Stock Recruitment Analyses Workshop V

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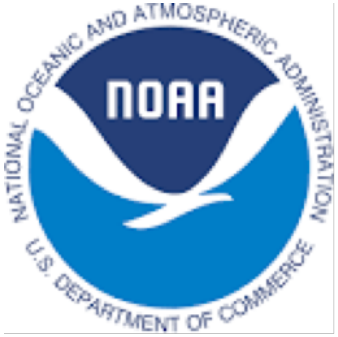
March 21, 2018

Overview

- Beverton Holt Stock Recruitment
- WRLCM Stock Recruitment
- WRLCM Stock Recruitment with management actions



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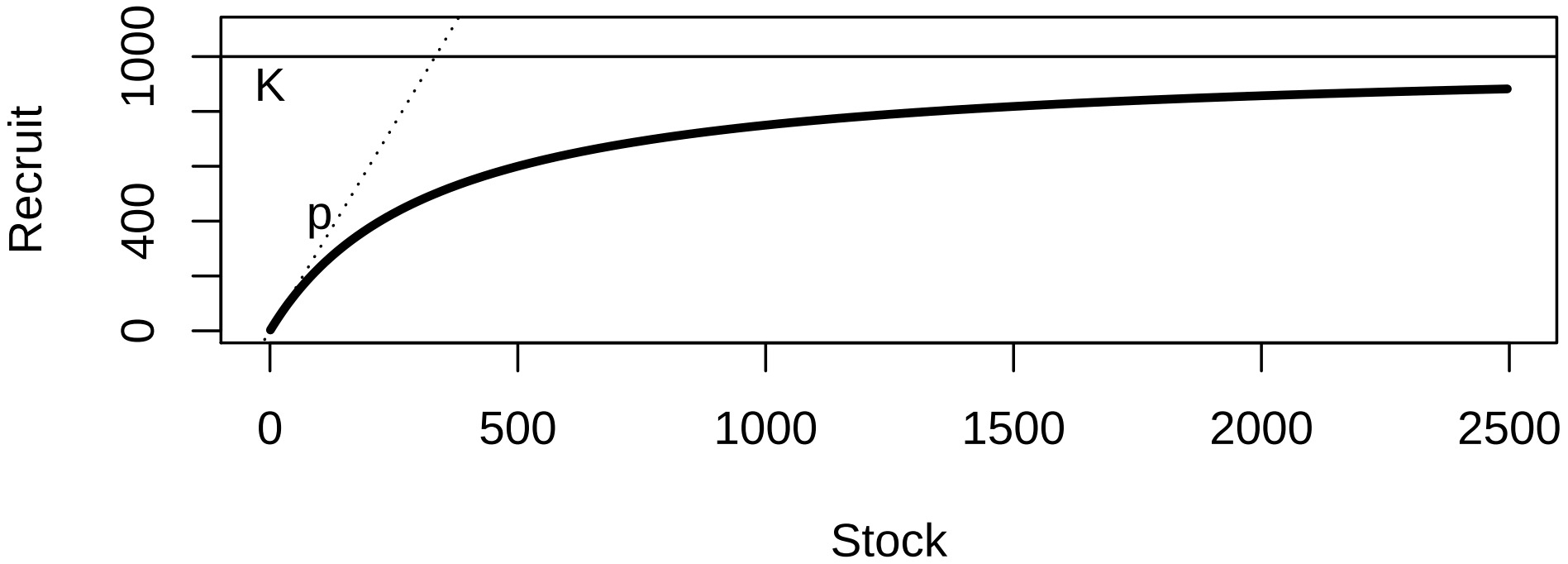
Beverton-Holt Stock Recruitment

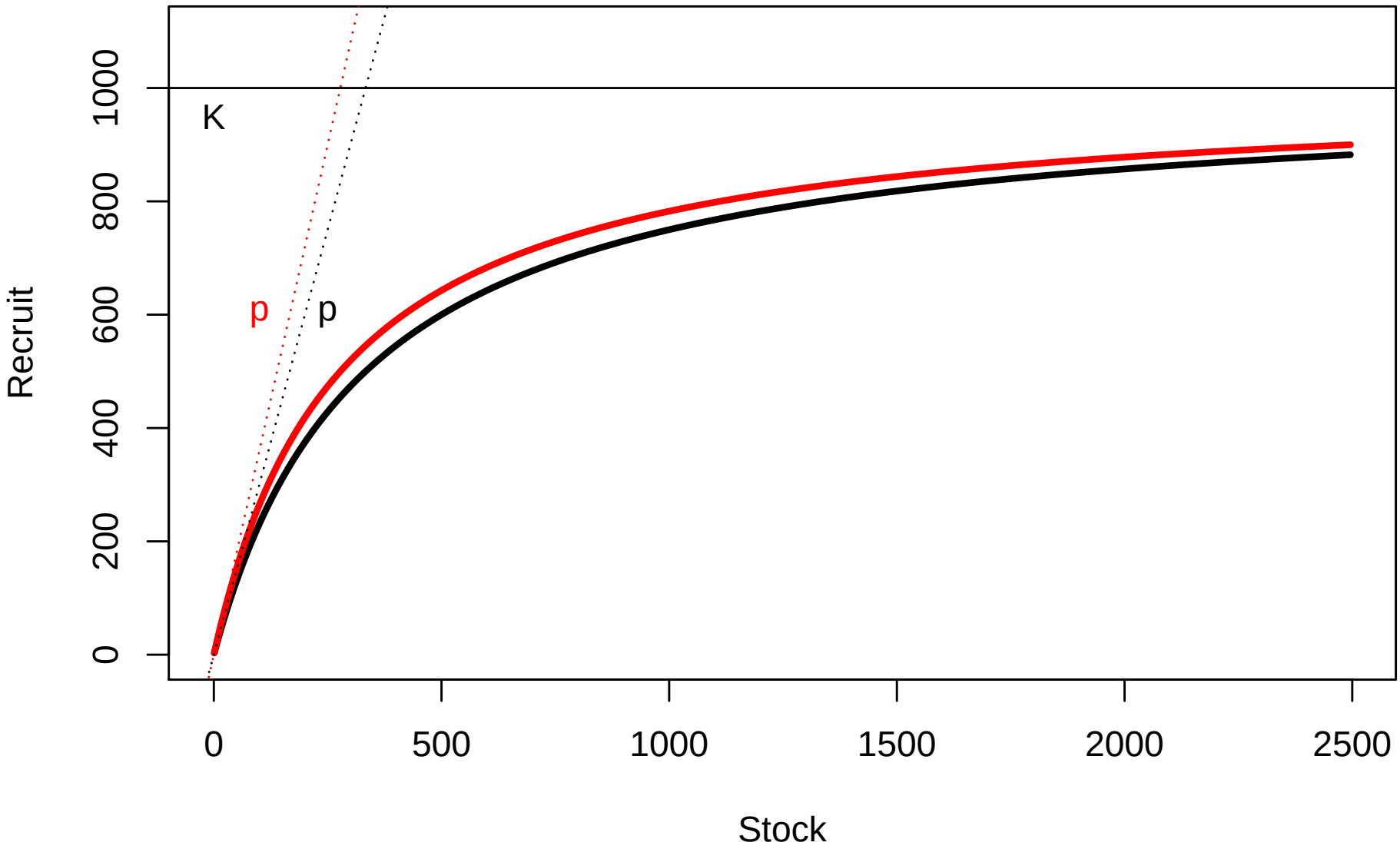
Beverton-Holt Stock Recruitment Equation

$$R = \frac{S \times p}{1 + \frac{S \times p}{K}}$$

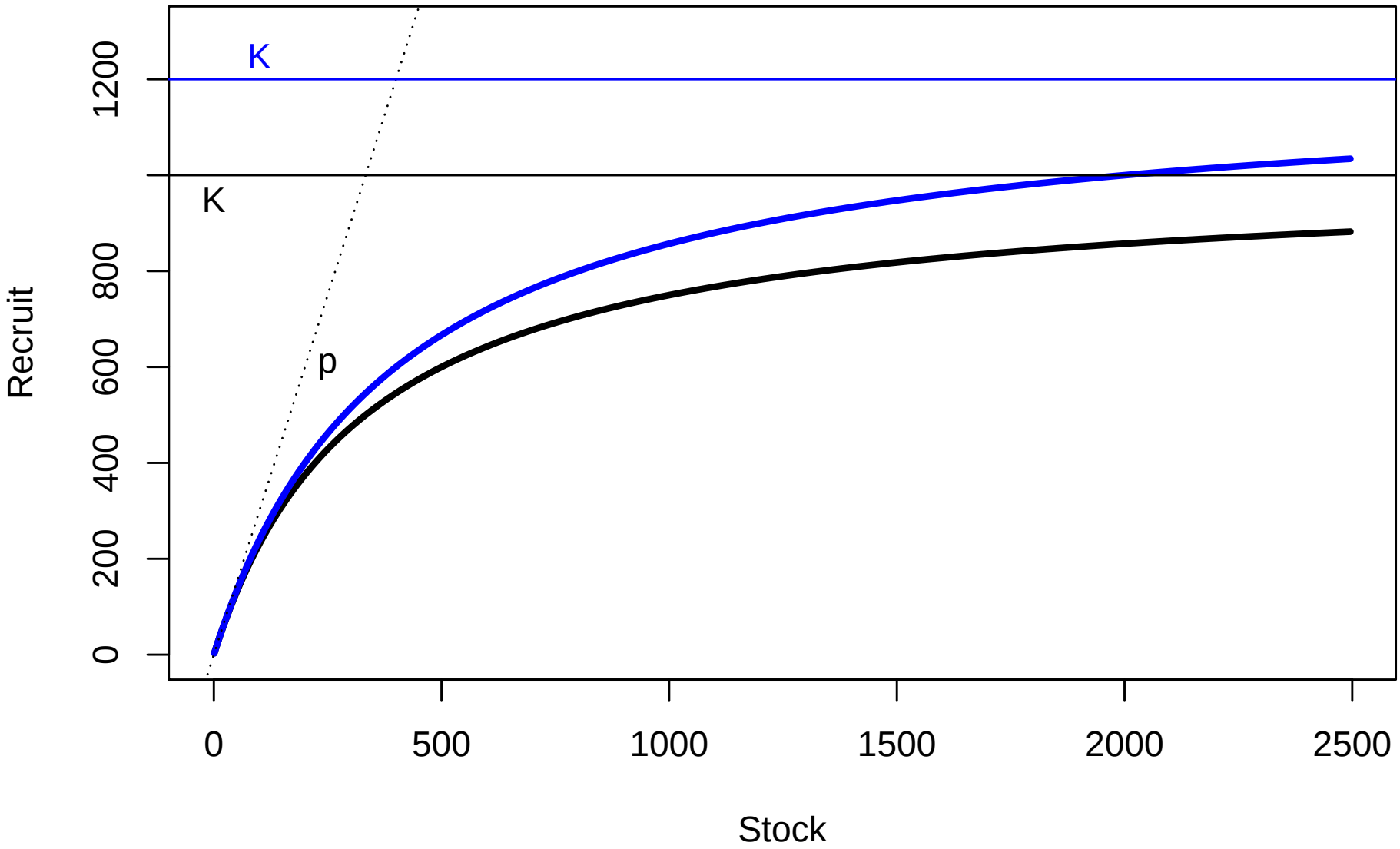
where R is the Recruits or juvenile production, S is the Stock size, p is the productivity or the slope of the line at the origin, and K is the asymptotic recruitment or carrying capacity.



Increasing the p parameter of the BH by 20%



Increasing the K parameter of the BH by 20%

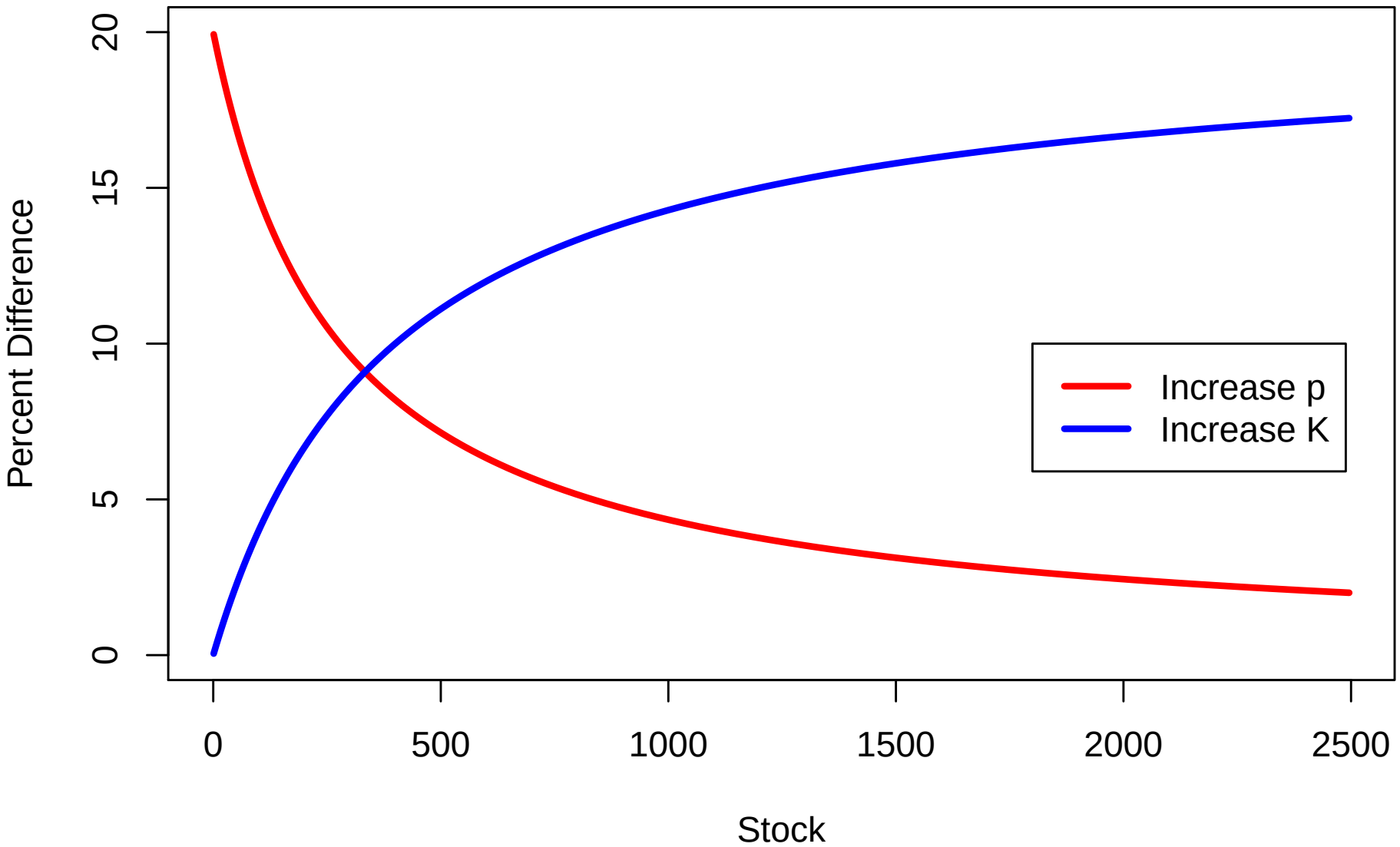


Effect of different management actions

- Actions that increase survival
  - Affect the p parameter
- Actions that improve the amount of available habitat
  - Affect the K parameter
- Which action will have the greatest benefit at low stock size?
- At high stock size?

Comparison of relative difference in recruits

Percent difference = (action - base)/base * 100%



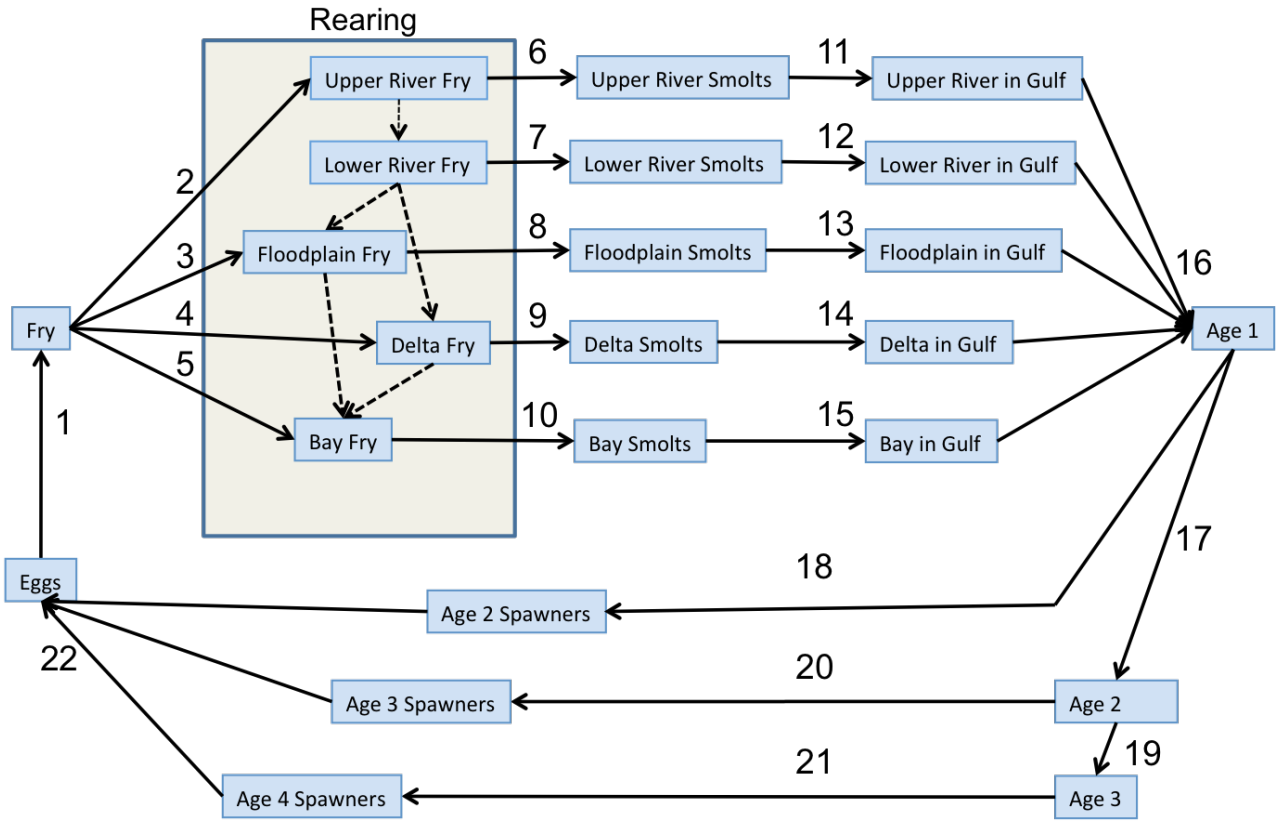
Why is this important?

- Recap
  - Actions that increase capacity K provide benefits at higher abundances
  - Actions that increase productivity p provide benefits at lower abundances
- To recover a population from low abundances, focus actions on increasing productivity p
- Actions that increase capacity K generally cannot mitigate for actions that reduce productivity p

WRLCM Stock Recruitment

WRLCM Stock Recruitment Model

- Single cohort model
- Run WRLCM from Spawners (Stock) to Smolts prior to Gulf (Recruits)
- Vary initial number of Spawners



WRLCM Beverton-Holt movement function

$$Res = \frac{S \times \phi(1-m)}{1 + \frac{S \times \phi(1-m)}{K}}$$

$$Mig = S \times \phi - R$$

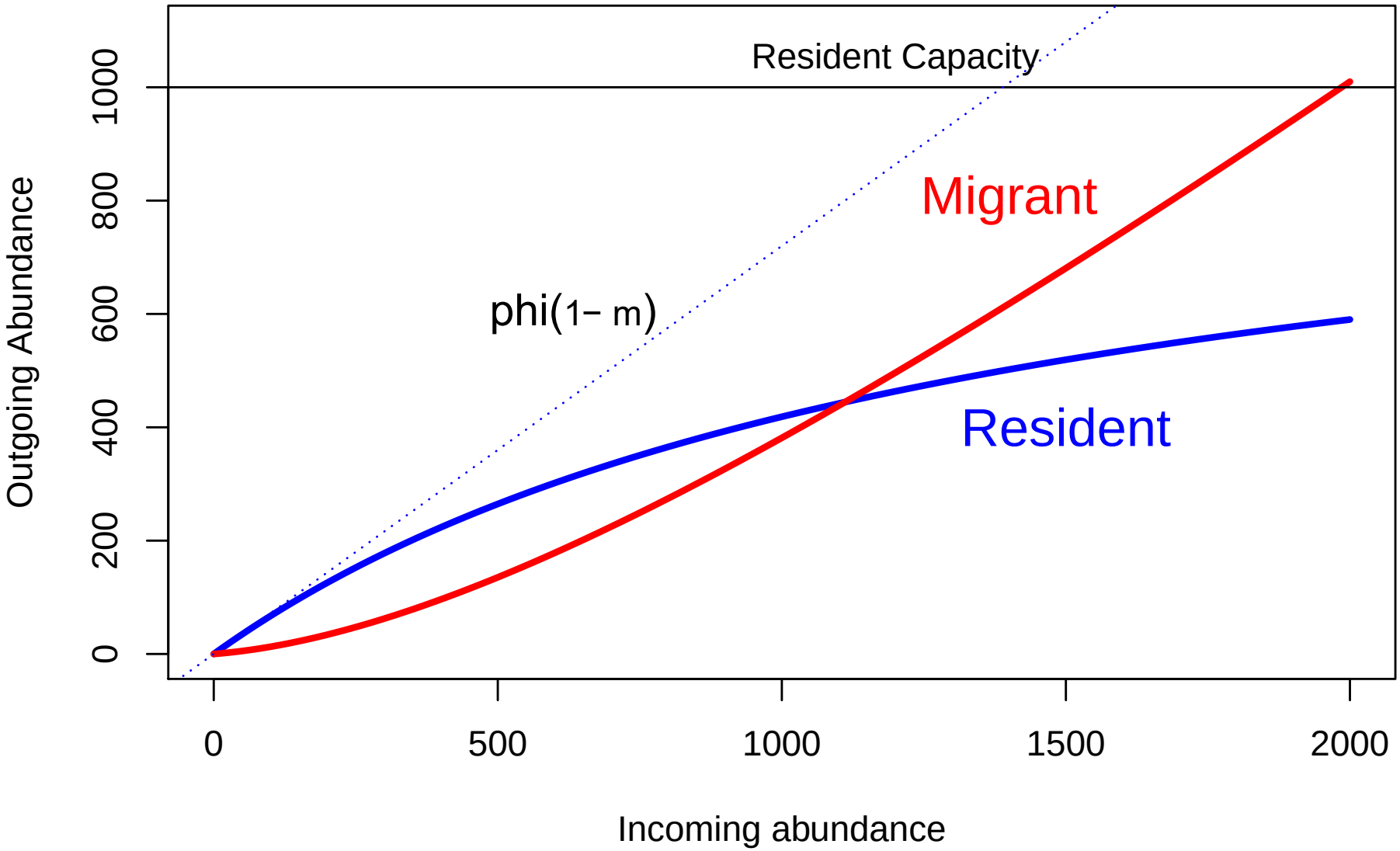
where Res are the Residents, S is the incoming abundance, ϕ is the density independent survival, m is the density independent migration rate, and K is the carrying capacity for Residents.

Note that for Residents the BH function is similar to the previous Stock Recruitment function:

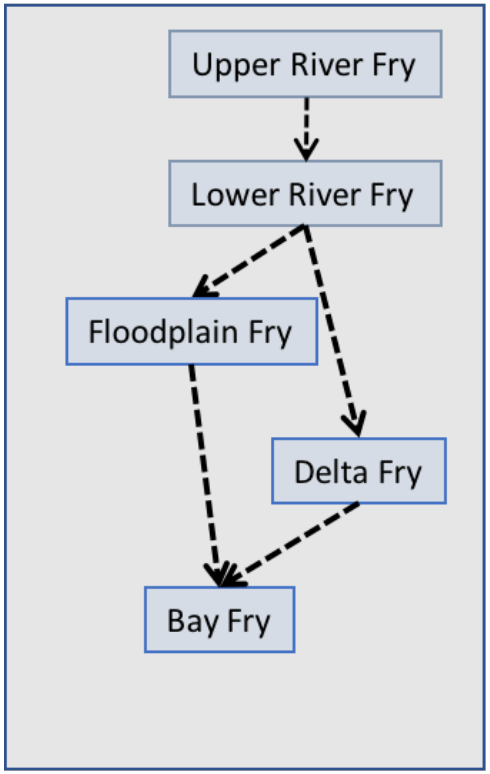
- Productivity $p = \phi(1-m)$, where $0 \leq \phi \leq 1$, and $0 \leq m \leq 1$
- Carrying capacity K for the Residents

The migrants Mig are the balance of those that survived but were not Residents

WRLCM Beverton-Holt movement figure



Fry movement due to density dependence



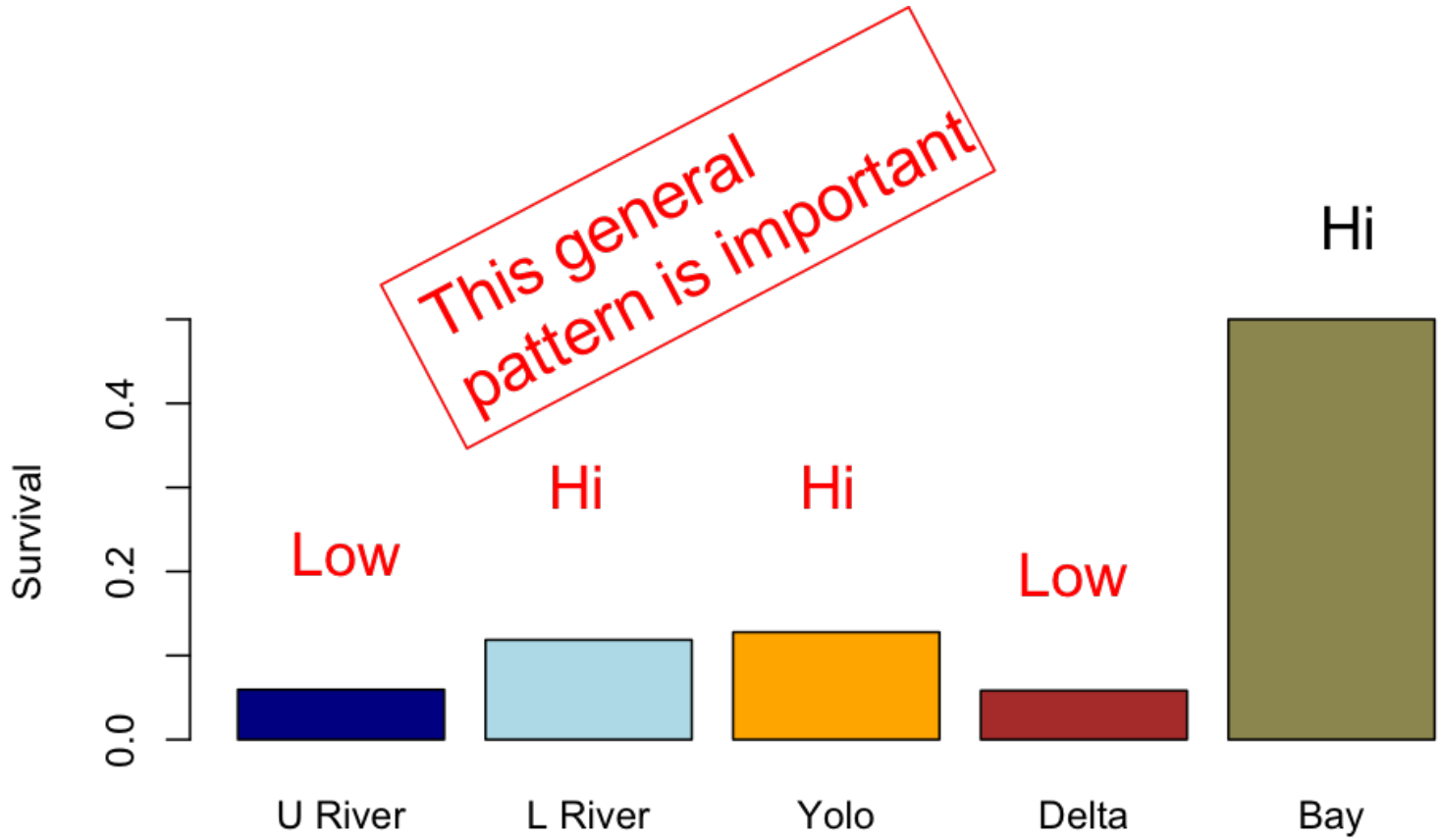
Initial abundance – 1 million

	URiver	LRiver	Yolo	Delta	Bay
Sept	100.0%	0.0%	0.0%	0.0%	0.0%
Oct	59.4%	40.6%	0.0%	0.0%	0.0%
Nov	37.2%	61.4%	0.5%	0.9%	0.0%
Dec	24.0%	71.5%	1.6%	2.9%	0.1%

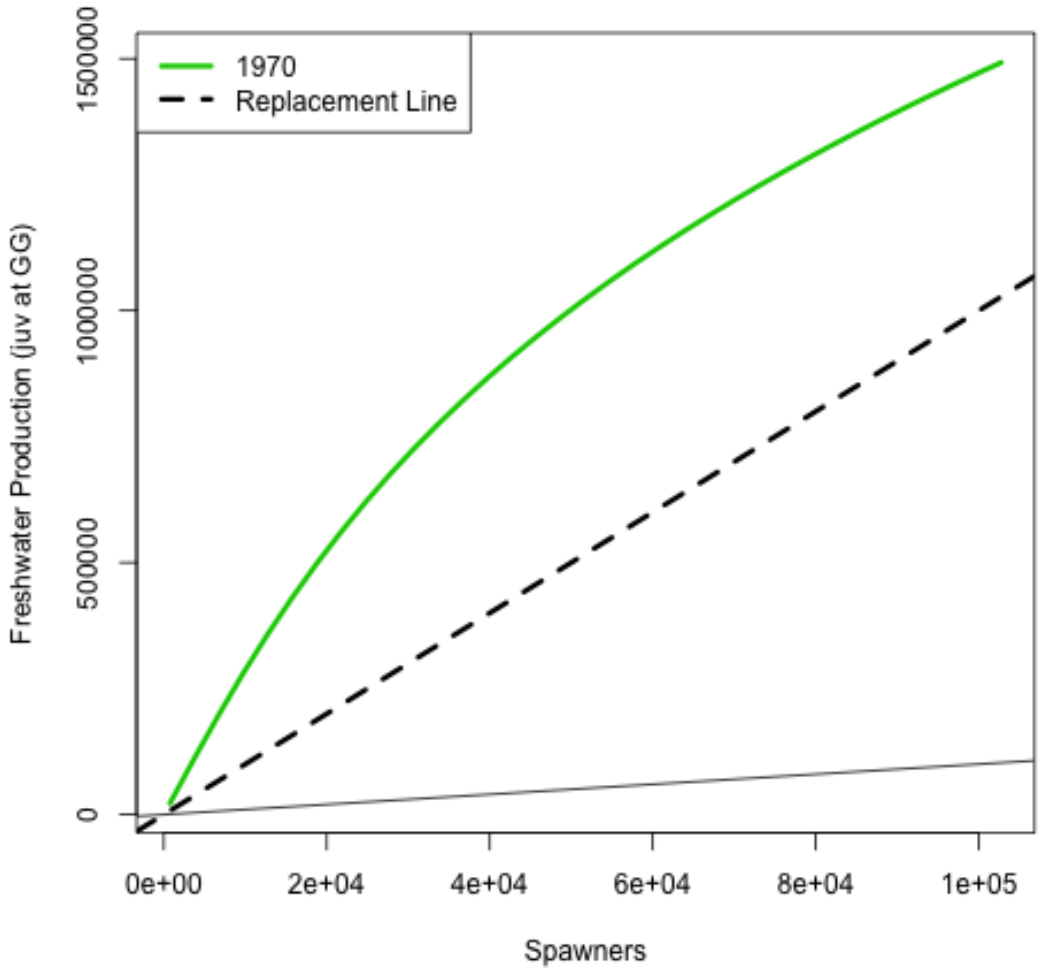
Initial abundance – 5 million

	URiver	LRiver	Yolo	Delta	Bay
Sept	100.0%	0.0%	0.0%	0.0%	0.0%
Oct	39.4%	60.6%	0.0%	0.0%	0.0%
Nov	20.8%	67.1%	4.2%	7.9%	0.0%
Dec	12.3%	61.1%	9.0%	16.9%	0.7%

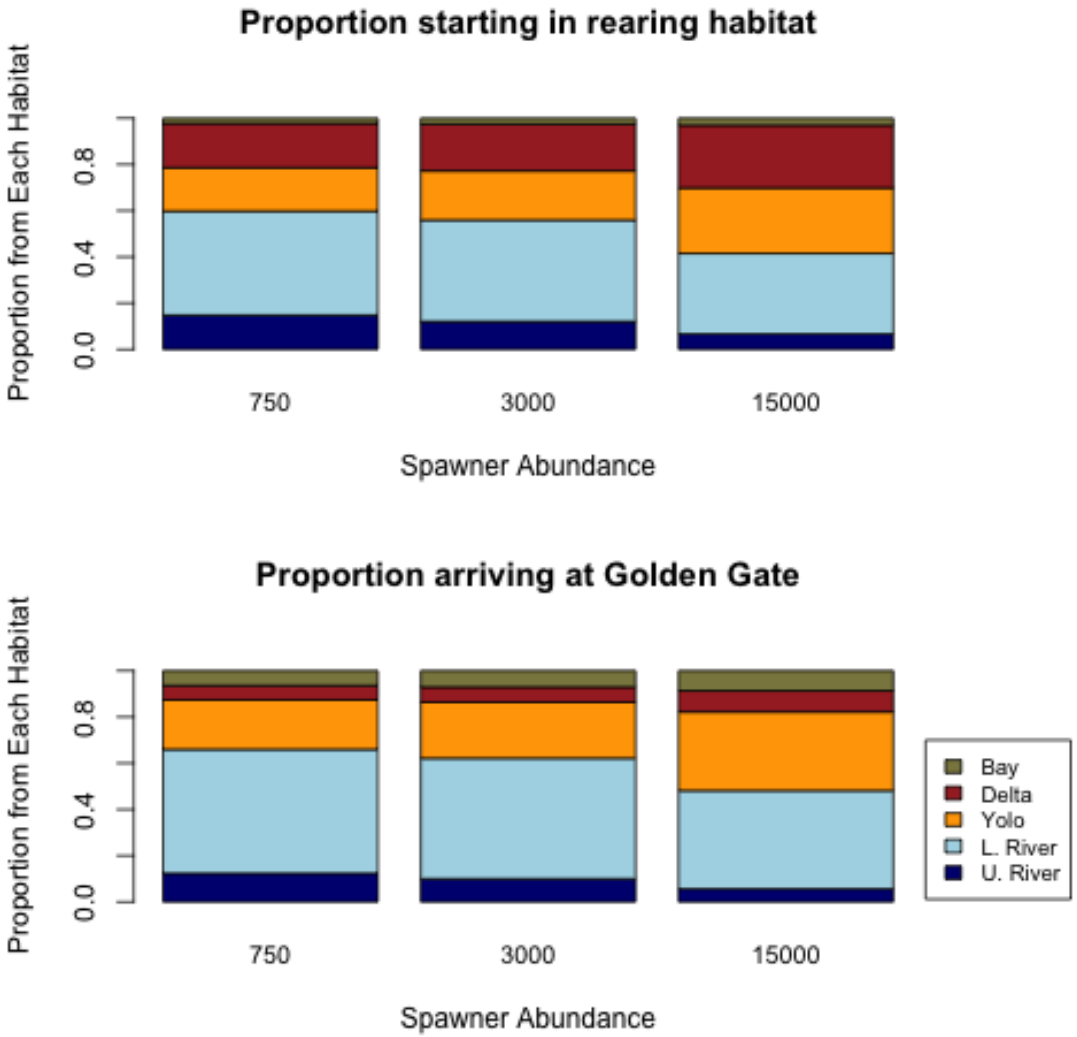
Average smolt survival by habitat



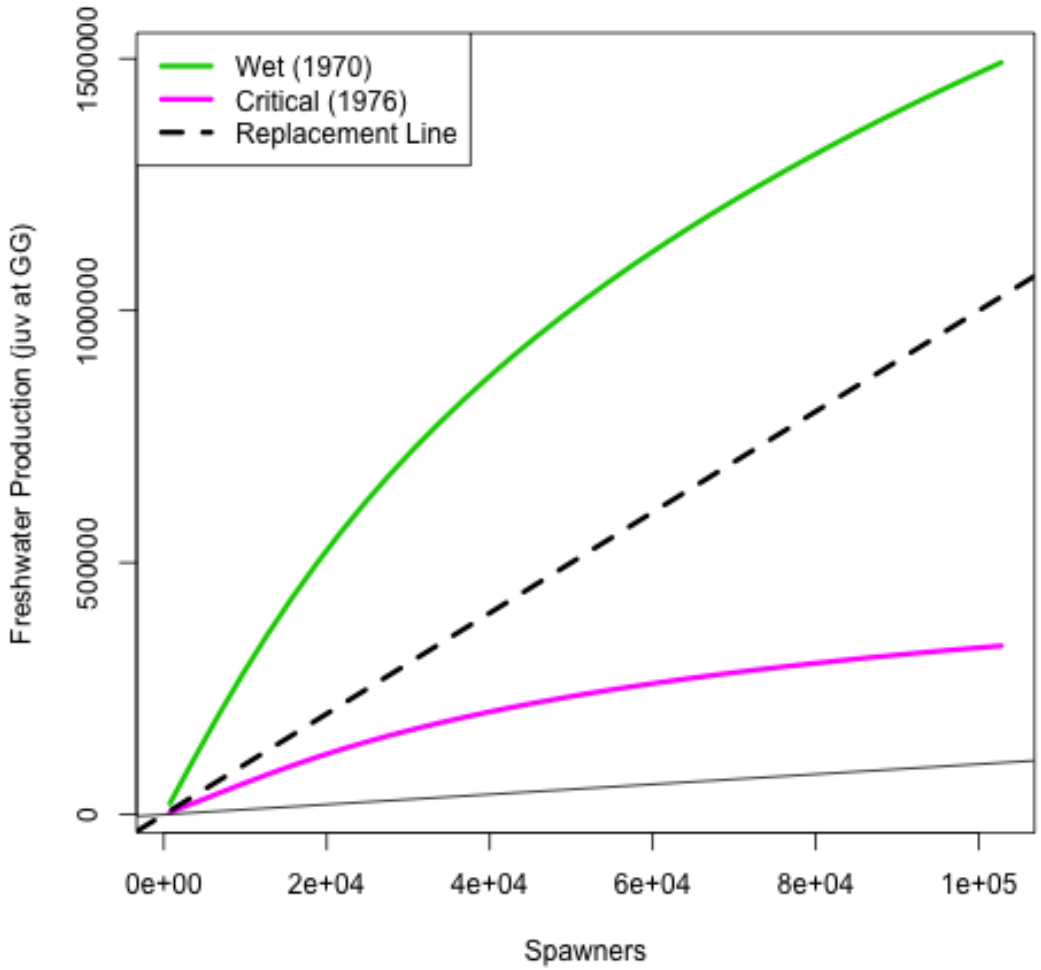
Results of WRLCM SR - a wet year 1970



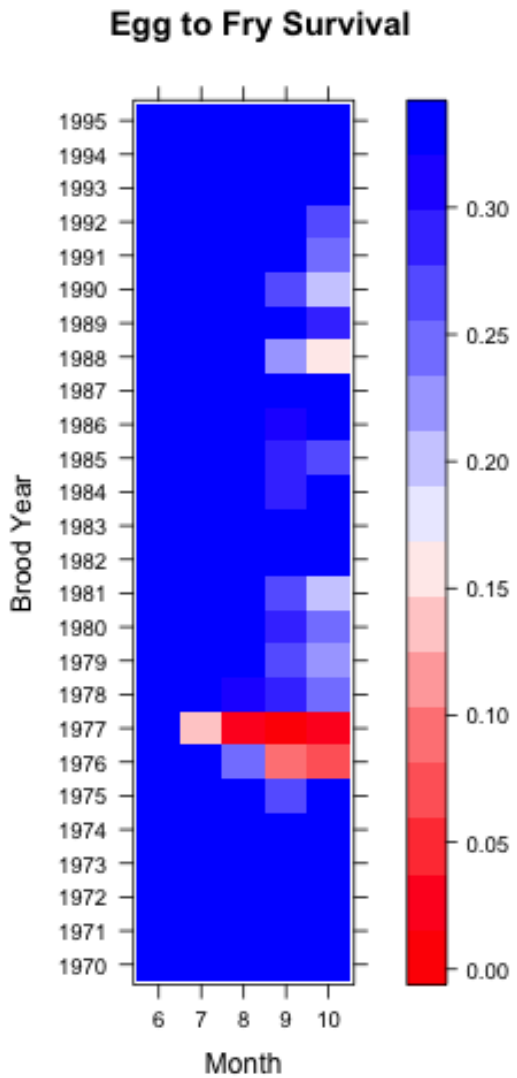
Distribution of freshwater production - 1970



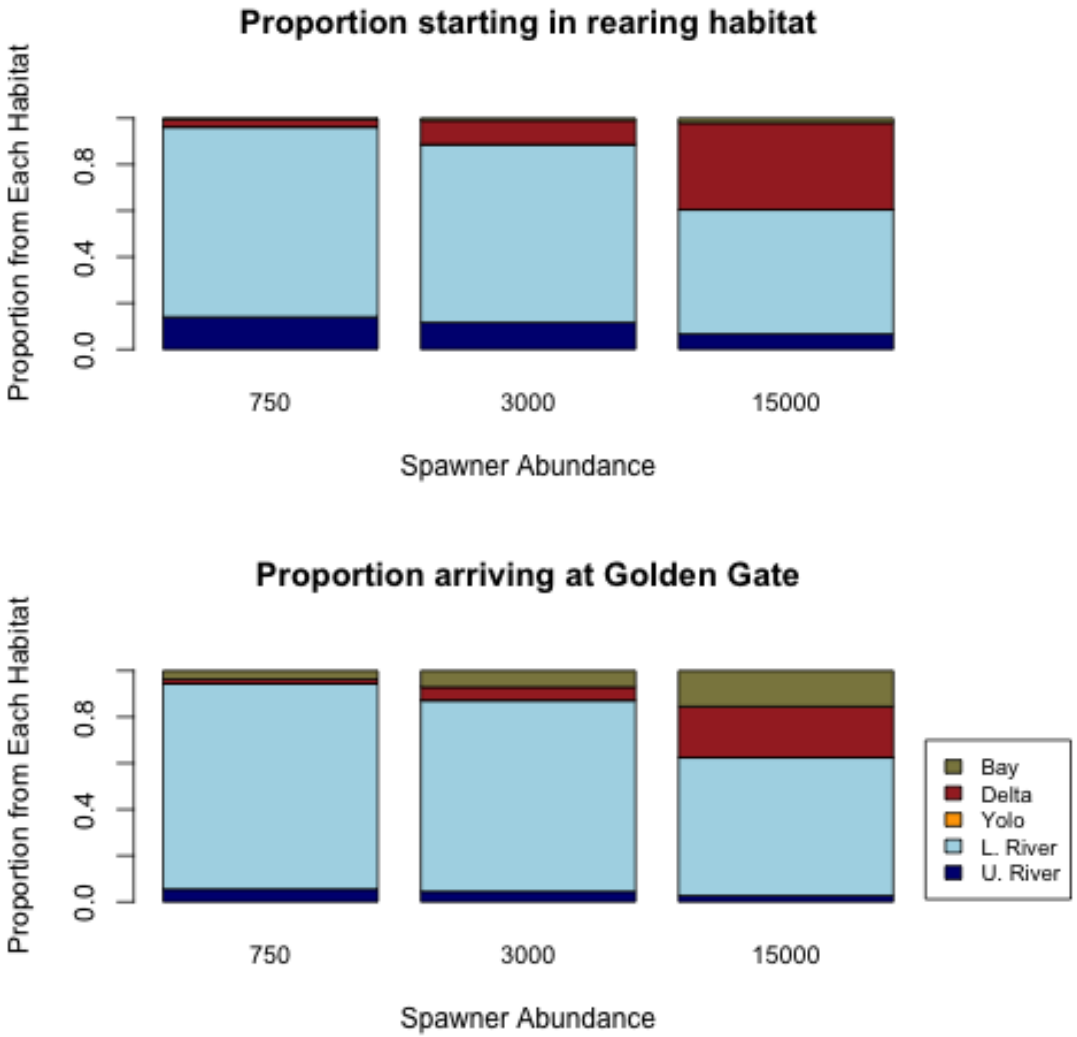
Results of WRLCM SR - a critical dry year 1976



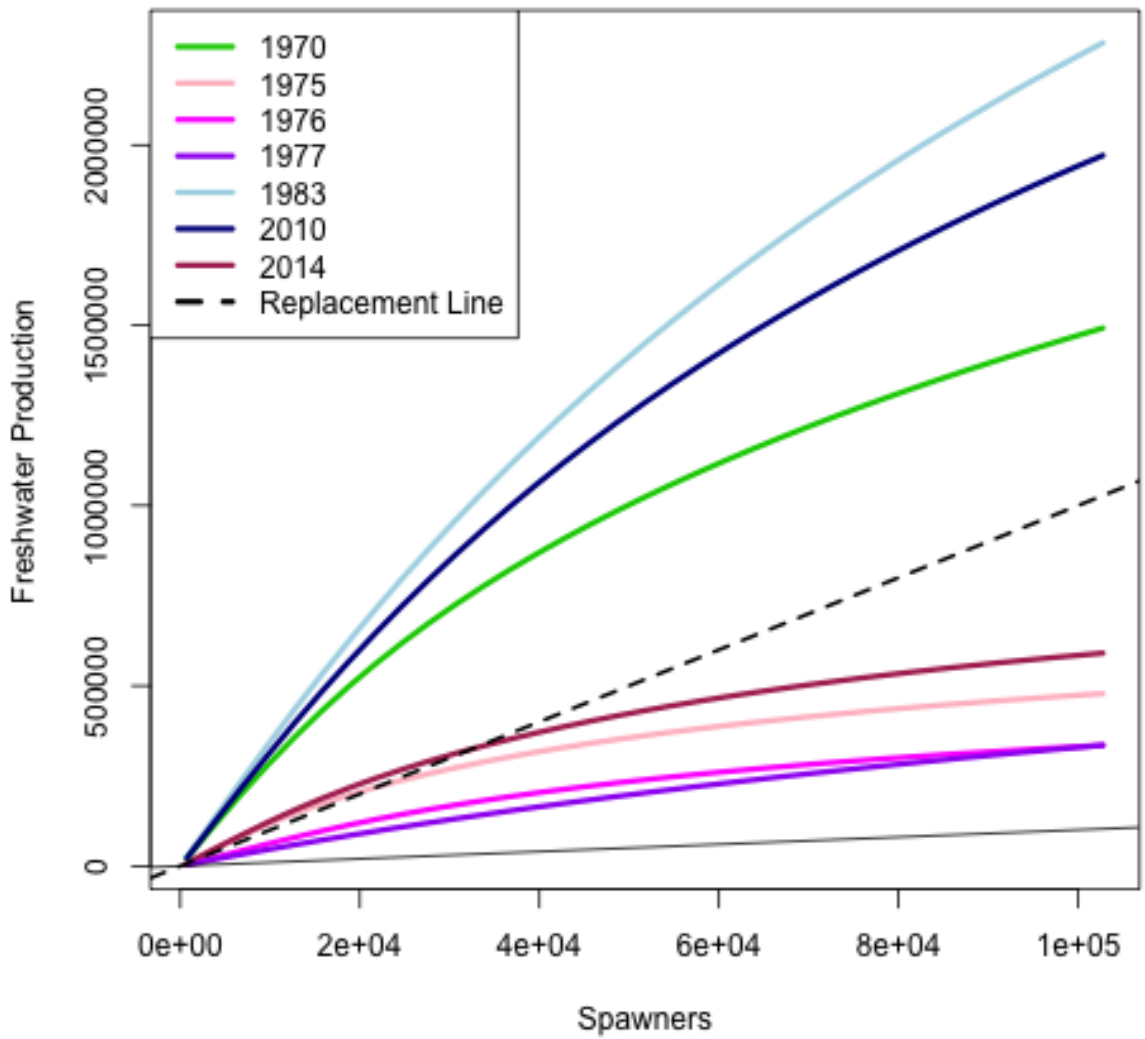
Effects of thermal mortality



Distribution of freshwater production - 1976



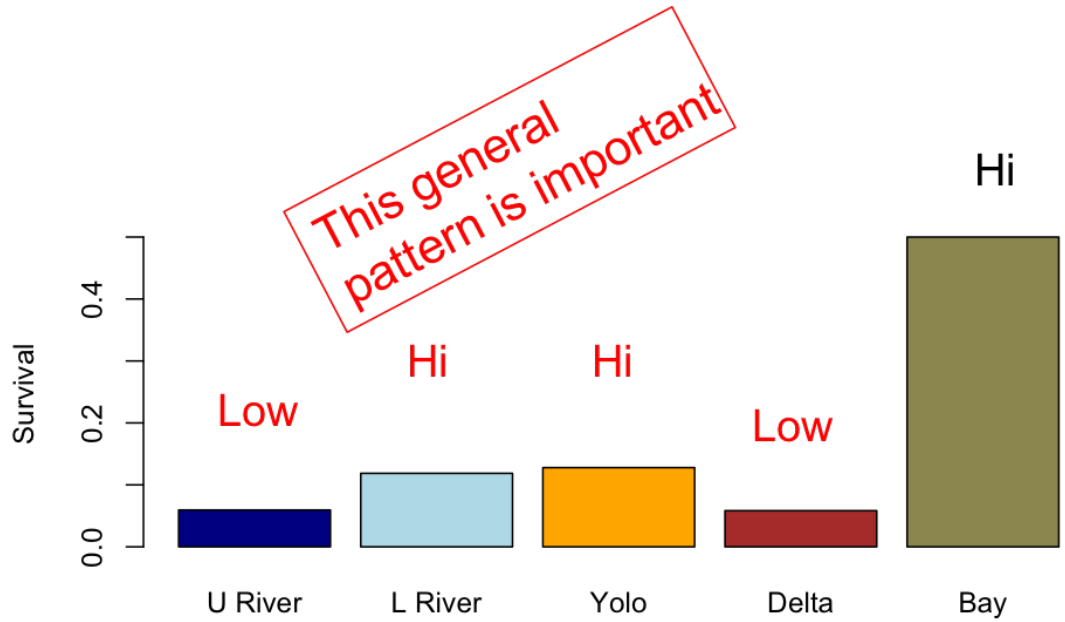
Annual variability in freshwater production



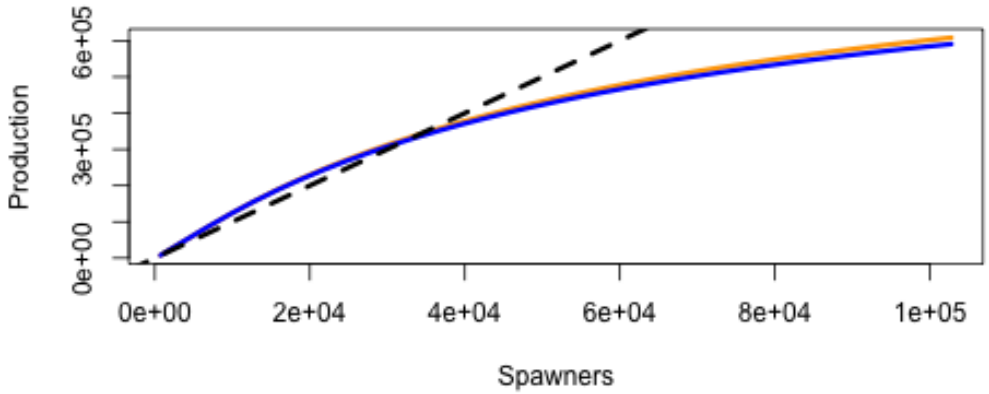
WRLCM Stock Recruitment with management actions

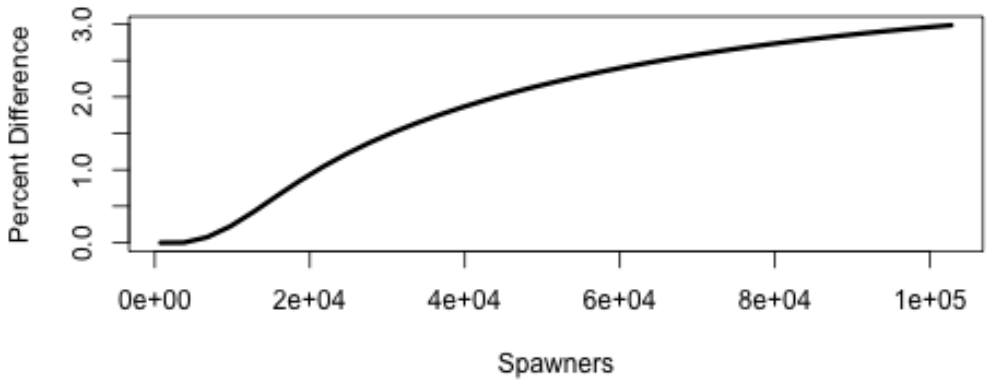
How does freshwater production respond to changes in rearing capacity?

- Changing rearing capacity may affect the fry distribution
  - . . . but the response is affected by fry density dependence
  - . . . and the subsequent smolt survival
- Shifting fry to habitats with higher smolt survival can potentially increase productivity

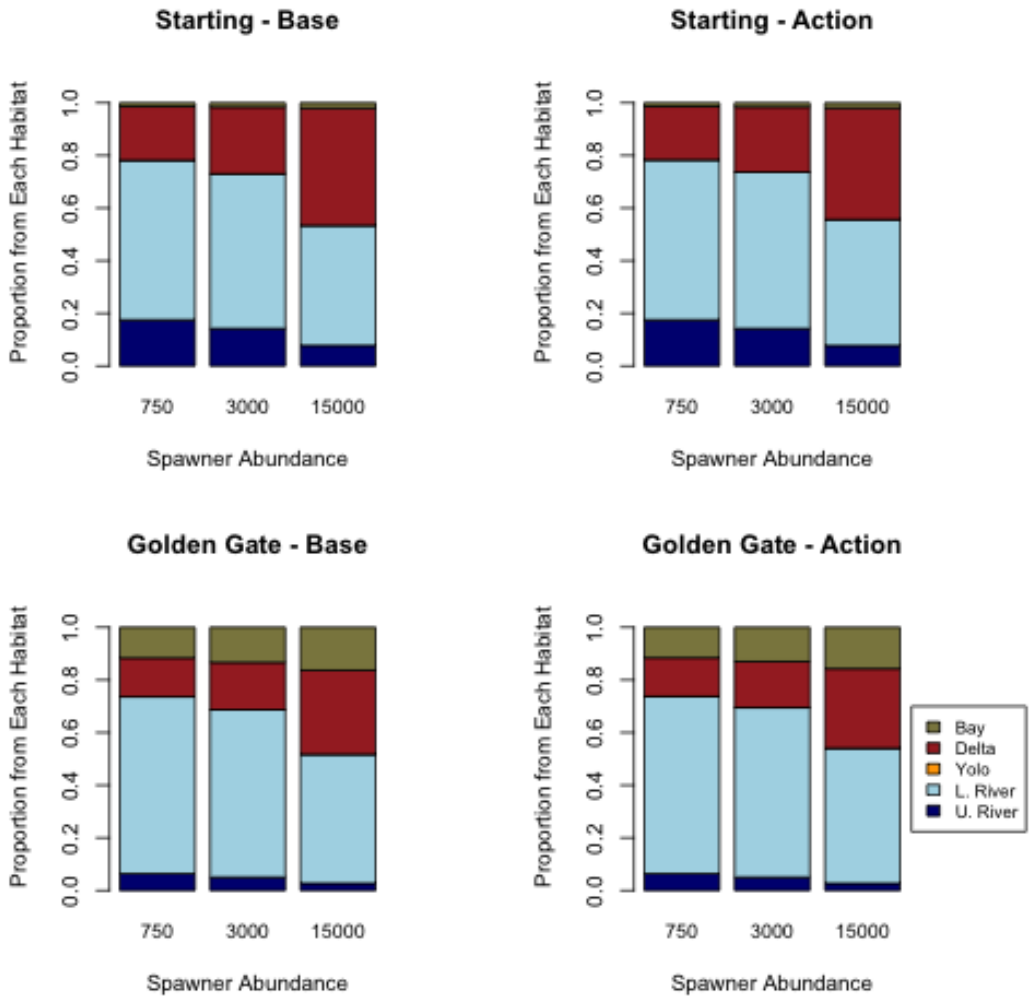


Increasing capacity in Lower River in 2014 in by 20%

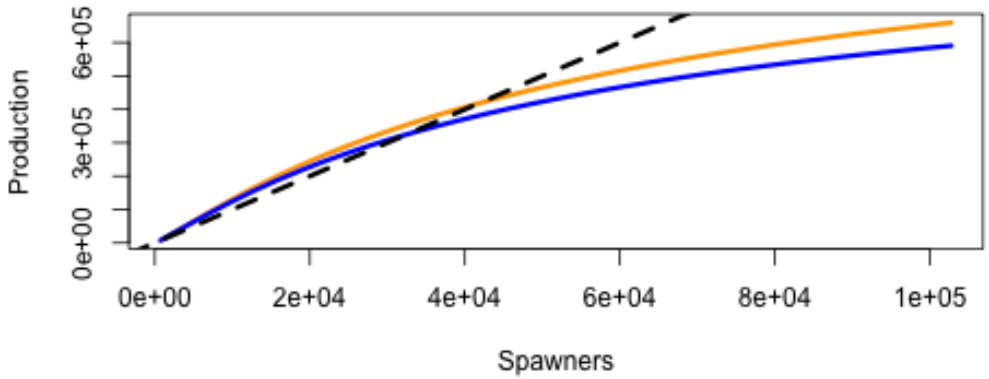


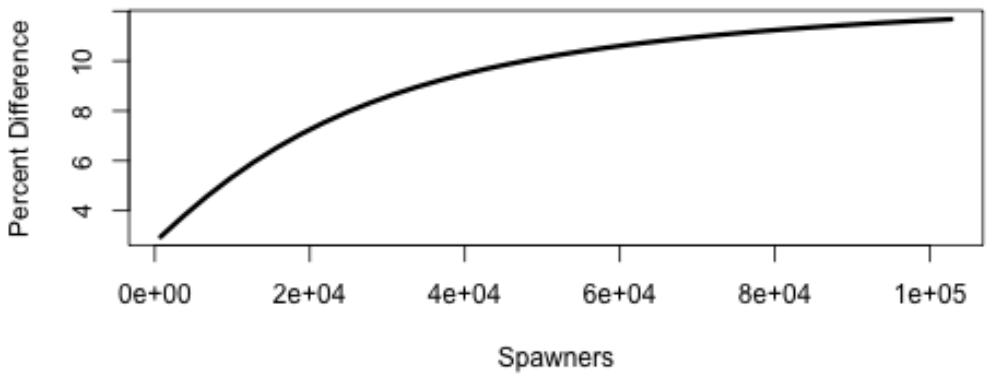


Distribution of freshwater productivity in 2011, Action is 20% Increase in LR

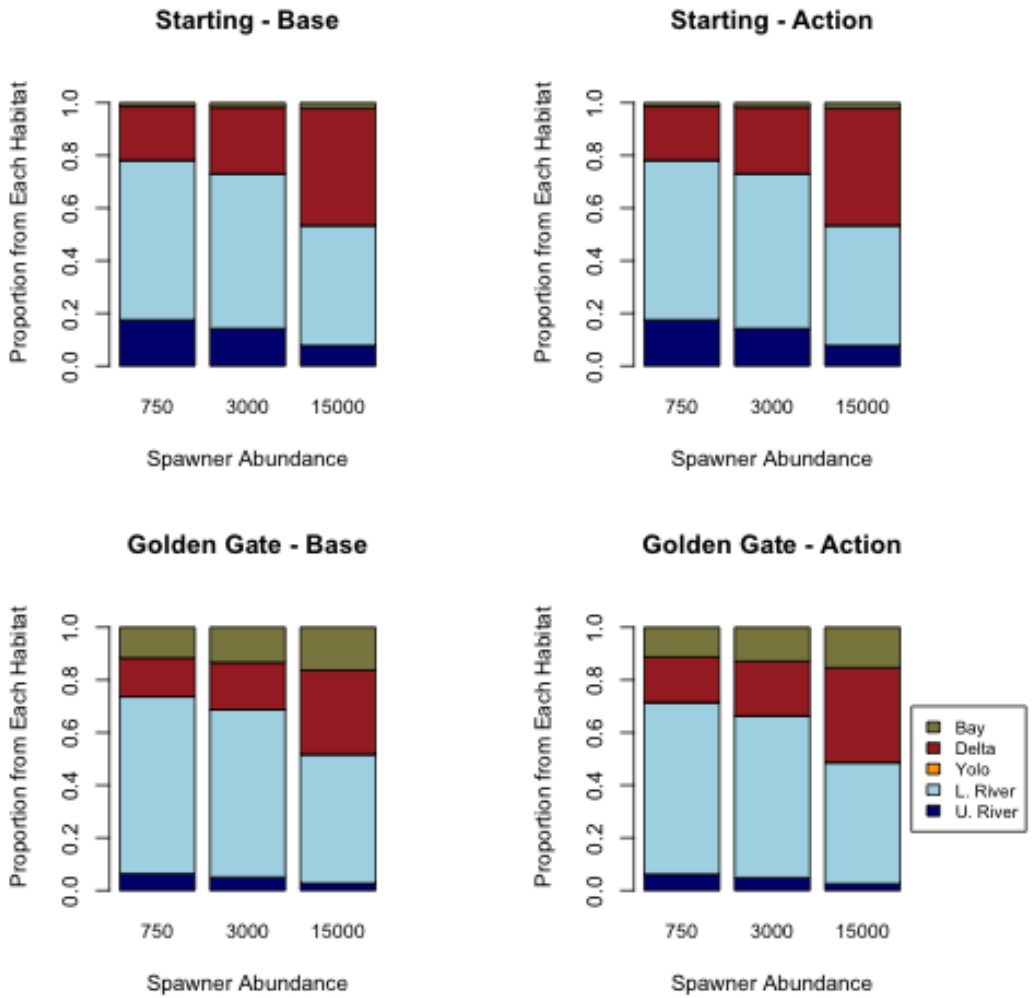


Increasing smolt survival in Delta in 2014 in by 20%

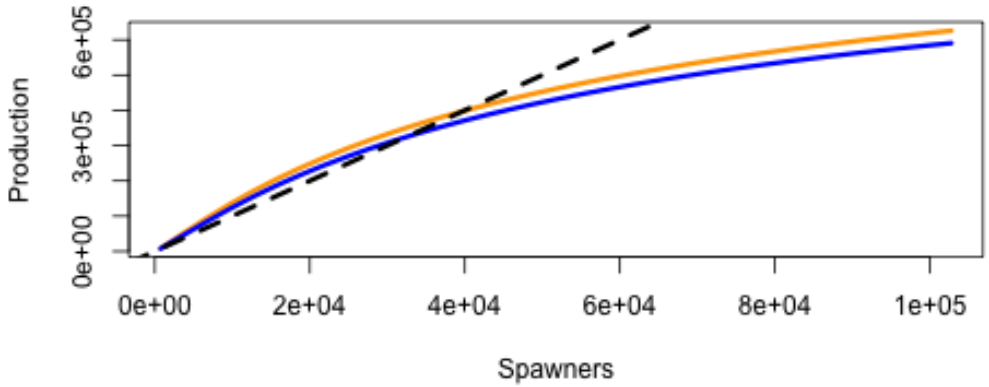


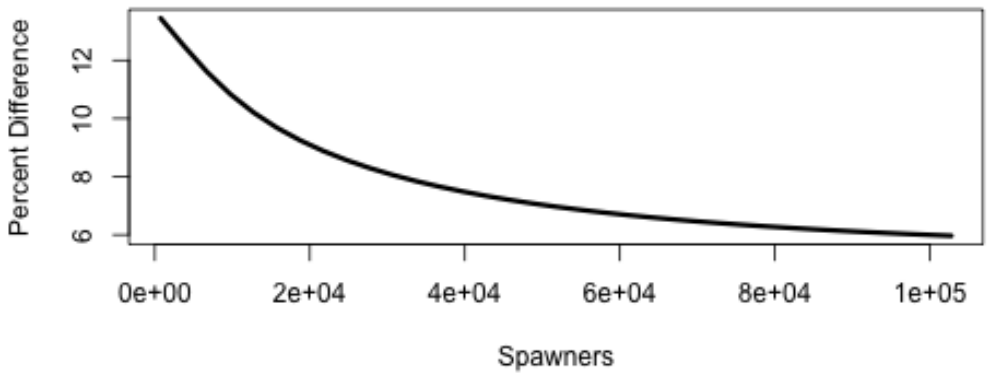


Distribution of freshwater productivity in 2014, Action is 20% Increase in Delta Survival

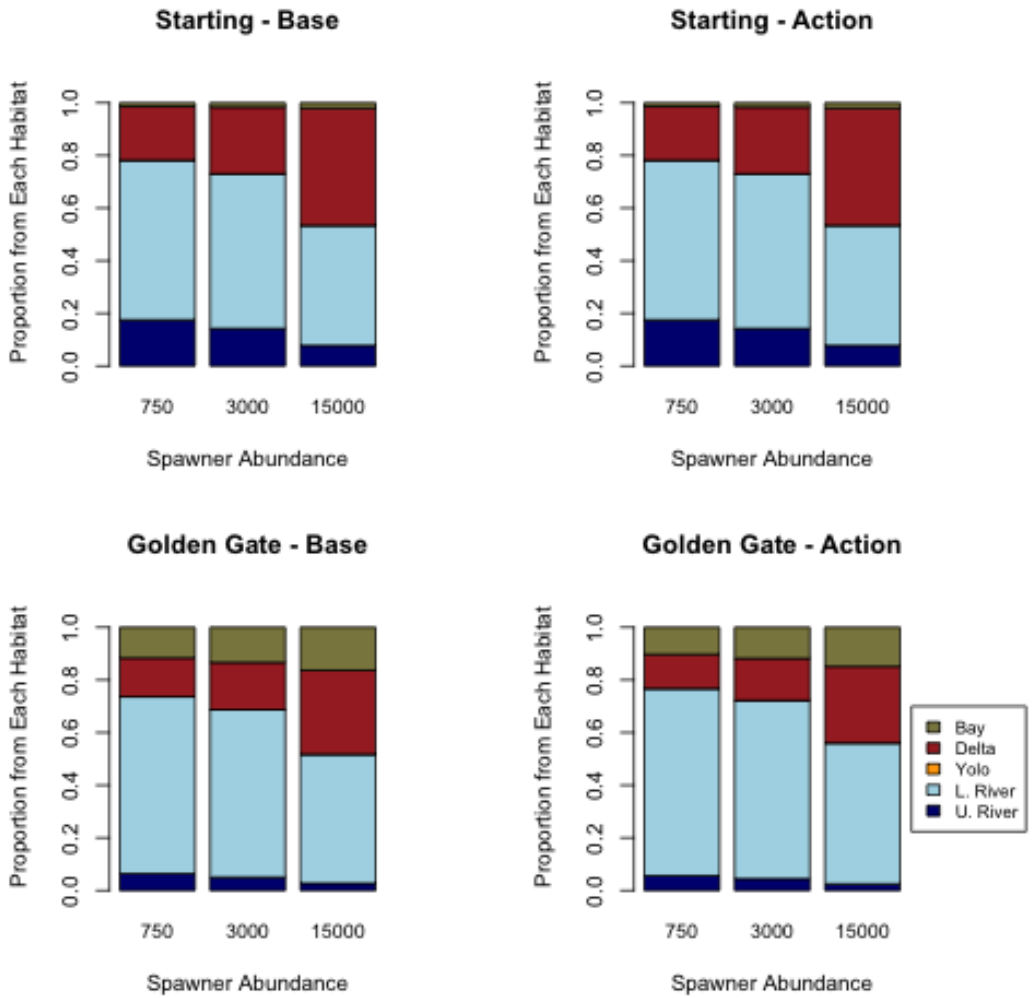


Increasing smolt survival in Lower River by 20% in 2014





Distribution of freshwater productivity in 2014, Action is 20% Increase in Lower River Survival



Summary

- Beverton-Holt (BH) functions are used to incorporate density dependence into survival or movement processes
- Results of actions in BH models in survival (e.g., Stock Recruit)
  - Actions that improve productivity p are effective at low abundances
  - Actions that affect the capacity K are effective at high abundances
- Results of actions in BH models in movement (e.g., WRLCM) are more complex
  - Actions that improve survival (productivity) in the Delta and Lower River differ in their overall effectiveness and the abundances at which they are effective
  - Actions that improve capacity depend on the relative productivity (survival rates) of habitats

Next steps

- Utilize freshwater productivity as a metric for ranking actions
- Evaluate a suite of potential management actions (e.g., capacity increases, smolt survival increases, Yolo access, etc.) for their efficacy at improving productivity over baseline (historical)
- Identify those actions that are most effective over the 1970 - 2014 period
- Identify those actions that are most effective over specific year types, e.g., dry and critical

Additional Questions?

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