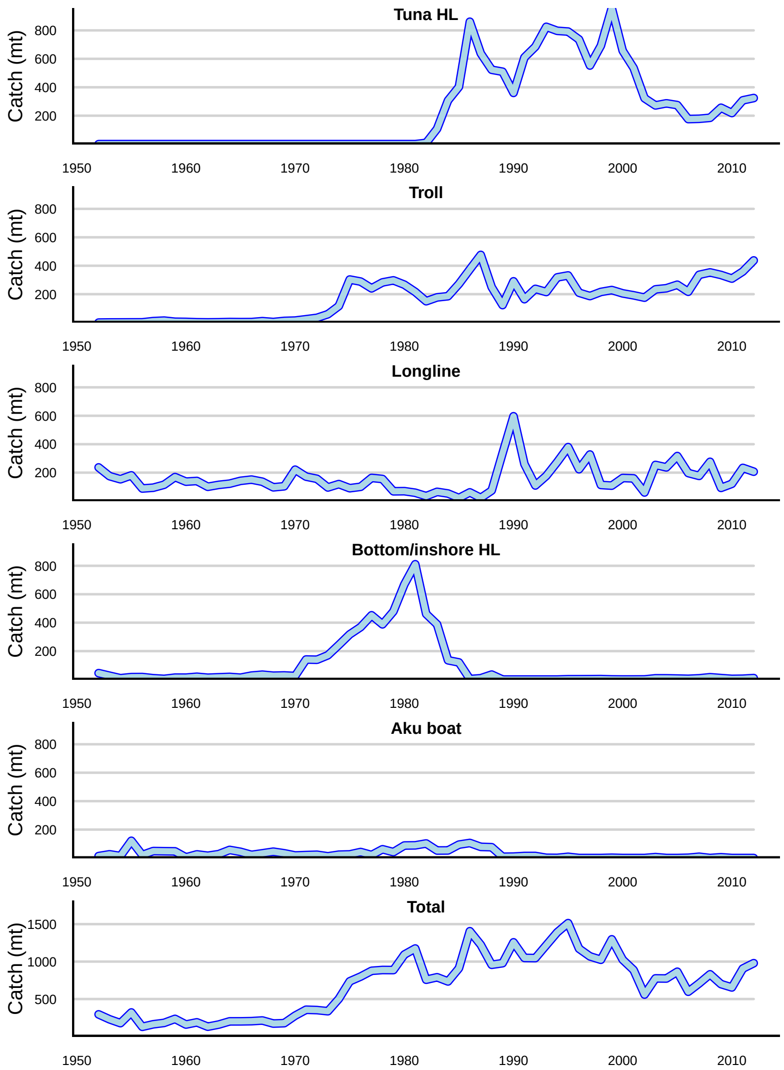
Feasibility of developing a stock assessment model for Main Hawaiian Islands Yellowfin Tuna Fishery

Part Deux

John Sibert, Retirement-failure Consulting

sibert@hawaii.edu

Combined HDAR and NOAA Catch Time Series



No Recreational Data

Feasibility questions

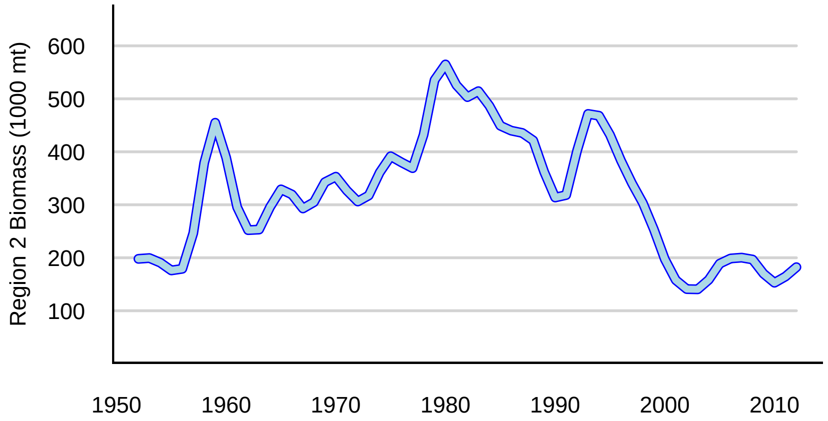
1. Can we contrive a simple model of the MHI YFT population and fishery?
2. Can model parameters be estimated from the data?
3. Are biomass estimates plausible?
4. Can model results be used in alphabet soup?

Principle model assumptions

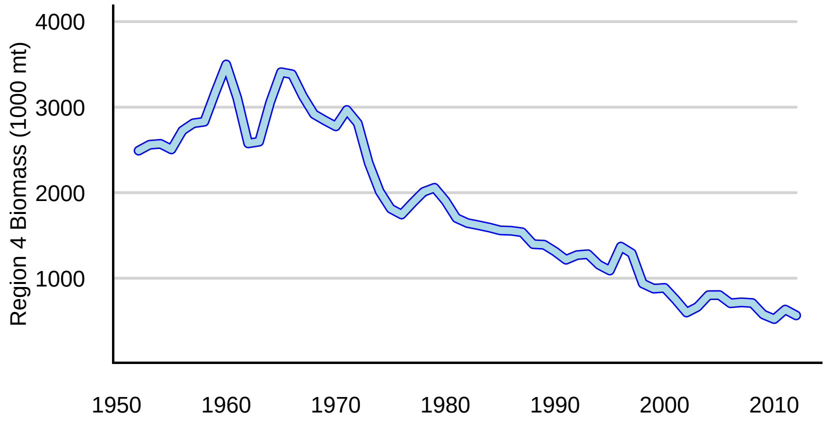
1. The dynamics of the population of YFT in the MHI follows a state-space surplus production (Schaefer) model.
2. Fishing mortality exerted by each gear is represented by distinct random walks with common variance.
3. Predicted catch by gear is the product of estimated fishing mortality for each gear and average predicted biomass during a year.
4. Optional use of MFCL biomass estimate as index of abundance so that local abundance is **approximately proportional** to the index biomass.

WCPFC Stock Assessments

MFCL Region 2



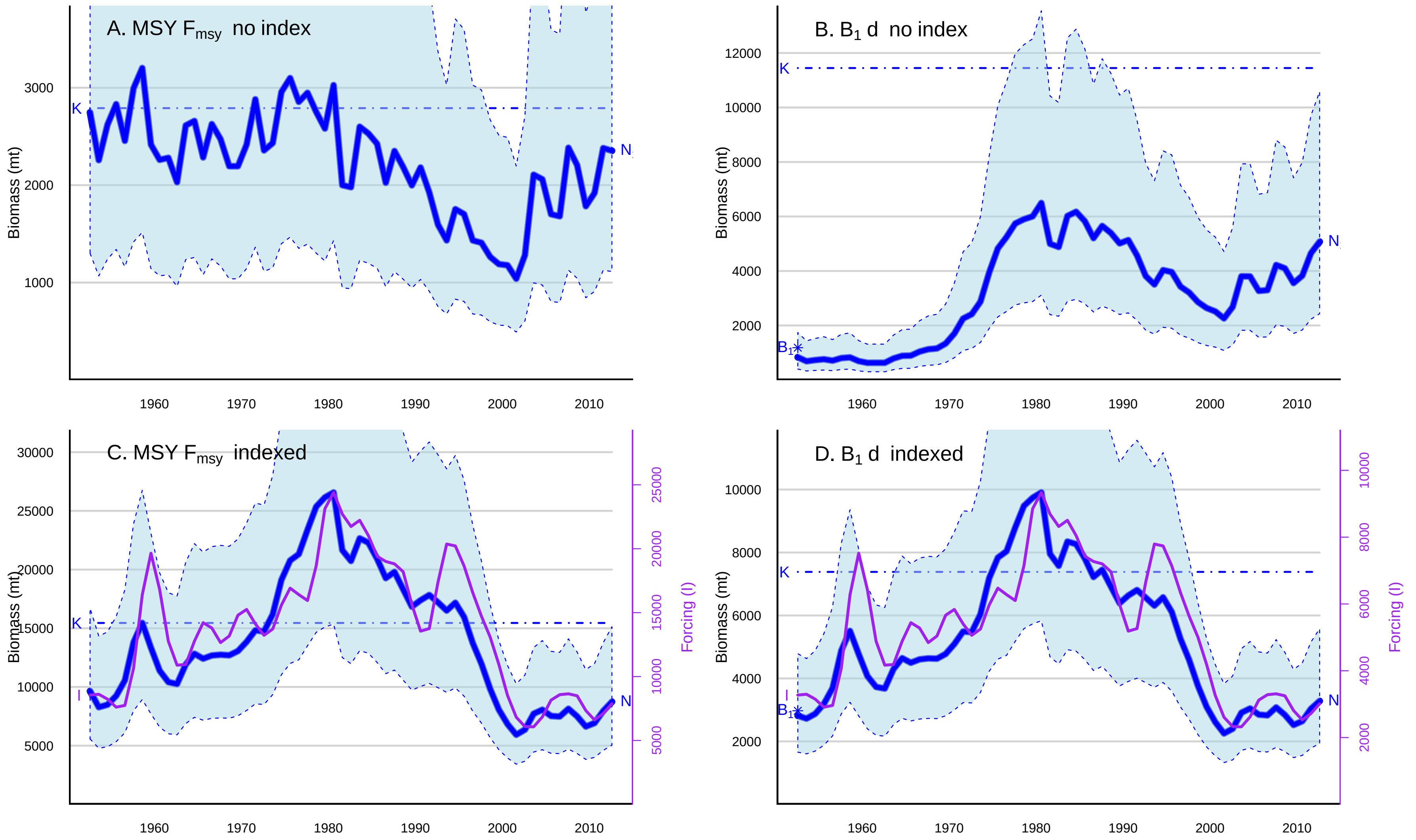
MFCL Region 4



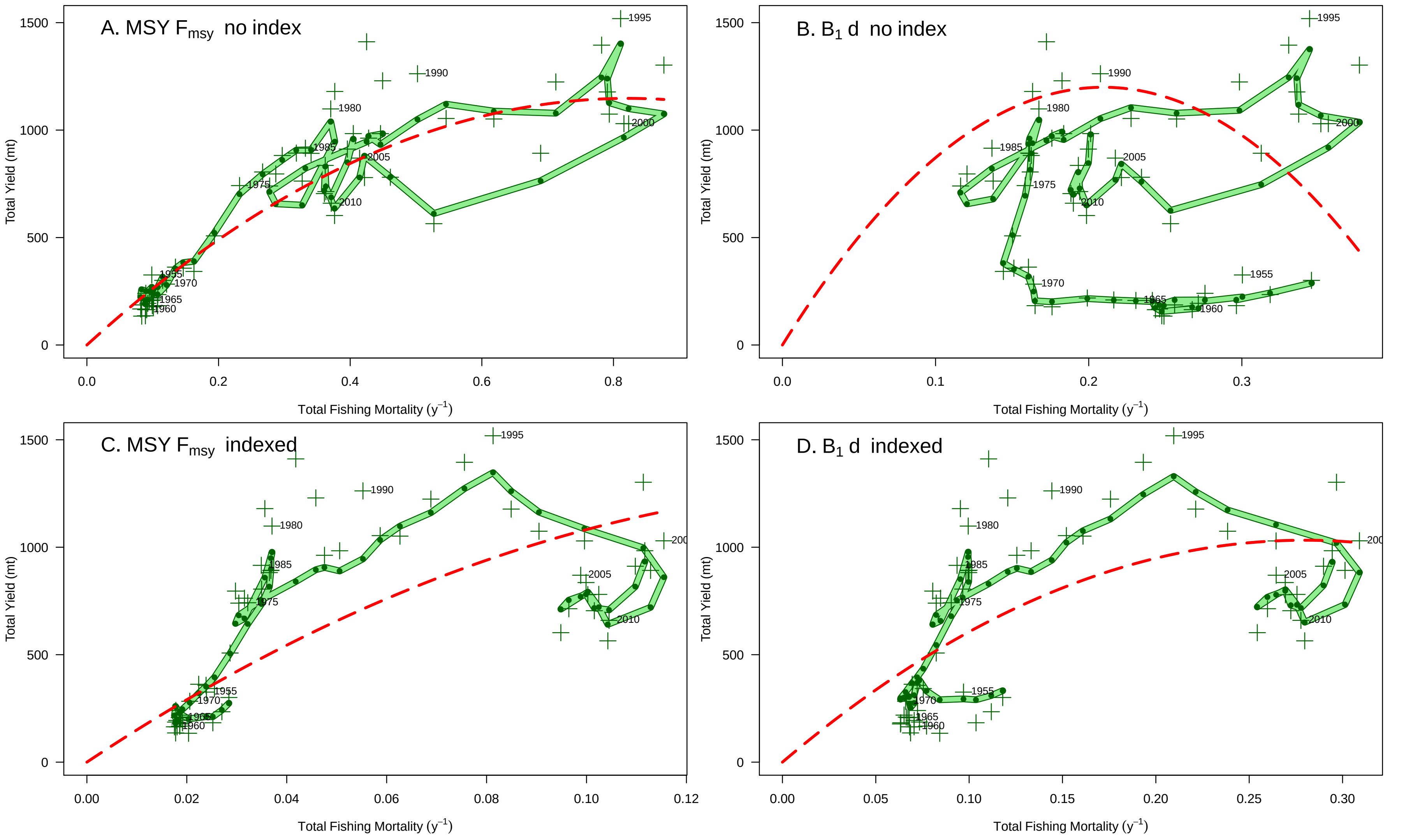
Estimabilty

Index		None		MFCL 2	
	Parameterization	$\widetilde{Y}\ F_{\widetilde{Y}}$	$B_1\ d$	$\widetilde{Y}\ F_{\widetilde{Y}}$	$B_1\ d$
	Designation	A	B	C	D
n	Estimated Parameters	4	5	5	6
$\|G\|_{max}$	Gradient at Minimum	$\underline{0.0016409}$	33.1289	$\underline{\underline{3.51082e-05}}$	3.77653
$-\log L$	Likelihood	-237.238	-237.968	-247.175	-243.343
B_1	Initial Biomass	—	1184.2	—	2802.3
d	$K = dB_1$	—	9.6674	—	2.6348
$\widetilde{Y}$	MSY	1147.5	(1199.3)	1288.7	(1032.6)
$F_{\widetilde{Y}}$	F at MSY	0.82239	(0.20952)	0.1668	(0.2797)
r	Growth Rate	(1.6448)	0.41904	(0.3336)	0.5594
K	Equilibrium Biomass	(2790.8)	(11448)	(15452)	(7383.5)
σ_P	Process Error	0.37416	0.36757	0.2743	0.2649
σ_Y	Observation Error	0.41693	0.43062	0.46924	0.47614
Q	Index Proportionality	—	—	0.04321	0.016535

Estimated Biomass Trends

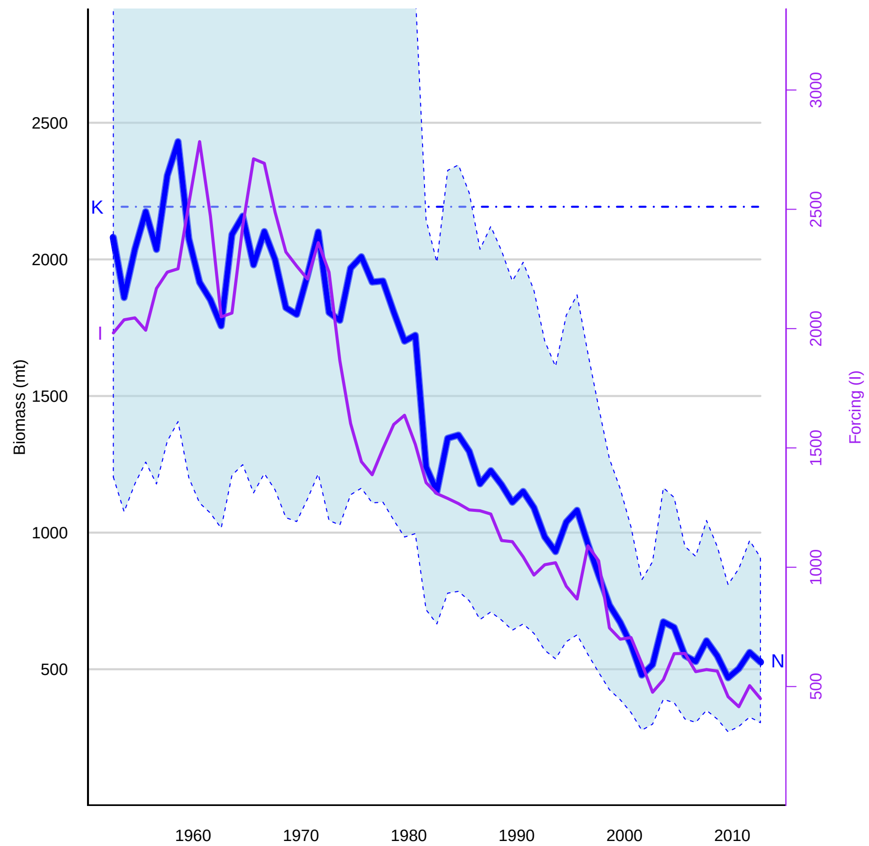


Production

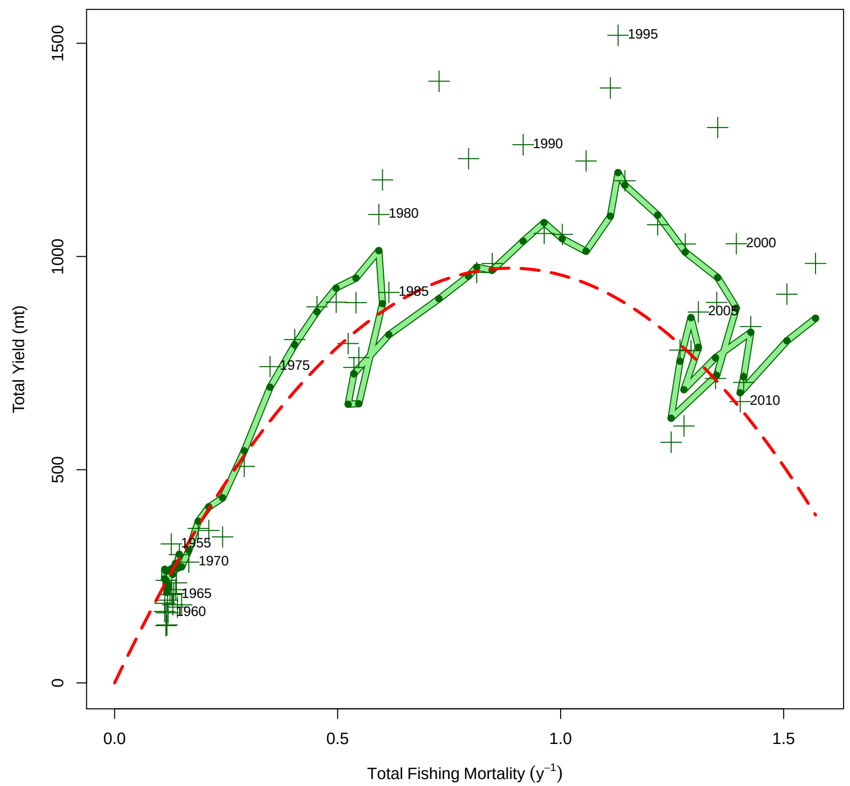


A. MSY F_{msy} no index
B. B_1 d no index
C. MSY F_{msy} indexed
D. B_1 d indexed
Total Yield (mt)
Total Fishing Mortality (y^{-1})
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

Alternate forcing: MFCL Region 4



(1)



(1)

Conclusions

1. Yellowfin catch data from fleets operating in the Main Hawaiian Islands waters are sufficiently informative to estimate **relative** biomass trends.
2. An index of abundance is required to estimate **absolute** biomass; **absolute estimates are sensitive to the choice of index population.**
3. Representing trends in fishing mortality as a random walk is a convenient and effective approach to accounting for the removal of biomass from the fish population.
4. Estimates of MSY and F_{msy} are possible, but should not be used for setting ACLs without further analysis.
5. The prior on r is difficult to assign and probably not required.

Next Steps?

1. Re-evaluate data: Complete (recreational catch)? Accurate (yellowfin or bigeye)? Stratified appropriately (quarterly or annual; gear types)?
2. Technical review of model, including statistical assumptions and computing methods.
3. Review previous work on Hawaiian yellowfin fisheries
4. Review previous uses of production models in tuna fisheries (to improve r prior).
5. Run simulations to evaluate sensitivity of estimates to different levels of process and observation error.
6. Test alternative biomass indices, e.g. MHI-specific SEAPODYM estimates.
7. Compare results to Catch-MSY analysis.
8. Work within WCPFC assessment process to improve applicability of WCPFC stock assessments to local requirements.

Thanks for your attention

Technical features

1. Fishing mortality and biomass are random effects.
2. All process errors (population growth, fishing mortality random walk, biomass index proportionality) are assumed to be equal to a single estimated error (σ_P).
3. Zero-inflated log-normal catch likelihood with estimated observation error (σ_Y).
4. Two alternate logistic model parameterizations:
   a) $K = \frac{4\widetilde{Y}}{r}; \quad r = 2F_{\widetilde{Y}}$
   b) $K = d \cdot B_1$
5. Optional log-normal prior on r with $\tilde{r} = 0.486$ and $\sigma_r = 0.8$.
6. Analytic solution to Schaefer ODE for stable propagation through time.

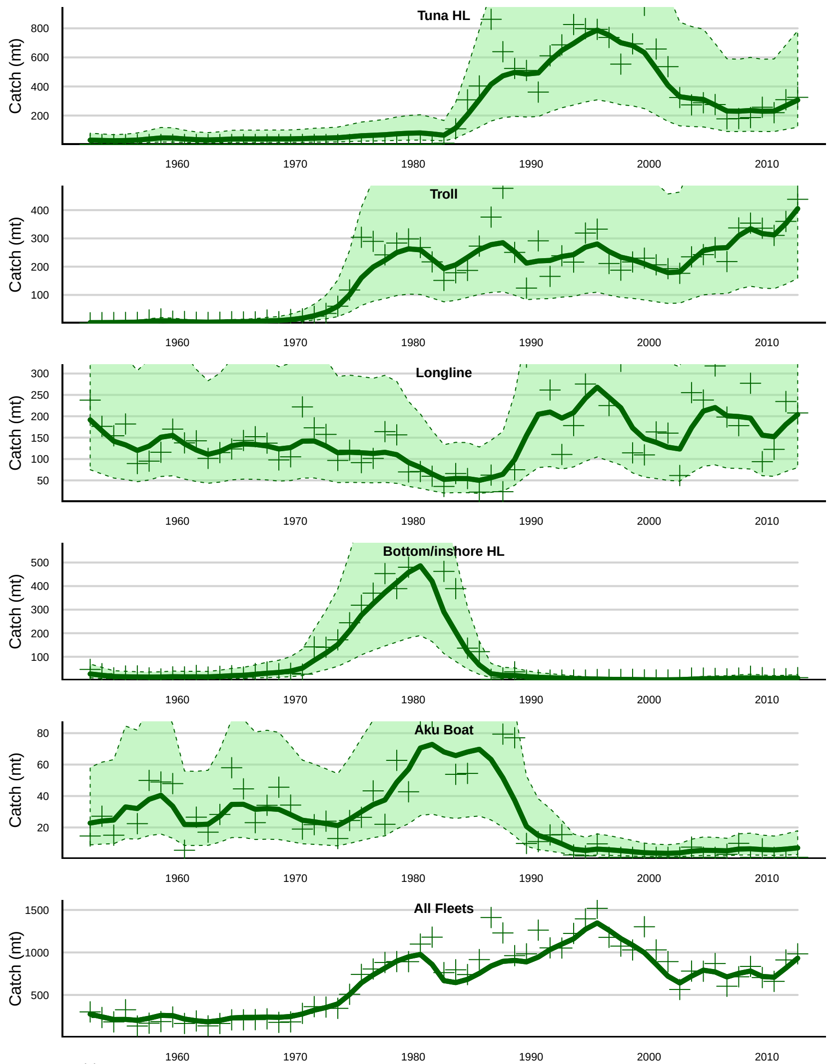
Models implemented in ADMB and TMB; all computer code, data files, and draft reports can be found at Github: https://github.com/johnrsibert/XSSA.git.

Alternative Schaefer Parameterizations

$$\frac{dN}{dt} = rN(1 - \frac{N}{K}) - FN$$

- $r = 2F_{\widetilde{Y}}; \quad K = \frac{4\widetilde{Y}}{r}.$
- Partial non-dimensional: $K = d \cdot B_1$.
- K as random walk $\log K_t = \log K_{t-1} + \xi_t; \quad \xi_t \sim N(0, \sigma^2_K)$?
- $K_t = Q \cdot I_t$?
- Fully non-dimensional ... ?

Catch Predictions

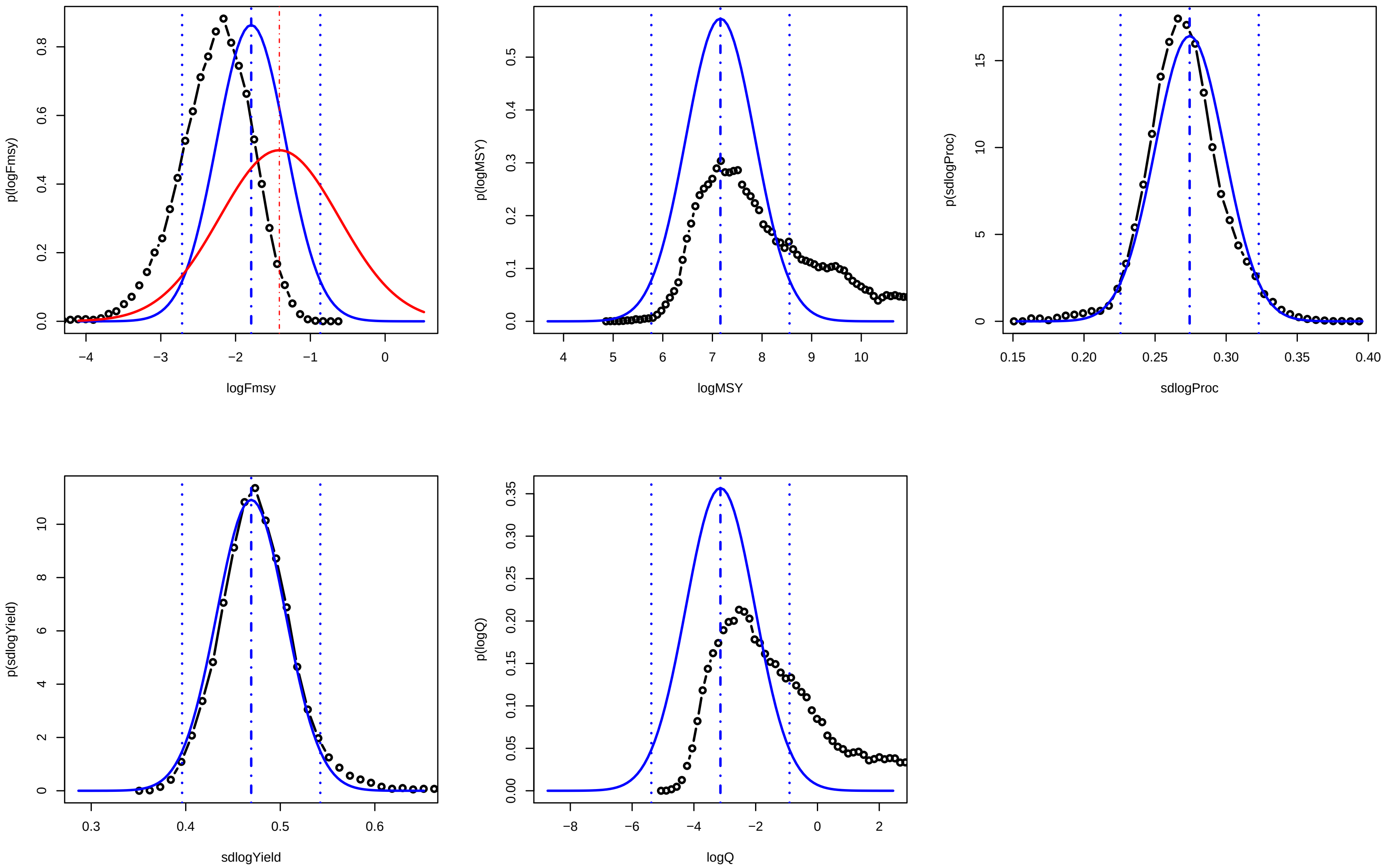


(1)

Omitting r prior

Index	None		MFCL 2	
Parameterization	$\widetilde{Y}\ F_{\widetilde{Y}}$	$B_1\ d$	$\widetilde{Y}\ F_{\widetilde{Y}}$	$B_1\ d$
Designation	A	B	C	D
n	4	5	5	6
$-\log L$	-284.898	-236.212	-246.302	-242.176
$\|G\|_{max}$	2.45563	151.693	1.24795e-05	39.9125
B_1	—	1540.2	—	—
d	—	12.567	—	—
$\widetilde{Y}$	—	1274.9	1579.3	—
$F_{\widetilde{Y}}$	—	0.13174	0.1293	—
r	—	0.26347	0.25859	—
K	—	19355	24430	—
σ_P	—	0.35682	0.27044	—
σ_Y	—	0.43481	0.47162	—
Q	—	—	0.073752	—

Posteriors — Estimated Parameters



Posteriors — Functions of Parameters