Using Population Models to Evaluate Management Alternatives for Gulf-strain Striped Bass

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Introduction

- Gulf striped bass have been managed for 30 years with efforts to restore the population to the maximum extent possible.
- Uncertainty exists regarding how management will impact the population
  - *Hydrilla* control
  - Stocking rates
  - Harvest rates
- Population models are a way to explore the consequences of management alternatives on population objectives.

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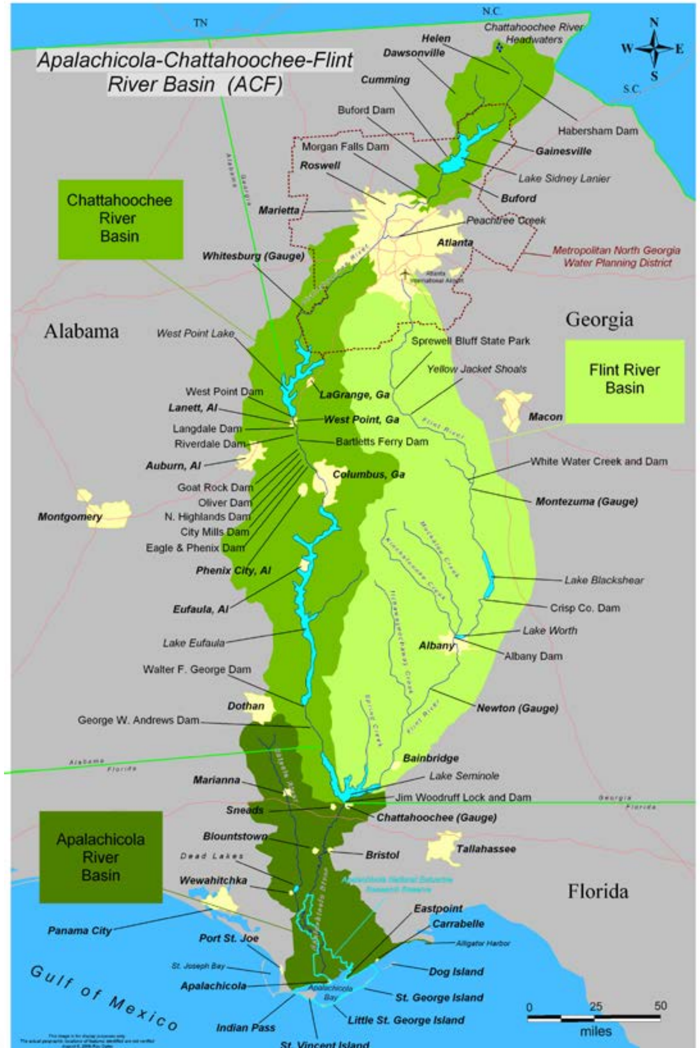
Study Site



•Apalachicola-Chattahoochee-Flint River System is approximately 19,800 mi^2, which begins in Georgia and flows into the Gulf of Mexico at Apalachicola Bay.

•Gulf striped bass are stocked annually throughout the ACF river system (approximately 500,000 fish/year).

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Objectives

- Fundamental objectives addressed by the models:
  - Maximize Gulf Striped Bass population
  - Maximize angler satisfaction
  - Minimize cost
- Our study objectives:
  - Use existing data from agency monitoring and published literature to estimate model parameters.
  - Construct age-based stochastic matrix models to evaluate alternatives identified by the management team.
  - Use the models to inform SDM for Gulf Striped Bass management.

Population Models

- We constructed three population models to examine:
  - 1) Effects of *Hydrilla* control on population growth rate.
  - 2) Stocking rates on population growth rate.
  - 3) Effects of fishing mortality on population growth rate.
- Age-based matrix models were used to simulate the abundance of Gulf striped bass populations over a 10 year period.
- These models will be used in a structured decision making framework to help aid in management decisions for Gulf striped bass.

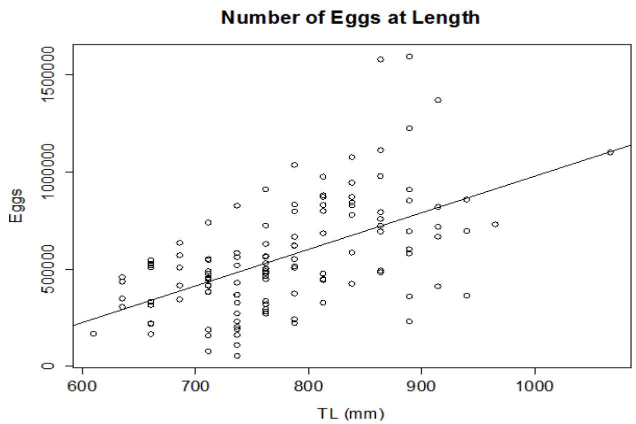
Age-classified matrix model

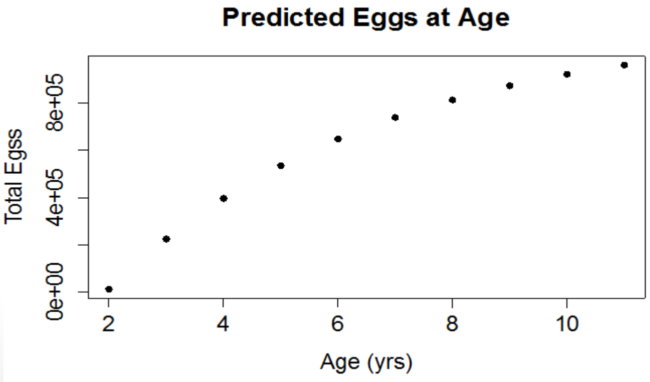
$F_0/2$	$F_1/2$	$F_2/2$	$F_3/2$	. . .	$F_{10}/2$	$F_{11}/2$
S_0	0	0	0	. . .	0	0
0	S_1	0	0	. . .	0	0
0	0	S_2	0	. . .	0	0
0	0	0	S_3	. . .	0	0
0	0	0	0	. . .	$S_{(t-1)}$	0

- Age-classified matrix model used to simulate population.
- The effects of *Hydrilla* control, stocking rates and harvest were applied to this matrix model to estimate their respective impacts on population growth.
- All matrix model projections were compiled using program R.

Parameter estimations

- Fecundity for each age class was predicted using a linear regression model from multiple years of broodfish egg number versus total length (mm).





- Regression model
  - Derive intercept and slope
  - Define relation between TL and number of eggs
- Fecundity-at-age

  $y = b_0 + b_1 \, x \, 1$

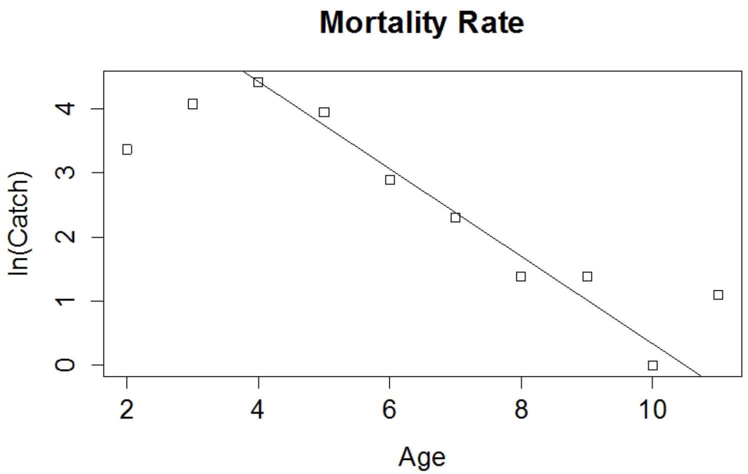
  where

  #eggs@age = $b_0 + b_1$* pred_vb

Parameter estimation

- Survival rate for each age class was determined using a catch curve analysis.

$$\ln(N_a) = \beta_0 + \beta_1 a$$



- Assumed that fish < 4 years of age were not fully vulnerable to the sampling gear.
- Z = -0.6825 (Instantaneous Mortality)
- Survival = exp(-Z) = 0.505352

Data

- Long-term *Hydrilla* data from US Army Corps of Engineers on HAC (aerial estimation) from 1985-2006 with corresponding CPUE of age-0 fish from Florida Fish and Wildlife Conservation Commission (FWC).
- Stocking rates compiled by FWC on the number of fish stocked in the ACF from 1986-2013.


Hydrilla

- Invasive aquatic weed first observed in 1967 and now dominates the submerged plant community in Lake Seminole.
  - Has covered up to 64% of surface area, negatively impacting habitat for age-0 Gulf Striped Bass.
- Hypothesis: *Hydrilla* control in Lake Seminole would increase the survival of age-0 fish and increase overall population numbers.
  - Reduces habitat availability (poor growth, condition, starvation)
  - Alters primary productivity pathway
- We modeled the relation between *Hydrilla* aerial counts (HAC) and its corresponding catch-per-unit-effort of age-0 fish in Lake Seminole.

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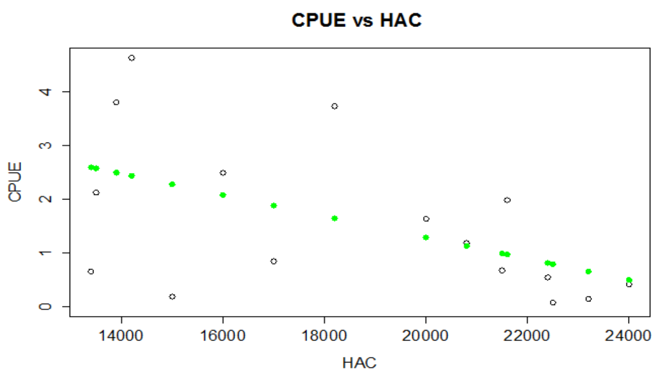
Hydrilla on Lake Seminole

Hydrilla

- Using the slope from the regression on CPUE and *Hydrilla* we were able to apply stochasticity to age-0 survival based on *Hydrilla* aerial counts.



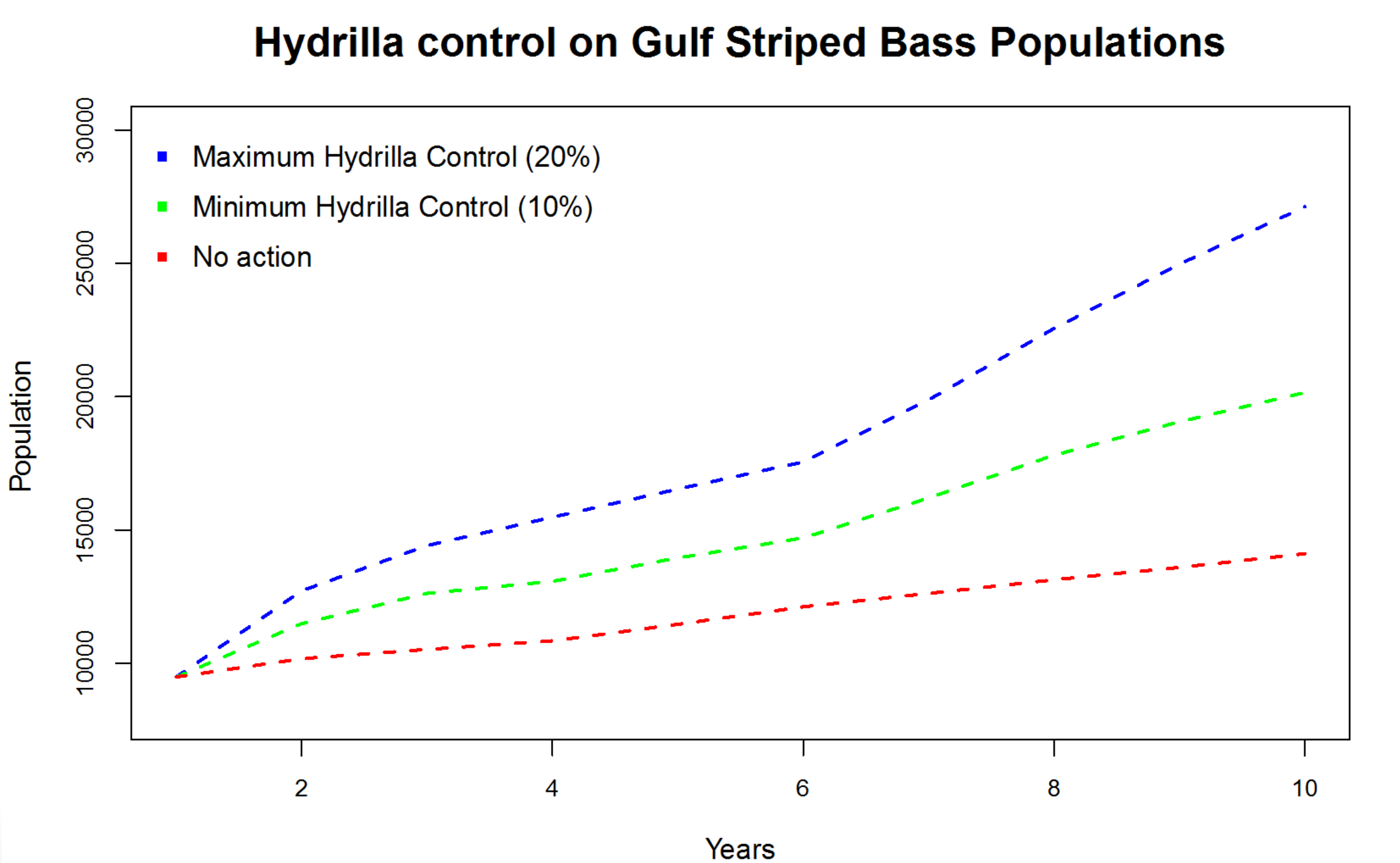
Survival = 1 - (b0 (intercept) – slope * HAC + b0(intercept) / b0 (intercept)) * Age-0 survival

- Age-0 survival will change according to the regression of *Hydrilla* present that year.

If HAC = 0 then survival = original age-0 survival rate.
If HAC =15,000 then survival = age-0 survival – proportional difference from regression.

- Because we don't know how much *Hydrilla* to expect, *Hydrilla* was given a random normal distribution each year based on previous *Hydrilla* counts.

Hydrilla control



Stocking

- Starting in the 1980's, efforts to re-establish Gulf Striped Bass began via stocking.
    - Over 10 million Phase 1 and Phase 2 fish stocked since 1980.
    - Harvest increased 10 fold amongst anglers.
    - 75%-100% of all age-0 fish caught (electrofishing) are stocked fish.
- Hypothesis: Increasing the stocking rate will improve population numbers.
    - Assess three different stocking rates on population growth.
    - Look for differences in population growth rate.

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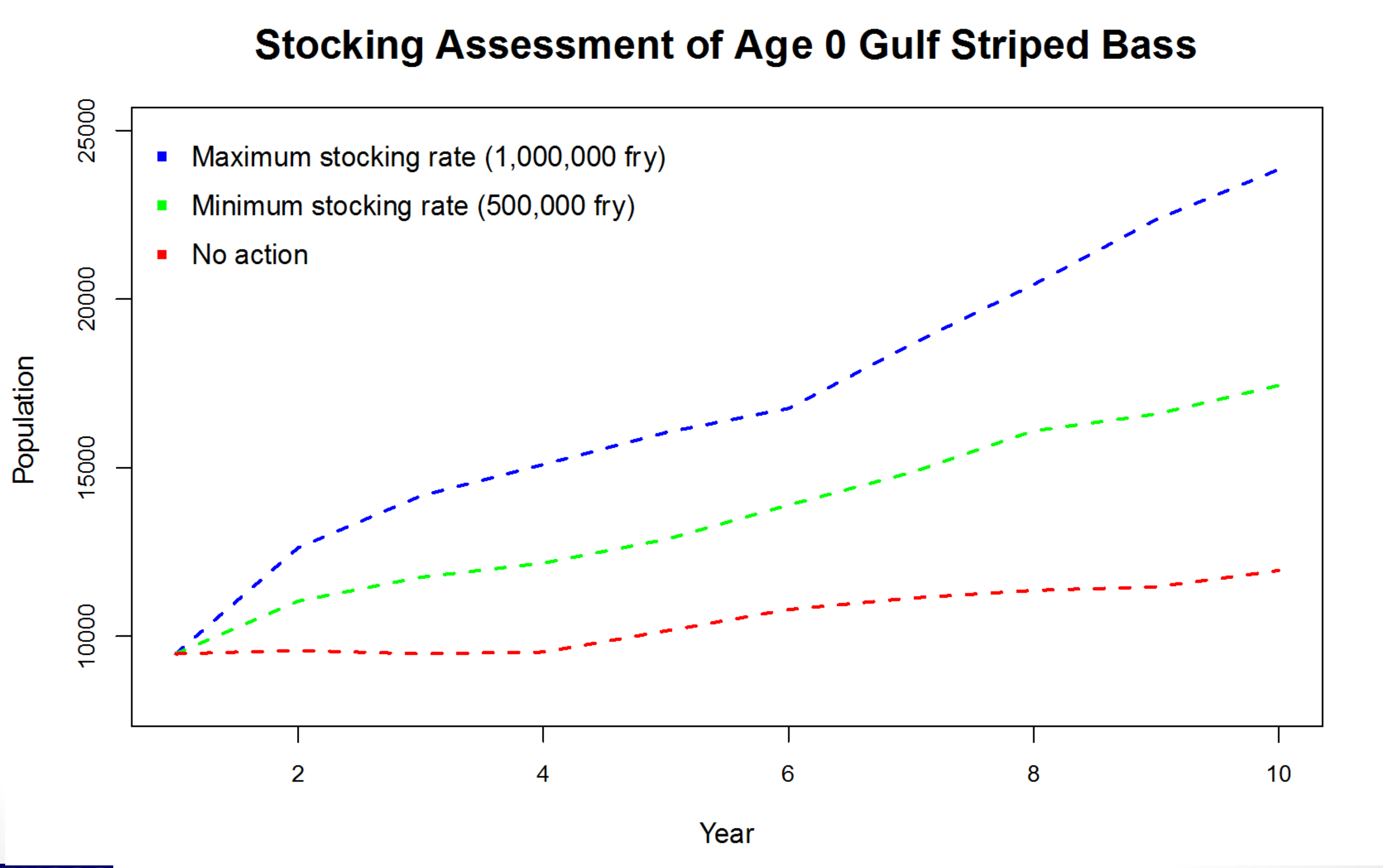
Stocking

- Three different stocking rates were incorporated into the matrix model.
  - Maximum stocking rate (1,000,000) fish
  - Minimum stocking rate (500,000) fish
  - No action (0) fish
- We assumed stocked fish have very low survival rate of 1 %.
  - The majority of fish caught during electrofishing sampling were stocked fish.
- Stocked fish survival would be directly affected by the amount of *Hydrilla* found that year in the same way as *Hydrilla* impacts survival of naturally recruited age-0 fish.

Stocking rates



Fishery regulations

- Gulf striped bass are regulated in the ACF by three state agencies.
  - Alabama Department of Conservation and Natural Resources
  - Georgia Department of Natural Resources
  - Florida Fish and Wildlife Commission
- Limited to 15 striped bass aggregates (striped bass, white bass, hybrid striped-white bass).
  - Only 2 are allowed to be over 22 inches.

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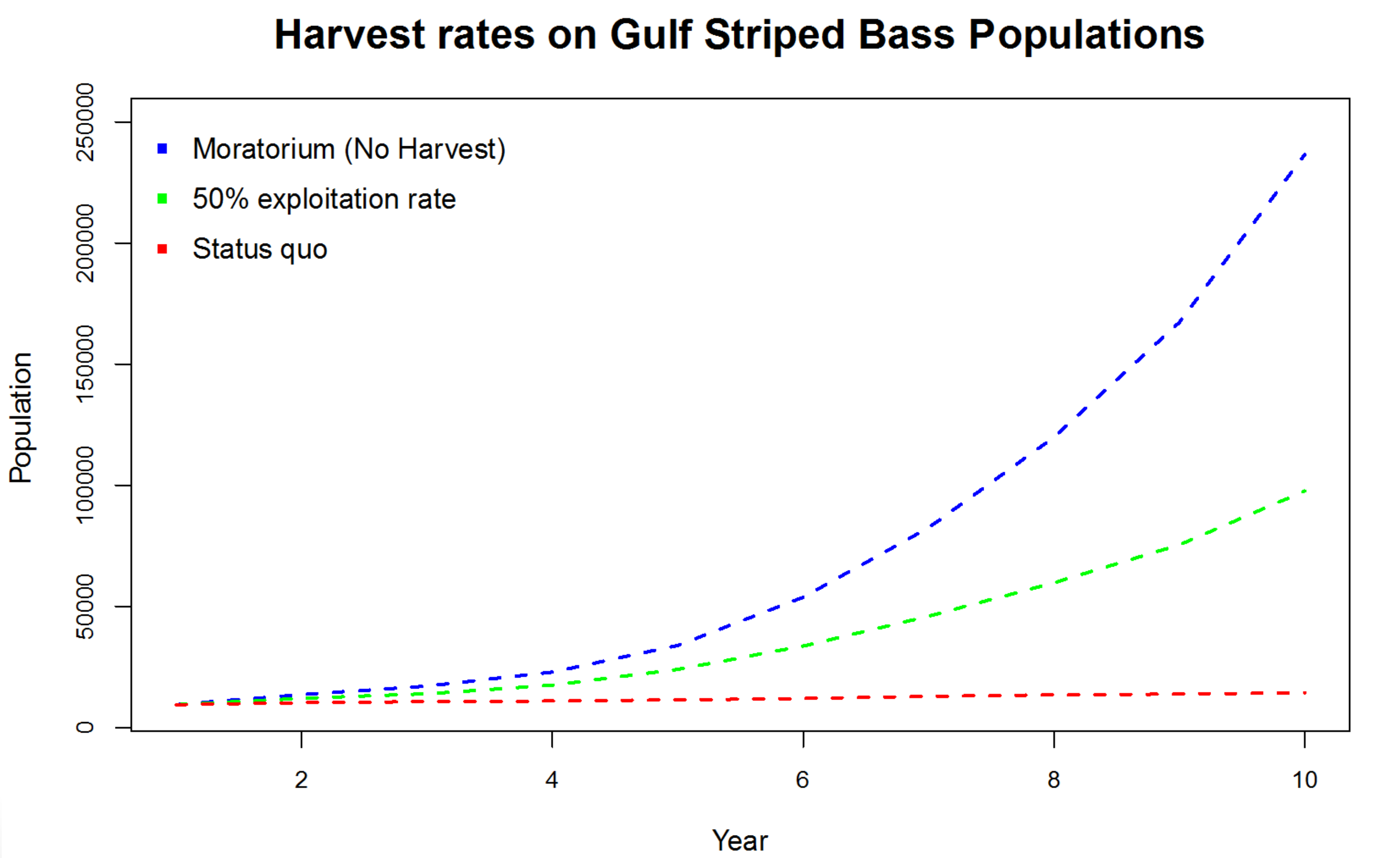
Harvest

- The Gulf striped Bass fishery is continuous; harvest from anglers takes place throughout the year.
  - Some areas restricted to fishing in springs.
- Fishing mortality was estimated using estimates of natural mortality from Atlantic stocks.
- Hypothesis: Different exploitation rates will impact overall population numbers for the GSB fishery.

Harvest



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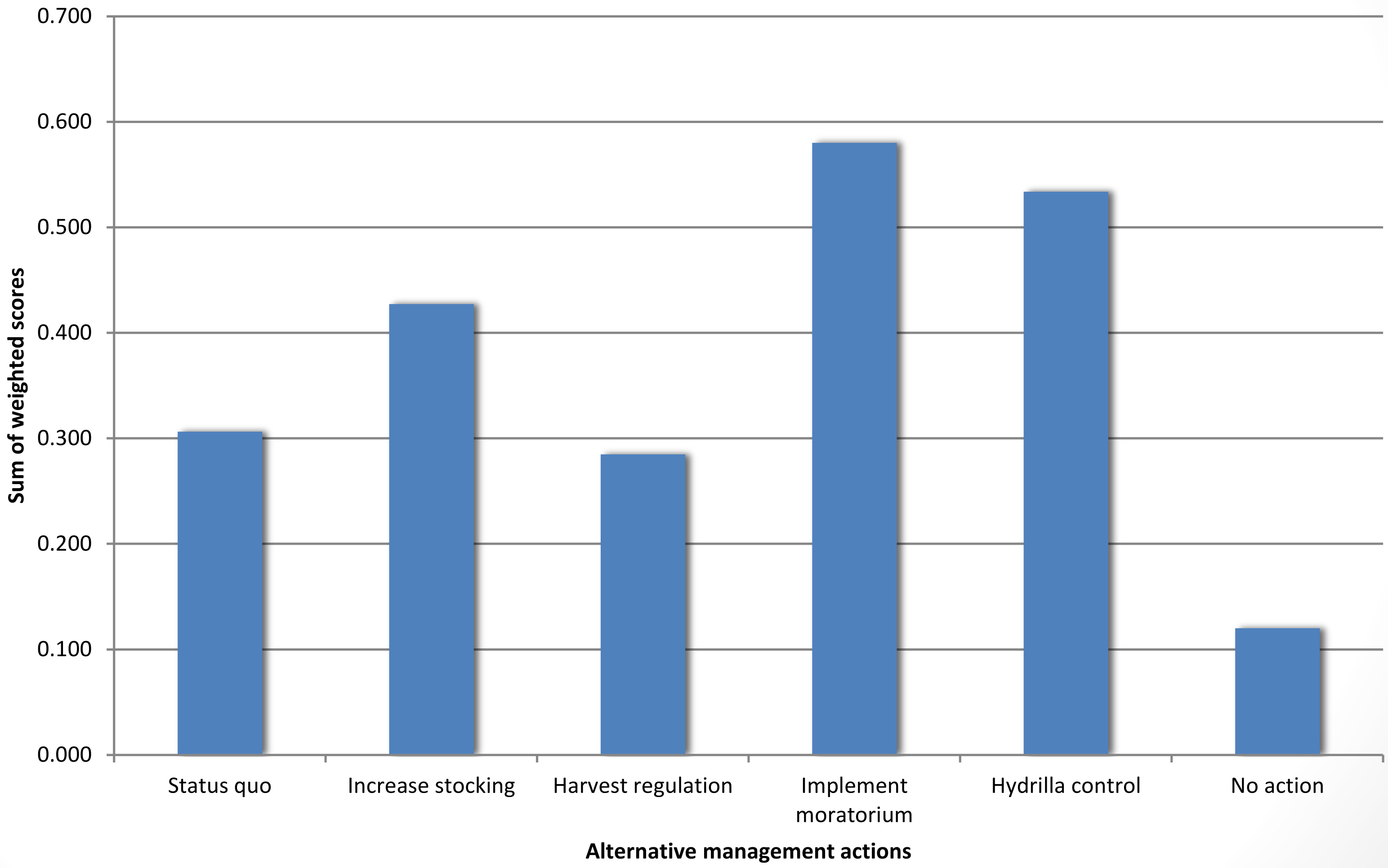
Informing management with model output

Gulf Striped Bass	*Fundamental*	Population	Angler Satisfaction	Cost
	Means	Population persistence	Morone aggregate	Cost
	Direction:	Max	Max	Min
	Attribute:	relative abundance	# caught	$/year
Alternative	*Scale:*	1,000 x	0-5	0-5
weights		0.5	0.3	0.2
status quo		15	3	2
increase stocking		25	4	1
Harvest regulations		100	1	4
implement moratorium		250	0	3
Hydrilla control		28	5	0
no action		12	2	5

Gulf Striped Bass	*Fundamental*	Population	Angler Satisfaction	Cost
	Means	Population persistence	Morone aggregate	Cost
	Direction:	Max	Max	Min
Alternative	*Attribute:*	relative abundance	# caught	$
	Scale:	#/hour	fish/hour	0-5
weights		0.5	0.3	0.2
Status quo		0.006	0.180	0.120
Increase stocking		0.027	0.240	0.160
Harvest regulation		0.185	0.06	0.04
Implement moratorium		0.500	0.000	0.080
Hydrilla control		0.034	0.300	0.200
No action		0.000	0.120	0.000

Making a decision-evaluate trade-offs



Results

- The top 3 management alternatives for Gulf-striped bass populations.
  - 1.) Introduce a moratorium (No fishing)
  - 2.) Hydrilla control
  - 3.) Increase stocking efforts
- Which alternative is the best?

Tradeoffs

- Introducing a moratorium would be our best management decision across objectives.
- *Hydrilla* control would be more effective in increasing GSB populations over increased stocking rates however it is extremely expensive.
- Increasing the stocking rate is not our best management decision, however it would make anglers happier than implementing a moratorium on the fishery.

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Future direction

- Include combinations of management alternatives into the model.
  - Introduce a moratorium and increase stocking rates.
  - Include minimum stocking rate and minimum *Hydrilla* control.
  - Reduce harvest and increase stocking rates.

- How would these alternatives affect our objectives:
  - Maximize GSB populations
  - Angler satisfaction
  - Minimize cost

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Acknowledgements

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Questions