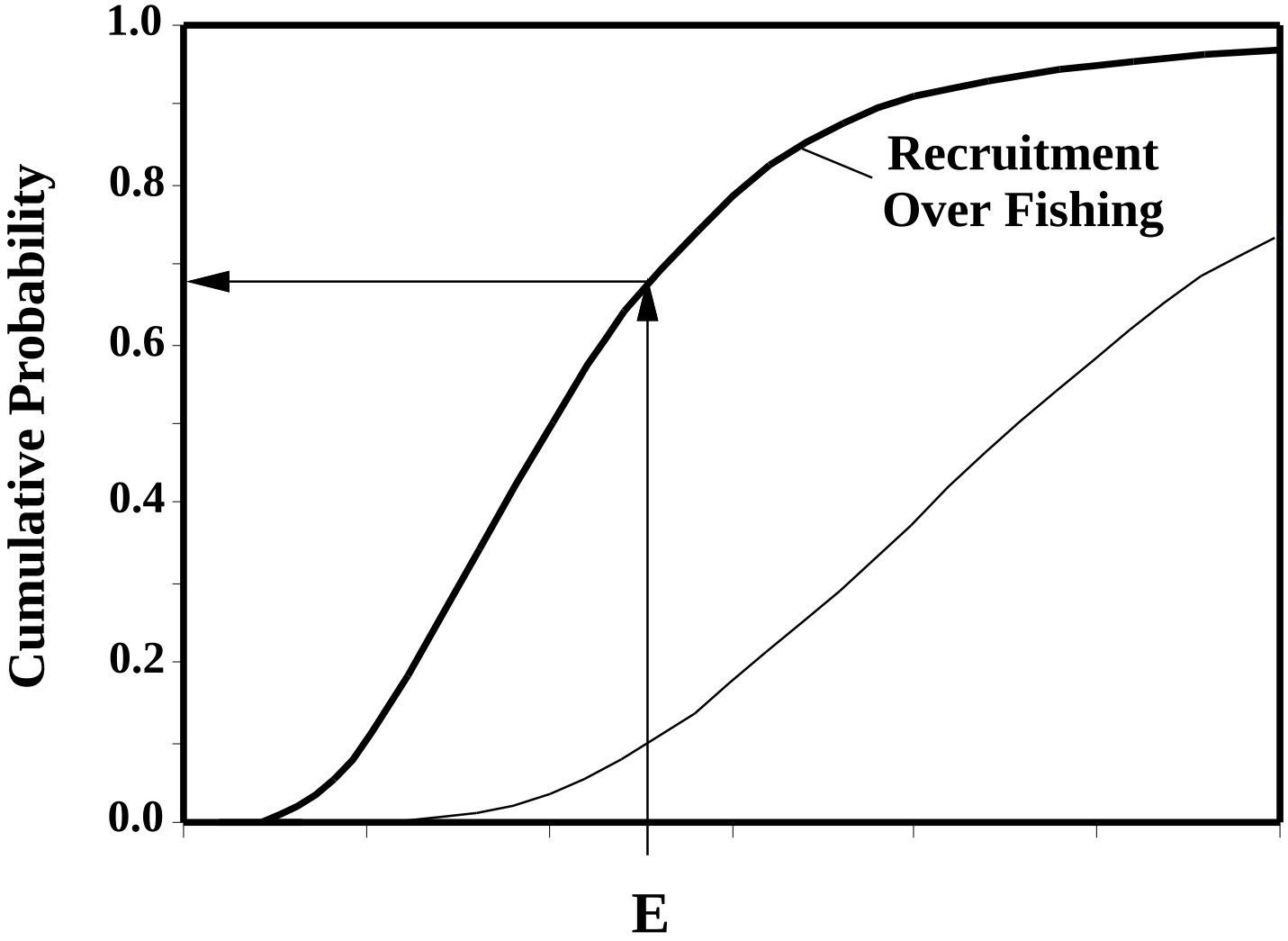


Management Action IS Needed



Management Action IS Needed

Even with recruitment overfishing, Spawning Biomass are ABOVE "E" in 32% of calendar years.



Setting Lower Bounds According to Acceptable Risks

1. **Decide what are acceptable risks:**
    a) **x % (e.g. 10%) risk of unnecessarily restricting fisheries; and**
    b) **y% (e.g. 5%) risk of not protecting overfished stocks.**

2. **Use simulations based on current information and estimated optimal harvest rates (optimal fishing) to estimate the general probability of <u>taking</u> an AMA.**

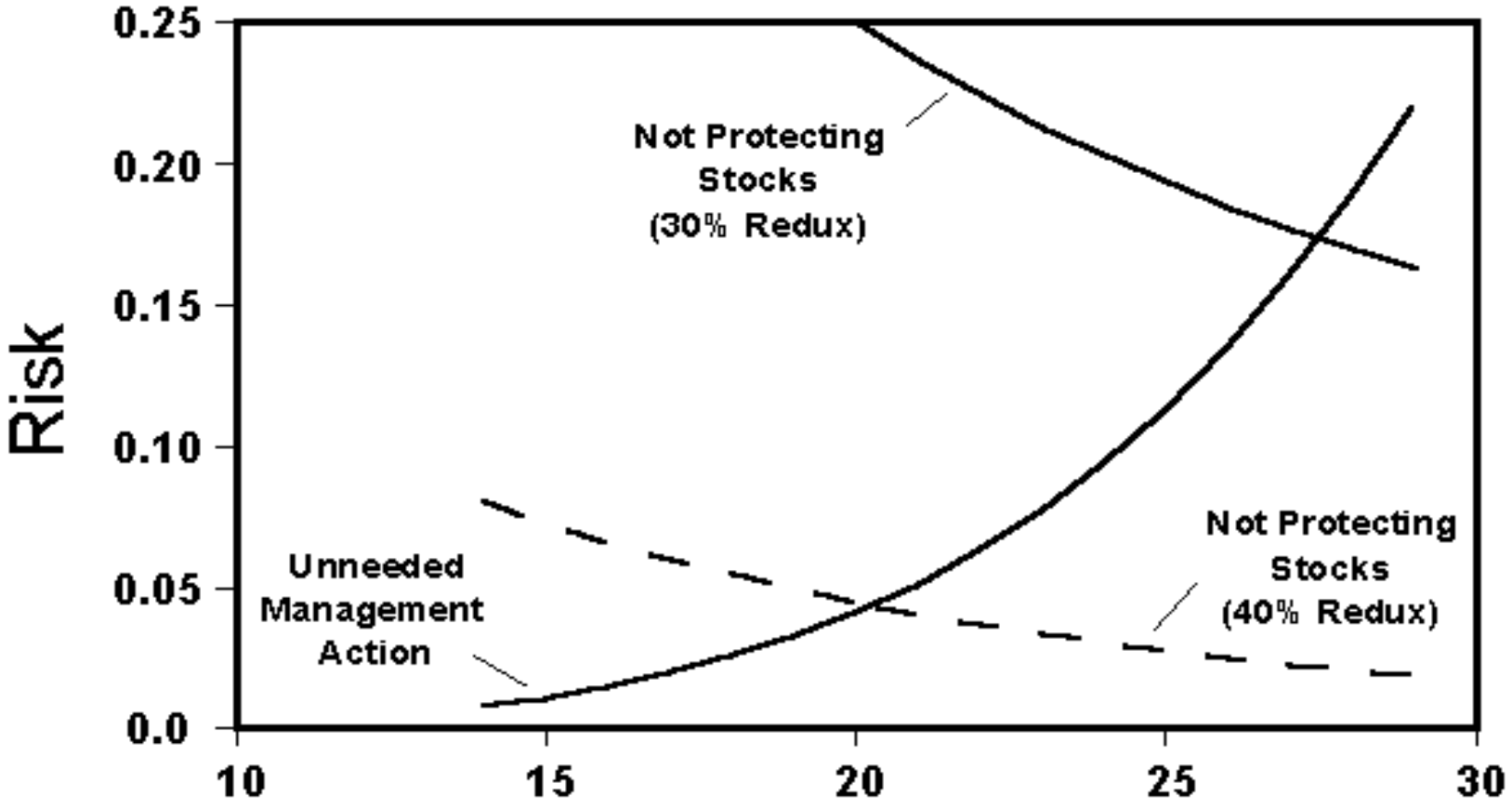
3. **Change lower bounds in simulations until the general probability of <u>taking</u> an AMA is x (eg. 10%).**

Setting Lower Bounds According to Acceptable Risks (cont.)

4. **Reduce productivity in simulated stock-recruit relationships by a substantial amount, say 40%, to simulate recruitment overfishing.**

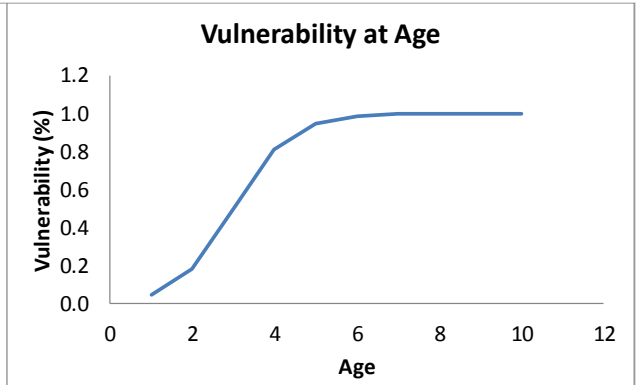
5. **Rerun simulations for overfished stocks and the lower bounds established in step 3 to estimate the general probability of <u>not taking</u> an AMA.**

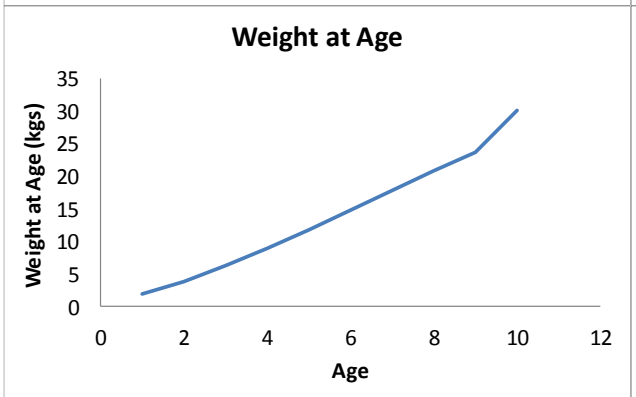
6. **If general probability of <u>not taking</u> an AMA is substantially different than y (eg 5%), alter productivity of simulated stocks and try again (back to step 4).**

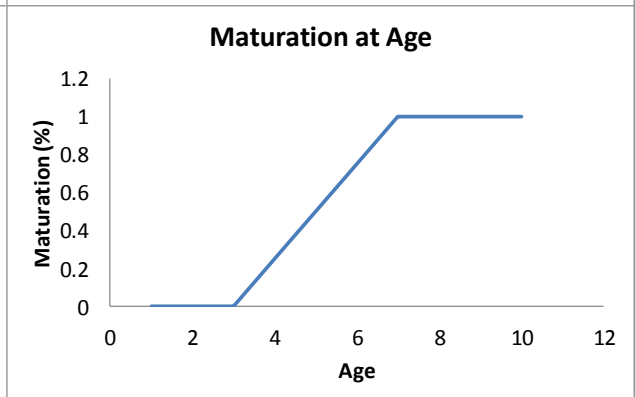

Risk
0.25
0.20
0.15
0.10
0.05
0.0
10
15
20
25
30
Not Protecting
Stocks
(30% Redux)
Unneeded
Management
Action
Not Protecting
Stocks
(40% Redux)

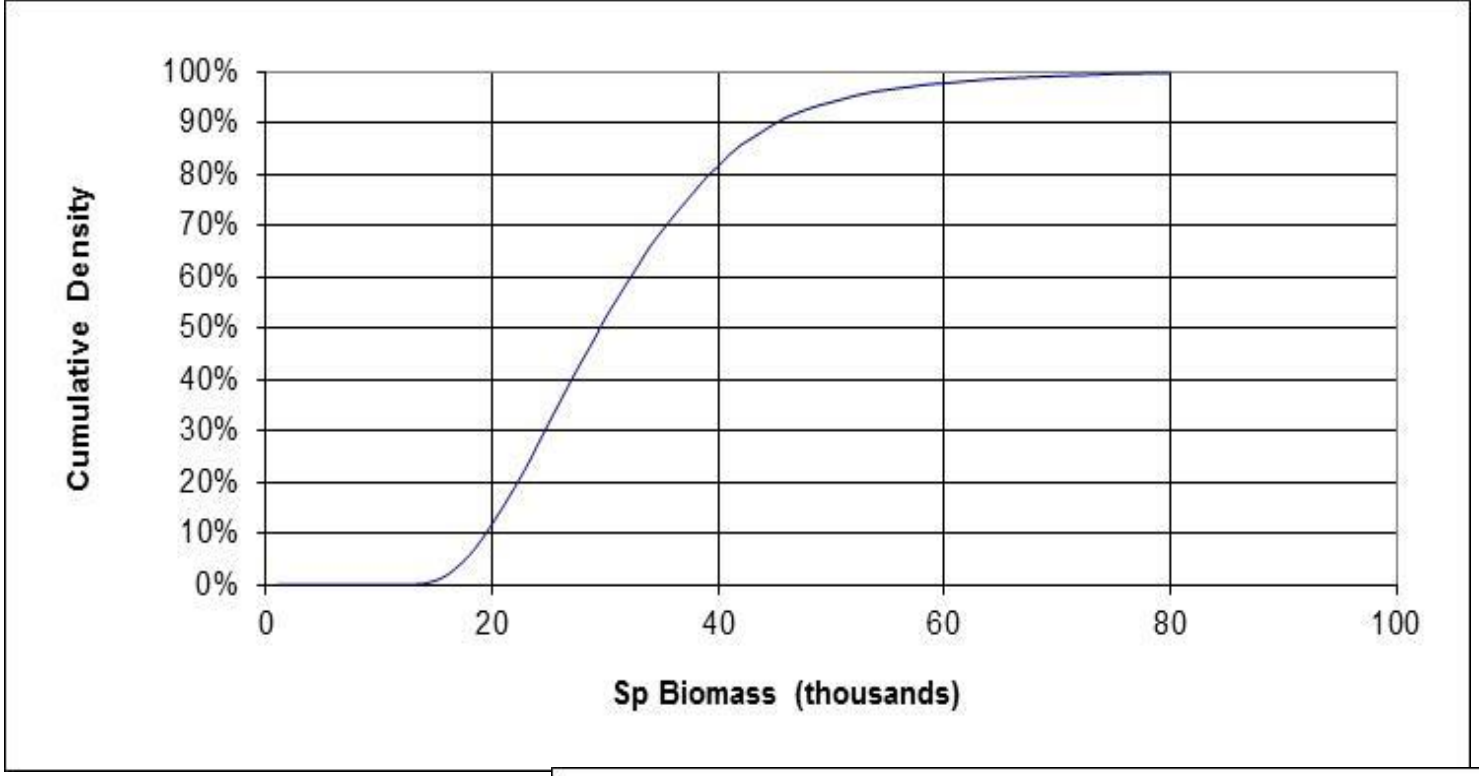
Results (Albacore) I

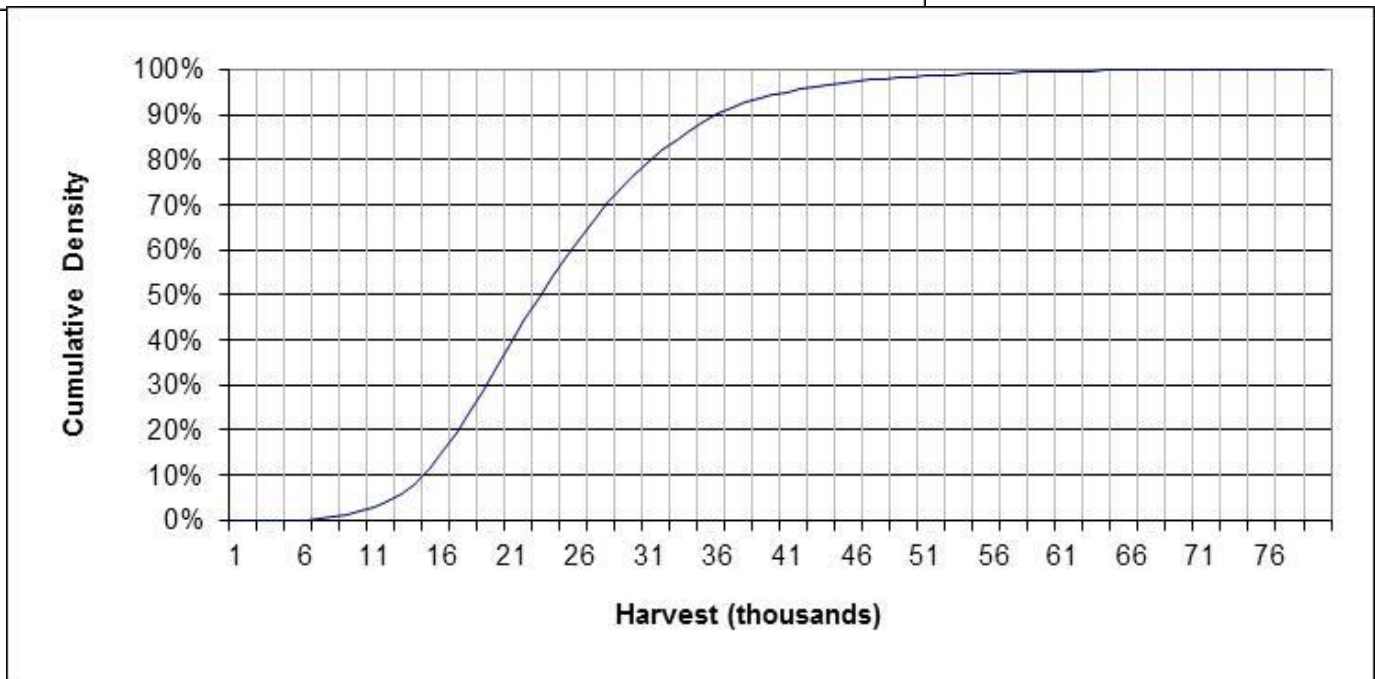
Biological and ecological structures	
#Gender Group	1 (Sex ratio 1:1)
Age classes	0 - 10
Natural mortality	M=0.2207 (/year) constant over ages
Growth formula	L=147.5(1-exp(-0.126(t+1.89))) common to sex
Weight-length allometry	$W = aL^b$ with $a = 5.691\times10^{-5}$, $b = 2.7514$. common to sex.
Maturity	Age-specific (0 for Age <=3, 0.25 for Age=4, 0.5 for Age=5, 0.75 for Age=6 and 1 for Age>=7)
Fecundity	Proportional to the spawning biomass
Spawner-recruitment	B-H (fixed steepness at 0.8) and sigma_R=0.2








Cumulative Density
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
20
40
60
80
100
Sp Biomass (thousands)


Cumulative Density
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
Harvest (thousands)

Probability of falling below 0.4 S_{MSY} (estimated at 40,348 t) fishing at different rates and assuming different auto-correlation of the process error term

		Harvest Rate					
		0.1	0.2	0.3	0.4	0.5	0.6
Auto-correlation	0.1	0.0%	0.0%	0.0%	1.3%	38.0%	76.0%
	0.15	0.0%	0.0%	0.0%	1.5%	38.5%	75.9%
	0.2	0.0%	0.0%	0.0%	2.1%	39.0%	76.1%
	0.25	0.0%	0.0%	0.0%	2.5%	39.6%	76.0%
	0.3	0.0%	0.0%	0.0%	3.0%	40.0%	76.0%
	0.35	0.0%	0.0%	0.0%	3.7%	40.7%	75.9%
	0.4	0.0%	0.0%	0.0%	4.3%	41.3%	76.0%
	0.45	0.0%	0.0%	0.0%	5.1%	41.7%	76.0%
	0.5	0.0%	0.0%	0.0%	6.1%	42.1%	75.9%
	0.55	0.0%	0.0%	0.1%	7.0%	42.7%	76.0%
	0.6	0.0%	0.0%	0.1%	8.2%	43.5%	76.0%
	0.65	0.0%	0.0%	0.2%	9.6%	44.0%	76.1%
	0.7	0.0%	0.0%	0.3%	11.1%	44.8%	75.8%
	0.75	0.0%	0.0%	0.7%	12.7%	45.5%	75.9%
	0.8	0.0%	0.0%	1.2%	14.6%	46.5%	75.7%
	0.85	0.0%	0.0%	1.9%	16.6%	47.4%	75.5%
	0.9	0.0%	0.1%	3.1%	19.5%	48.6%	75.0%

		Harvest Rate					
		0.1	0.2	0.3	0.4	0.5	0.6
Auto-correlation	0.1	0	0	0	36	48	61
	0.15	0	0	0	35	49	61
	0.2	0	0	0	38	49	62
	0.25	0	0	0	39	50	62
	0.3	0	0	0	41	51	62
	0.35	0	0	0	43	52	63
	0.4	0	0	0	43	53	63
	0.45	0	0	26	45	54	64
	0.5	0	0	31	47	55	64
	0.55	0	0	39	48	56	64
	0.6	0	0	34	50	57	65
	0.65	0	0	39	51	58	65
	0.7	0	0	41	53	59	66
	0.75	0	0	46	55	60	66
	0.8	0	0	52	57	61	67
	0.85	0	31	56	58	62	67
	0.9	0	62	58	59	63	68

Number of years to recovery

RESULTS (Albacore) 3:

The lower the Lower Bound,

- **the fewer the number of actions taken, but**
- **the slower Spawning Biomass increase to S_{MSY}.**

The higher the Lower Bound,

- **the higher the number of actions taken; but**
- **the quicker Spawning Biomass increase to S_{MSY}.**

If actions are taken relative to a Lower Bound,

- **average Spawning Biomass is higher than S_{MSY}**
- **average harvest is similar to MSY**