Indian Ocean Tuna Commission
Commission des Thons de l'Océan Indien
iotc ctoi

Defining risk and evaluating IOTC limit reference points

WPM,

Ispra, Italy,

Mar. 24th -28th , 2014.

The Dilemma of Low Spawning Biomass

Spawning Biomass have been low for two years:

Are these low Sp Biomass due to a passing weakness in year class strengths, and no additional action should be taken?

Or

Is this the start of overfishing, and additional action is warranted?

Defining Risk

- **You're a farmer who's just brought in his crop of soy beans. Do you sell now, or store the beans for sale later. You run a risk that the price will rise later if you sell now, and you run a risk of falling prices if you store the grain.**

- **You're an equities investor holding some stock. Do you sell or continue holding? You too run a risk that price will rise later if you sell now, and you too run a risk if you hold now and the share price falls.**

- **You're owner of a fishing boat business, booking clients for the upcoming season. Do you add an extra boat and crew to increase catch? You run a risk of having too many clients if regulations unexpectedly reduce harvest. You also run a risk of having too few clients if regulations are unexpectedly relaxed.**

Defining Risk

- You're a farmer who's just brought in his crop of soy beans. Do you sell now, or store the beans for sale later. You run a risk that the price will rise later if you sell now, and you run a risk if you store now and the price will fall.

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- You're owner of a fishing boat business, booking clients for the upcoming season. Do you add an extra boat and crew to increase catch? You run a risk of having too many clients if regulations unexpectedly reduce harvest. You also run a risk of having too few clients if regulations are unexpectedly relaxed.

Defining Risk

- **You're a farmer who's just brought in his crop of soy beans. Do you sell now, or store the beans for sale later. You run a risk that the price will rise later if you sell now, and you run a risk if you store now and the price will fall.**

- **You're an equities investor holding some stock. Do you sell or continue holding? You too run a risk that price will rise later if you sell now, and you too run a risk if you hold now and the share price falls.**

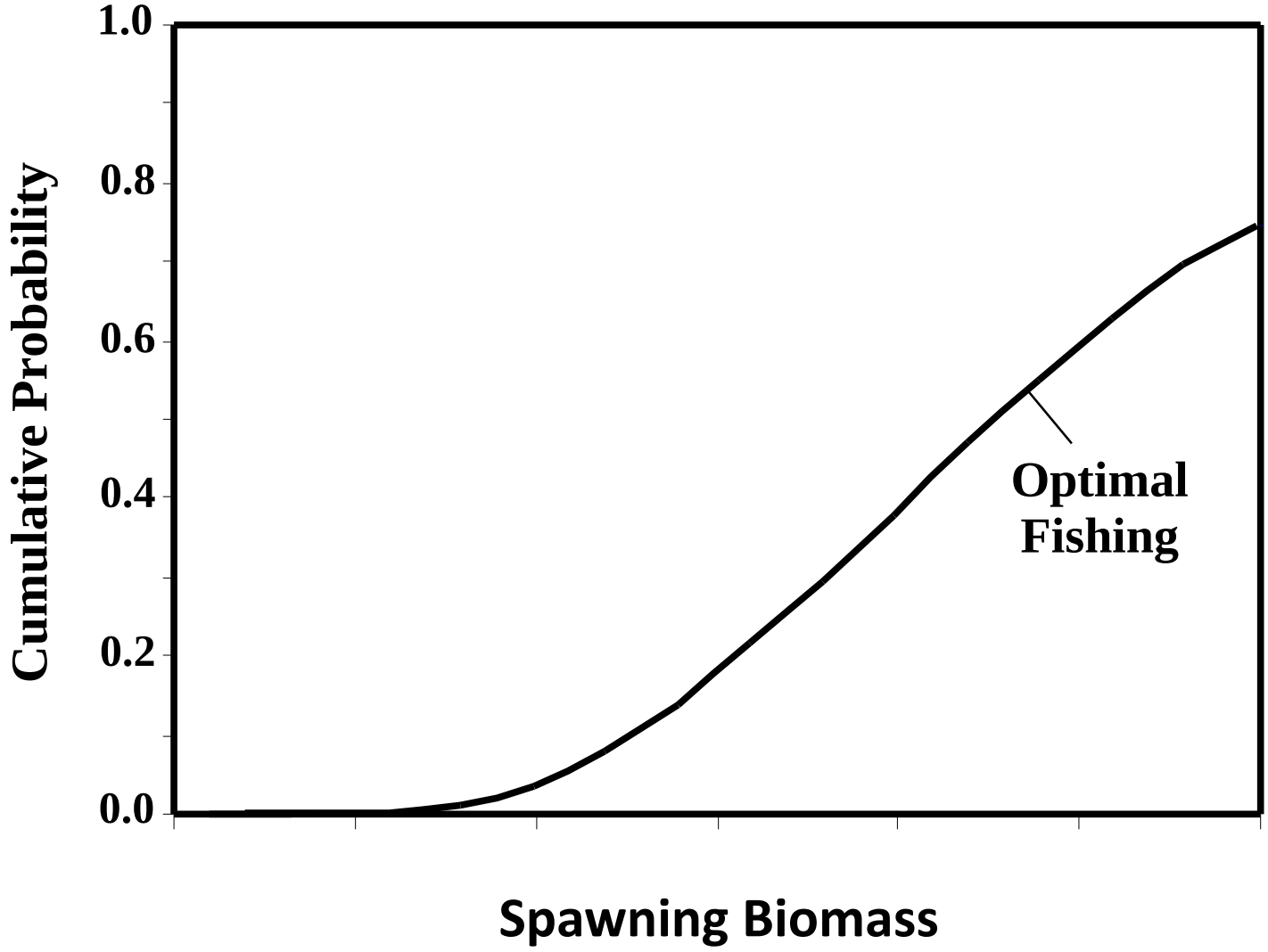
- **You're owner of a fishing boat business, booking clients for the upcoming season. Do you add an extra boat and crew for increasing catch? You run a risk of having too many clients if regulations unexpectedly reduce harvest. You also run a risk of having too few clients if regulations are unexpectedly relaxed.**

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

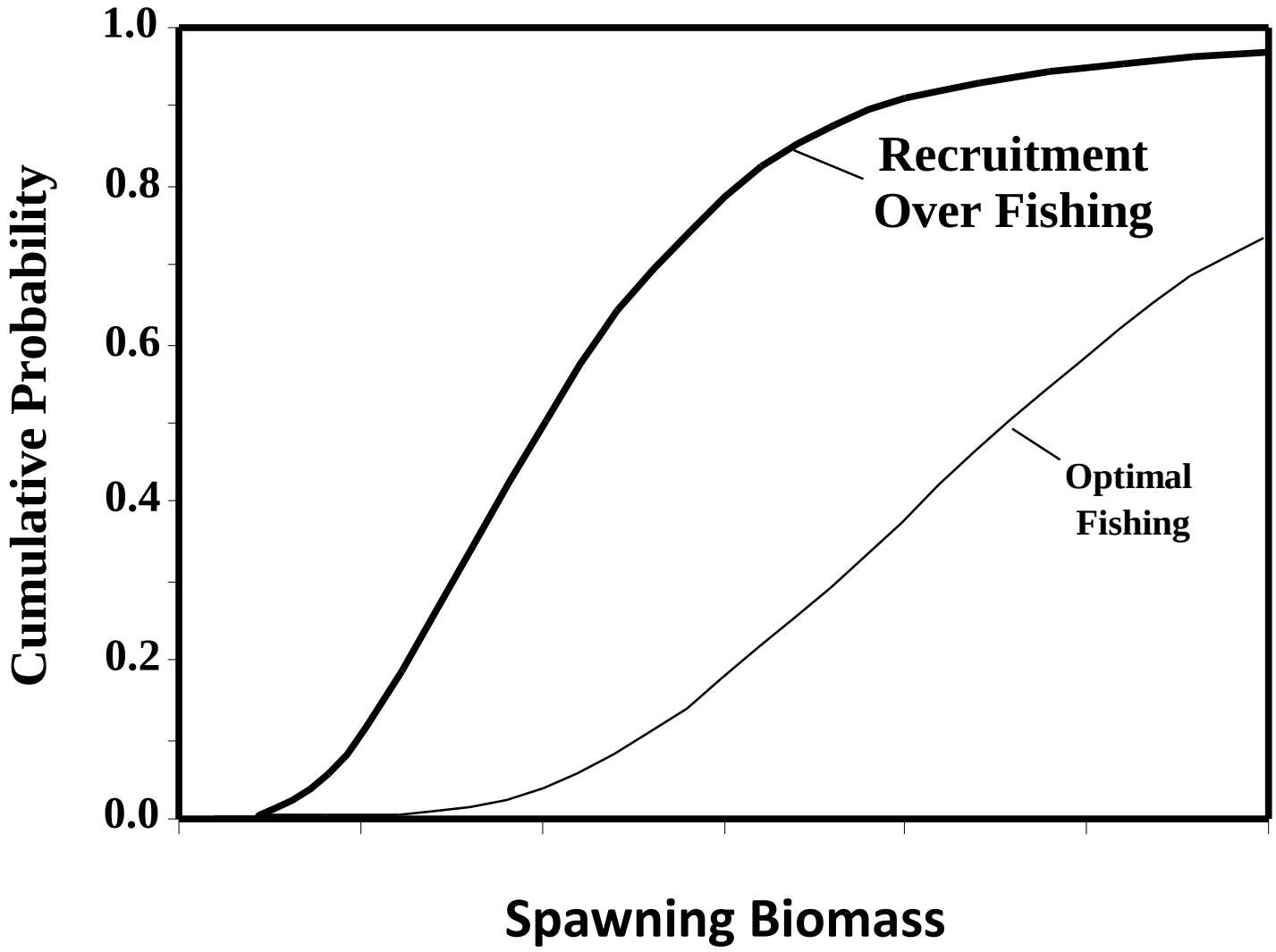
Risk for the fisheries manager is the probability of making the wrong decision:

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

Management Action is NOT Needed

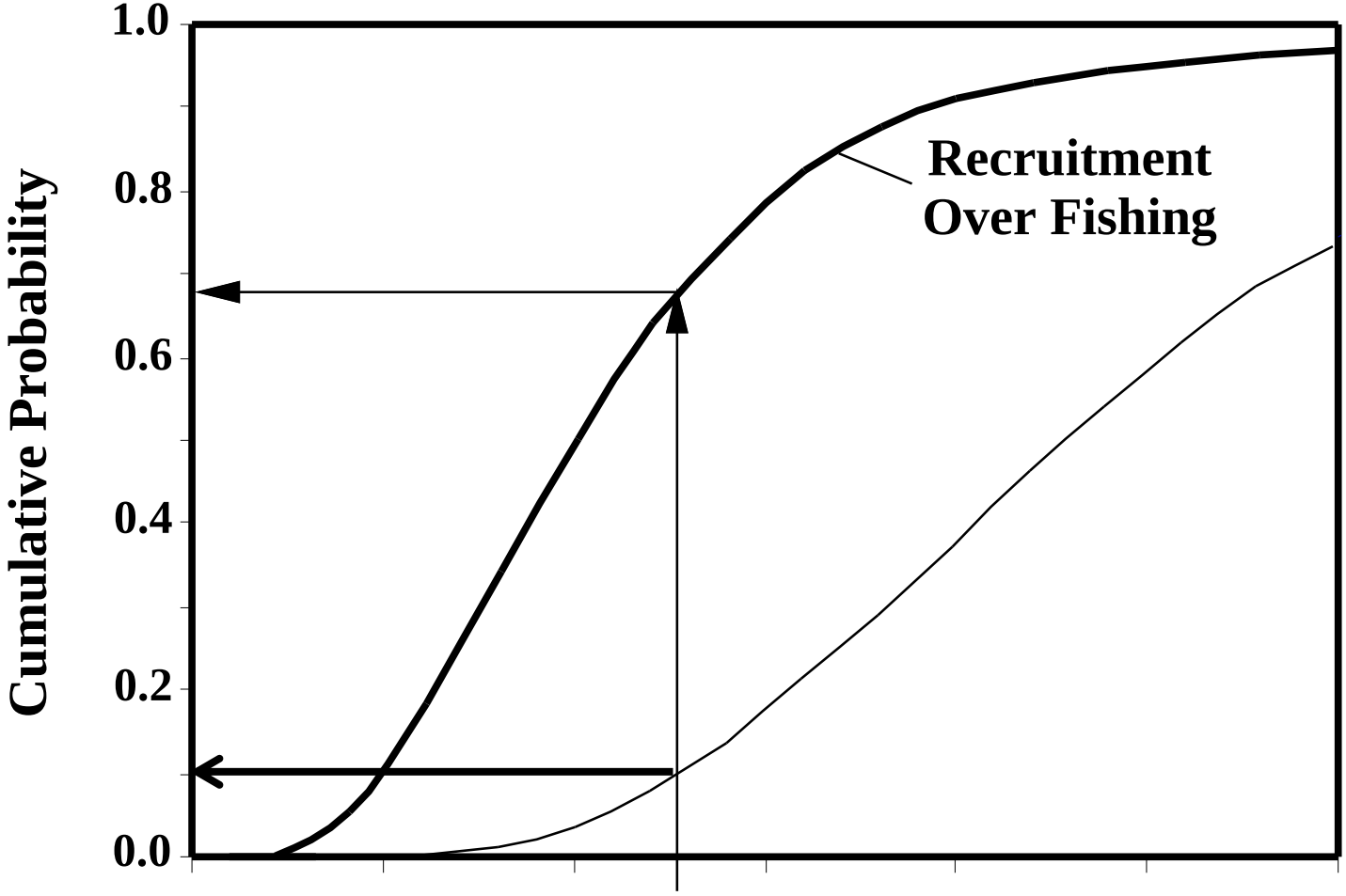


Management Action IS Needed



Management Action IS Needed

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



Objective: Probability that spawning biomas

Setting clear objectives for MSE

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 taking an AMA (based on some limit reference point, in our case the interim ref. points).**
3. **In order to meet that rule, we need to operate under some F's, which can be estimated and will be the set of HCR's.**

Assessing Type II-errors, i.e. failing to take a restriction when there was a need to do so

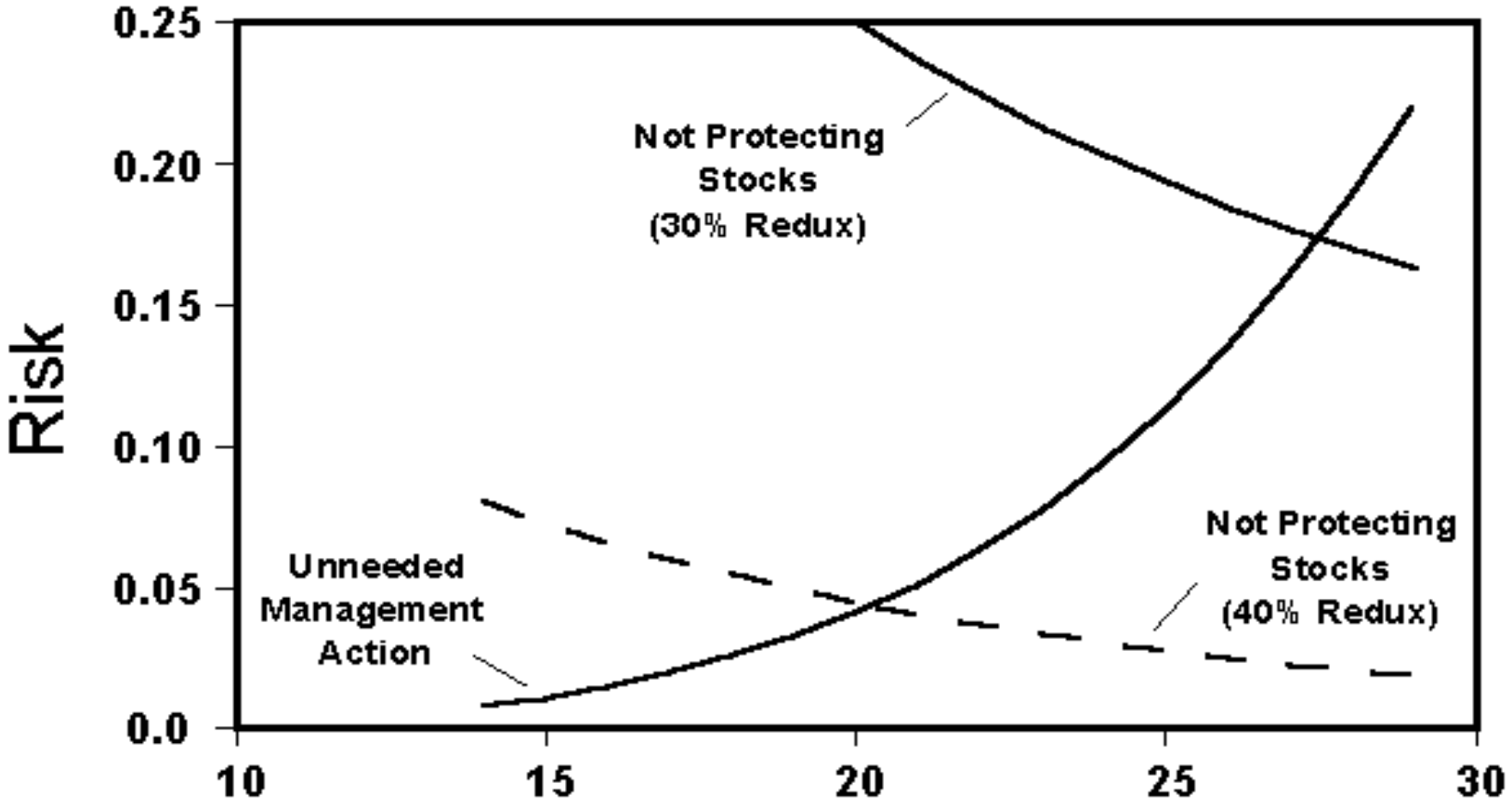
4. **Reduce productivity in simulated stock-recruit relationships by a substantial amount, say 40%, to simulate recruitment overfishing.**

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.**

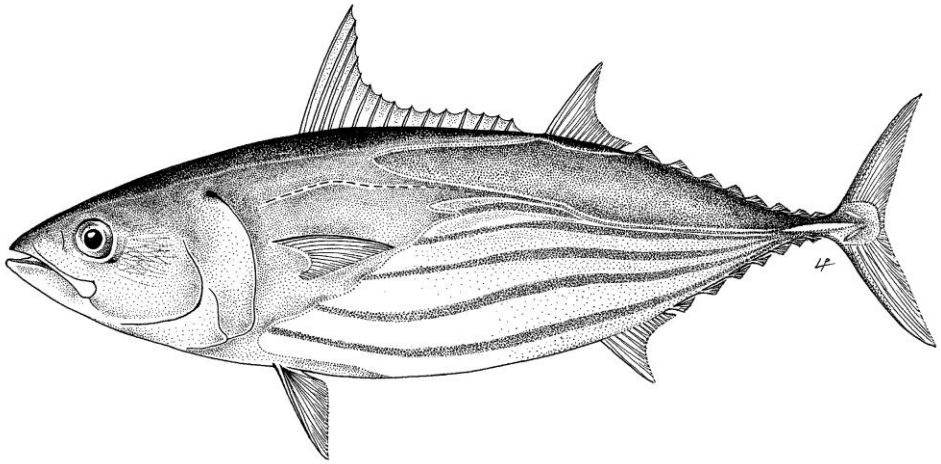
6. **Minimize this risk, i.e. if this is less than y (eg 5%), alter productivity of simulated stocks and try again (back to step 4)., i.e. the ability to detect a drop in productivity and take a decision is only detectable to some critical level.**

IOTC Interim Reference Points Resolution 13/10

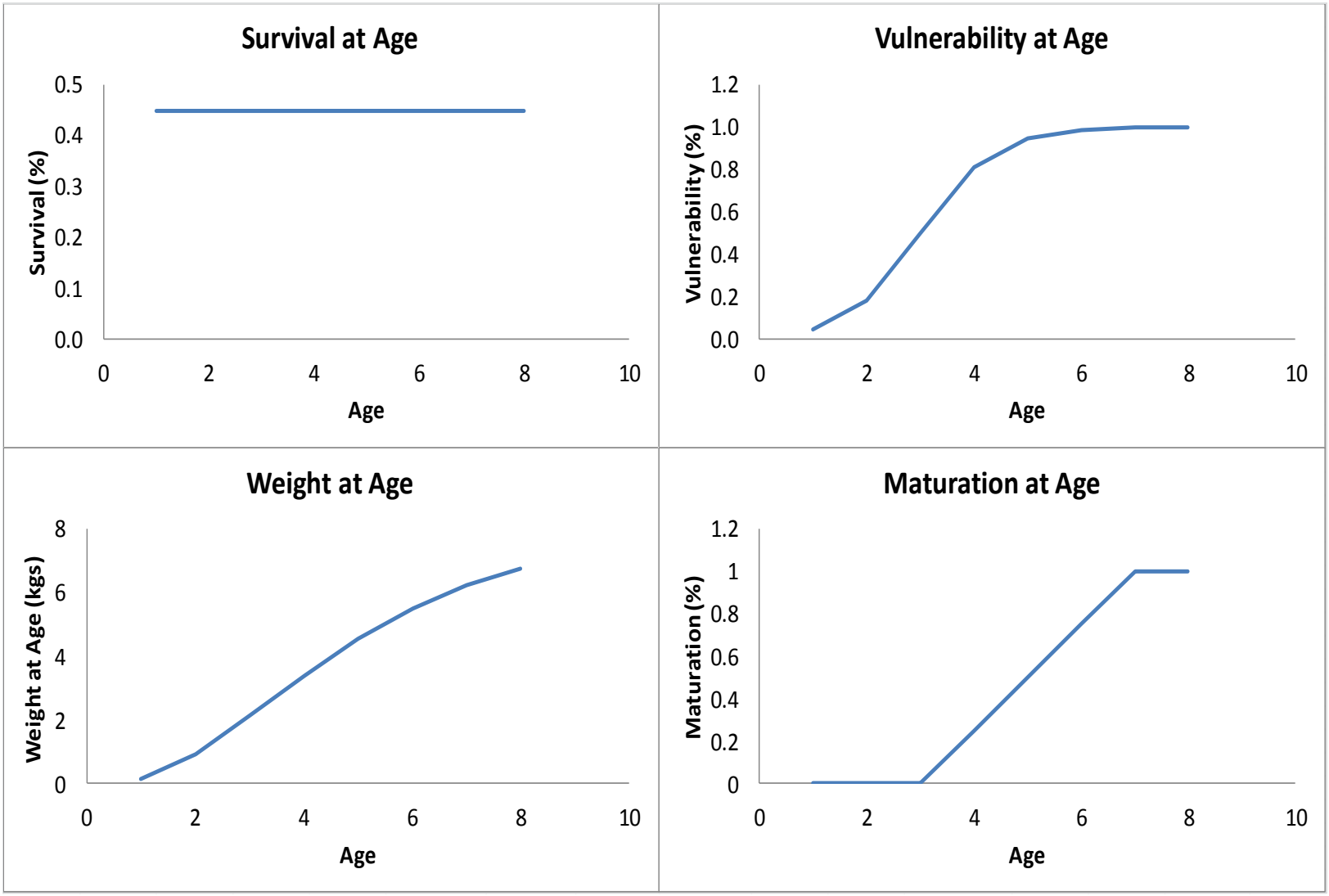
Stock	Target Reference Point	Limit Reference Point
Albacore	B_{MSY}; F_{MSY}	$B_{LIM} = 0.40\ B_{MSY}$; $F_{LIM} = 1.40\ F_{MSY}$
Bigeye tuna	B_{MSY}; F_{MSY}	$B_{LIM} = 0.50\ B_{MSY}$; $F_{LIM} = 1.30\ F_{MSY}$
Skipjack tuna	B_{MSY}; F_{MSY}	$B_{LIM} = 0.40\ B_{MSY}$; $F_{LIM} = 1.50\ F_{MSY}$
Yellowfin tuna	B_{MSY}; F_{MSY}	$B_{LIM} = 0.40\ B_{MSY}$; $F_{LIM} = 1.40\ F_{MSY}$
Swordfish	B_{MSY}; F_{MSY}	$B_{LIM} = 0.40\ B_{MSY}$; $F_{LIM} = 1.40\ F_{MSY}$

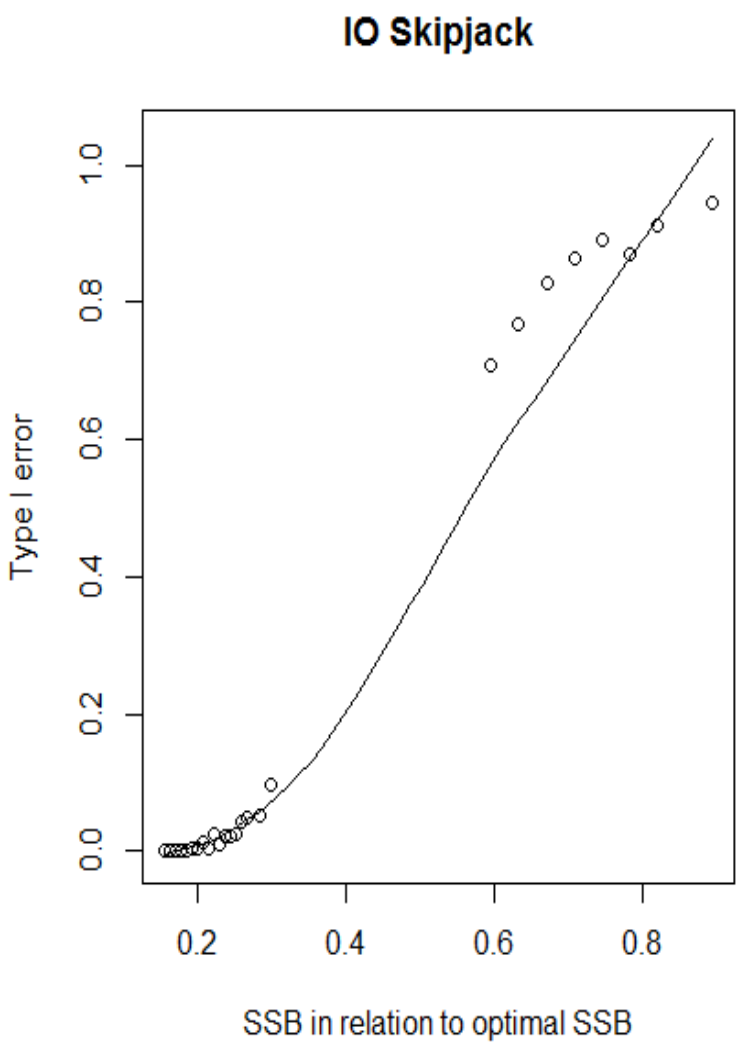

Risk
0.25
0.20
0.15
0.10
0.05
0.0
10
15
20
25
30
Not Protecting
Stocks
(30% Redux)
Unneeded
Management
Action
Not Protecting
Stocks
(40% Redux)

Skipjack Like Stock IO



Skipjack Life History Parameters IO




IO Skipjack
Type I error
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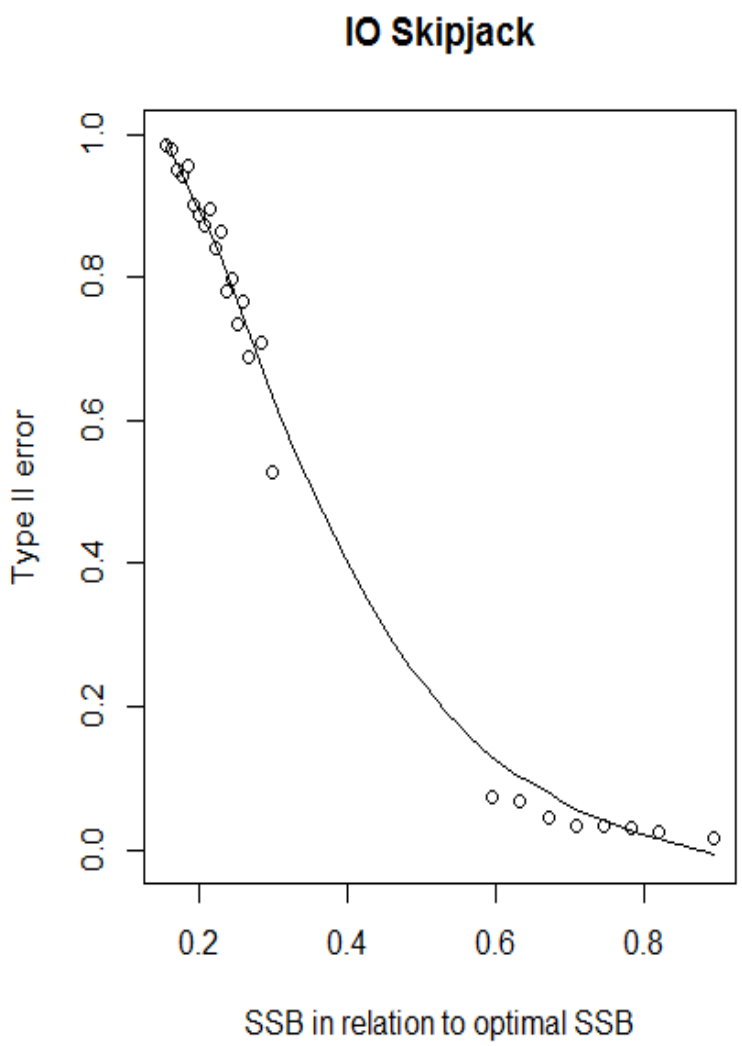
0.4
0.6
0.8
1.0
0.2
0.4
0.6
0.8
SSB in relation to optimal SSB


IO Skipjack
Type II error
0.0
0.2
0.4
0.6
0.8
1.0
0.2
0.4
0.6
0.8
SSB in relation to optimal SSB

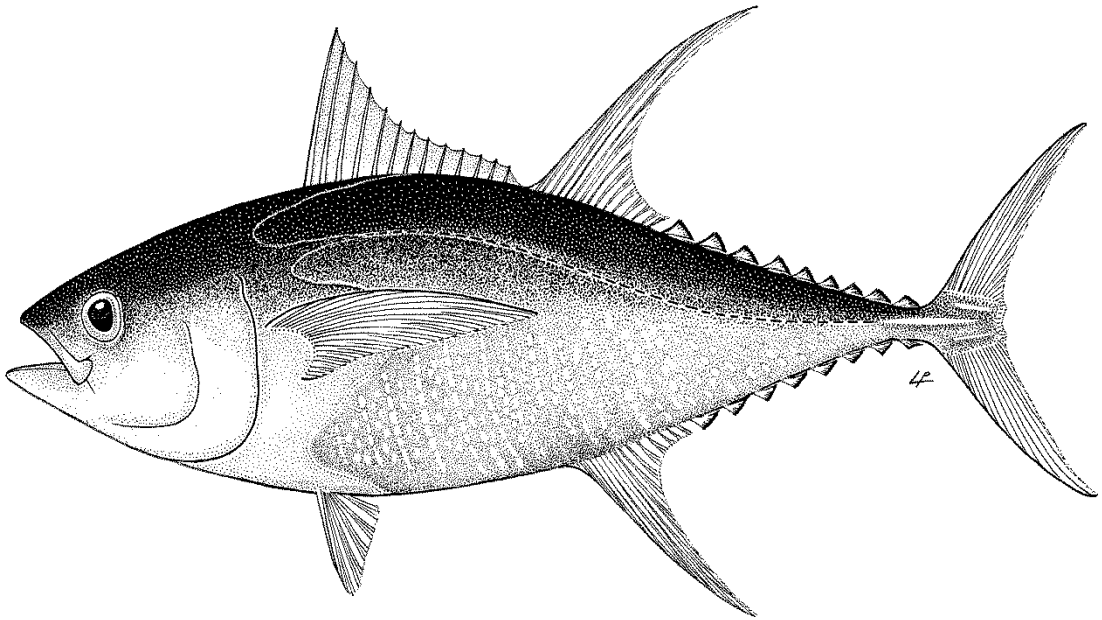
Auto-correlation	Harvest Rate (F/F_{MSY})					
	0.25	0.5	0.75	1	1.25	1.5
0.1	0	0	0	1	1	3
0.15	0	0	0	1	1	3
0.2	0	0	0	1	1	3
0.25	0	0	0	1	2	3
0.3	0	0	1	1	2	3
0.35	0	0	1	1	2	3
0.4	0	0	1	1	2	3
0.45	0	0	1	1	2	4
0.5	0	0	1	1	2	4
0.55	0	1	1	2	3	4
0.6	0	1	2	2	3	4
0.65	0	1	2	2	3	5
0.7	0	1	2	2	3	+76
0.75	1	2	2	3	4	+76
0.8	3	3	3	3	4	+76
0.85	3	4	4	4	20	+76
0.9	4	5	4	6	64	+76

Simple HCR and Recovery Time (Limit)

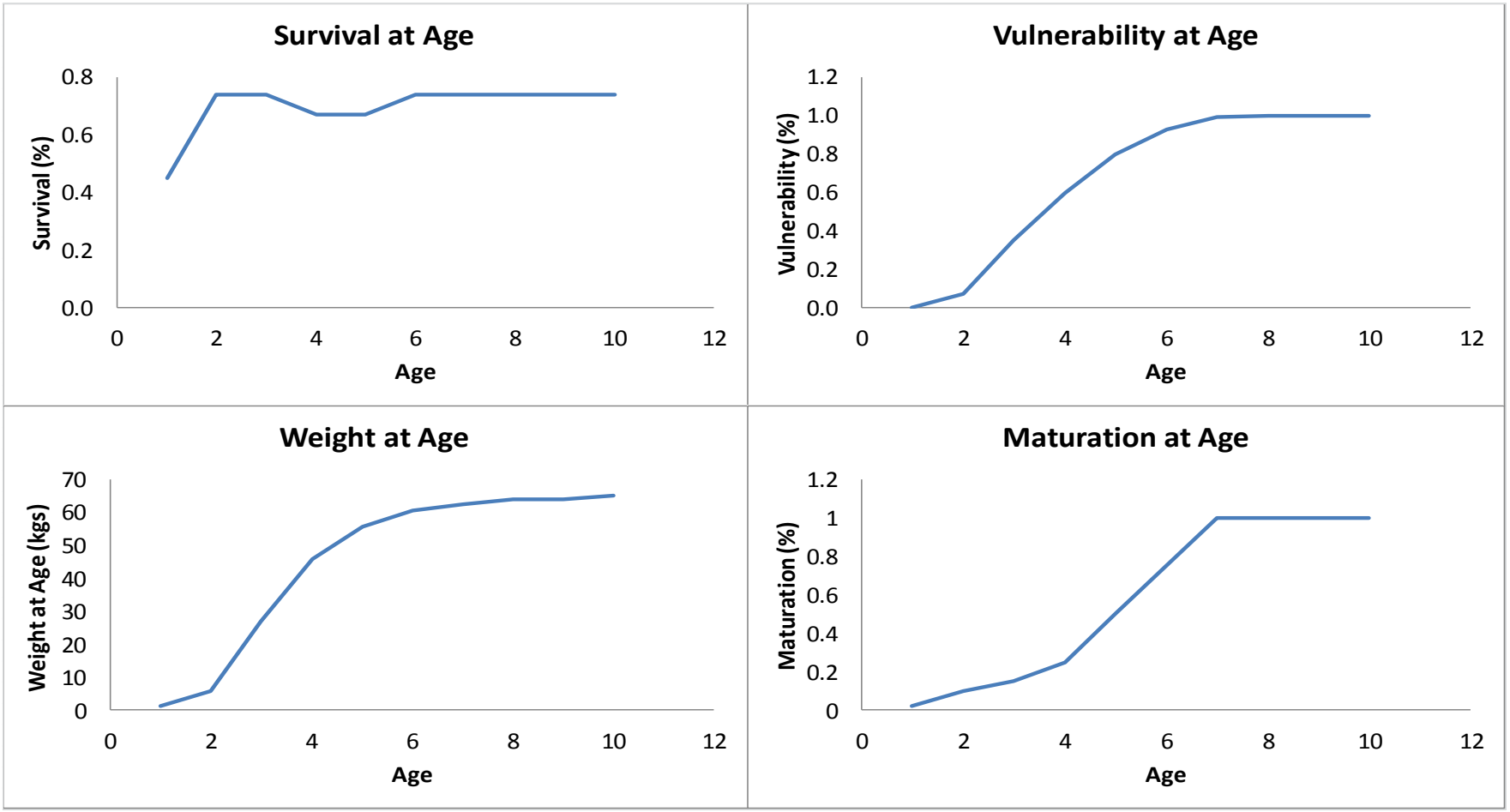
Simple HCR and Recovery Time (Target)

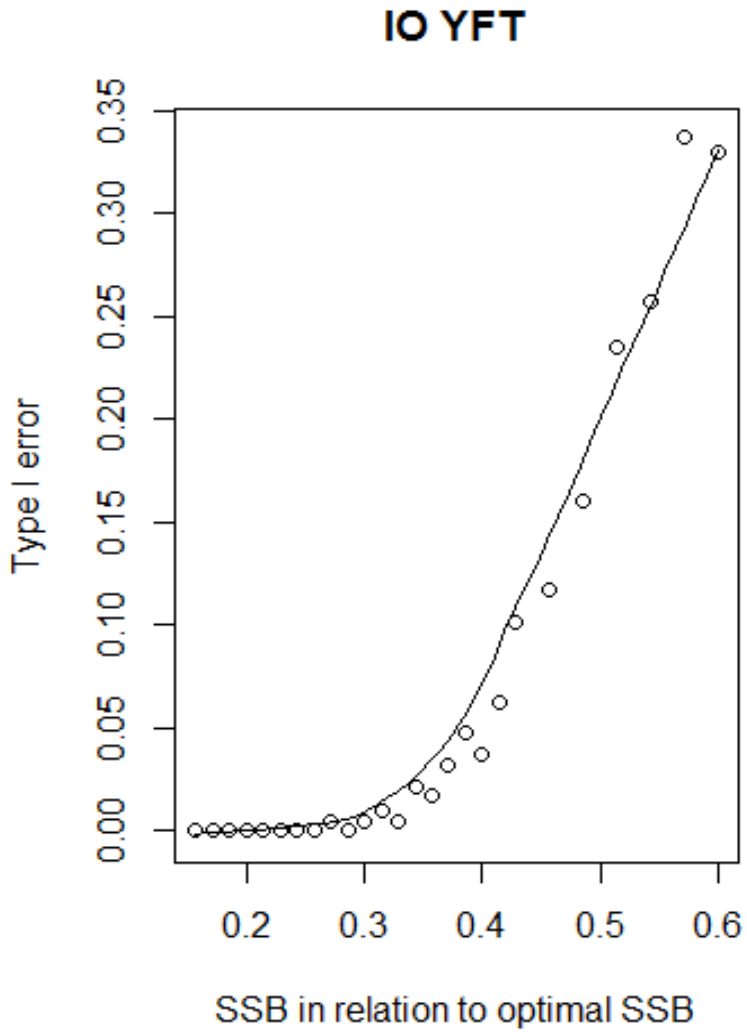
Auto-correlation	Harvest Rate (F/F_{MSY})					
	0.25	0.5	0.75	1	1.25	1.5
0.1	0	1	1	3	7	+76
0.15	0	1	2	3	7	+76
0.2	1	1	2	3	7	+76
0.25	1	1	2	3	7	+76
0.3	1	1	2	4	8	+76
0.35	1	1	2	4	8	+76
0.4	1	1	2	4	71	+76
0.45	1	2	3	4	73	+76
0.5	1	2	3	5	75	+76
0.55	2	2	3	5	+76	+76
0.6	2	2	3	5	+76	+76
0.65	2	3	4	6	+76	+76
0.7	3	3	4	6	+76	+76
0.75	3	4	5	17	+76	+76
0.8	4	4	6	21	+76	+76
0.85	5	6	10	41	+76	+76
0.9	6	7	18	+76	+76	+76

Evaluation: Yellowfin Like Stock IO



Life-history Parameters: YFT




IO YFT
Type I error
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0.10
0.15
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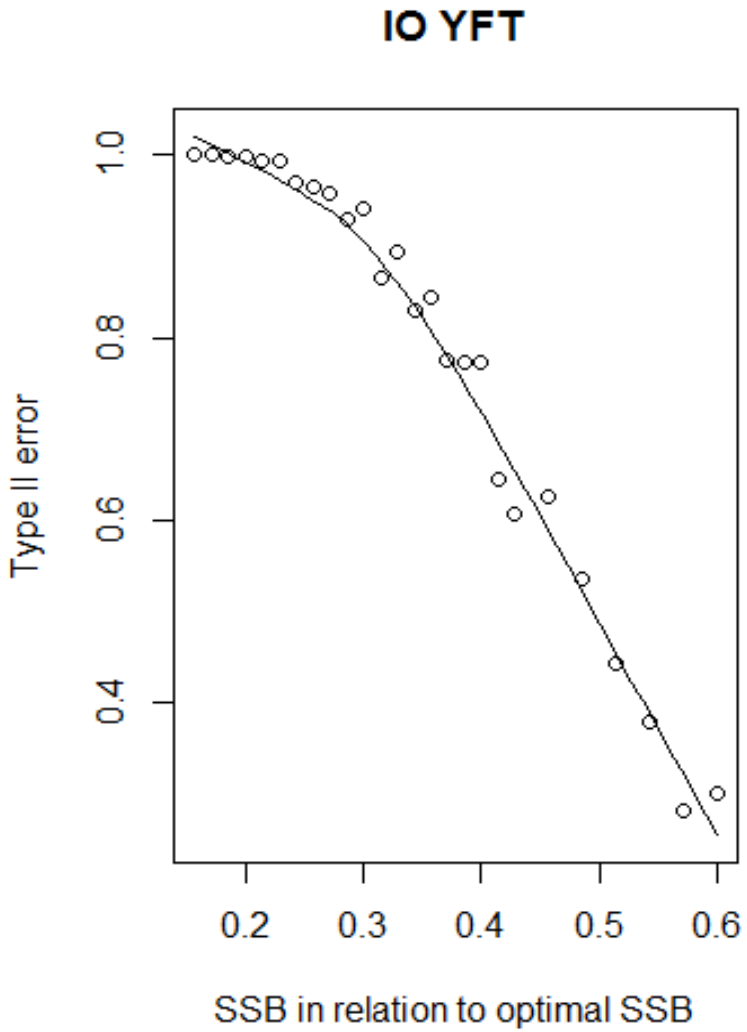
0.25
0.30
0.35
0.2
0.3
0.4
0.5
0.6
SSB in relation to optimal SSB


IO YFT
Type II error
0.4
0.6
0.8
1.0
0.2
0.3
0.4
0.5
0.6
SSB in relation to optimal SSB

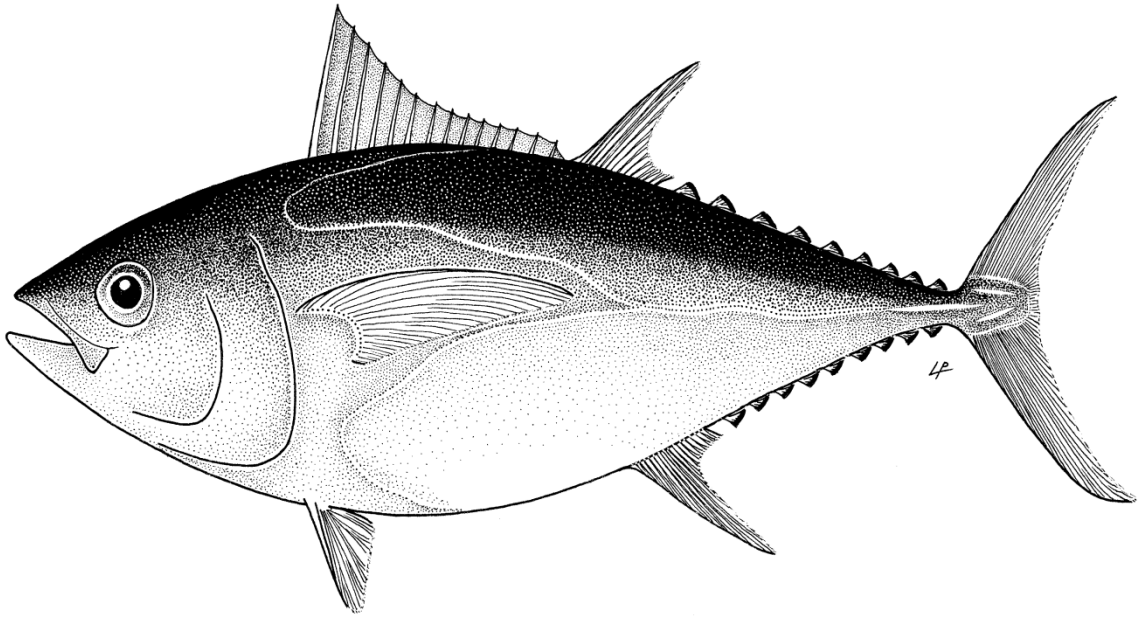
Auto-correlation	Harvest Rate (F/F_{MSY})					
	0.4	0.8	1.2	1.6	2	2.4
0.1	0	0	1	2	4	+76
0.15	0	0	1	2	4	+76
0.2	0	0	1	2	4	+76
0.25	0	1	1	2	4	+76
0.3	0	1	1	2	5	+76
0.35	0	1	2	3	5	+76
0.4	0	1	2	3	5	+76
0.45	0	1	2	3	5	+76
0.5	0	1	2	3	26	+76
0.55	0	1	2	4	49	+76
0.6	0	1	3	4	40	+76
0.65	0	2	3	4	41	+76
0.7	2	2	3	5	47	+76
0.75	2	4	4	5	67	+76
0.8	3	4	5	10	+76	+76
0.85	3	5	5	18	+76	+76
0.9	5	5	7	50	+76	+76

Simple HCR and Recovery Time (Limit)

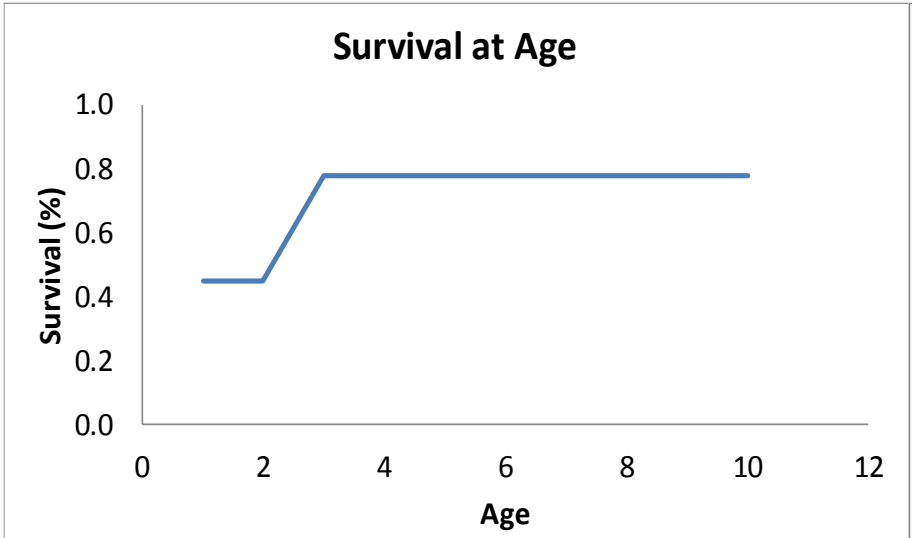
Simple HCR and Recovery Time (Target)

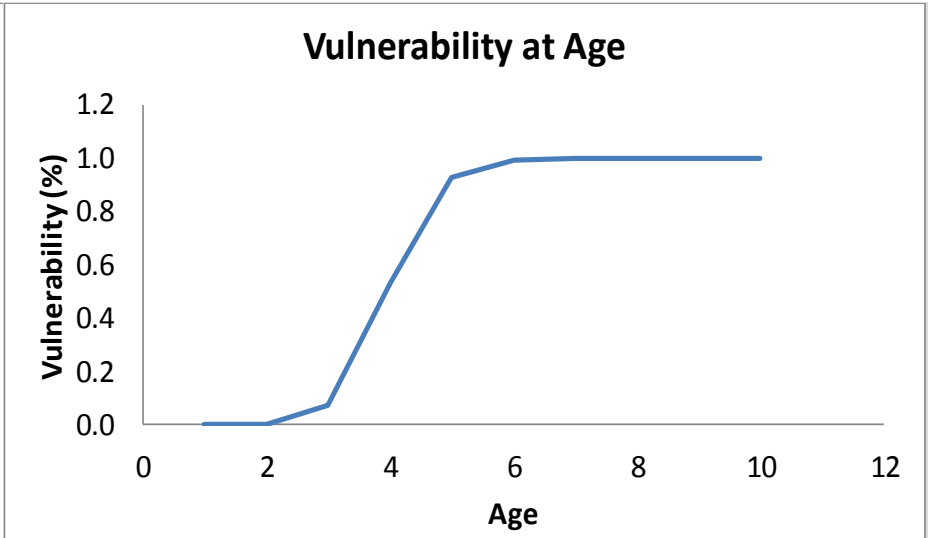
Auto-correlation	Harvest Rate (F/F_{MSY})					
	0.4	0.8	1.2	1.6	2	2.4
0.1	0	0	38	4	+76	+76
0.15	0	0	38	14	+76	+76
0.2	0	0	36	14	+76	+76
0.25	0	6	36	14	+76	+76
0.3	0	7	34	14	+76	+76
0.35	0	8	31	18	+76	+76
0.4	0	7	31	28	+76	+76
0.45	0	8	34	28	+76	+76
0.5	0	11	35	30	+76	+76
0.55	0	13	33	33	+76	+76
0.6	0	15	33	37	+76	+76
0.65	0	17	32	36	+76	+76
0.7	6	18	33	35	+76	+76
0.75	7	19	34	36	+76	+76
0.8	10	22	36	+76	+76	+76
0.85	12	26	36	+76	+76	+76
0.9	16	31	39	+76	+76	+76

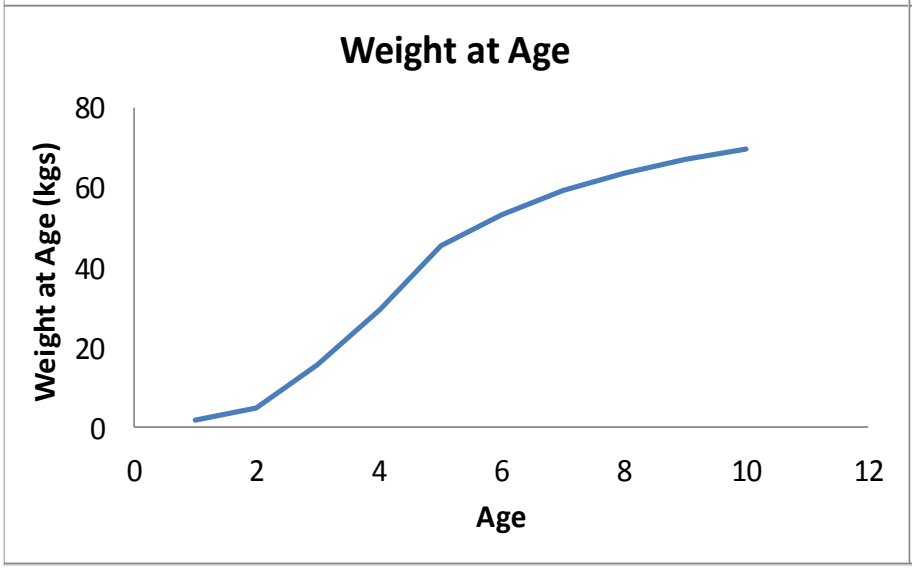
Evaluation: Bigeye Like Stock IO

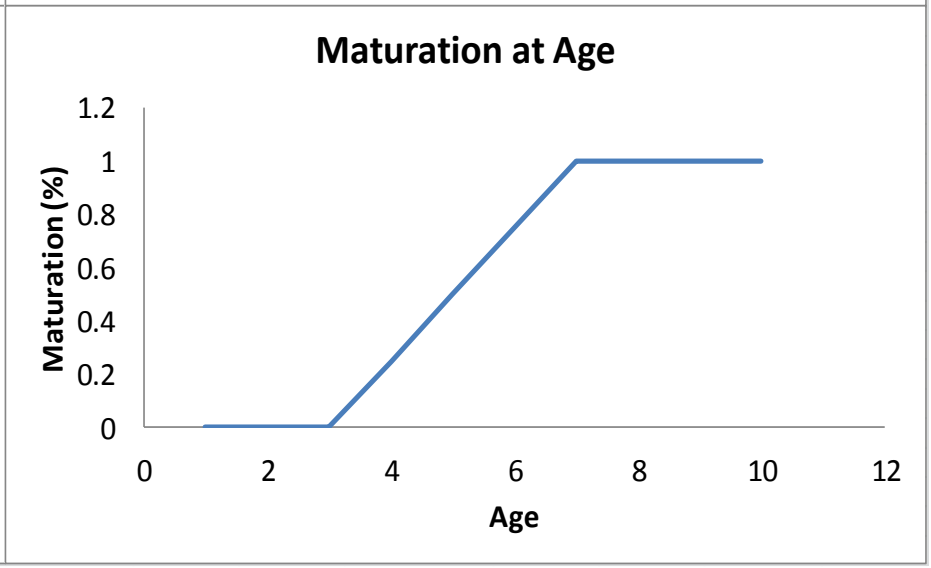


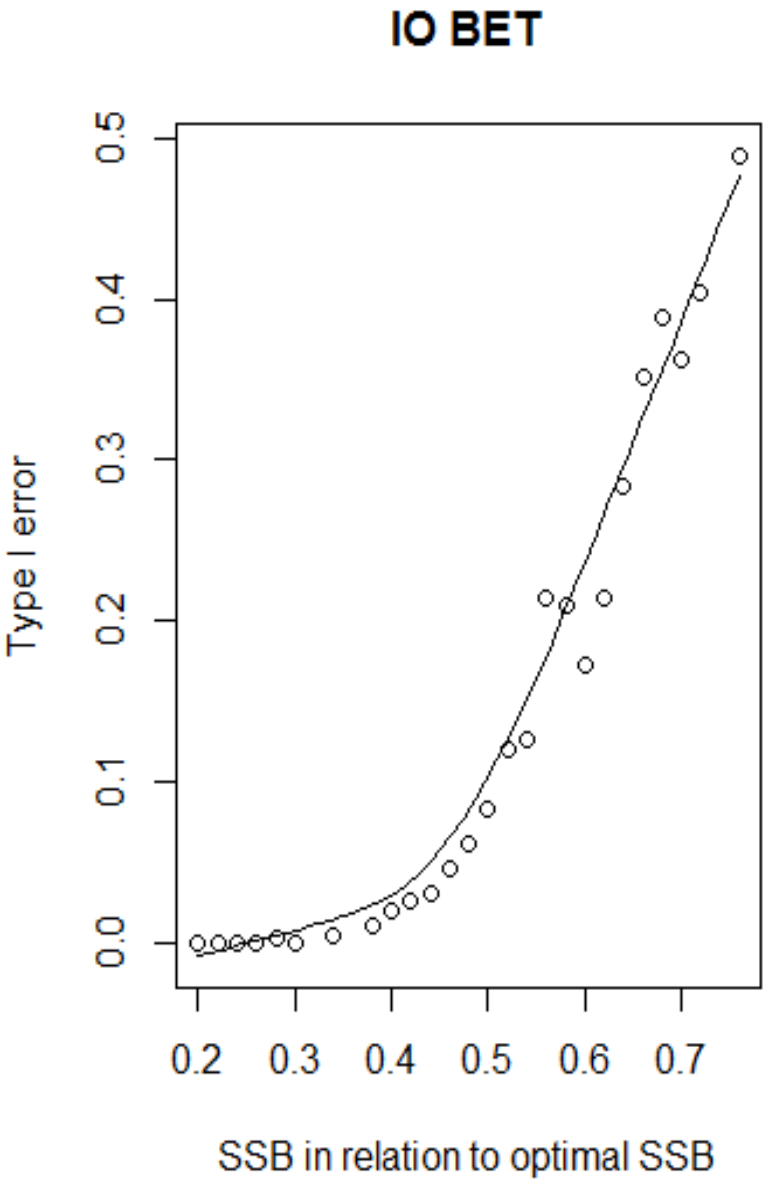
Life history based parameters- BET

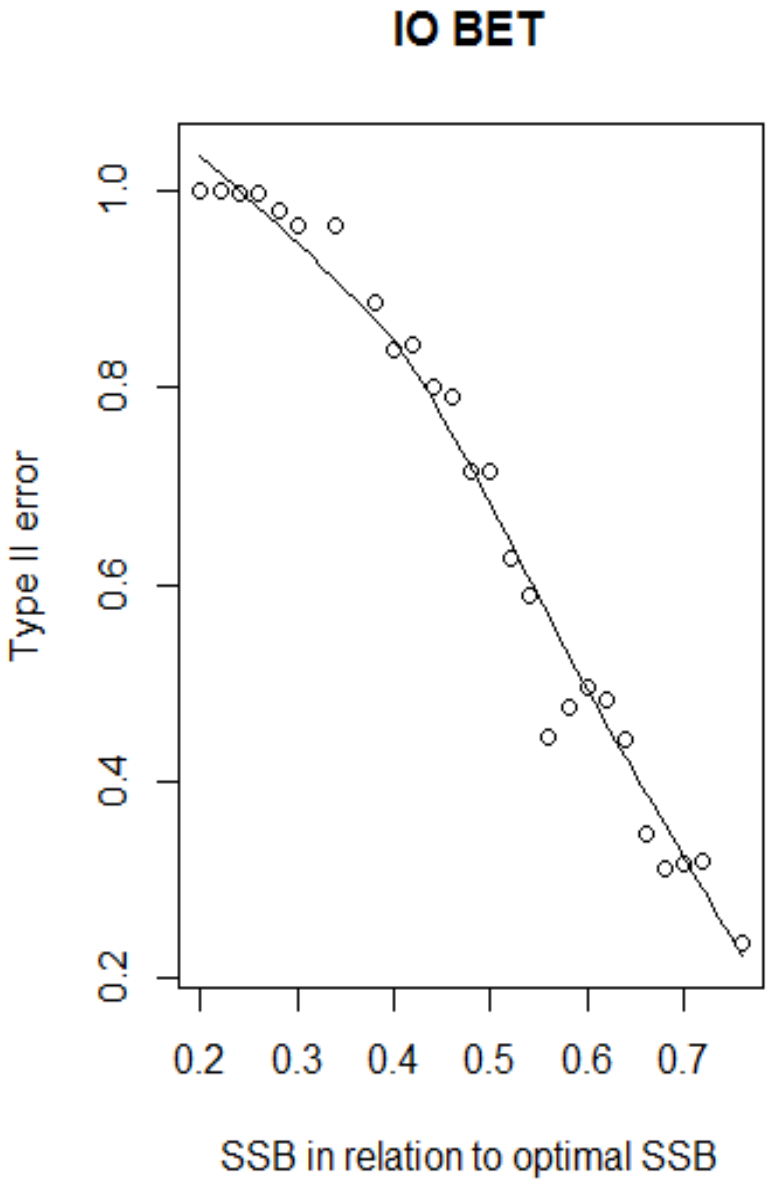









IO BET
Type I error
0.0
0.1
0.2
0.3
0.4
0.5
0.2
0.3
0.4
0.5
0.6
0.7
SSB in relation to optimal SSB


IO BET
Type II error
0.2
0.4
0.6
0.8
1.0
0.2
0.3
0.4
0.5
0.6
0.7
SSB in relation to optimal SSB

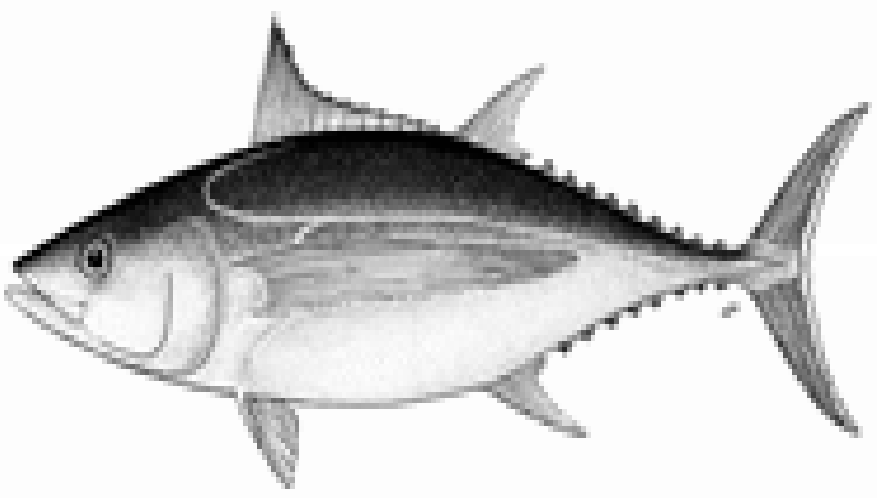
Auto-correlation	Harvest Rate (F/F_{MSY})					
	0.5	1	1.5	2	2.5	3
0.1	0	1	1	3	7	+76
0.15	0	1	2	3	7	+76
0.2	1	1	2	3	7	+76
0.25	1	1	2	3	7	+76
0.3	1	1	2	4	8	+76
0.35	1	1	2	4	8	+76
0.4	1	1	2	4	71	+76
0.45	1	2	3	4	73	+76
0.5	1	2	3	5	75	+76
0.55	2	2	3	5	+76	+76
0.6	2	2	3	5	+76	+76
0.65	2	3	4	6	+76	+76
0.7	3	3	4	6	+76	+76
0.75	3	4	5	17	+76	+76
0.8	4	4	6	21	+76	+76
0.85	5	6	10	41	+76	+76
0.9	6	7	18	+76	+76	+76

Simple HCR and Recovery Time (Limit)

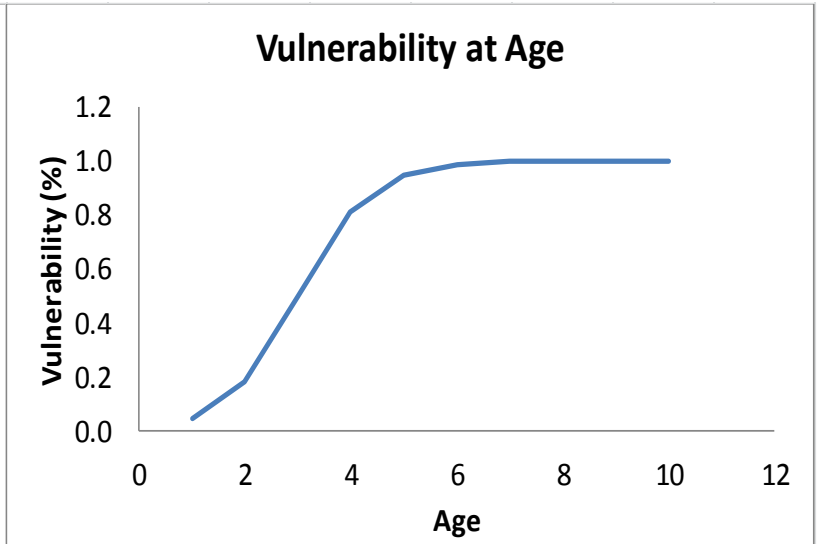
Simple HCR and Recovery Time (Target)

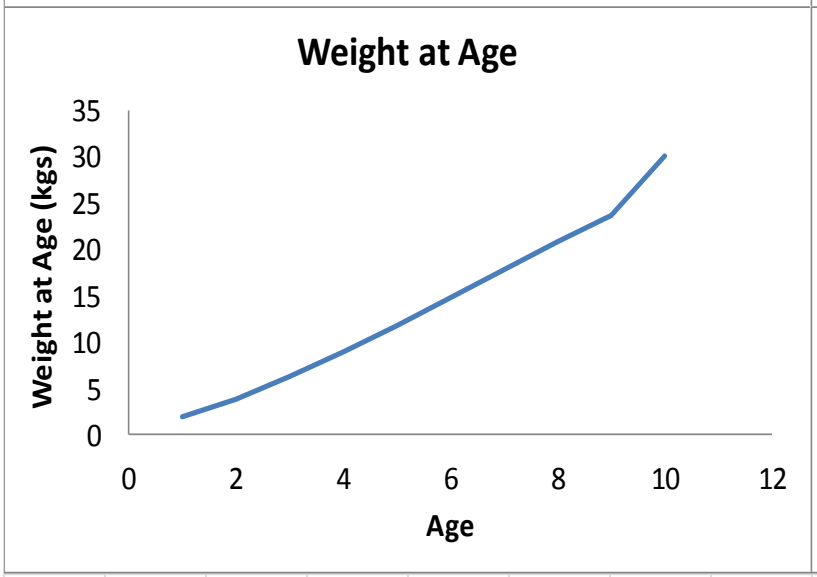
Auto-correlation	Harvest Rate (F/F_{MSY})					
	0.5	1	1.5	2	2.5	3
0.1	0	73	+76	+76	+76	+76
0.15	0	73	+76	+76	+76	+76
0.2	0	73	+76	+76	+76	+76
0.25	0	73	+76	+76	+76	+76
0.3	0	73	+76	+76	+76	+76
0.35	0	74	+76	+76	+76	+76
0.4	0	75	+76	+76	+76	+76
0.45	0	75	+76	+76	+76	+76
0.5	64	+76	+76	+76	+76	+76
0.55	63	+76	+76	+76	+76	+76
0.6	65	+76	+76	+76	+76	+76
0.65	68	+76	+76	+76	+76	+76
0.7	69	+76	+76	+76	+76	+76
0.75	70	+76	+76	+76	+76	+76
0.8	71	+76	+76	+76	+76	+76
0.85	72	+76	+76	+76	+76	+76
0.9	74	+76	+76	+76	+76	+76

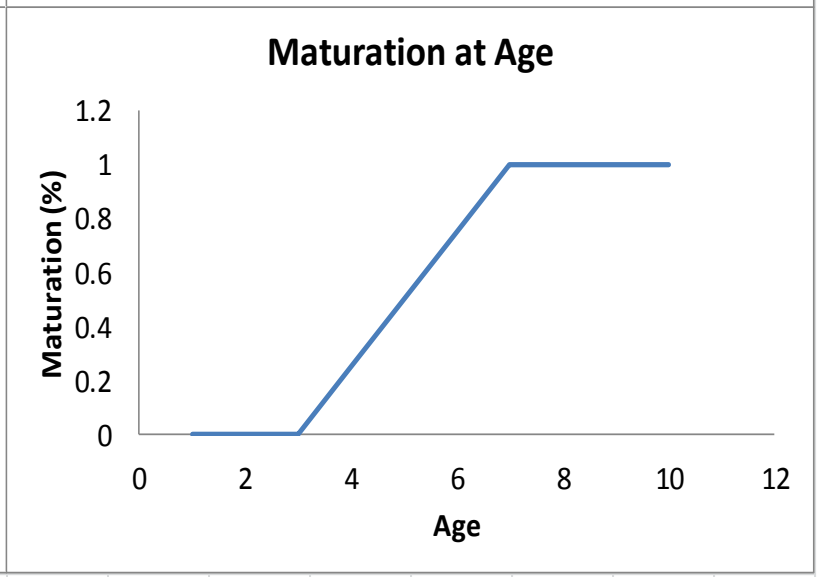
Evaluation Albacore Like Stock IO

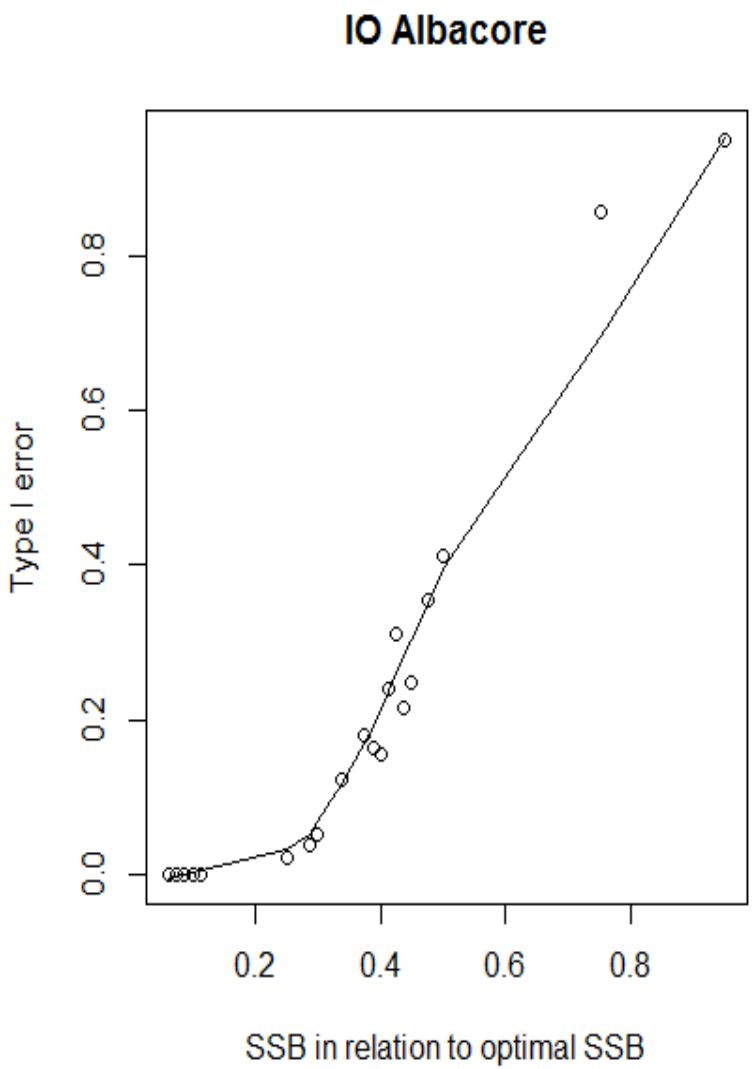


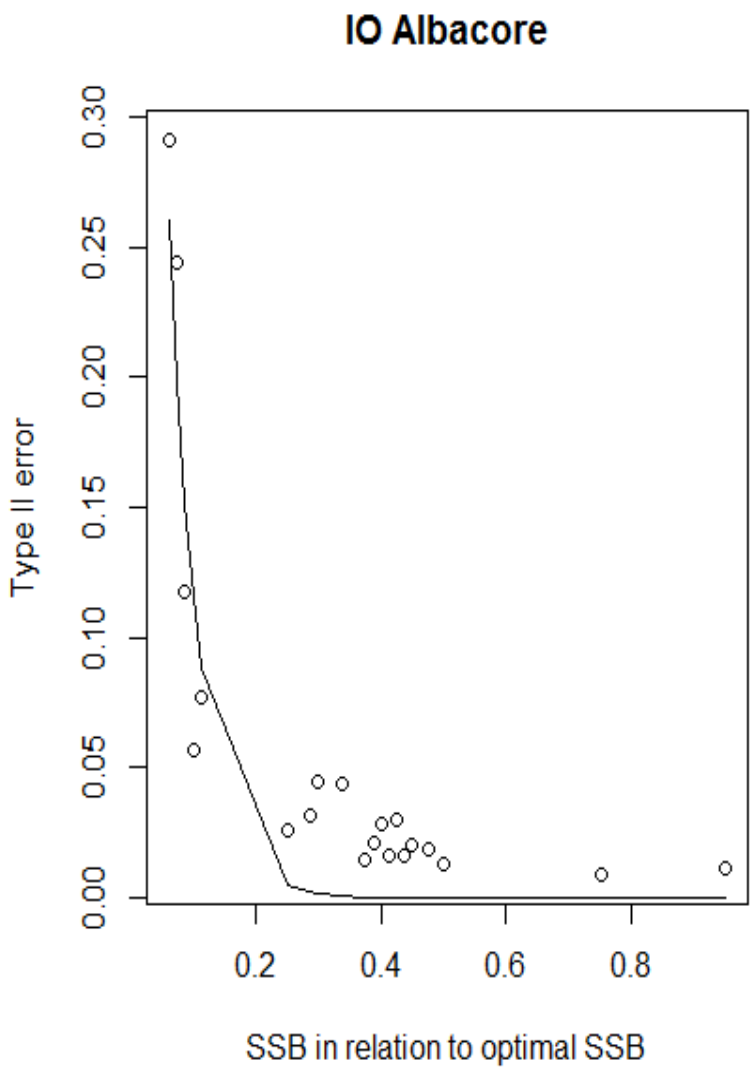
Albacore Life History








IO Albacore
Type I error
0.0
0.2
0.4
0.6
0.8
0.2
0.4
0.6
0.8
SSB in relation to optimal SSB


IO Albacore
Type II error
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.2
0.4
0.6
0.8
SSB in relation to optimal SSB

Auto-correlation	Harvest Rate (F/F_{MSY})					
	0.5	1	1.5	2	2.5	3
0.1	0	3	4	8	21	70
0.15	1	3	5	8	21	70
0.2	1	3	5	8	22	71
0.25	1	3	5	9	23	71
0.3	1	3	5	9	24	72
0.35	2	4	6	9	24	72
0.4	2	4	6	10	25	72
0.45	3	4	6	10	26	73
0.5	3	5	7	11	28	73
0.55	4	5	7	12	29	74
0.6	4	6	8	13	32	74
0.65	5	6	8	15	34	75
0.7	6	7	9	16	35	+76
0.75	7	8	10	18	36	+76
0.8	8	9	12	20	37	+76
0.85	9	10	15	23	38	+76
0.9	12	13	20	26	34	+76

Simple HCR and Recovery Time (Limit)

Simple HCR and Recovery Time (Target)

Auto-correlation	Harvest Rate (F/F_{MSY})					
	0.5	1	1.5	2	2.5	3
0.1	4	8	20	66	+76	+76
0.15	5	8	20	64	+76	+76
0.2	5	8	21	63	+76	+76
0.25	5	9	21	62	+76	+76
0.3	5	9	22	62	+76	+76
0.35	6	10	23	63	+76	+76
0.4	6	10	24	63	+76	+76
0.45	7	11	25	65	+76	+76
0.5	7	11	26	67	+76	+76
0.55	8	12	28	70	+76	+76
0.6	8	13	29	75	+76	+76
0.65	9	14	30	75	+76	+76
0.7	10	15	32	76	+76	+76
0.75	11	17	33	+76	+76	+76
0.8	12	19	37	+76	+76	+76
0.85	15	24	37	+76	+76	+76
0.9	19	29	41	+76	+76	+76

Conclusions-I
Evaluating Current Reference Points

- Risks of falling below 40% of S_{MSY} are below 7% and 10% for albacore and skipjack respectively if fished at optimal levels.
- For bigeye and yellowfin these risks are less than 1% respectively to fall below 50% of S_{MSY} and 40% S_{MSY} respectively.
- Risks of failing to detect an issue with overfishing is less than 2% for albacore at levels exceeding optimal fishing levels (about 1.2 times F_{MSY}), about 40% for skipjack, and about 60% for bigeye and yellowfin at these reference points.

Conclusions-II

Assuming we can estimate reference points with certainty and implement management without error (BOTH BIG ASSUMPTIONS):

- Target reference points should be limits probably if we want to preserve the stocks
- Current limits maybe too optimistic.
- Probably F_{limit} should be 1.2 for most Tuna stocks to recover stocks within 3-4 generations for most Tuna stocks (20-40 years depending on the species)
- Probably B_{limit} should be 0.8 for most Tuna stocks to minimize risk of overfishing (between 0.1-0.2).