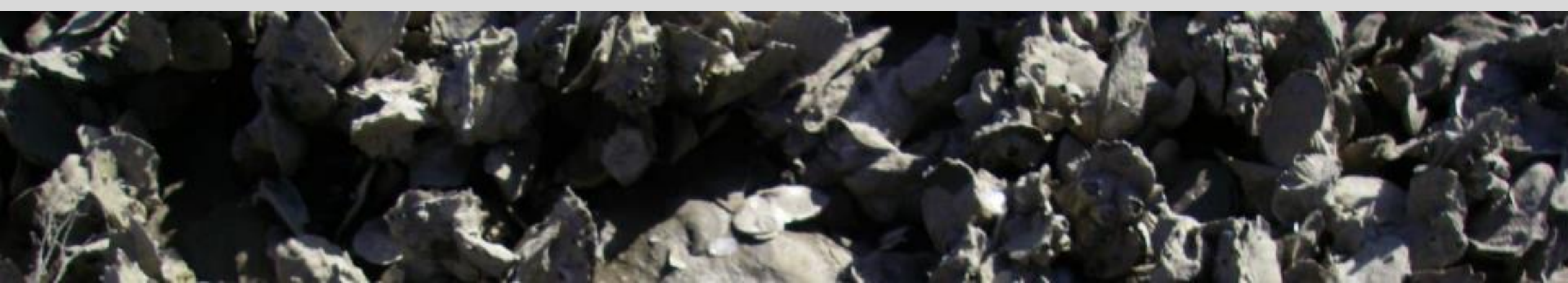
ABSI CAB
February 1st, 2023

Ed Camp
Fisheries and Aquatic Sciences, University of Florida



Outline of things to go over

1. Disclaimer/disambiguation
2. Review of previous results
3. Simulation results: Unexpected increase in M
4. Simulation results: Annual restoration (alternating)
5. Simulation results: Stochasticity

1. Disclaimers and disambiguation

1. Disclaimers regarding models

1. Model results are draft—they will change
2. Models shown today are more useful for comparing (across assumptions and strategies) than for predicting absolute values
3. There is massive uncertainty in what I'm showing. There is some evidence for depensation but we don't know what drives it. <u>These results assume it is driven by habitat.</u> If that is incorrect, most of these results (wrt restoration) will be useful

1. Disambiguation re: "models"

- Multiple different modeling work I'm doing
  - Stock assessment models—estimating parms
    - Initially traditional fisheries (i.e. no shell dynamics explicit, subsumed with recruitment anomalies)
    - Extended to (try to) estimate shell dynamics (2-stage estimation, not ideal but necessary)
  - Simulation models— "what if" analysis
    - Detailed shell dynamics, but how to inform?
    - Best guesses (lit, data)
    - Inform from newer assessment models
    - *Today you will see simulation models that have been informed by stock assessment models. More formally statistically fit models in future.*
  - Other projects too, not talking about them today

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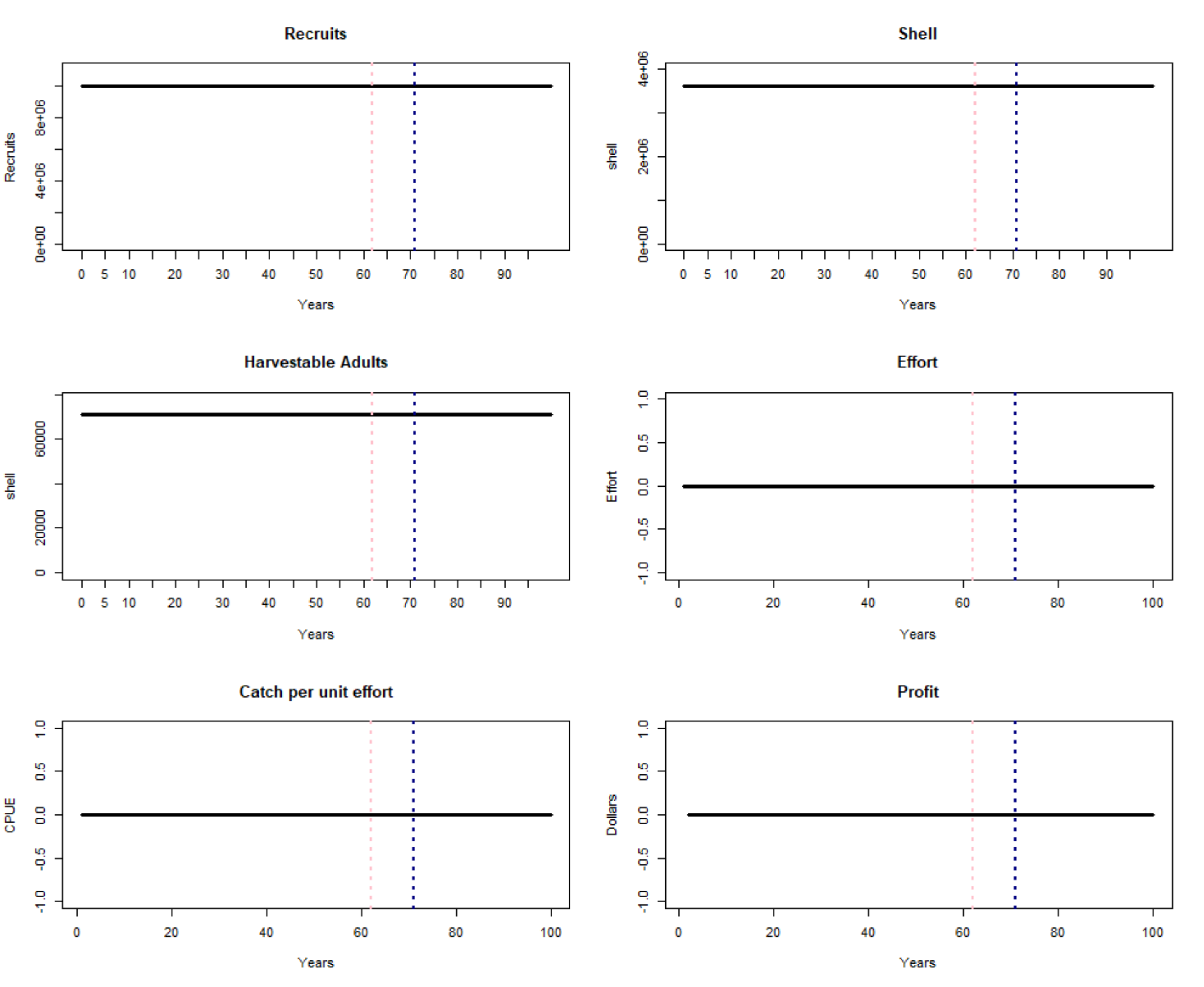
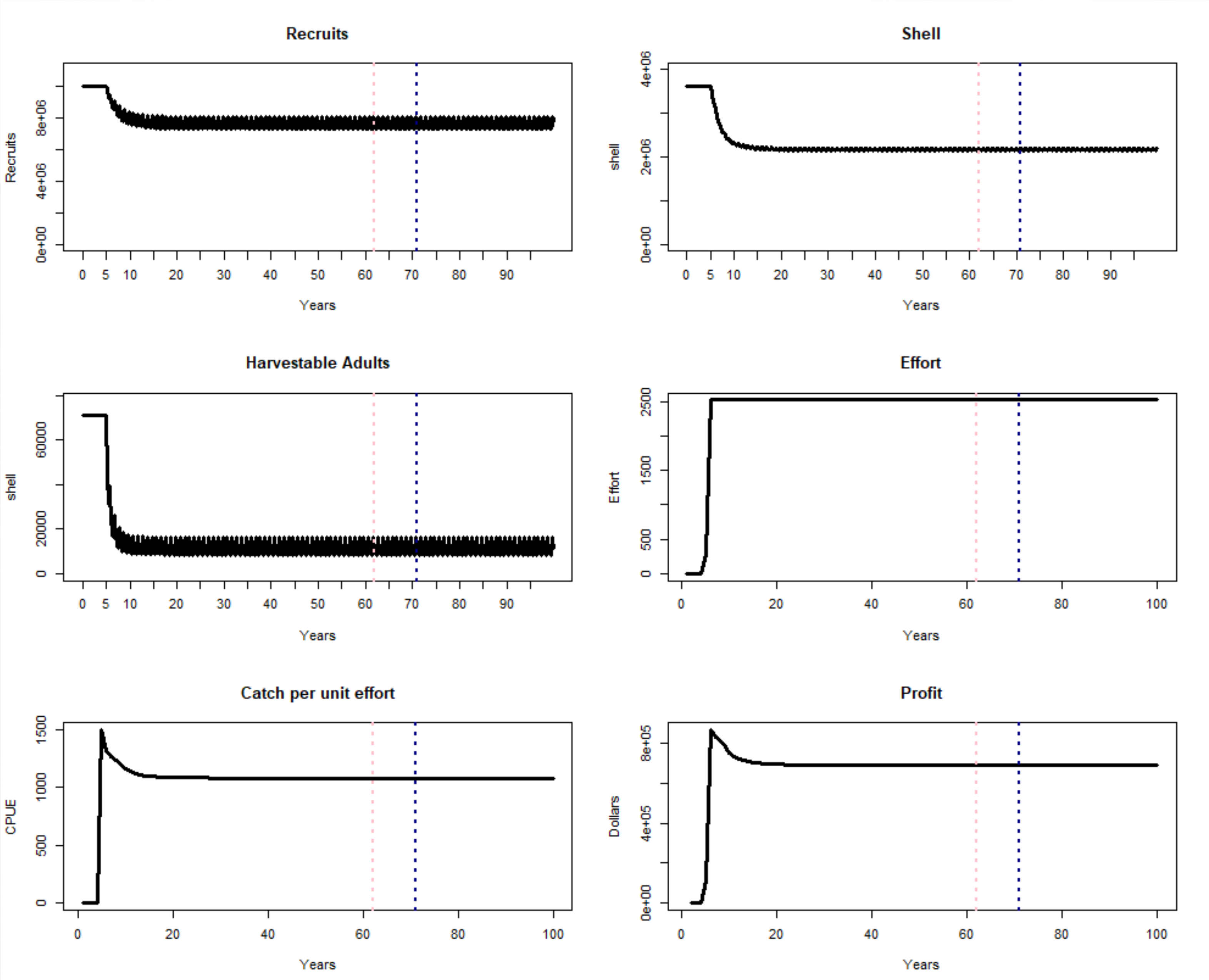
2. Review of recent results

- Dynamics that show the sensitivity of the system

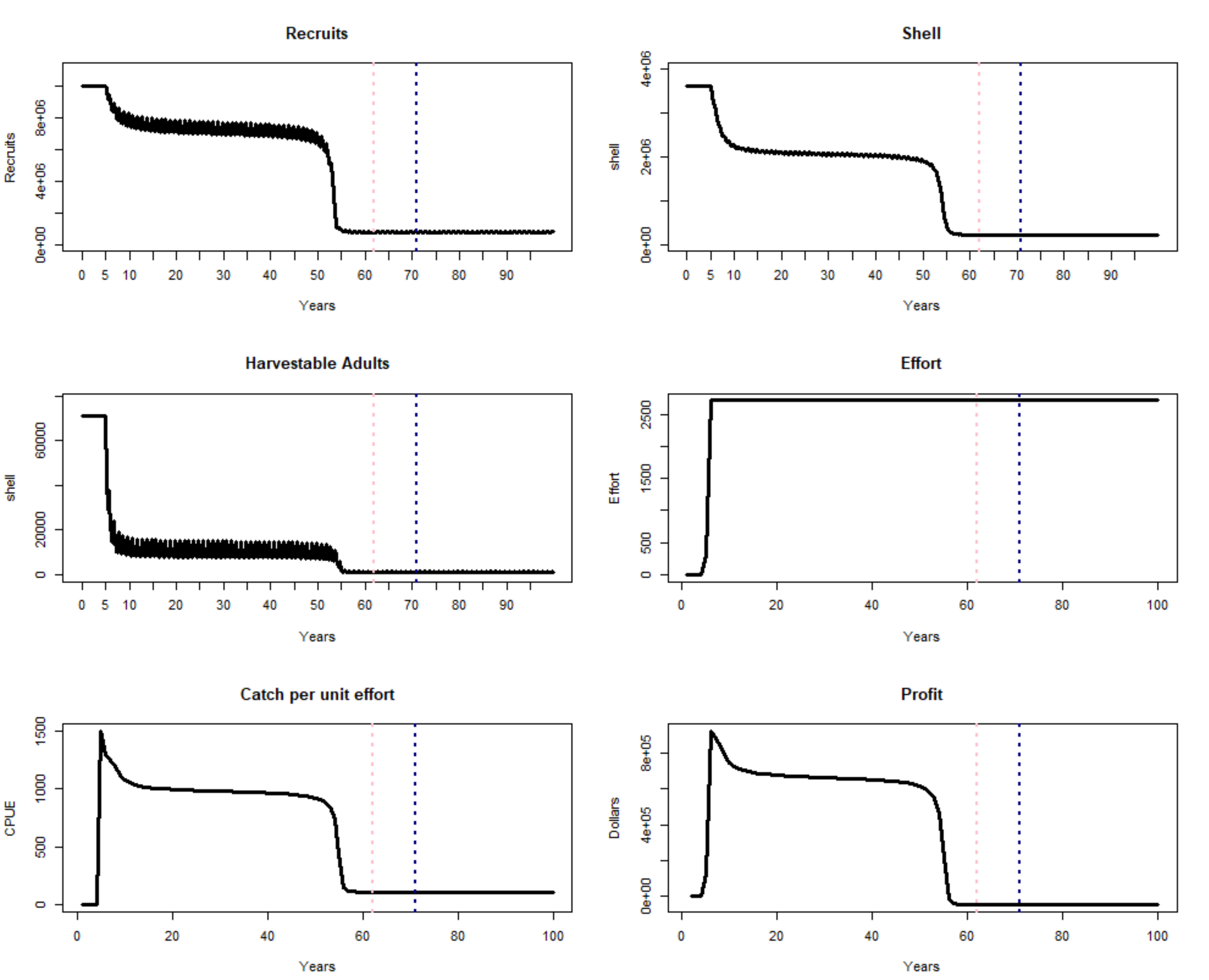
2.1 Null model, no fishing



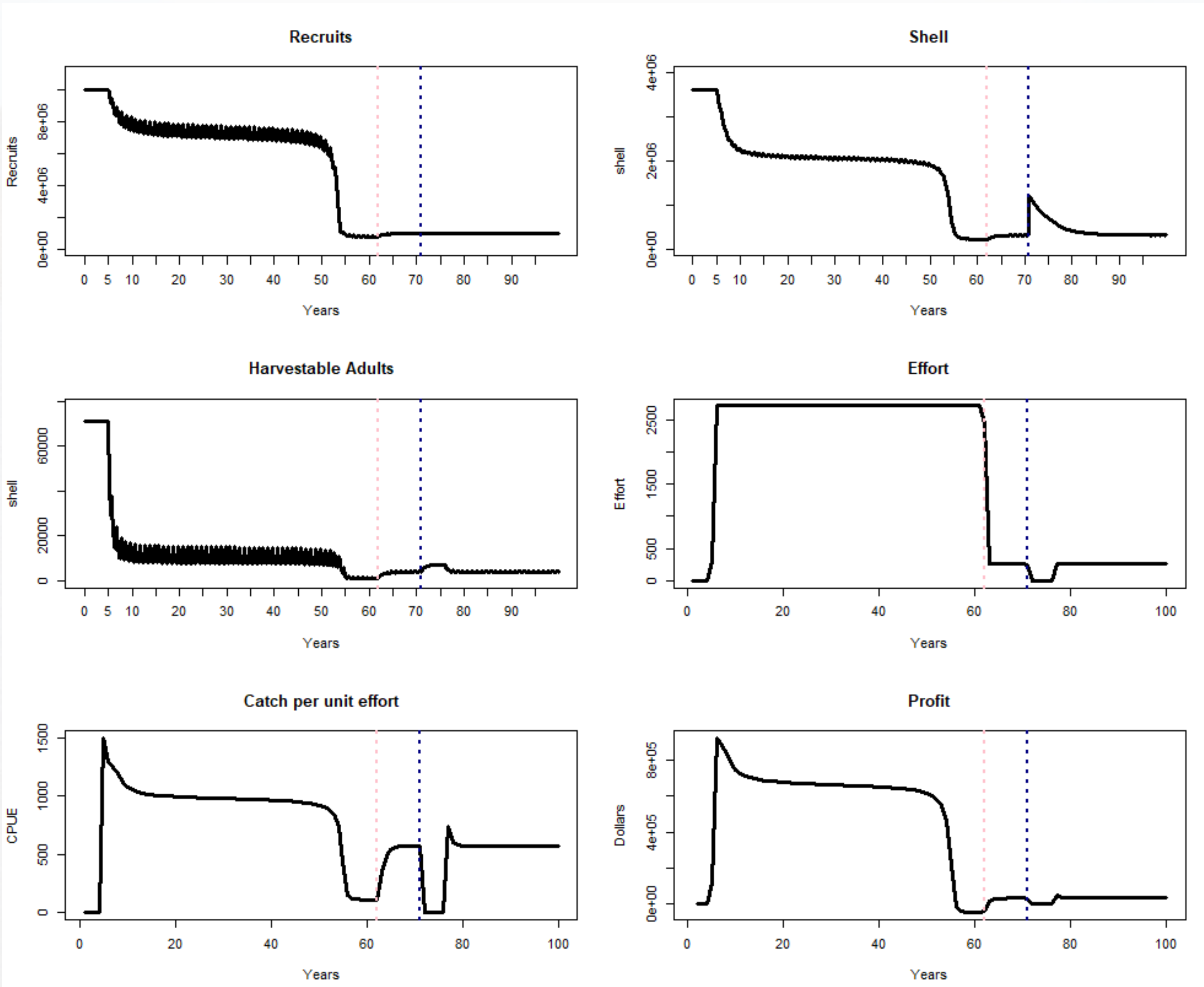
2.2 Fishing, but no “collapse”…yet



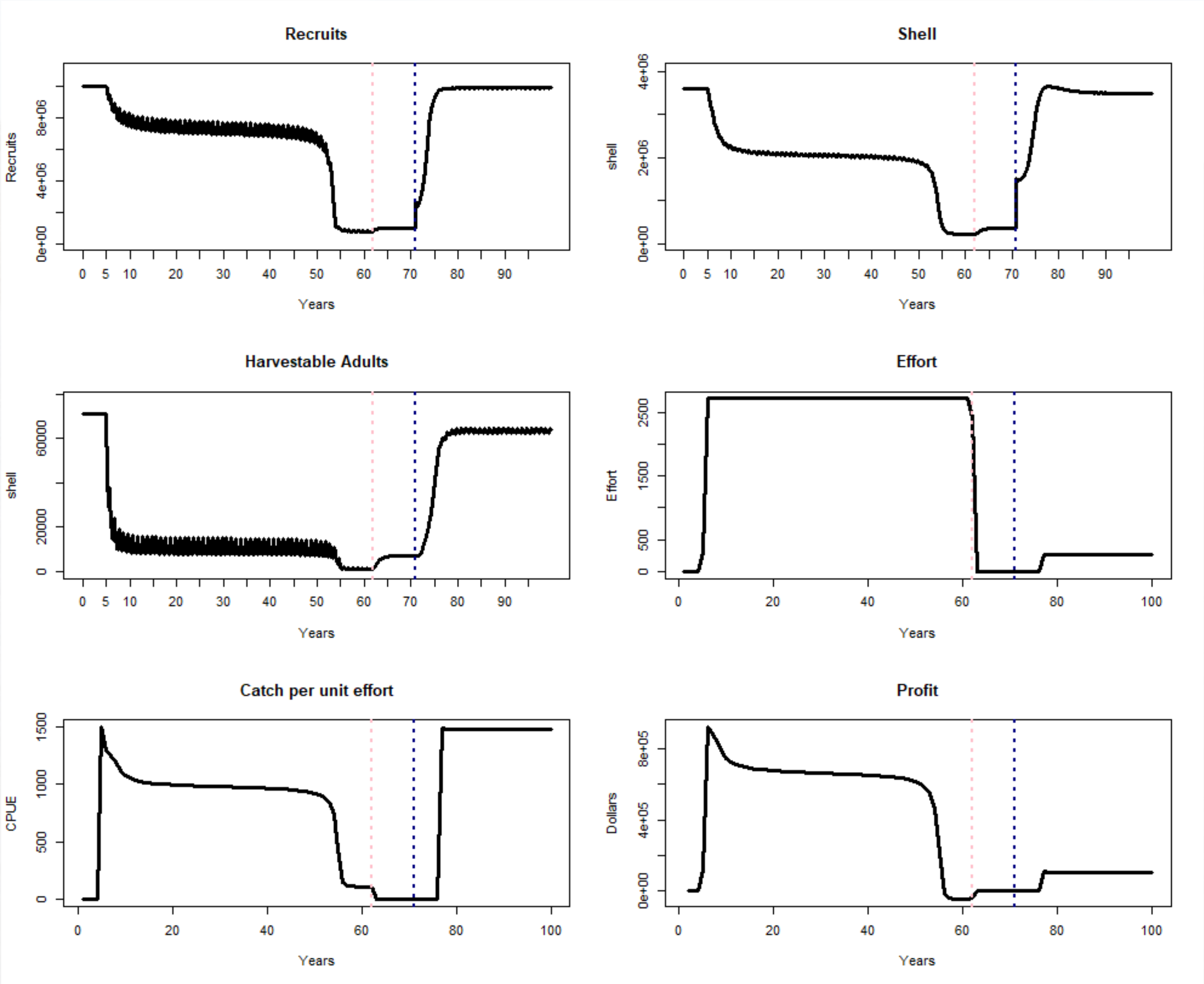
2.3 More effort, collapse



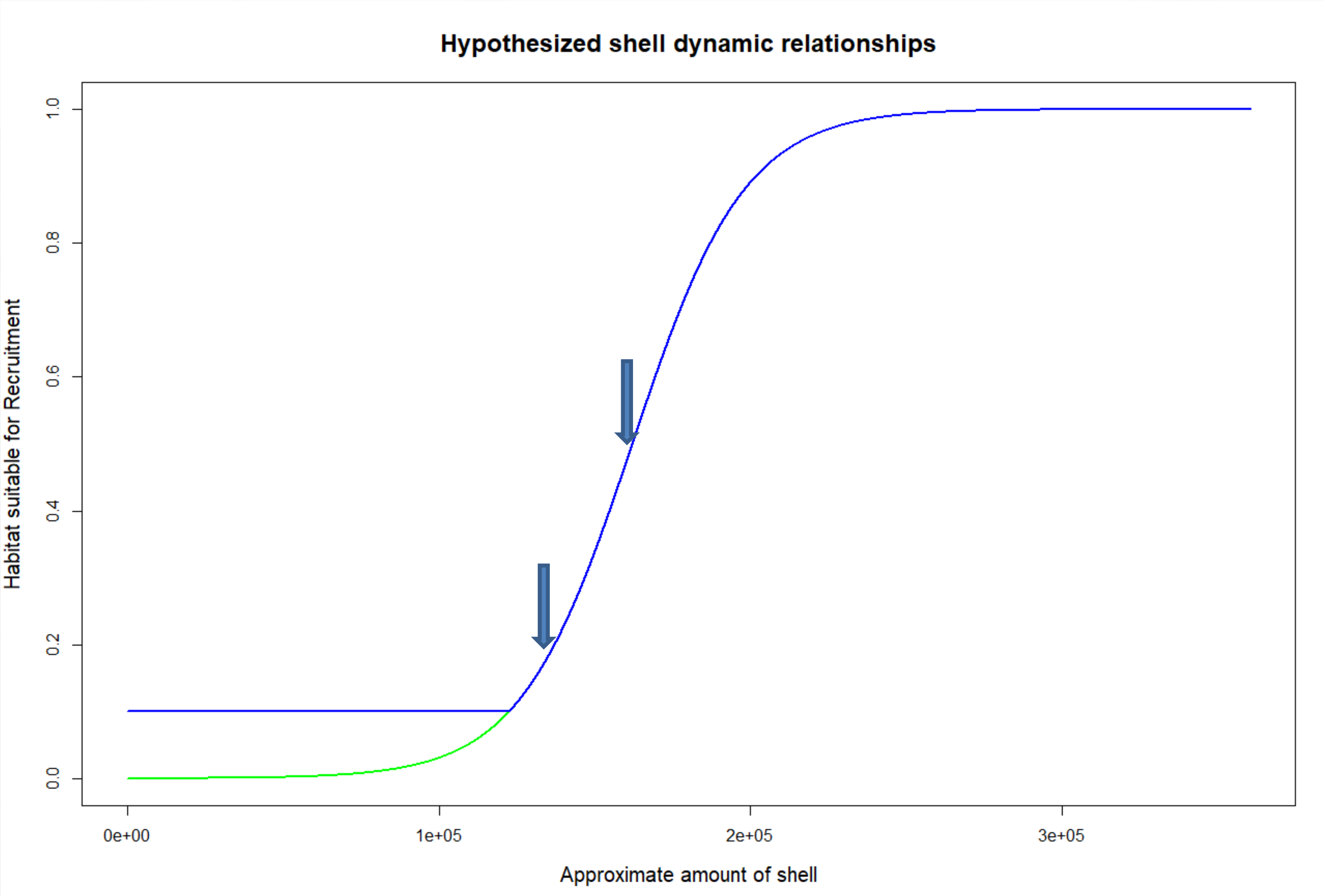
2.4 Eff. Reduction, 5yr closure, major restoration (25% initial shell), post-restoration effort 10% original



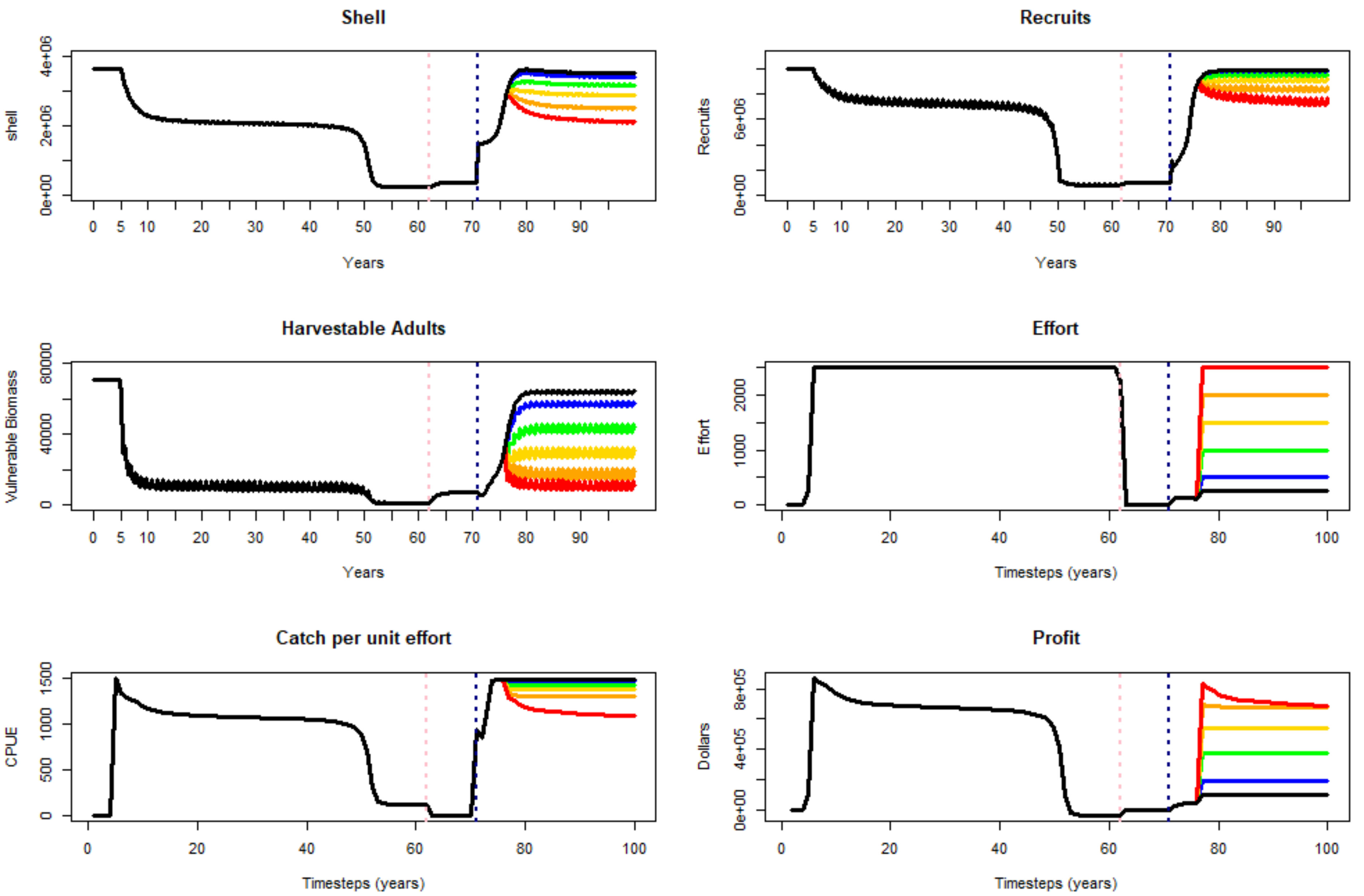
2.5 Eff. Reduction, 5yr closure, major restoration (33% shell init), post-restoration effort 10% original



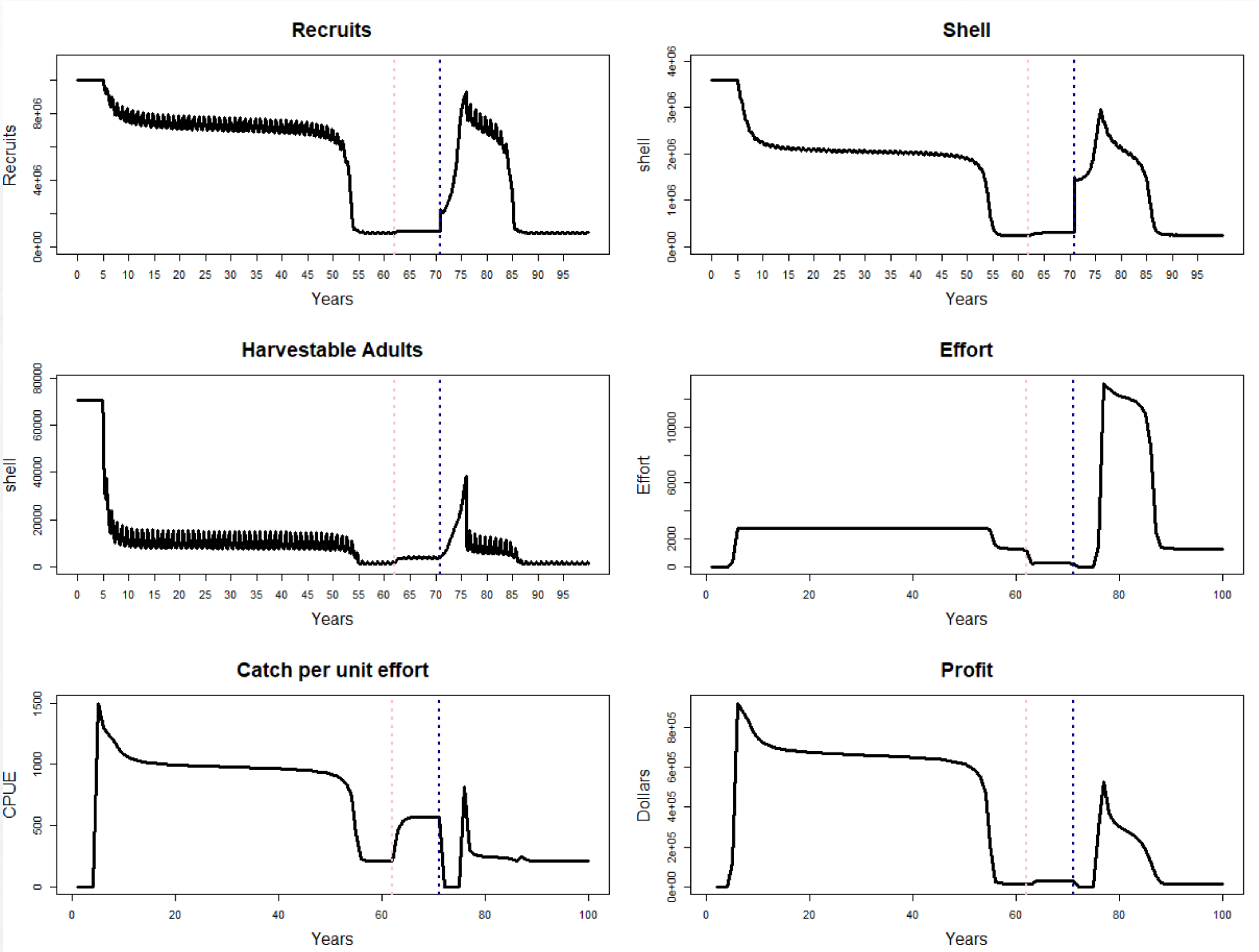
2. Shell dynamic oyster simulations



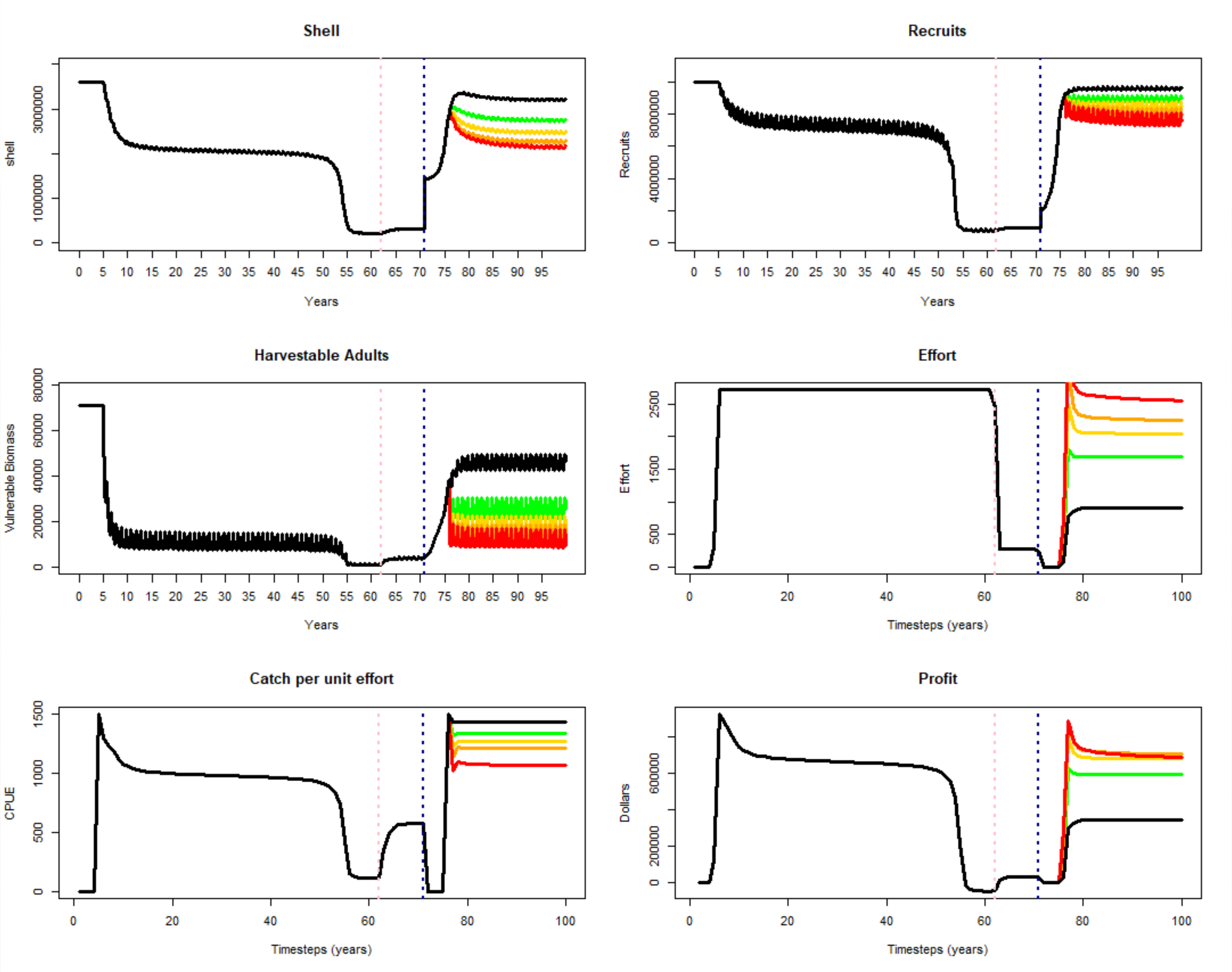
2.6 Limited entry



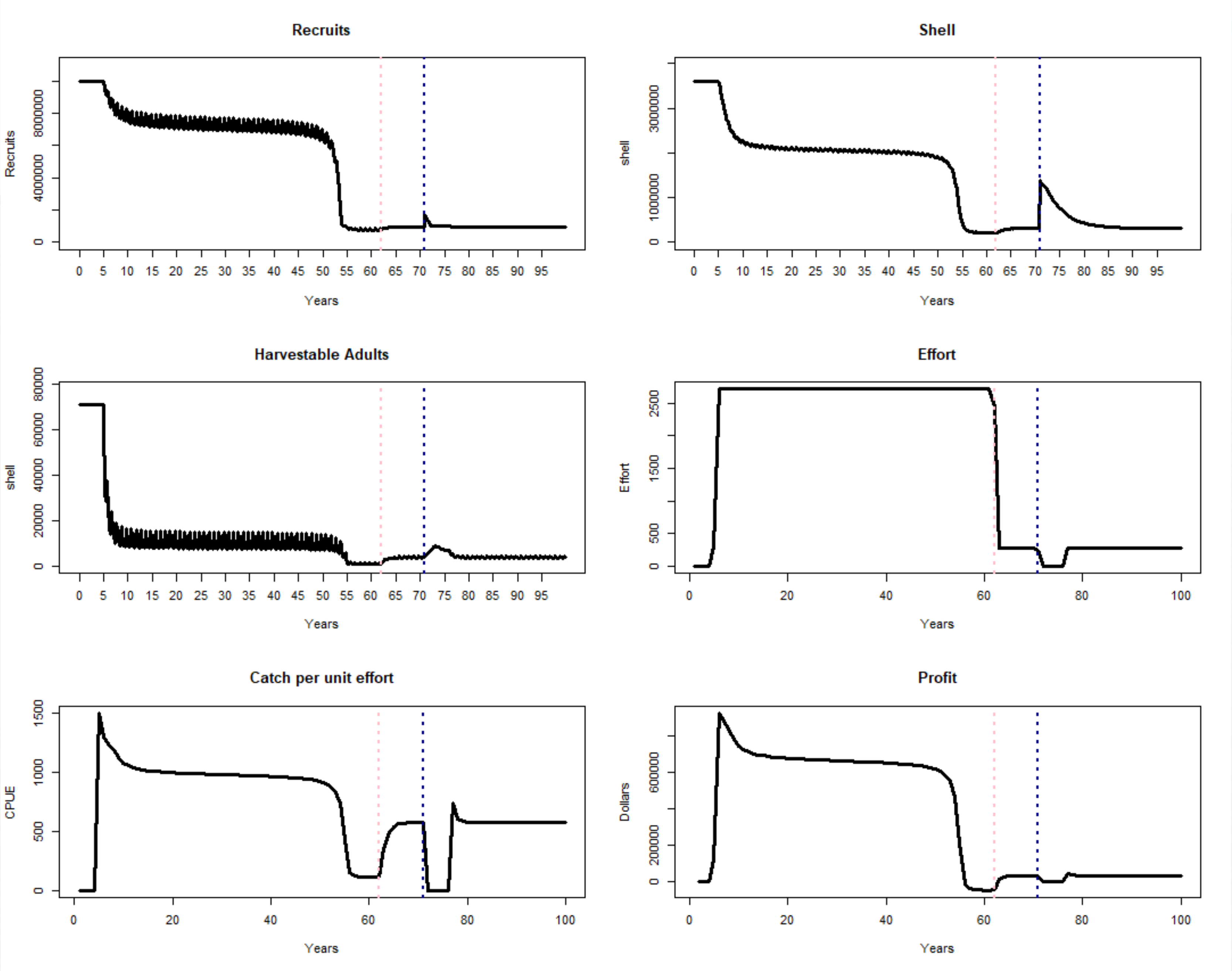
2.7 Open Access



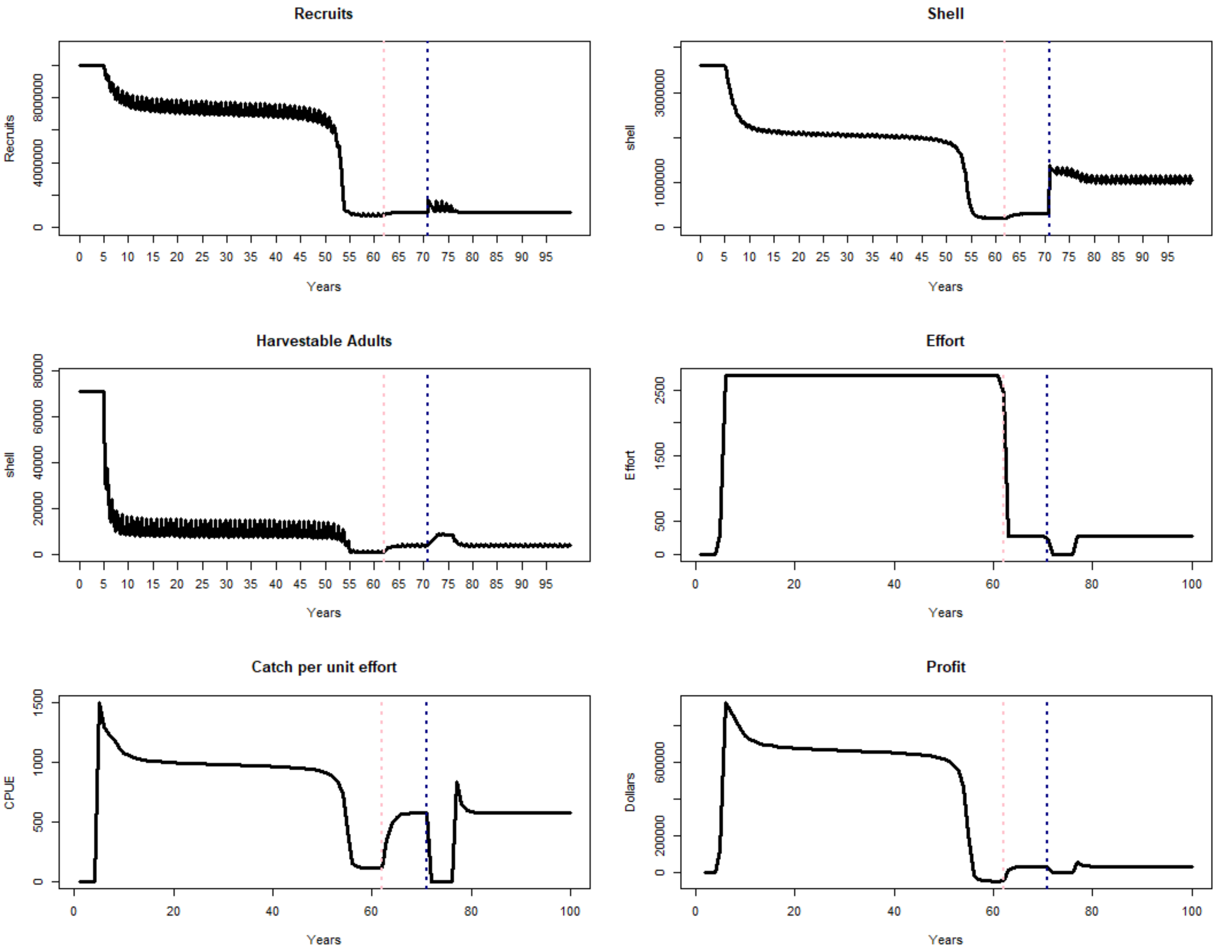
2.8 Active Harvest Mgmt.



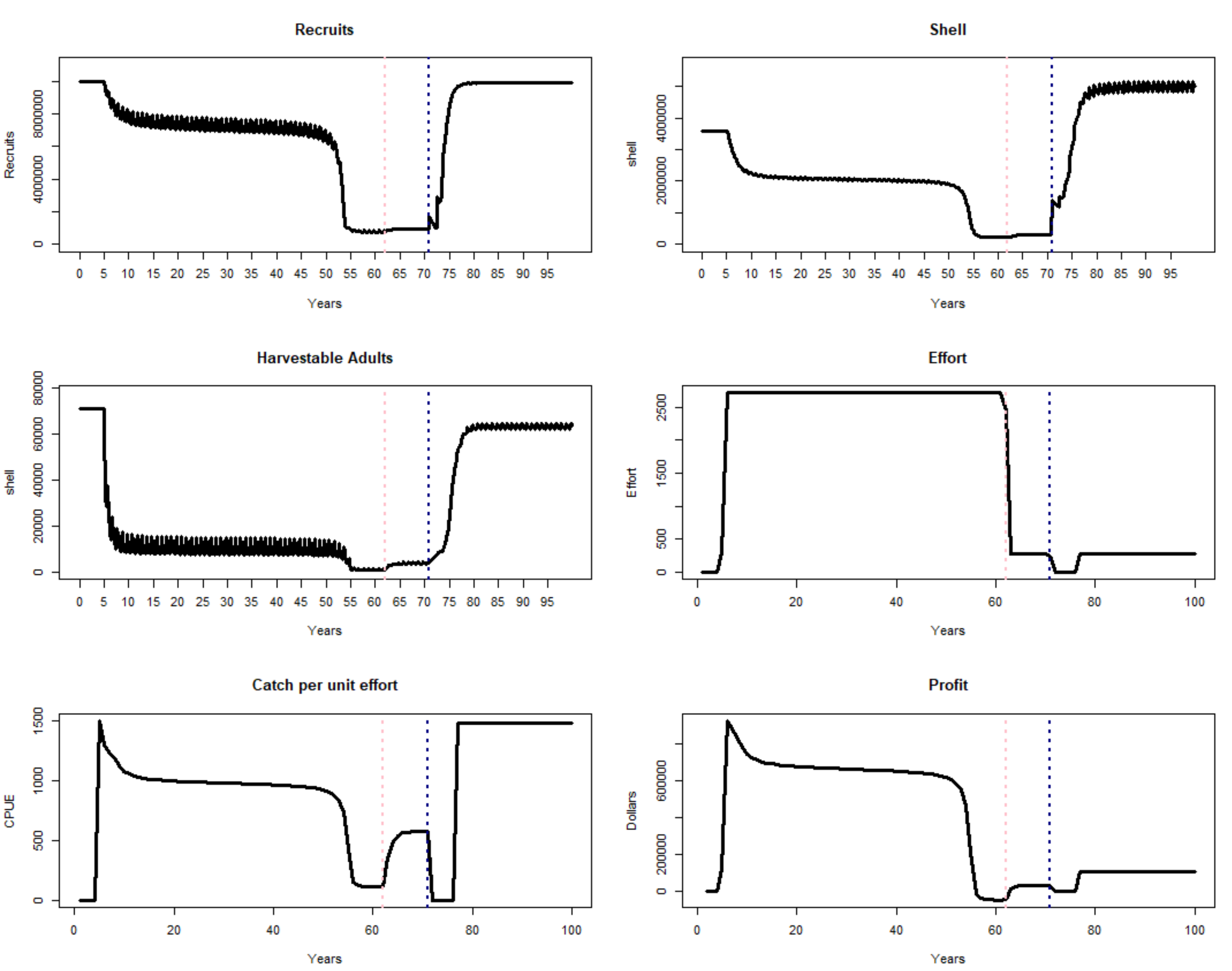
2.9 Annual shelling—No annual rest.



2.9.1 Annual shelling—5% annual rest



2.9.2 Annual shelling—10% annual rest



2. Review summary

- Substrate-recruitment relationship is critical but very uncertain.
  - Very asymmetrical risk (not enough vs. “too much” restoration)
- Limited Entry or Active Harvest Mgmt. can sustain a fishery
  - Both show trade-off between Effort/total rev and Profitability/Oyster pops
  - LE can allow for fewer people to make more profit
  - AHM would create a “race to fish” or derby
- Open Access is likely to cause collapse again, soon.
- Enough annual restoration *could* compensate for too small initial rest.
  - But it would be costly

2. Discussion and questions (so far)

Outline of things to go over

1. Disclaimer/disambiguation
2. Review of previous results
3. Simulation results: Unexpected increase in M
4. Simulation results: Annual restoration (alternating)
5. Simulation results: Stochasticity

3. Unexpected increase in M

- Could happen for lots of reasons
  - Predators, weather, environment, etc.
- Looked at several different things:
- First, variable “size” of increase (10-50%), assuming a single mgmt (limited entry at 10% pre-collapse effort)
- Second, looked at 15% M increase for various limited entry levels
- Third, looked at Open Access with 15% M increase
- Fourth, looked at Active Harvest Mgmt with 15% M increase.

3.1 Unexpected increase in M

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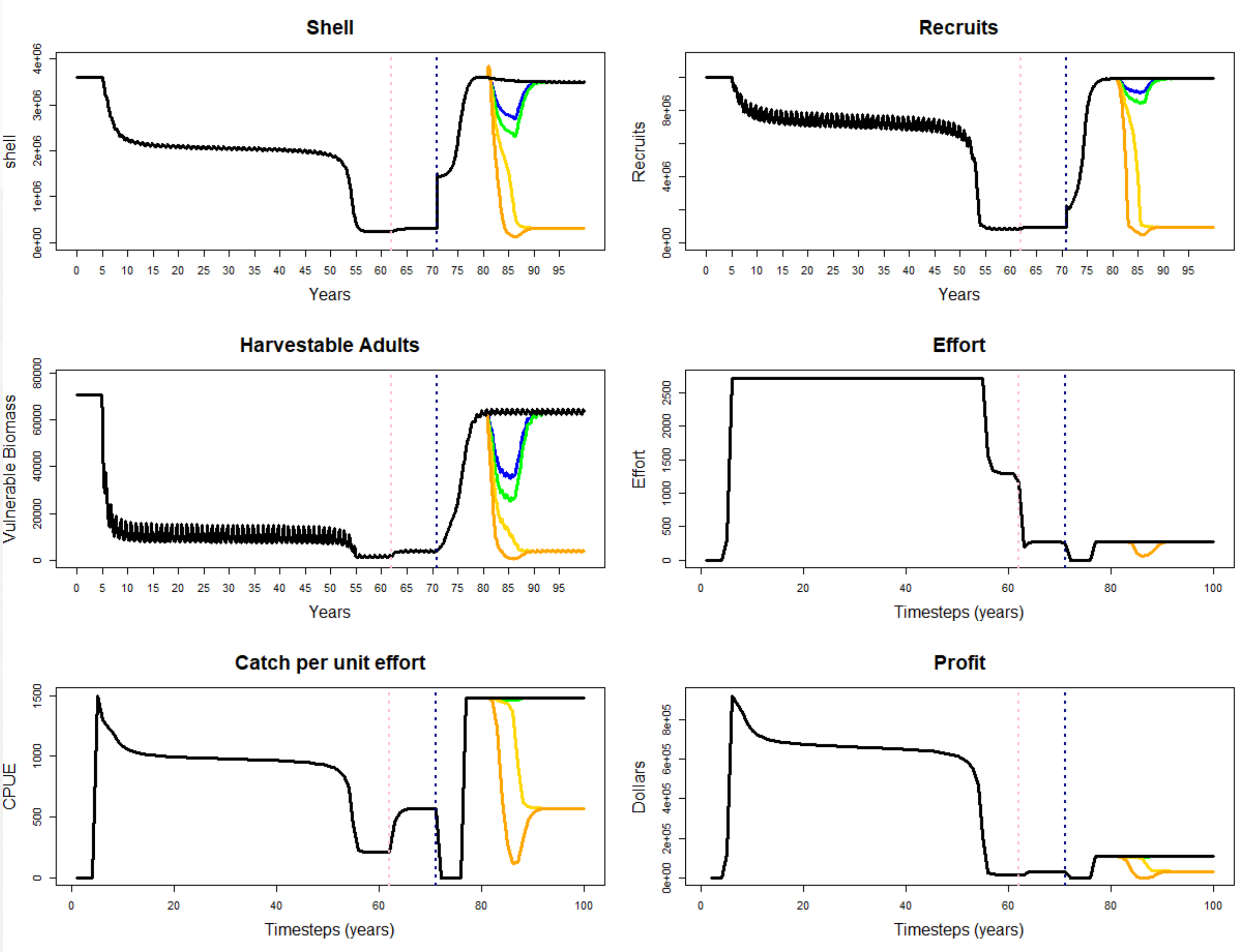
3.1 Increase in M (10-50%, 5yrs)



3.1 M increase summary

- A big enough shock (increase in M) can crash a recovered system
- Note, this did not allow an mgmt. response to increase—e.g. shutting down effort, or increasing habitat
- BUT smaller shocks (10, 15%) were fine, with this lower level of effort (10% pre-collapse effort)

3.2 Unexpected increase in M

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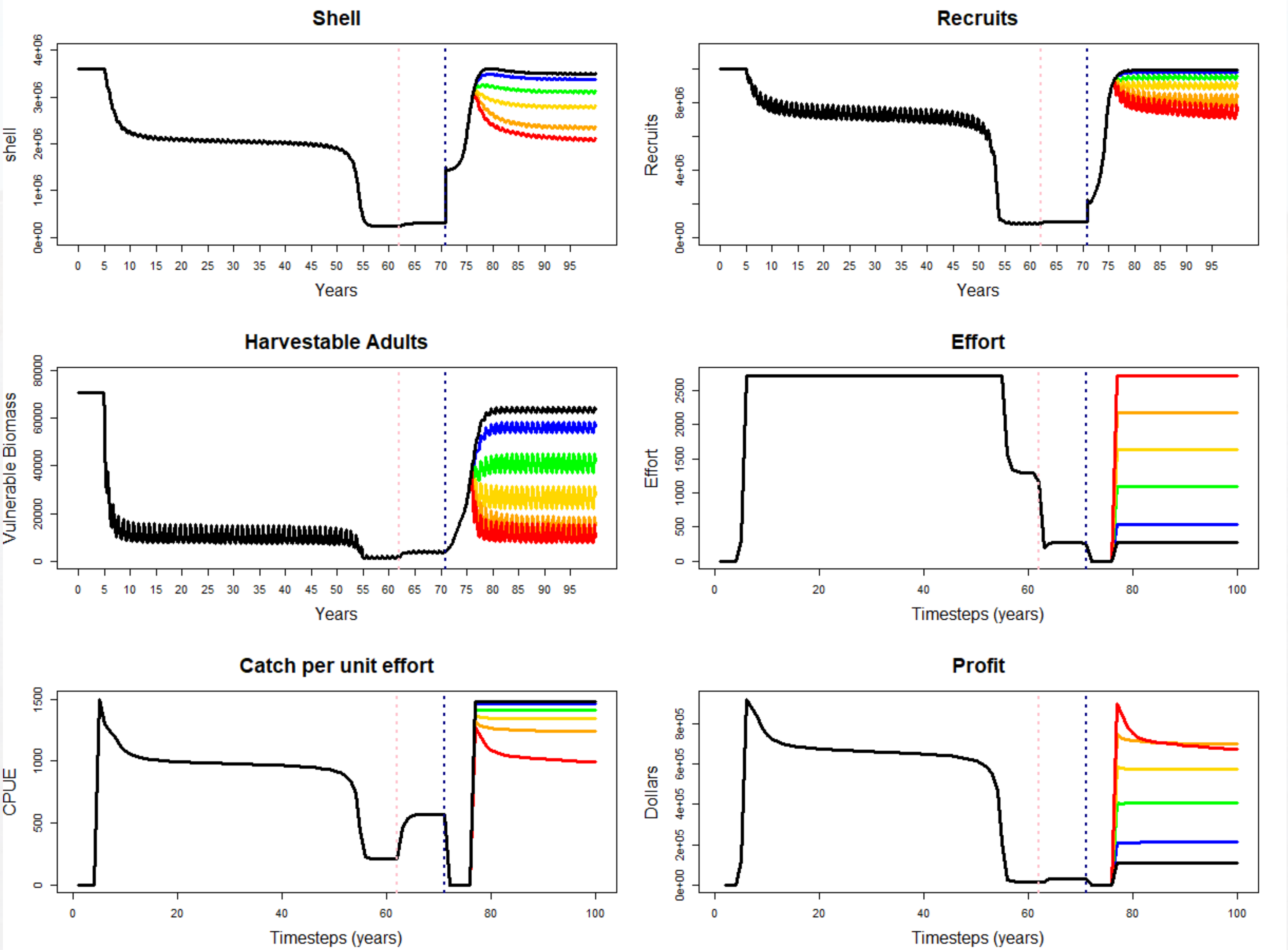
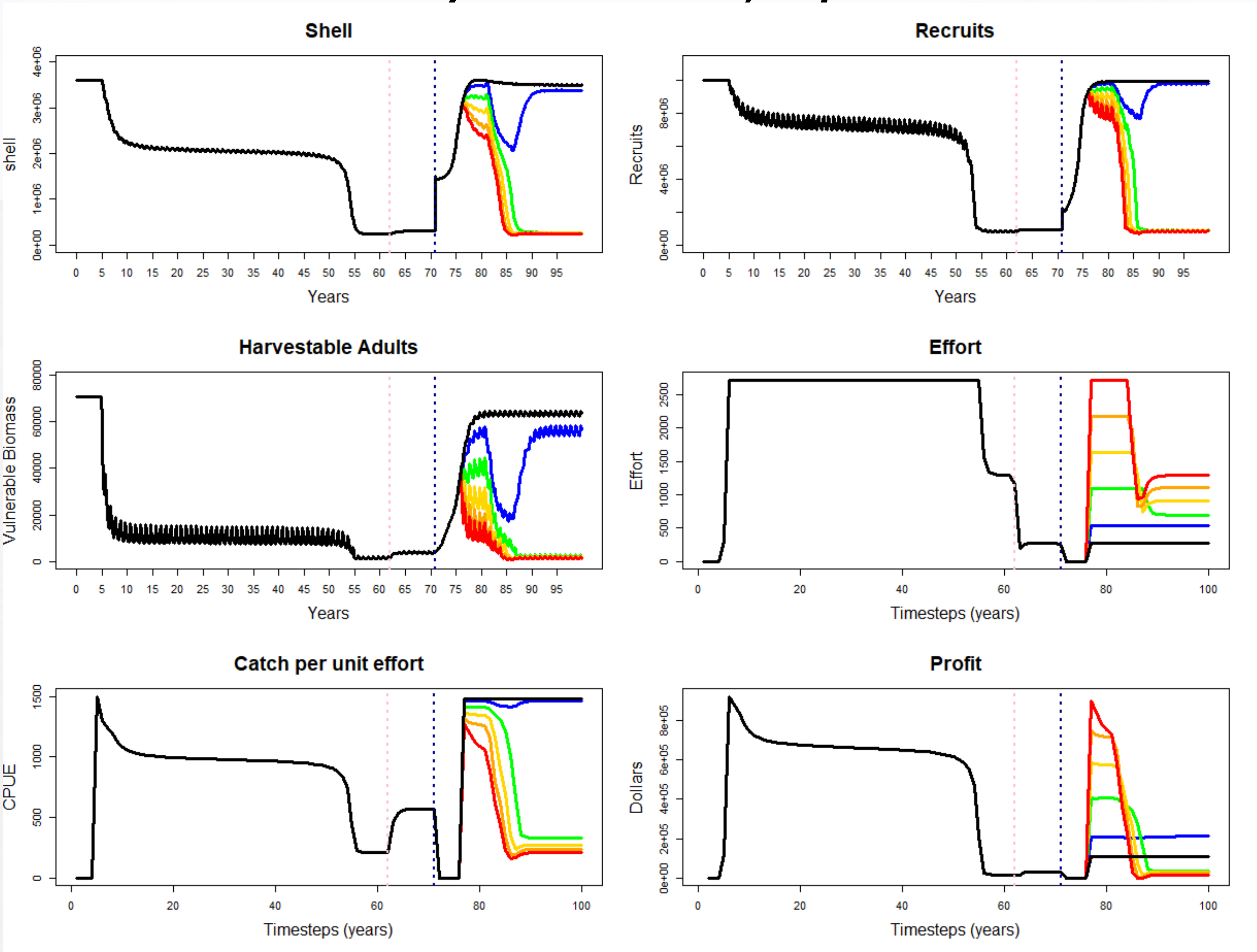
3.21 Limited Entry with NO M increase



3.22 Limited Entry with 15%, 5yr M increase



3.2 M increase Limited Entry summary

- Limited entry can protect against unexpected M increase
- But only if the effort is limited substantially below the bioeconomic equilibrium
- That means when there is no problem: it’s going to appear as if the system could sustain much more effort
- What would it take to have the political/social will to do this?

3.3 Unexpected increase in M

- Could happen for lots of reasons
  - Predators, weather, environment, etc.
- Looked at several different things:
- First, variable “size” of increase (10-50%), assuming a single mgmt (limited entry at 10% pre-collapse effort)
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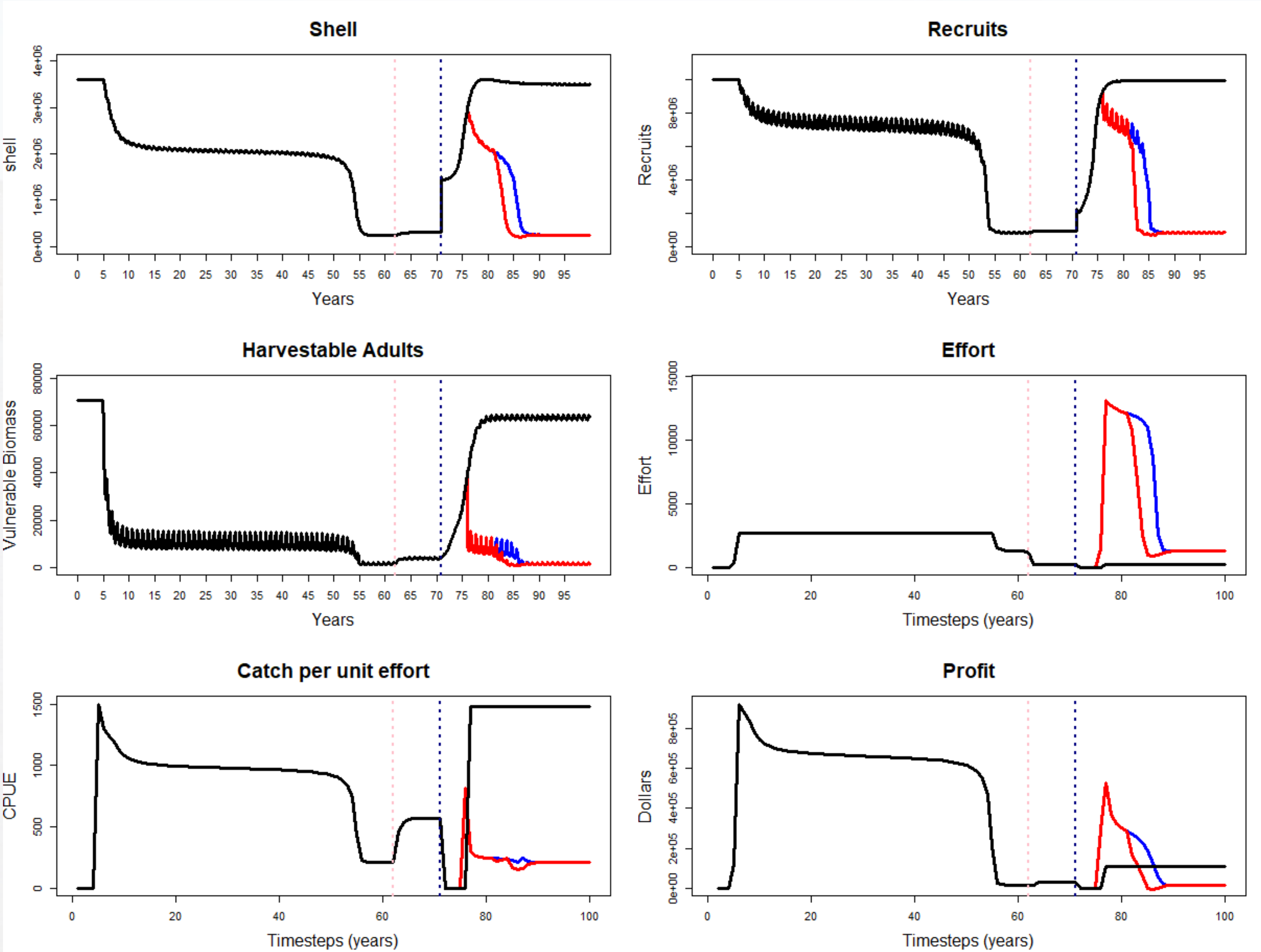
3.3 Open Access with 15%, 5yr M increase



3.3 M increase Open Access summary

- Actually very hard to tell a difference
  - May have happened before and not been noticed?
- So, if we have open access, we might not worry about further increase in M…but not for good reasons.

3.4 Unexpected increase in M

- Could happen for lots of reasons
  - Predators, weather, environment, etc.
- Looked at several different things:
- First, variable “size” of increase (10-50%), assuming a single mgmt (limited entry at 10% pre-collapse effort)
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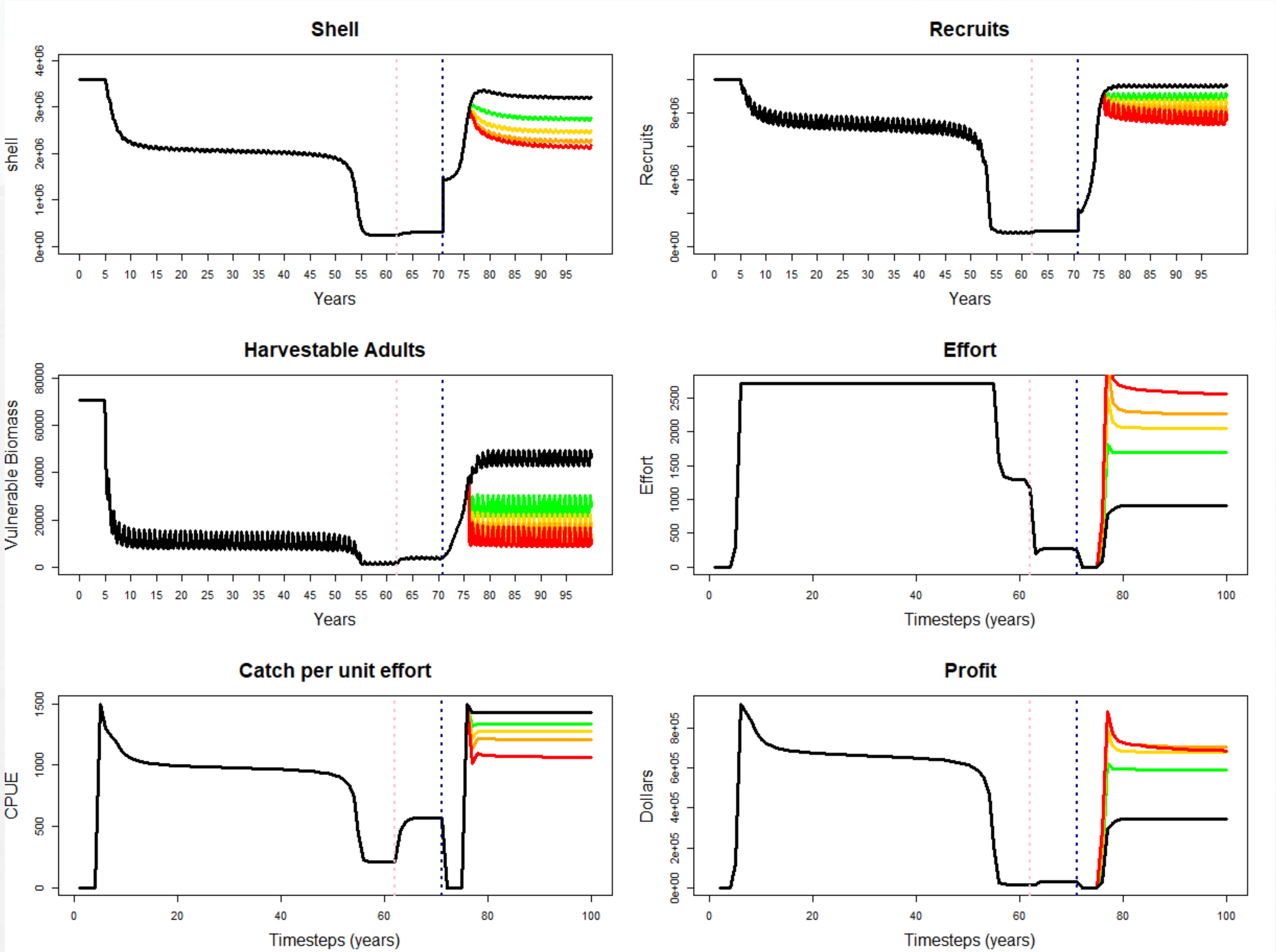
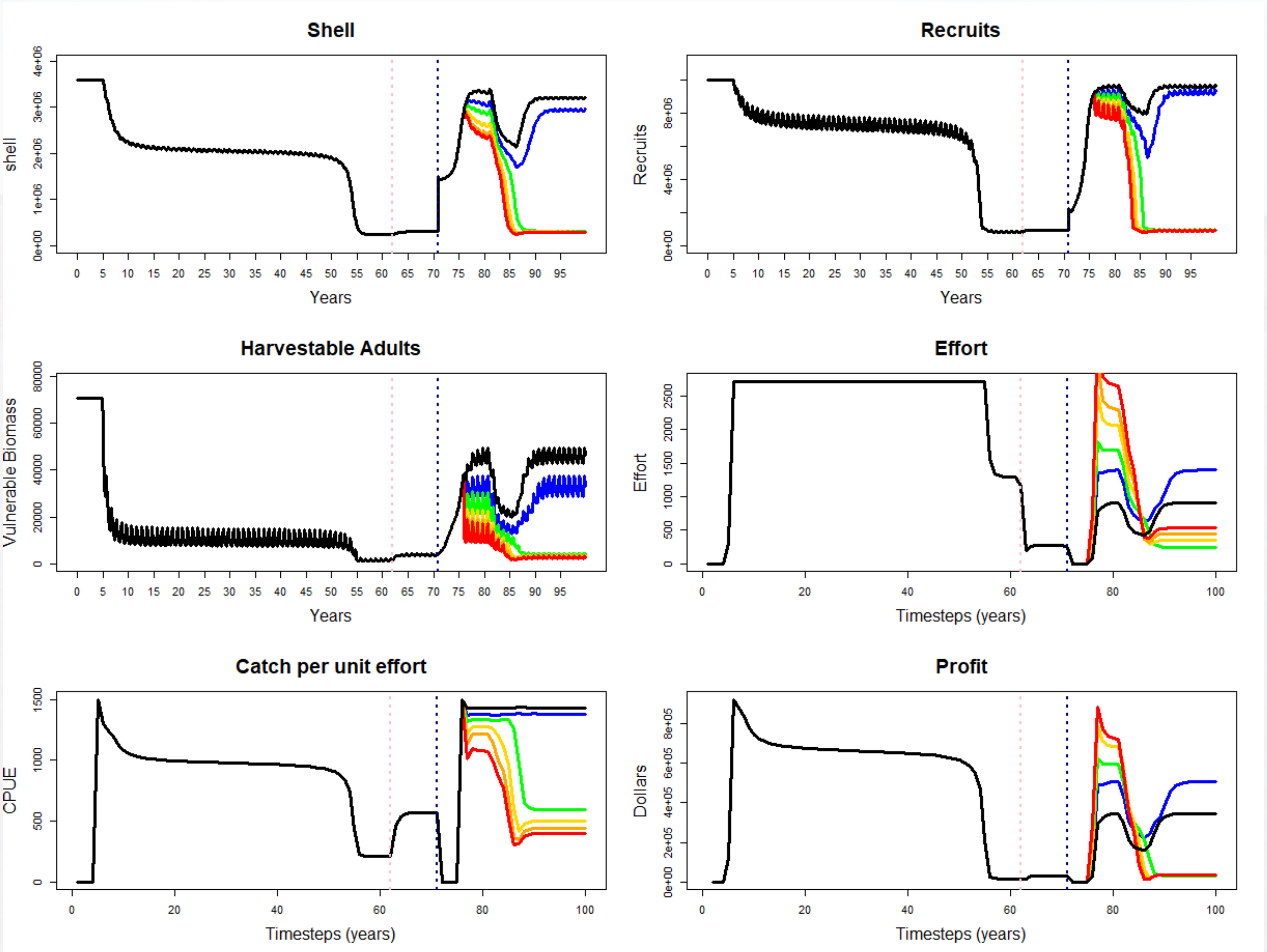
3.4 Active Harvest Mgmt.—no increase in M



3.4 Active Harvest Mgmt. with 15%, 5yr M increase



3.4 M increase Active Harvest Mgmt summary

- Similar to Limited Entry—can work if harvest rate set low enough
  - Interesting that in this simulation, 30% is too high
  - Even with perfect monitoring, taking 30% of the legal oysters, combined with the unexpected increase in M, led to too much death for the system to be sustained.
  - Oysters are not well-evolved to become rare

3. Overall summary of increase in M

- If we want to avoid a future collapse, we must:
  - Control harvest (limited entry, active harvest mgmt.)
  - Be more conservative with harvest than “average” conditions

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4. Alternating restoration--methods

- Adding a small amount of substrate* (about 1/6, ~15%) of the “big” restoration **every other year.**

- Same caveats as last time, the model adds this substrate without concern for how it’s applied without smothering existing oysters.

- *This substrate is assumed to function like “good rock”, as in, it degrades very slowly and is used for recruitment. Same assumptions as all the substrate. Just remember we’re not sure what the formula for “good rock” is.

4. Alternating restoration: simulations

- Show what this looks like in baseline no recovery/recovery
- Combine alt. rest. with M increase (different intensities)
- Combine alt. rest. with Limited Entry
- Combine alt. rest with open access
- Combine alt. rest with Active Harvest Mgmt.

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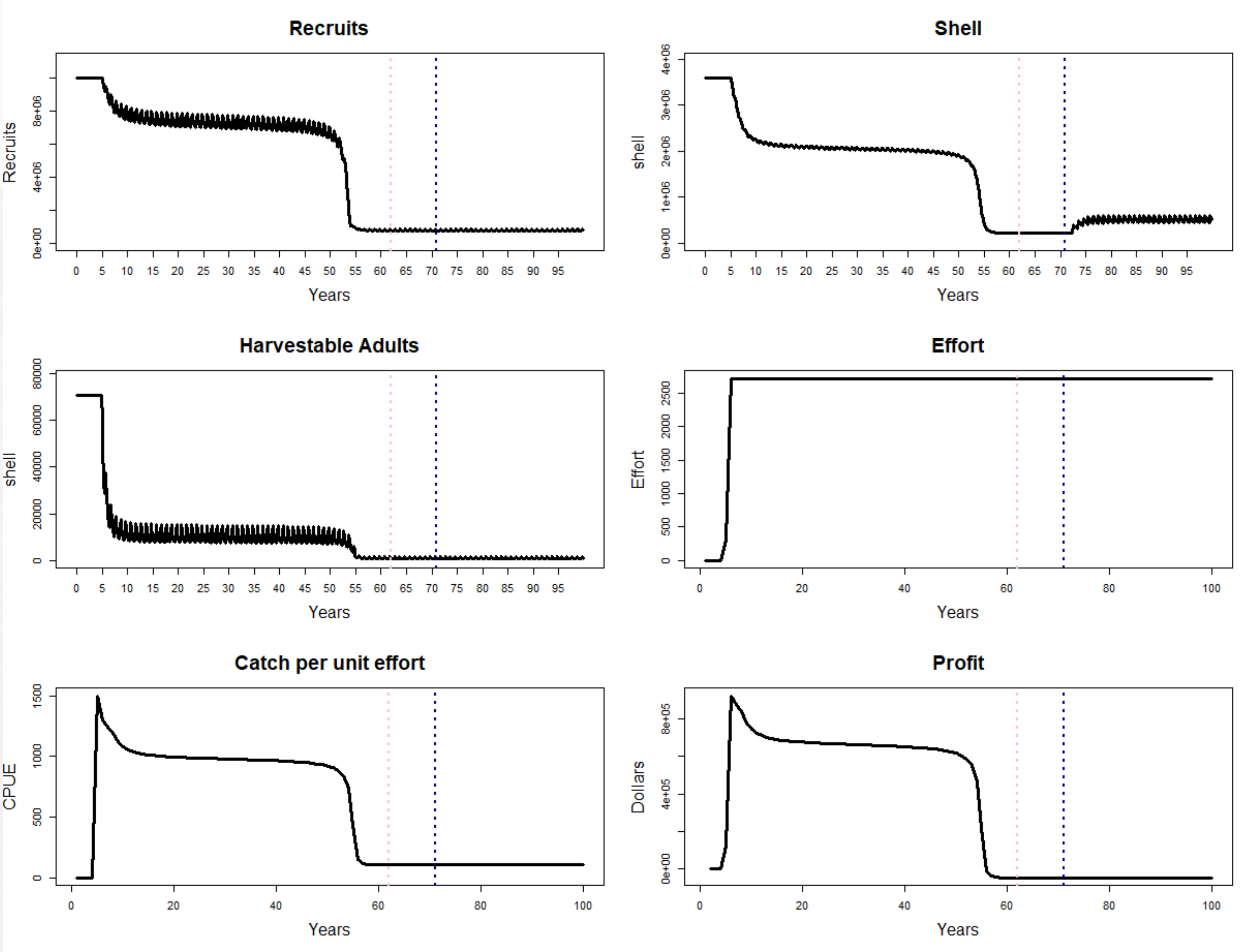
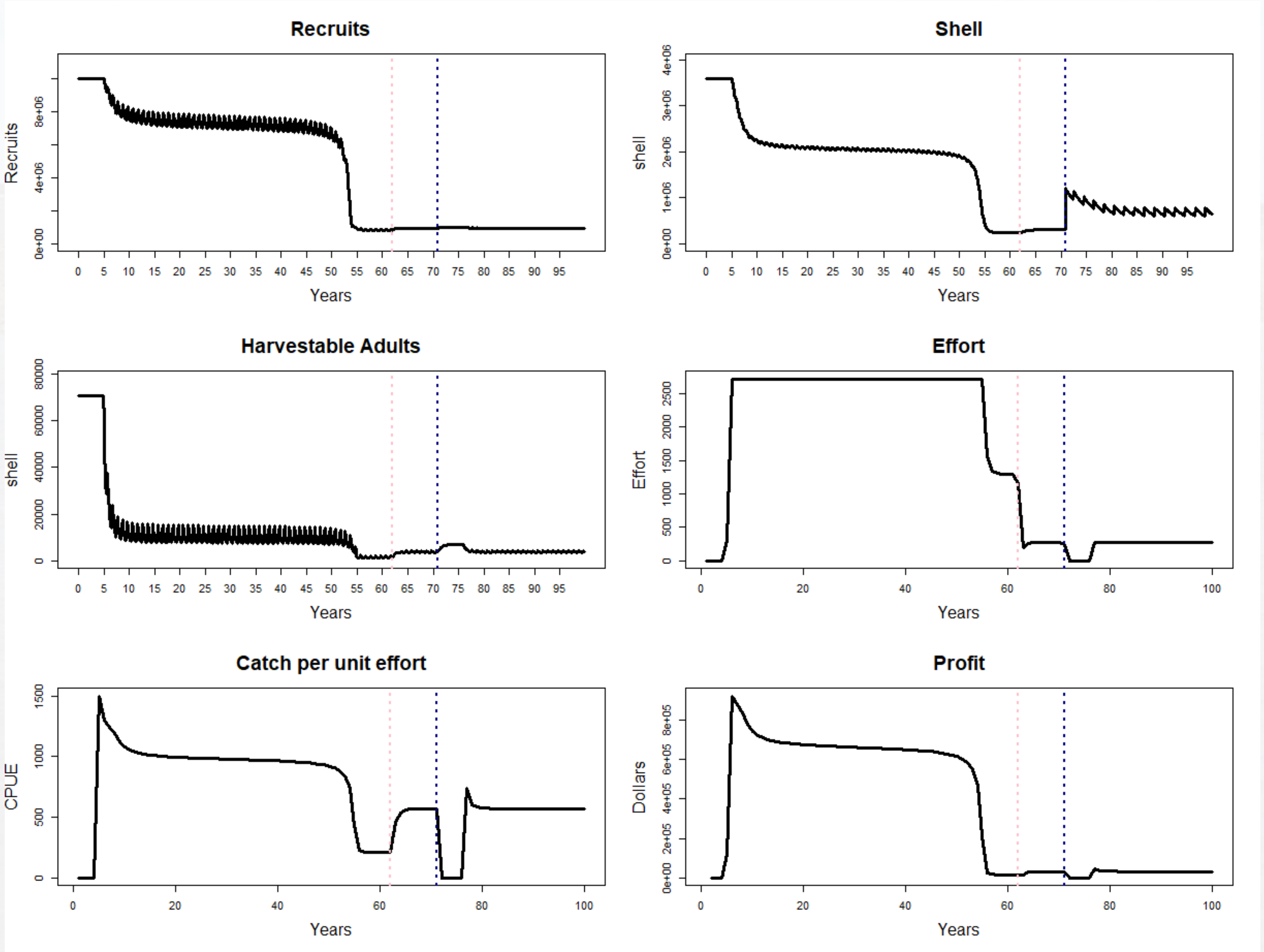
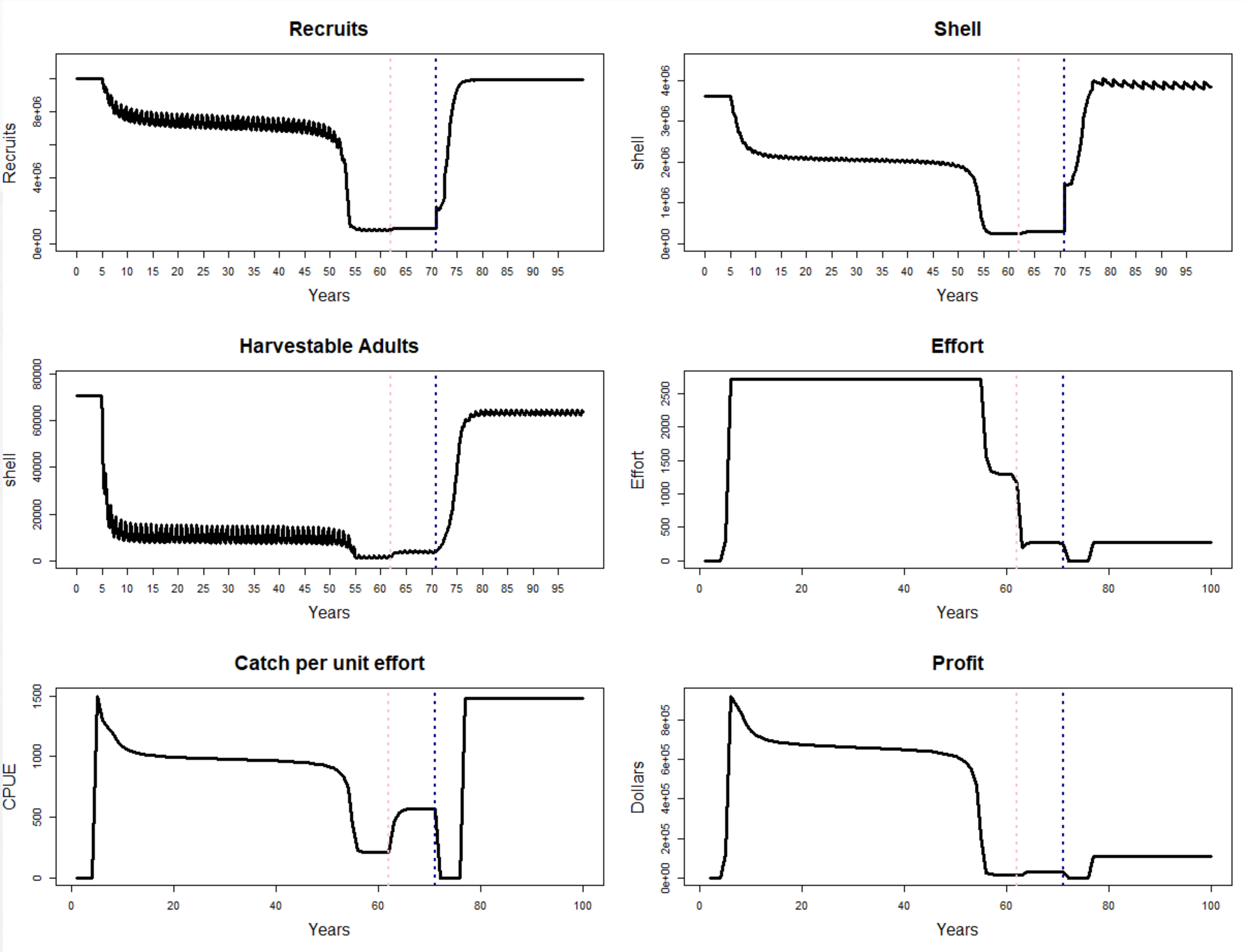
4.1 Old: shelling every year (no recovery)



4.1 Alternating years shelling, (no recovery)



4.1 Alternating years shelling, no recovery



4.2 Alternating restoration: simulations

- Show what this looks like in baseline no recovery/recovery
- Combine alt. rest. with M increase (different intensities)
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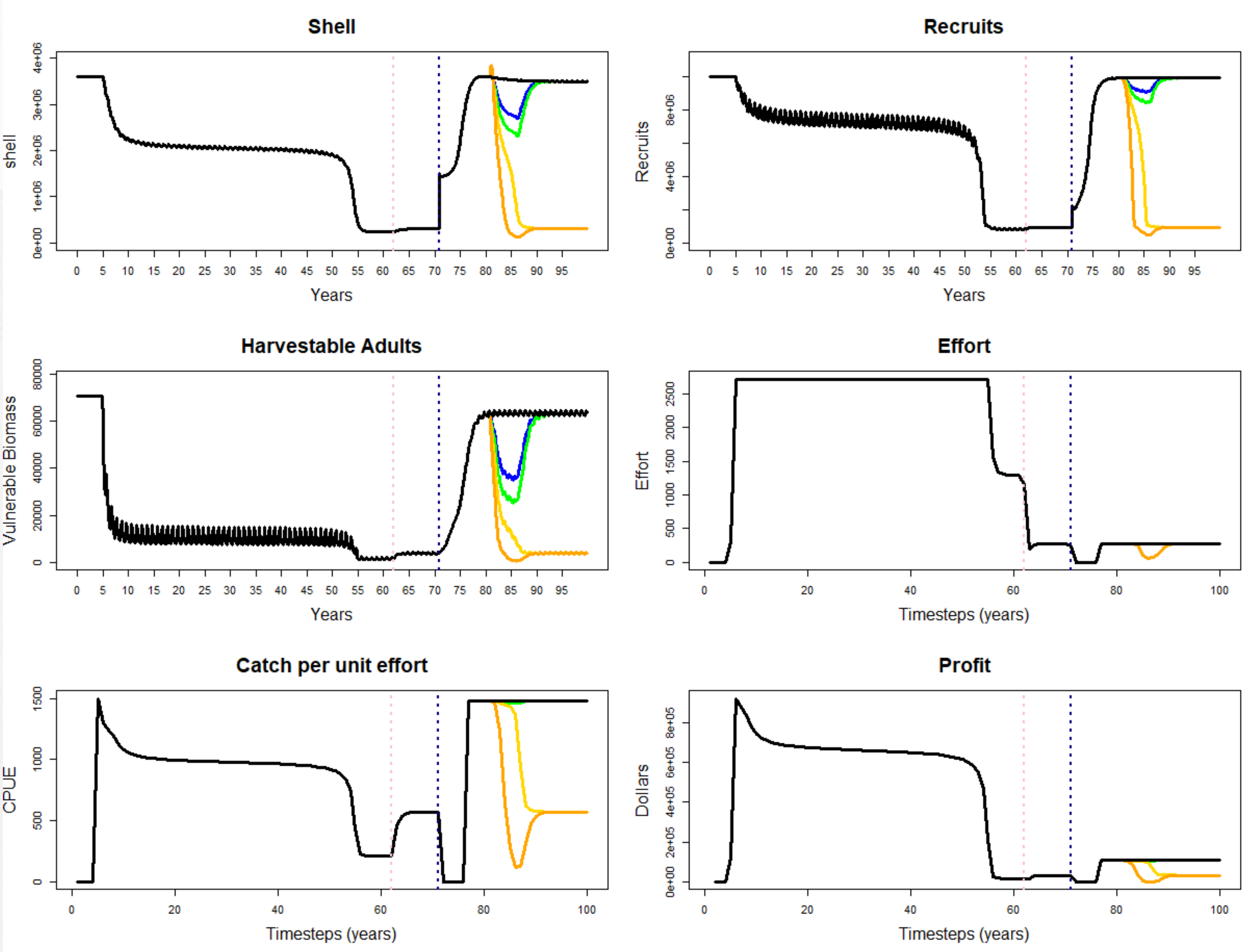
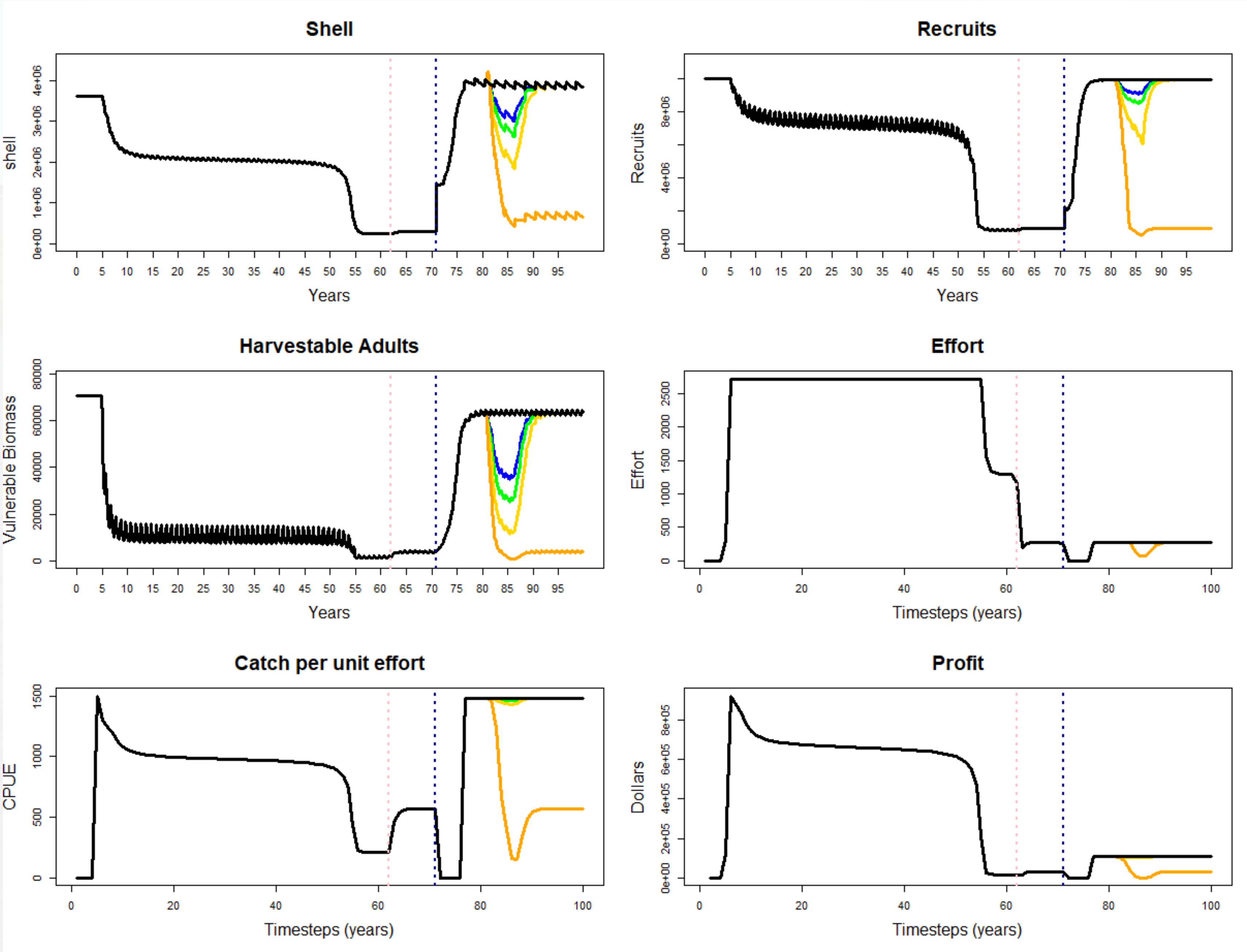
- Combine alt. rest with open access
- Combine alt. rest with Active Harvest Mgmt.

4.2 Without alt. rest: Increase in M (10-50%, 5yrs)



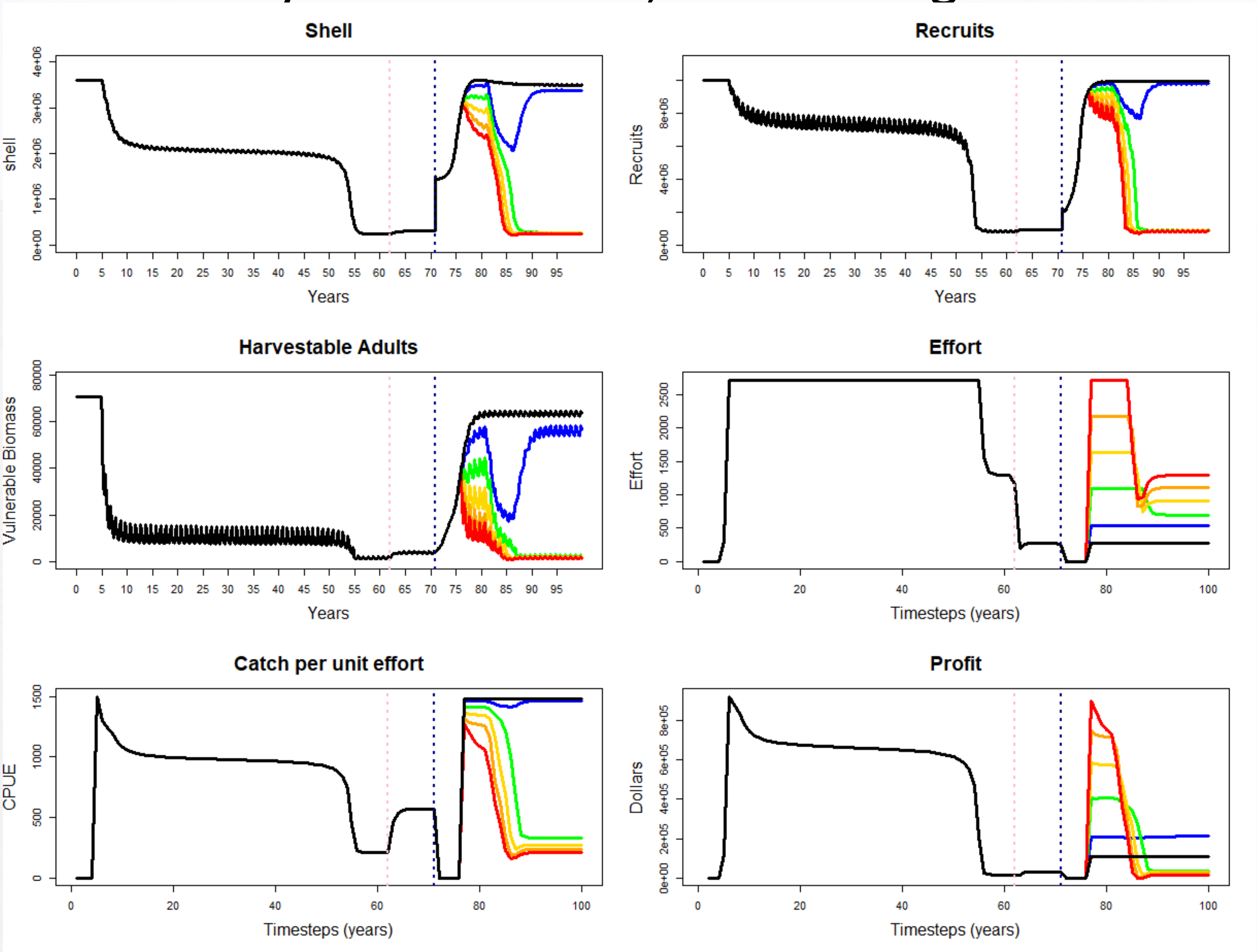
4.2 Alternating years shelling, M increase



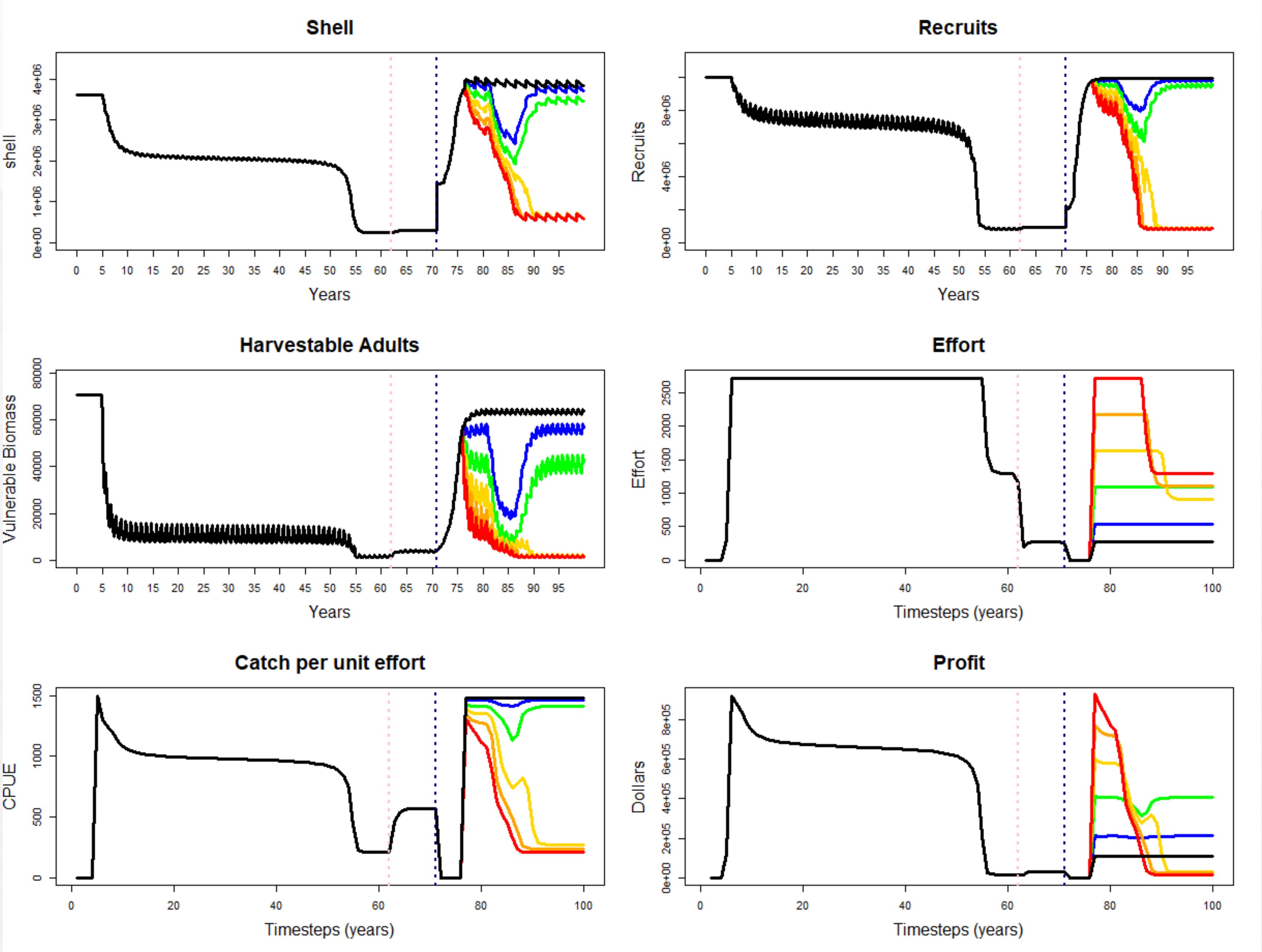
4.3 Alternating restoration: simulations

- Show what this looks like in baseline no recovery/recovery
- Combine alt. rest. with M increase (different intensities)
- Combine alt. rest. with Limited Entry
- Combine alt. rest with open access
- Combine alt. rest with Active Harvest Mgmt.

4.3 Lim. Entry w M increase, NO shelling



4.3 Lim. Entry w M increase, alt shelling



4.4 Alternating restoration: simulations

- Show what this looks like in baseline no recovery/recovery
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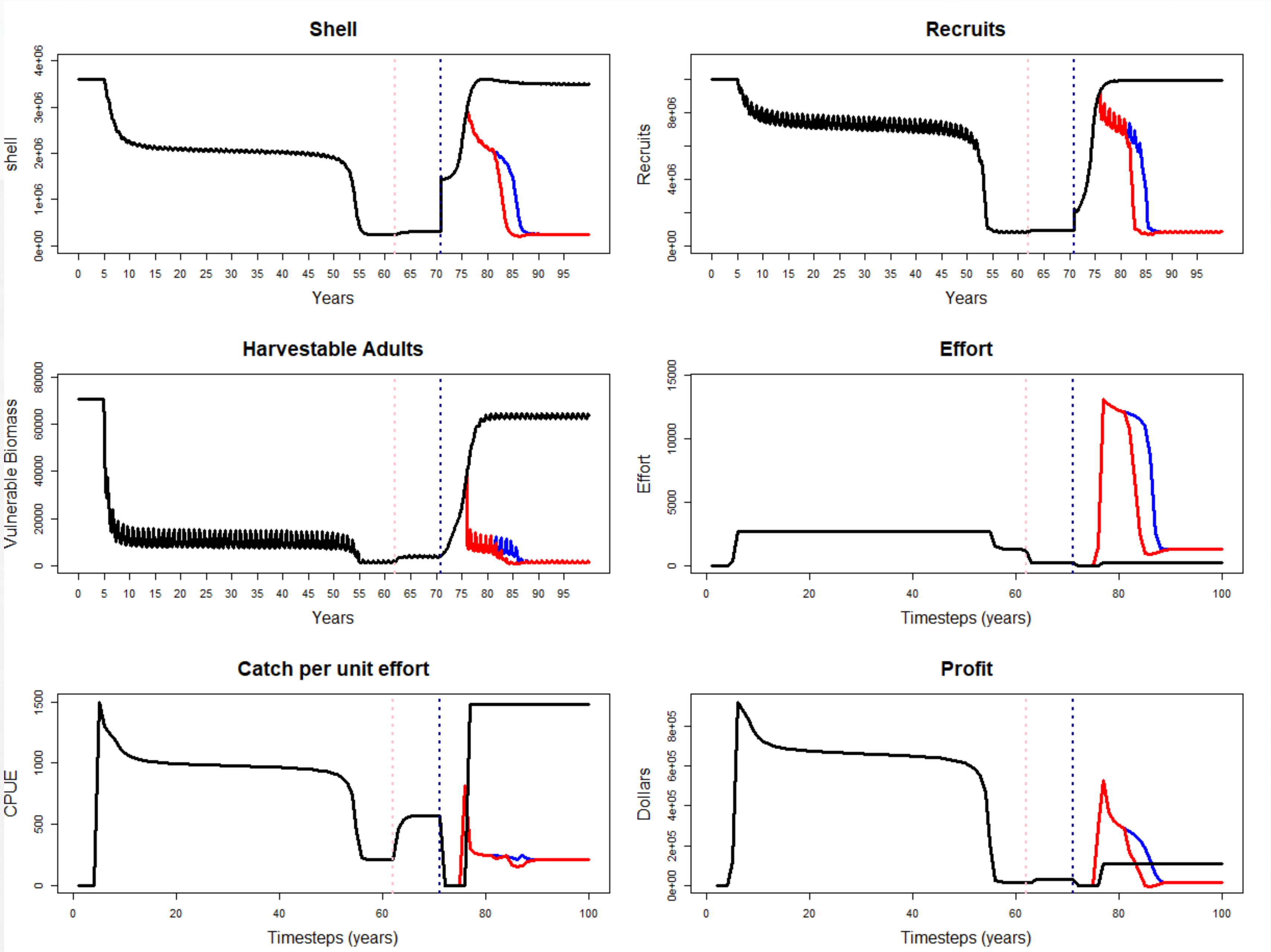
4.4 Open Access with 15%, 5yr M increase



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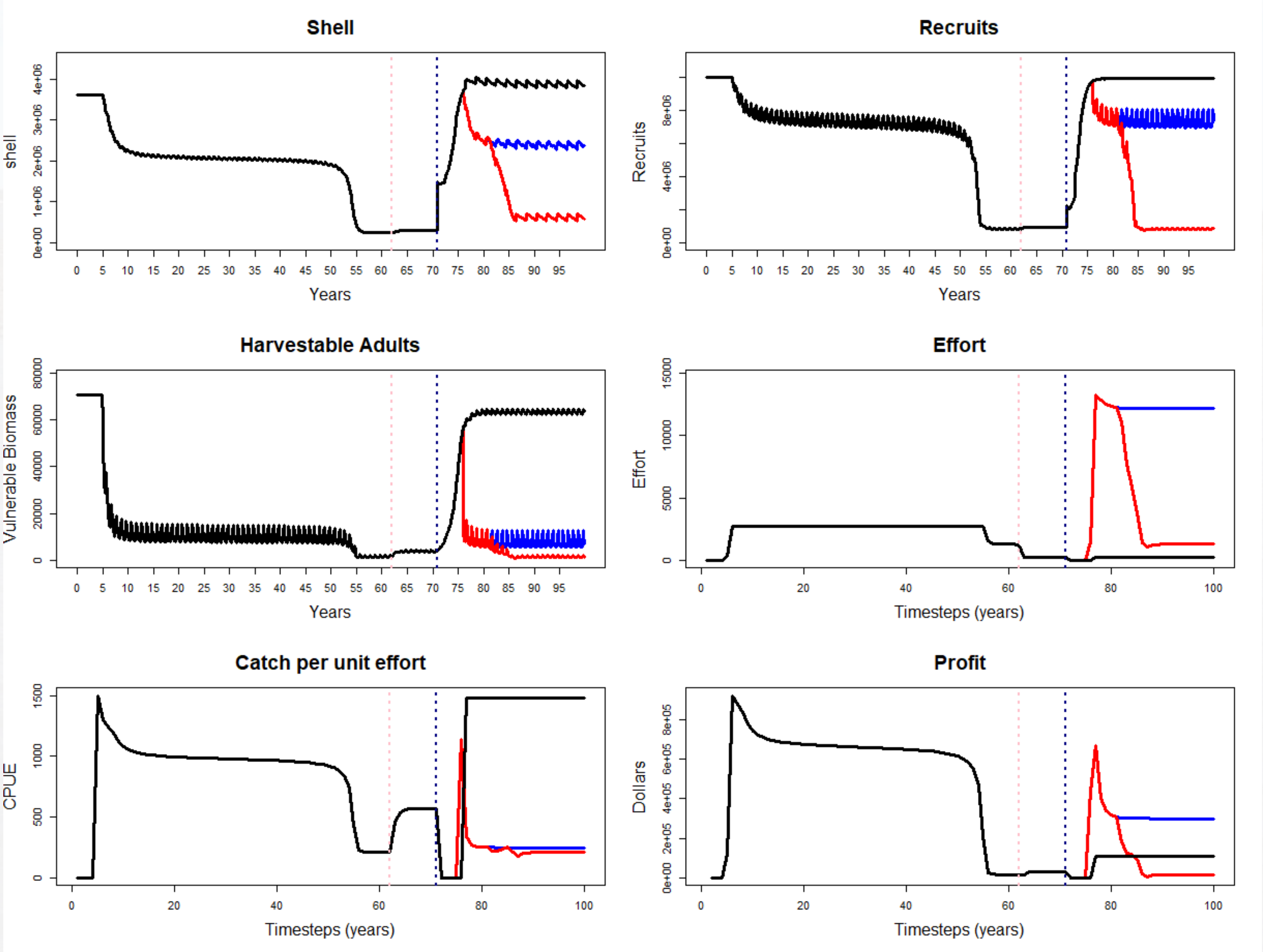

4.5 Alternating restoration: simulations

- Show what this looks like in baseline no recovery/recovery
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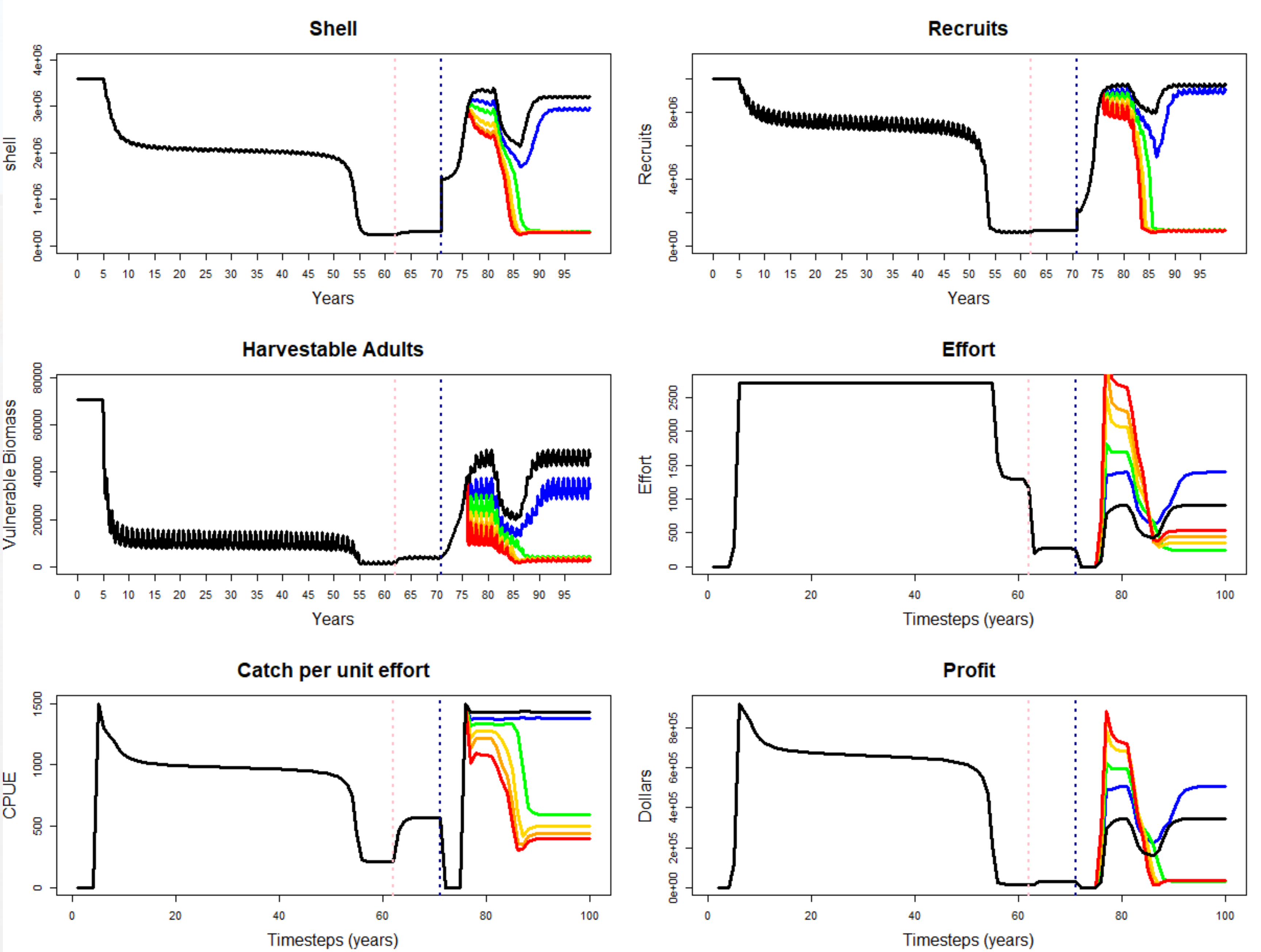
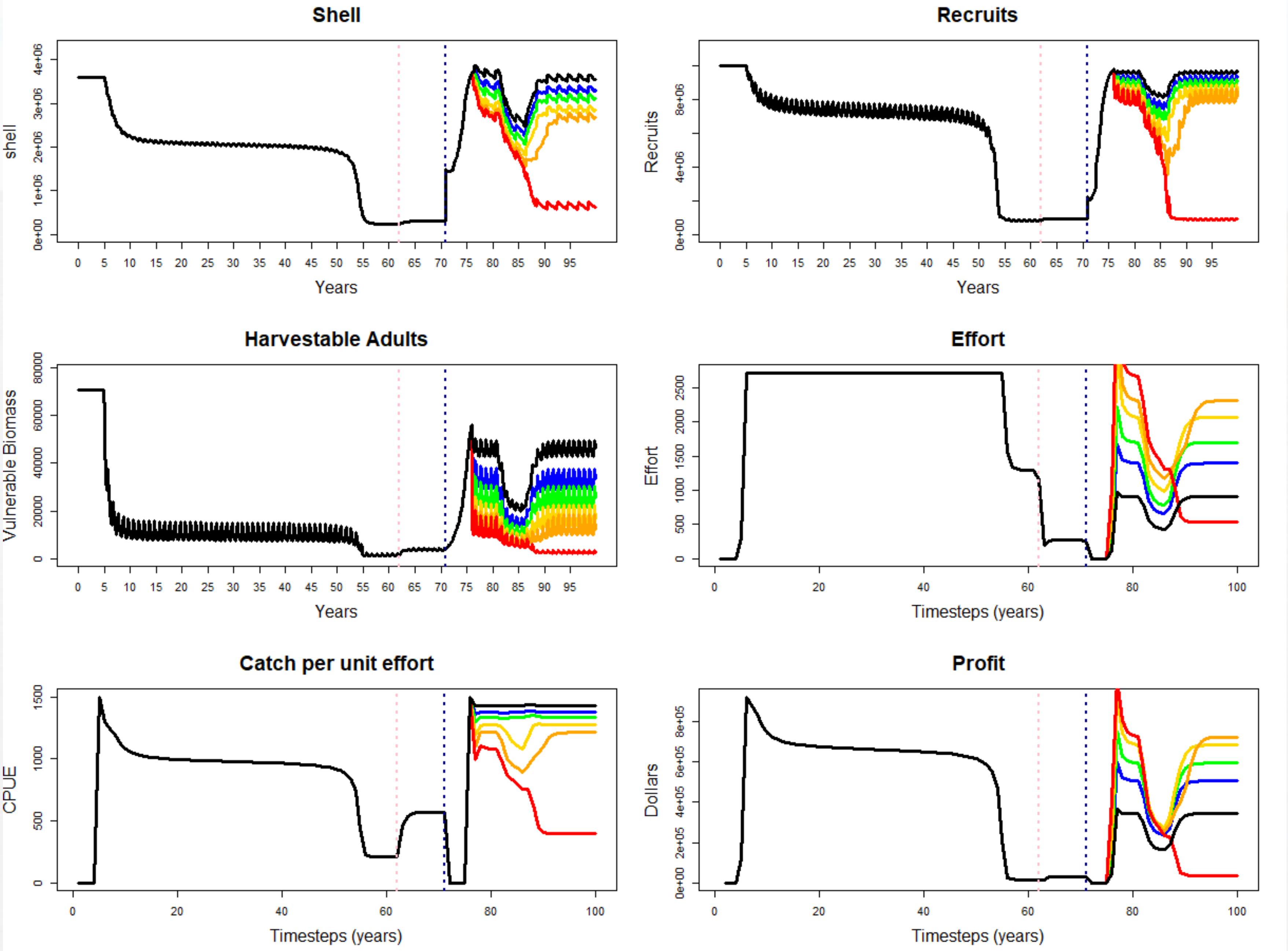
- Combine alt. rest with Active Harvest Mgmt.

4.5 Act. Harv. Mgmt. with M increase, no shelling



4.5 Act. Harv. Mgmt. with M increase, alt. shelling



4.6 Alternating restoration: summary

- As expected, alternative shelling makes everything a bit better.
- Limited entry can sustain more effort, even with M increase
- Open access sustains populations <u>without</u> M increase
- Active Harvest Mgmt. does really well—allowing much greater levels of harvest, at least for a while.

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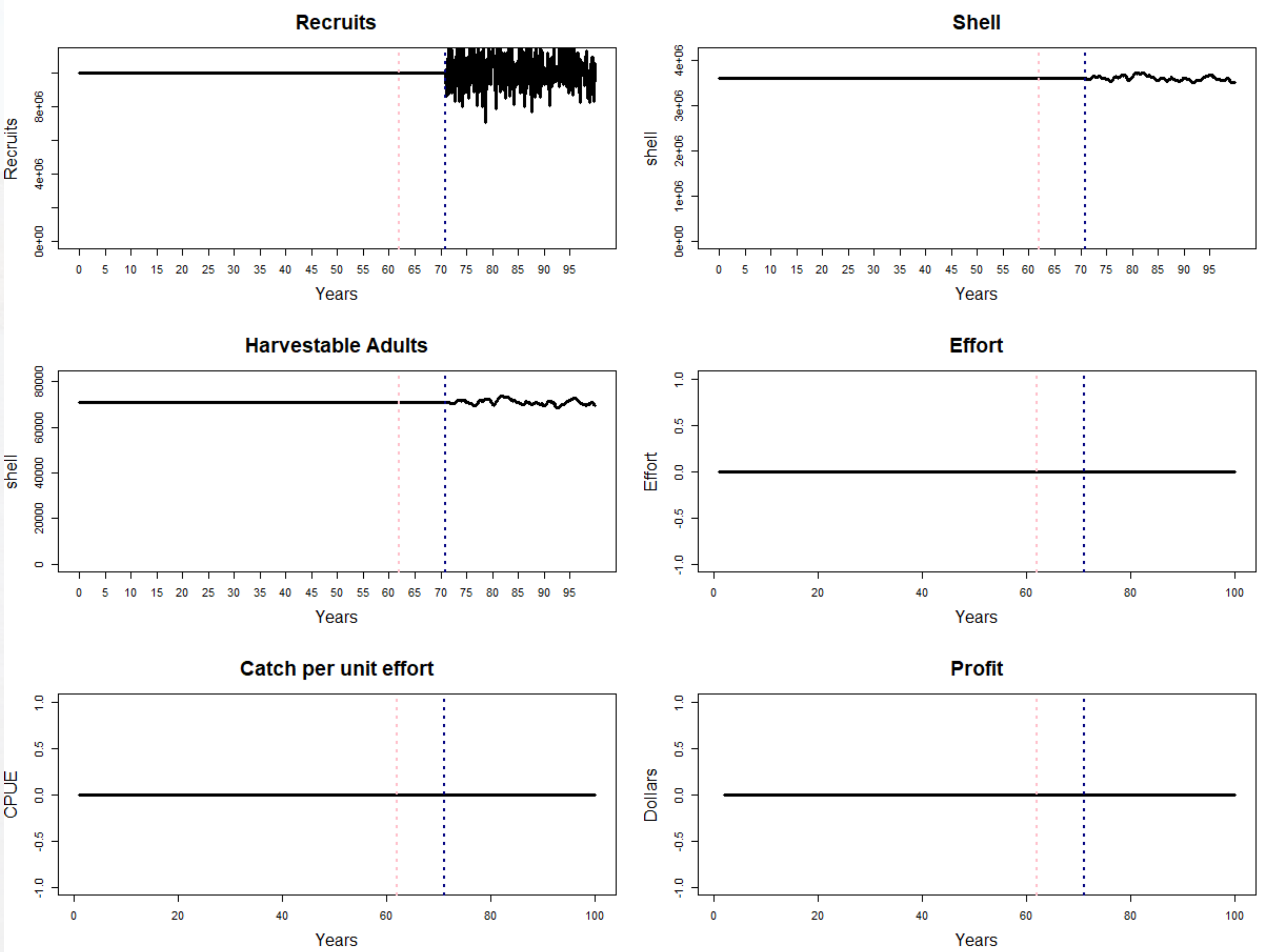
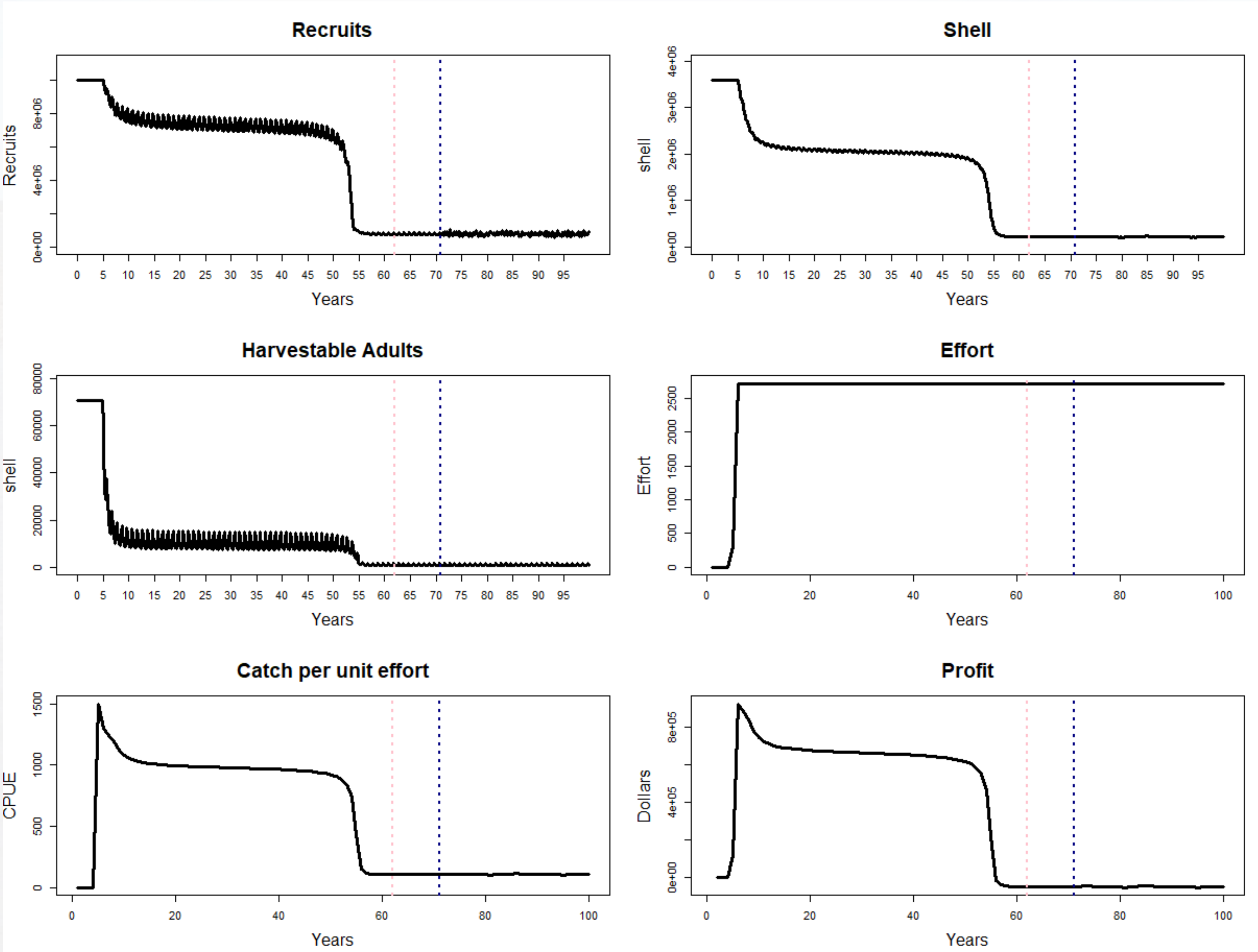
5. Stochasticity-methods

- Assume “process error” (variation in nature)
- Assume happens in recruitment process—basically survival in randomly varying year-to-year
- Assume only 10%--this is very low for recruitment variation
- **Each model “run” (time I “run” the code) is uses a new random process.** This makes things messy.
- Only going to show a lot of slides of previous scenarios, but now with randomness.

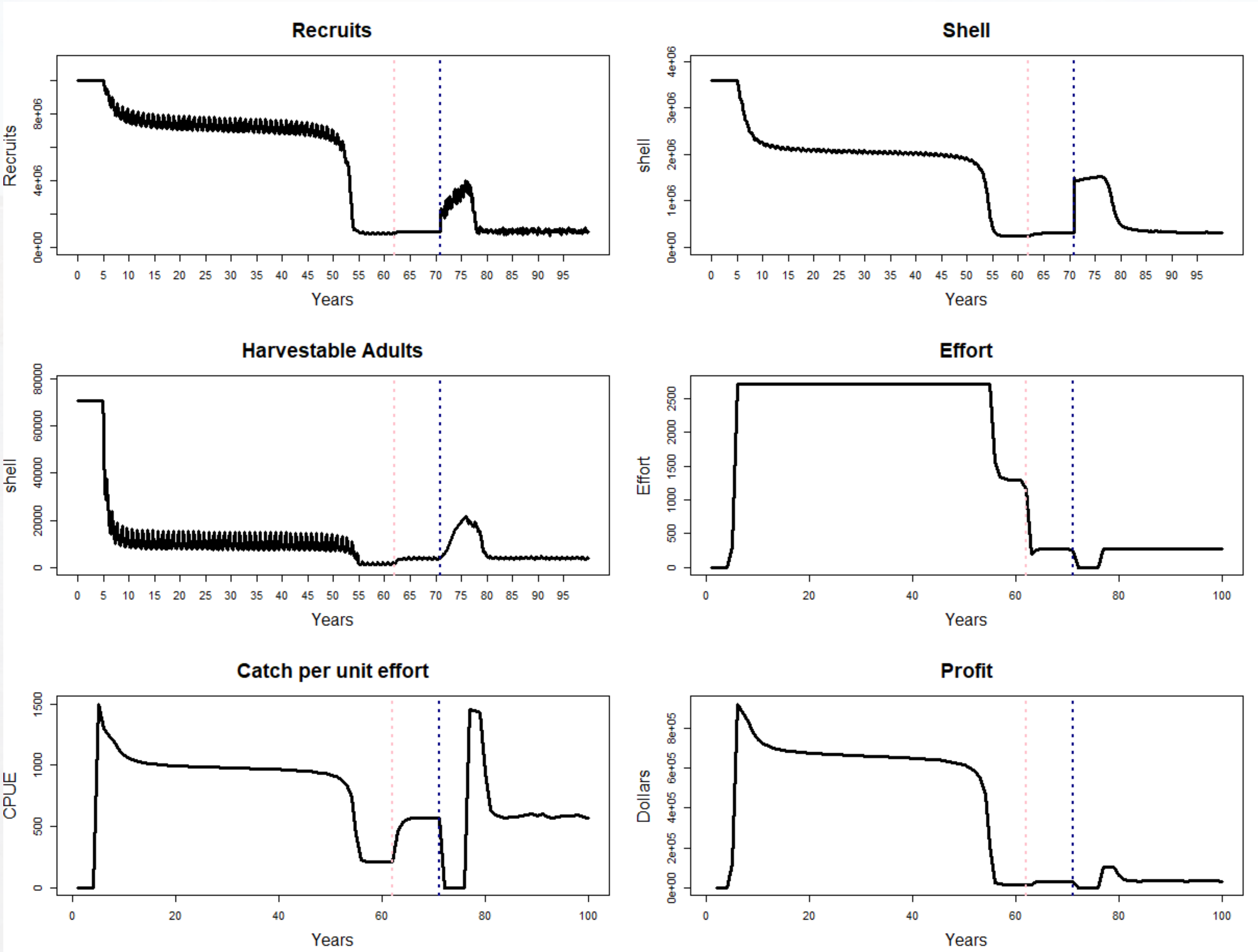
5.11 Null model stoch.—no fishing



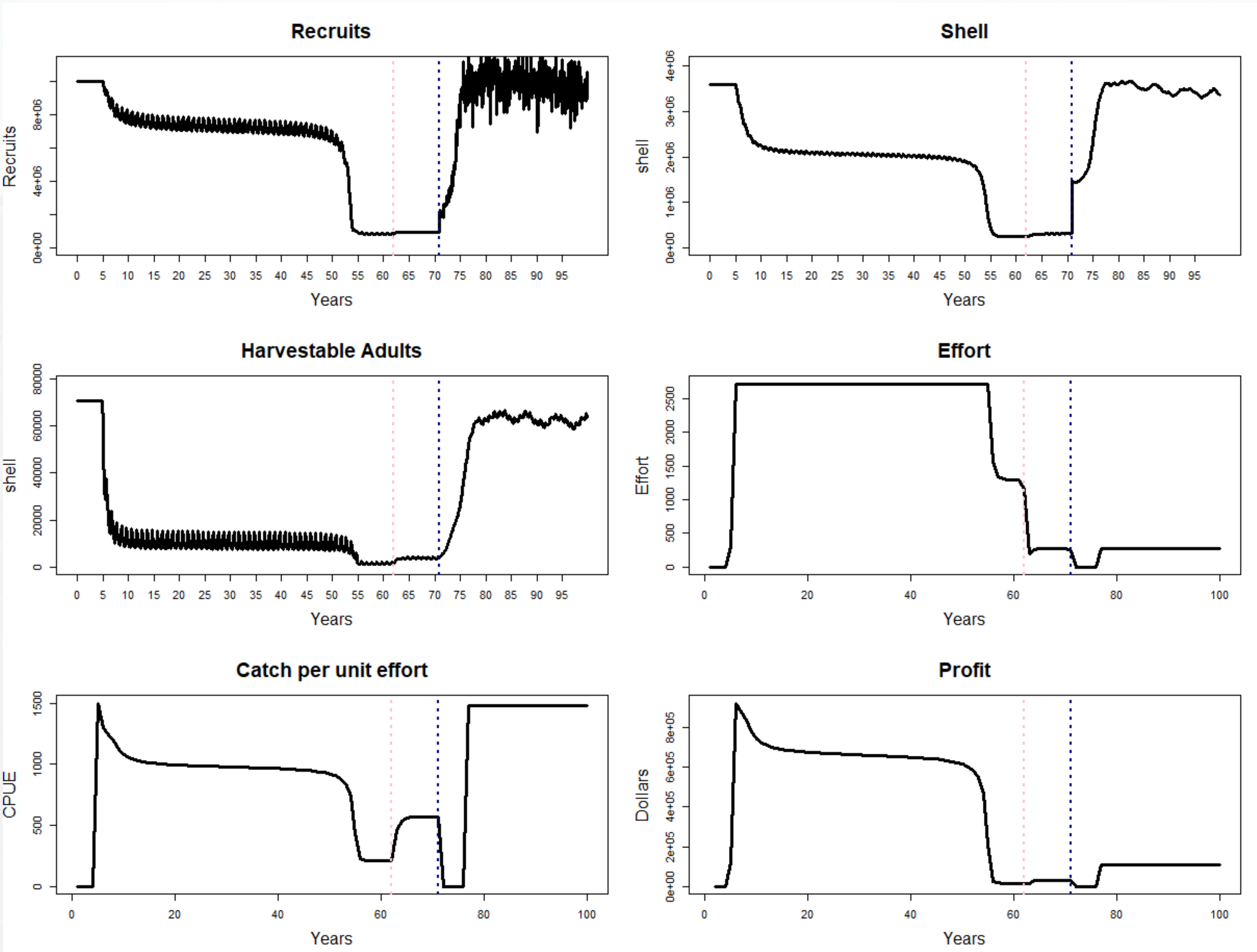
5.12 Stoch.—collapse



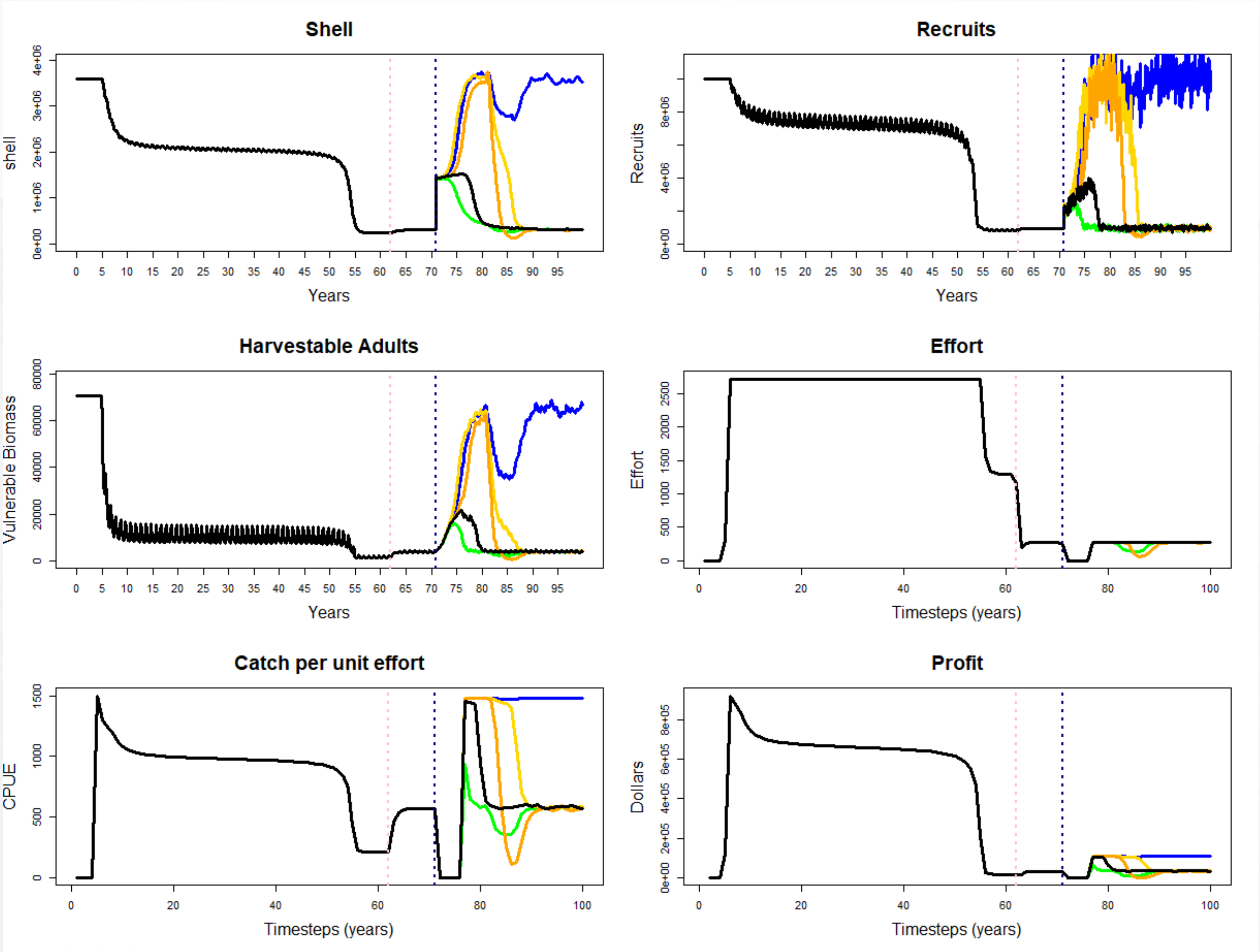
5.13 Stoch.—Recovery run1



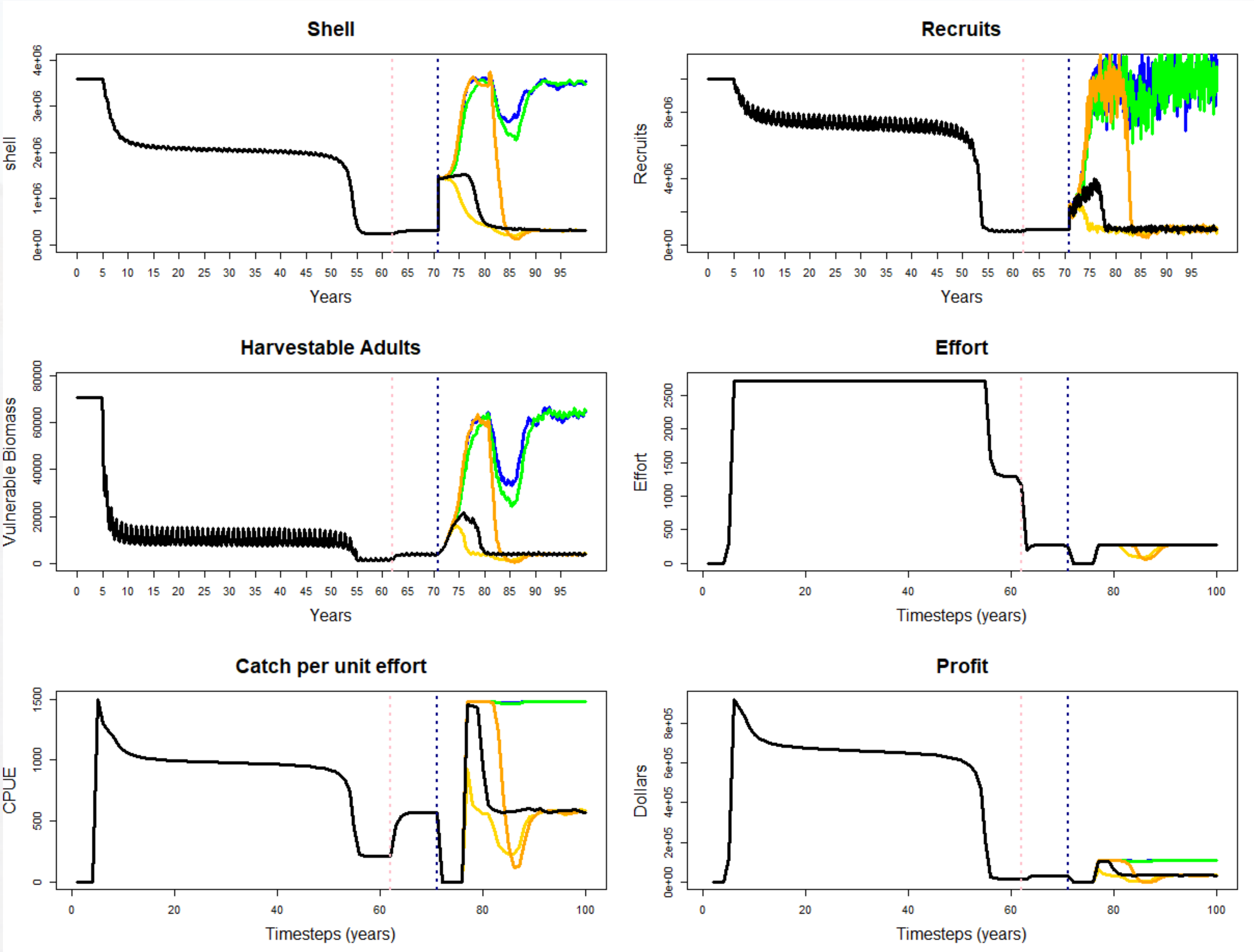
5.13 Stoch.—Recovery run2



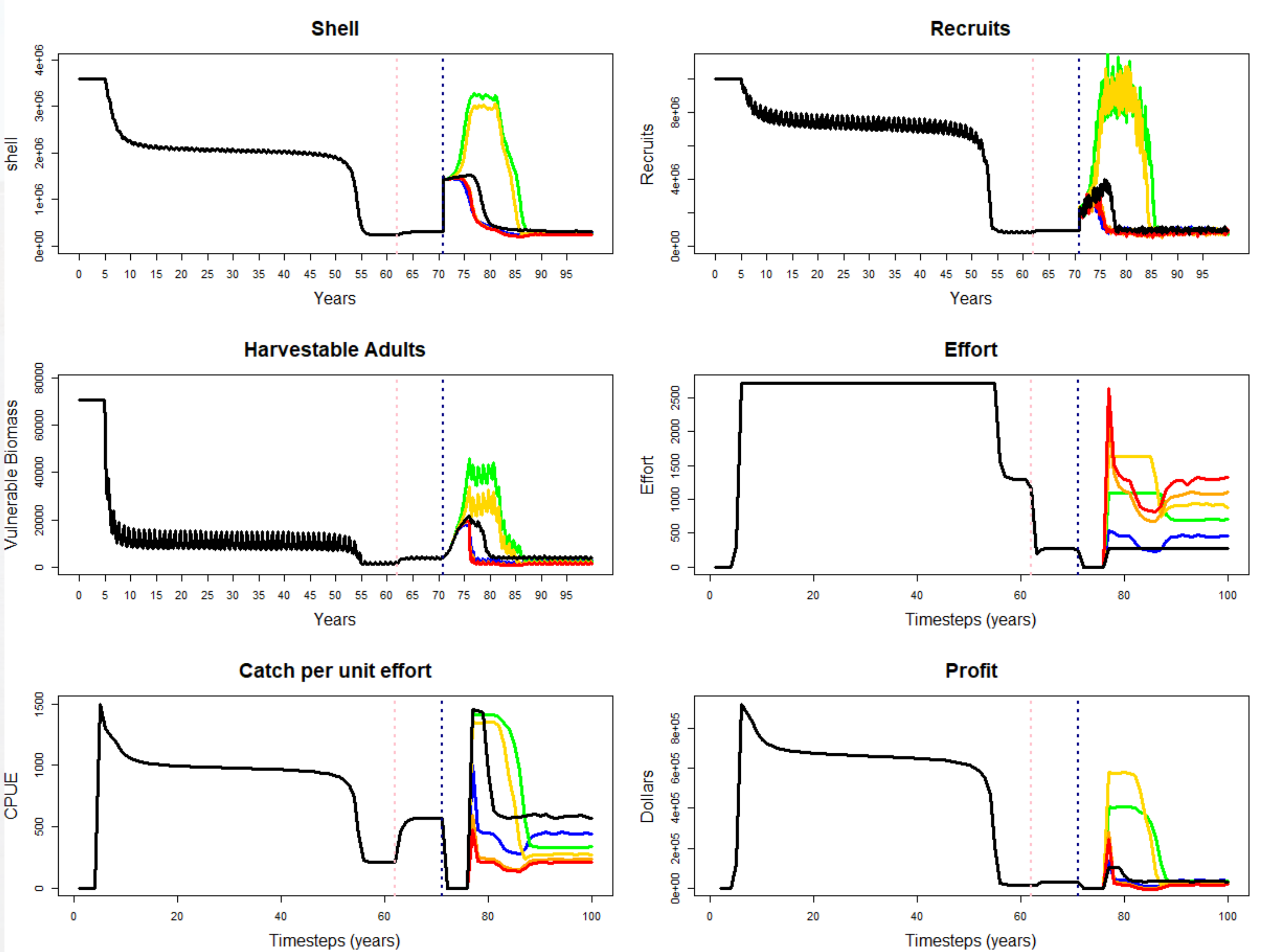
5.2 Stoch.—M inc.(Lim. Entry 10%) run1



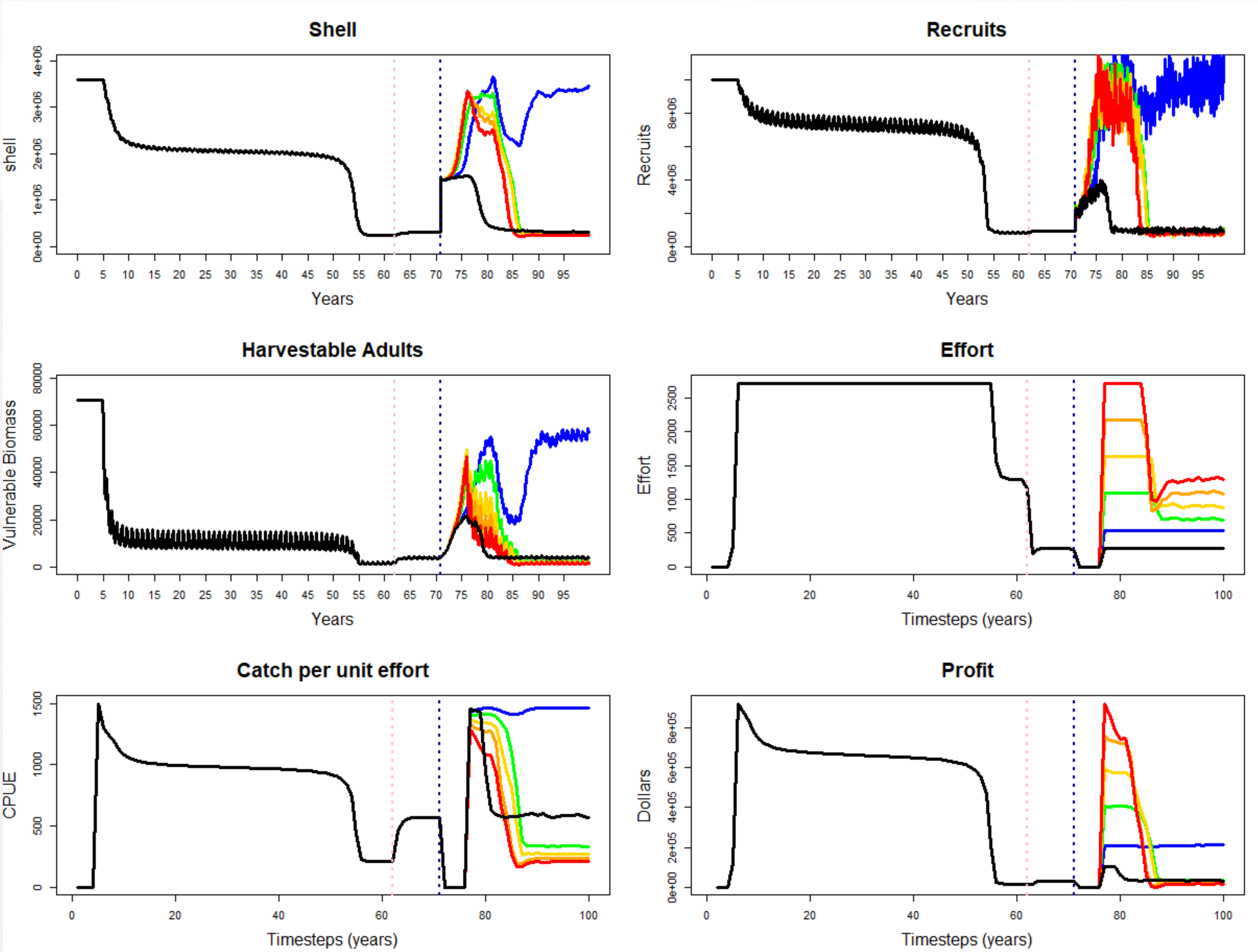
5.2 Stoch.—M incr. (Lim. Entry 10%) run2



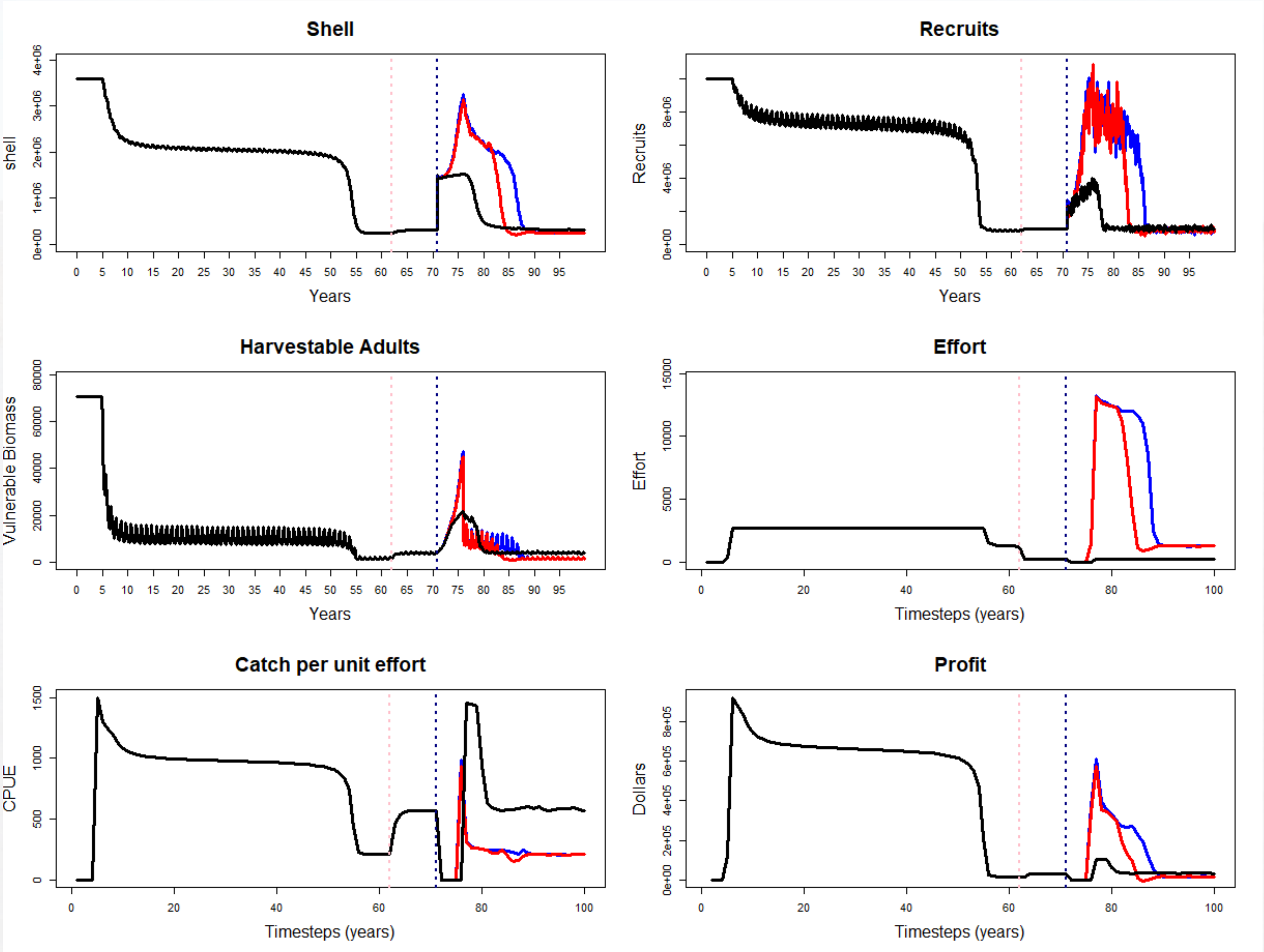
5.3 Stoch.—M incr. Limited entry run1



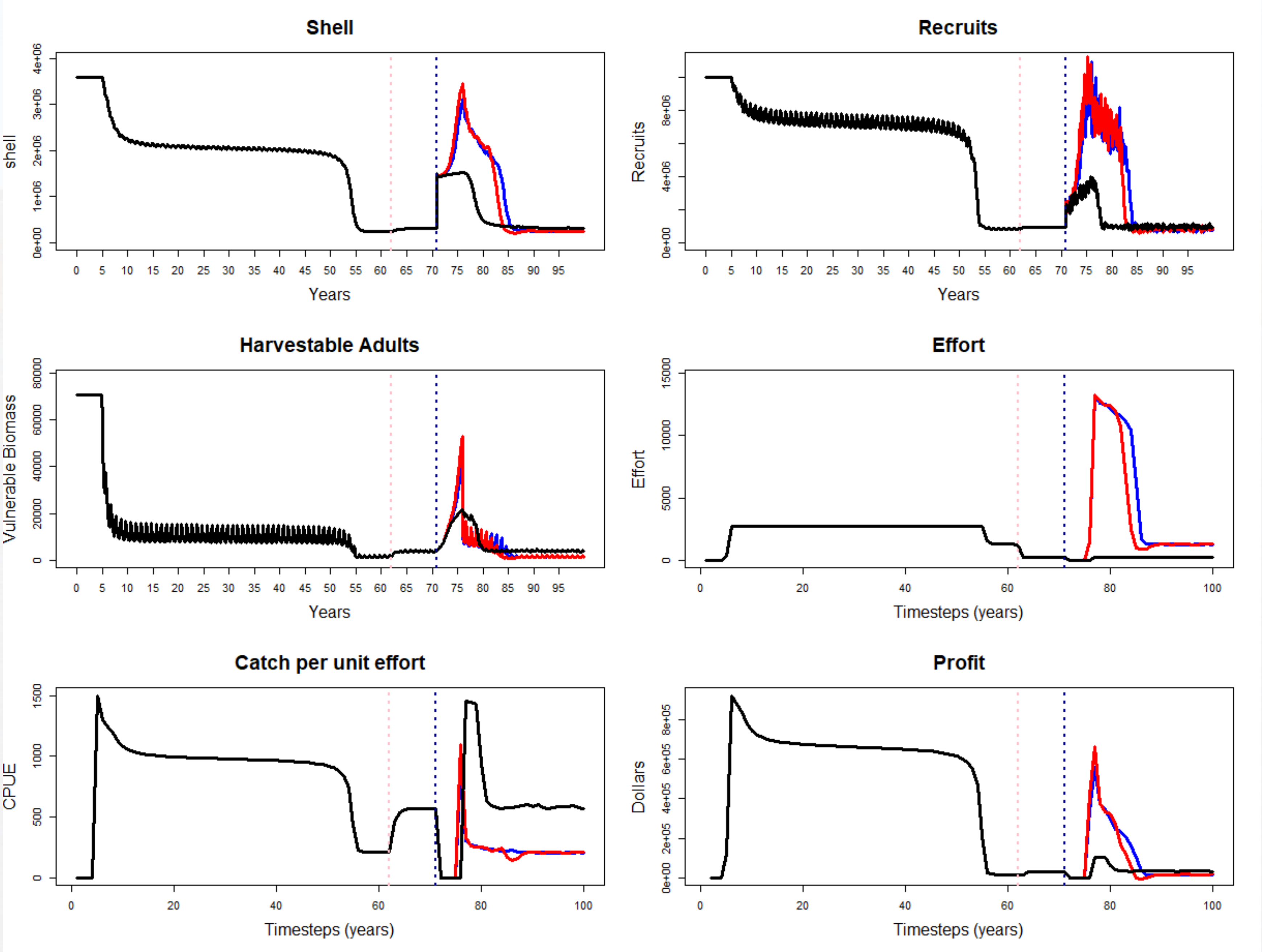
5.3 Stoch.—M incr. Limited entry run2



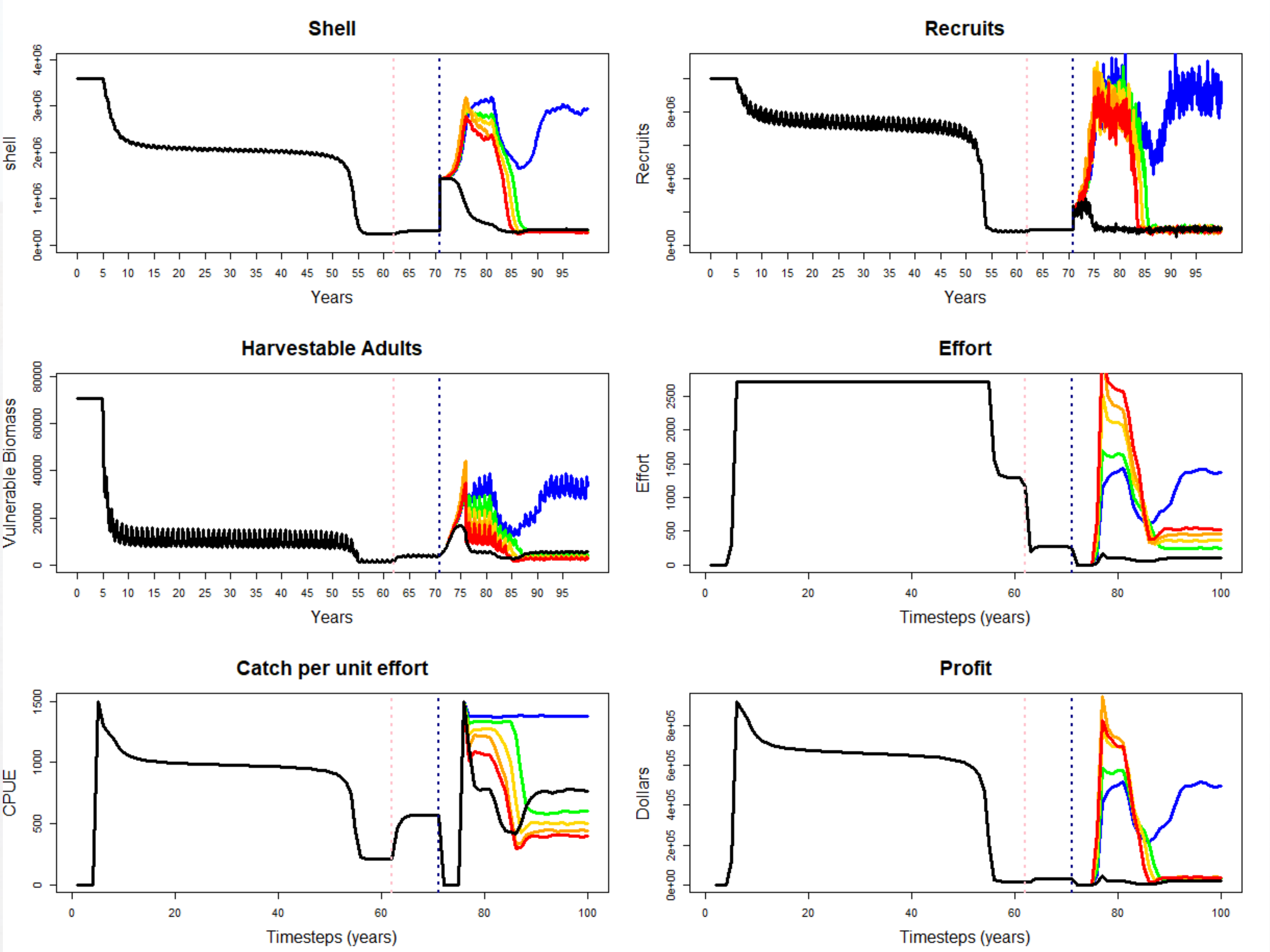
5.4 Stoch.—M incr. Open Access run1



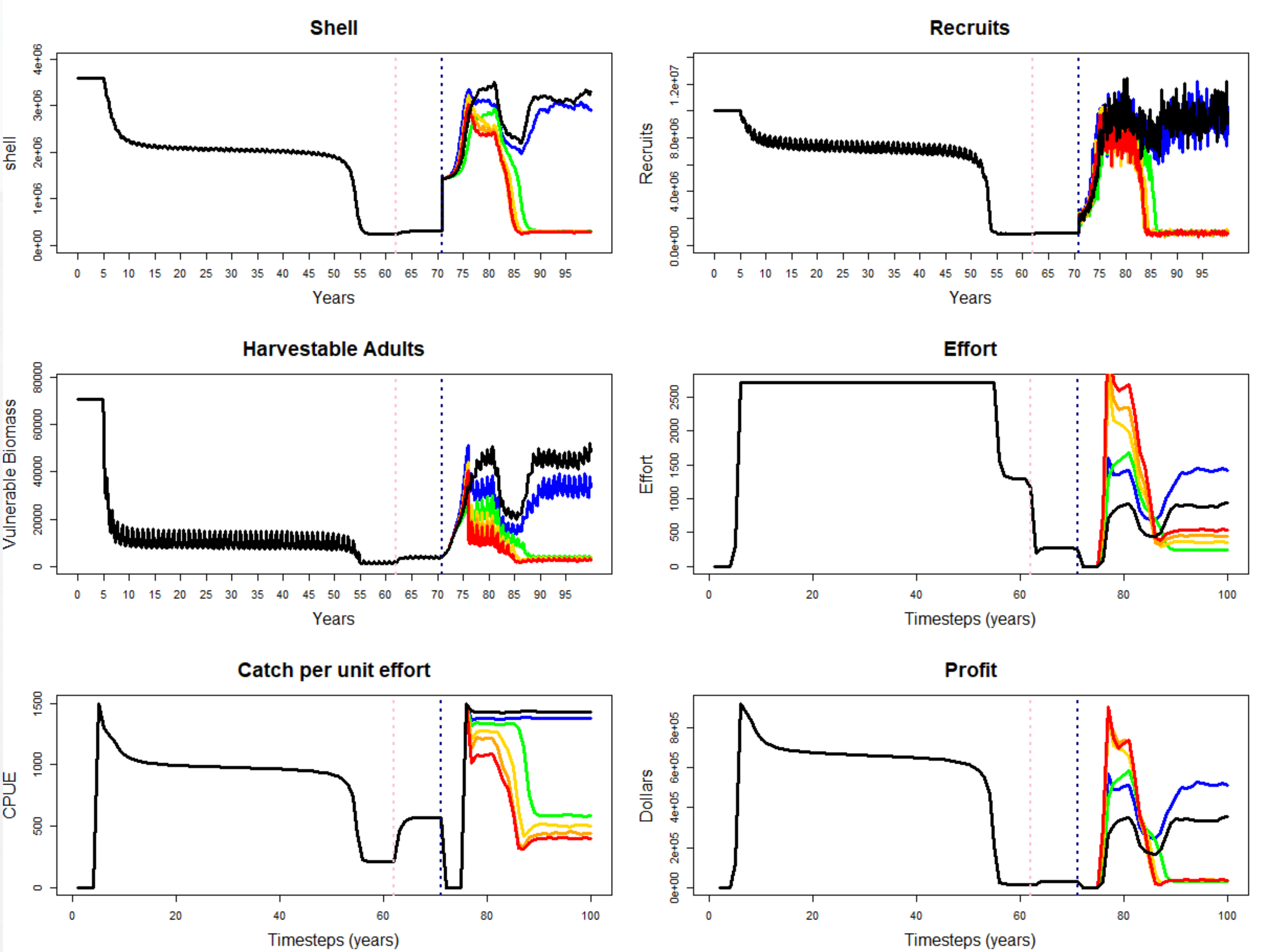
5.4 Stoch.—M incr. Open Access run2



5.5 Stoch.—M incr. Act. Harv. Mgmt. run1



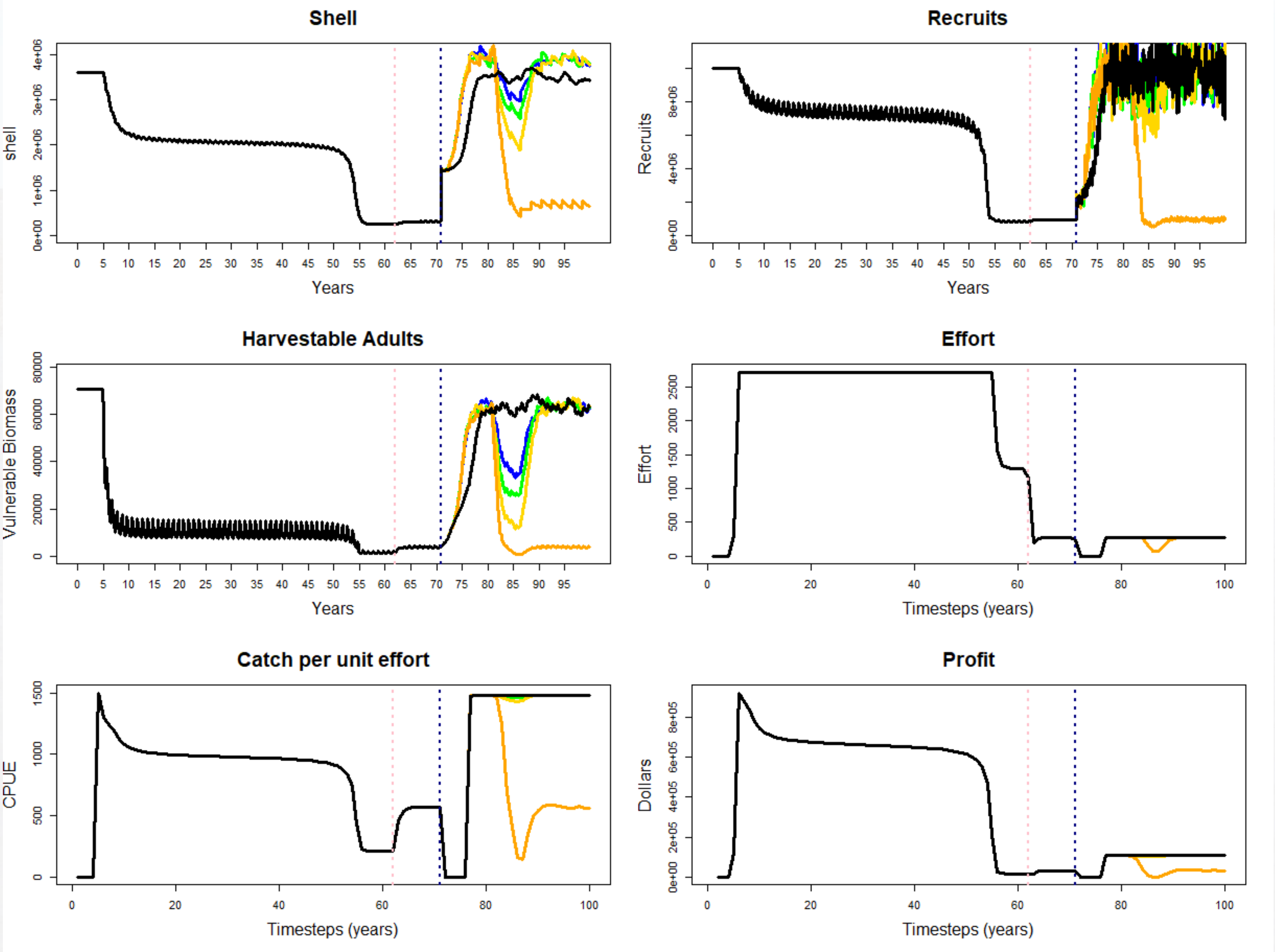
5.5 Stoch.—M incr. Act. Harv. Mgmt. run2



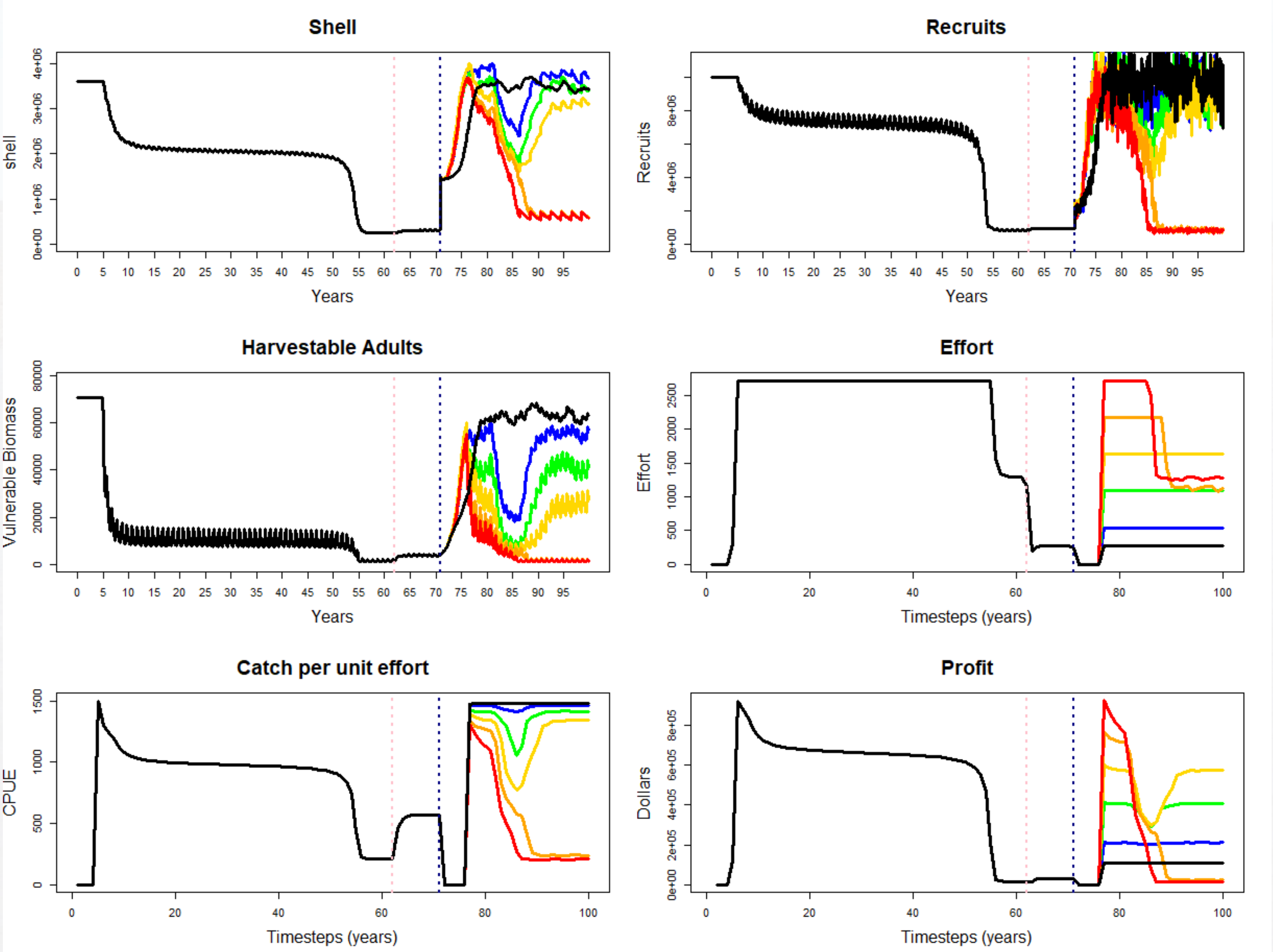
What if we combine everything?

- Increase in M
- Alternating restoration
- Stochasticity in recruitment
- Look at different mgmt options?

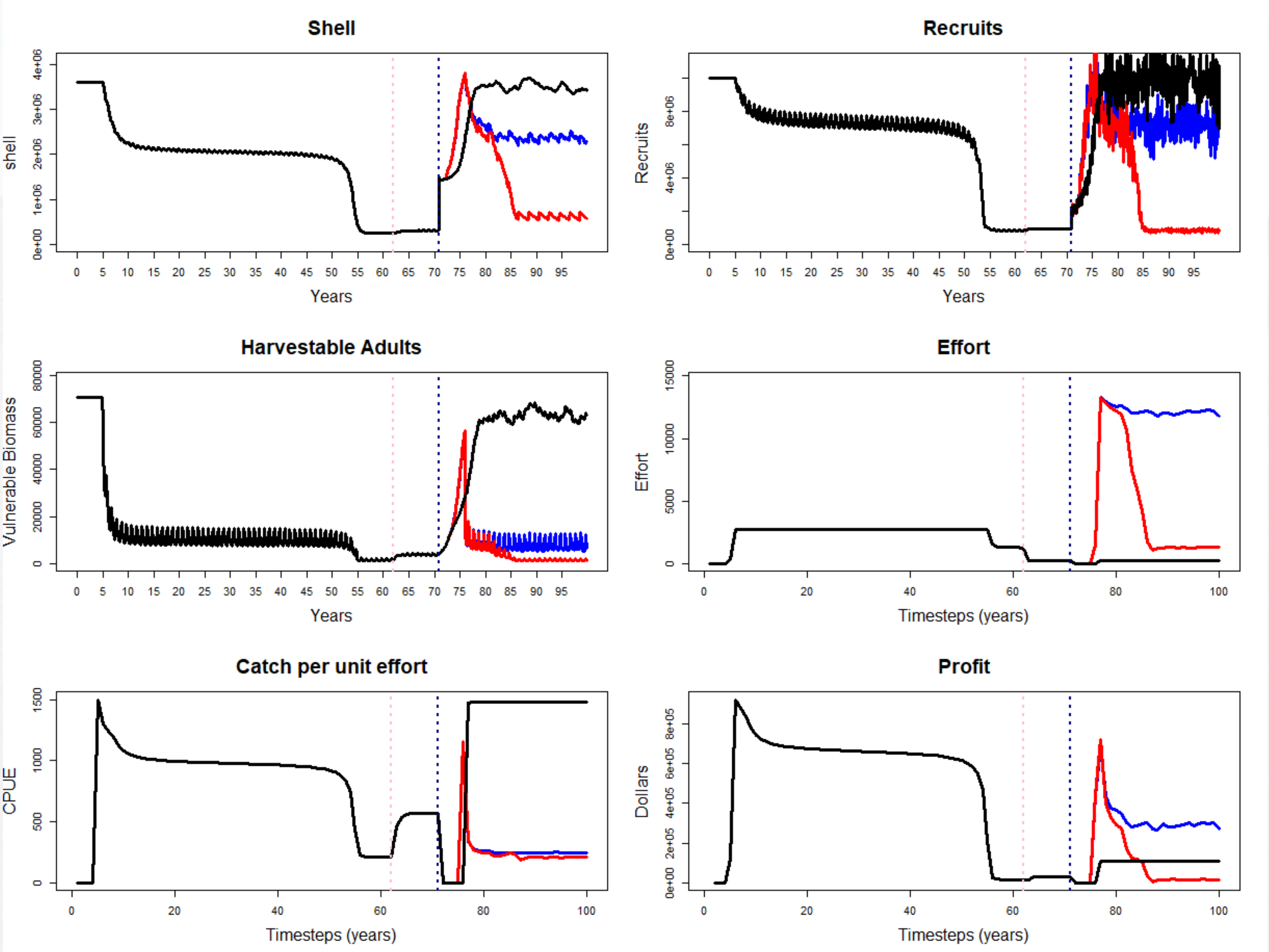
5.6—everything all at once! (different M increases)



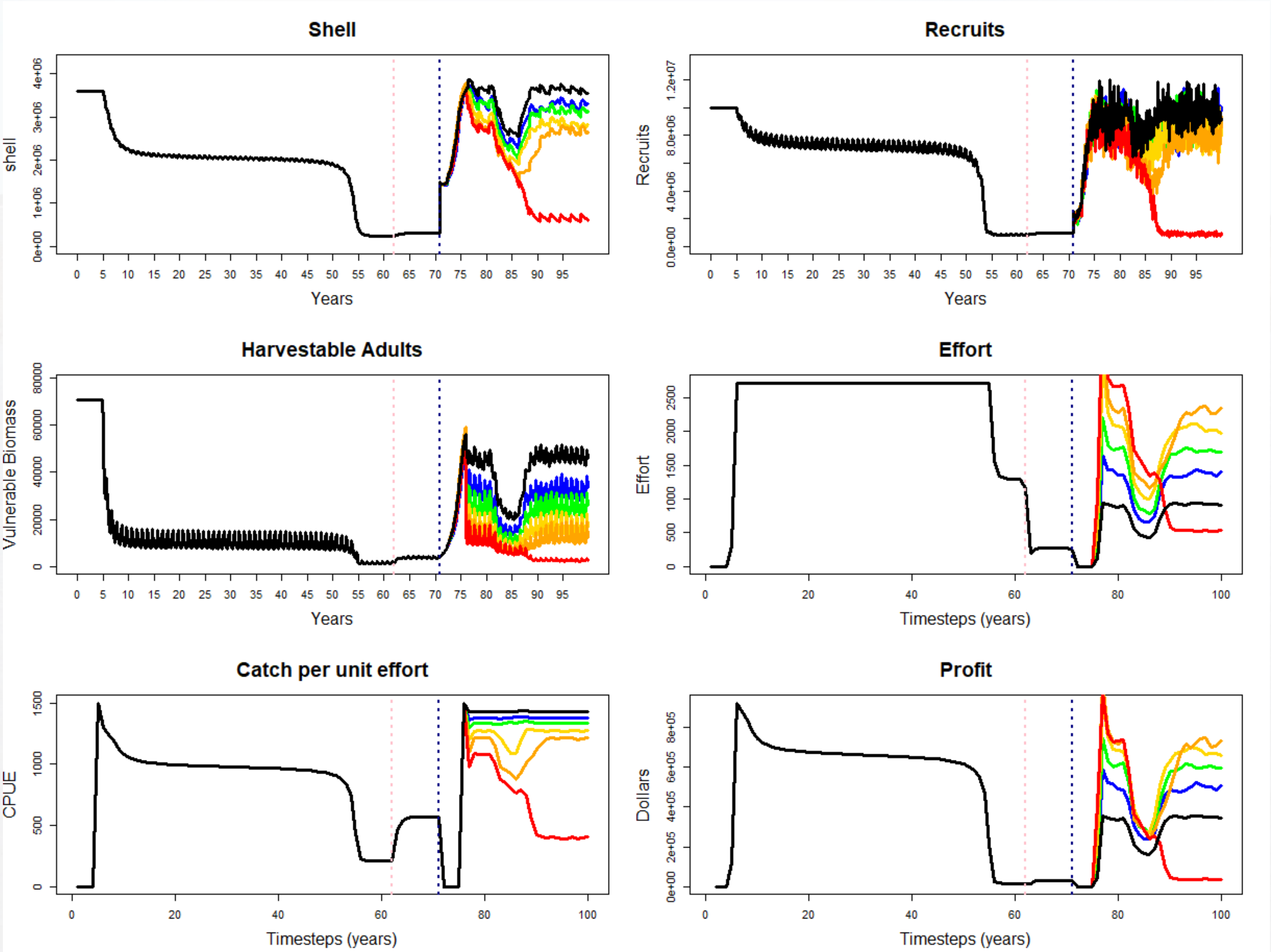
5.7—everything all at once! (Lim. Entry)



5.8—everything all at once! (Open Access)



5.9—everything all at once! (Act. Harv. Mgmt.)



5. Stochasticity-summary

- How should we interpret the messiness of these runs?

- Sometimes conservative mgmt decisions will still have problems
- Sometimes lenient mgmt will work out o.k.
- BUT conservative will have lower risk, lenient higher risk

- Lenient: Open Access, no regular restoration
- Conservative: Limited entry or Active Harvest Mgmt, regular restoration

- We do **not** <u>need</u> regular restoration to sustain oysters, or even an oyster fishery. The less we want to control the harvest, the more we need regular restoration.

Overall Summary

- Uncertain things (stochasticity, M increase) will happen
- Sustained larger oyster populations will handle them (much) better
- Therefore, oyster sustainability requires maintaining greater oyster populations.
  - That is going to look like “there’s all those oysters out there and ‘they’ won’t let us take them”
  - At the same time, all those untaken oysters are going to be providing ecosystem services, improving the bay, and making the probability of a collapse lower.
  - How will mgmt handle this?

Overall question to the CAB and especially management agencies:

- How can we obtain the political and social will to implement sustainable practices