Potential outlines for q2 paper

Here I narrow to aquatic systems and then quickly to fisheries, later in the intro

1. Ecosystems often can exhibit multiple stable states
   1. The transition between these states is often non-linear and may come with little warning
   2. Because of this, keeping ecosystems in a safe operating space is crucial to buffering against disturbances and preventing regime shifts to undesirable states
2. Ecosystems transition between stable states due to changes in the community dynamics. This can occur either through slow moving changes to underlying abiotic factors that favor some species over others (nod to Hansen climate change work) or through direct impacts by humans on the species themselves.
   1. There is evidence of these shifts in aquatic systems
      1. Fisheries are an interesting case study within these systems, as they are systems in which human impacts play a direct role.
   2. Talk about ways in which humans alter species interactions - both play a role in reinforcing or changing the stable state.
      1. Harvest, catch and release – (thinking these are the things the average person controls)
         1. This is more of an emergent thing – people do not really think about the stable state when they do this, they are thinking about catch rate, etc.
      2. Stocking, limiting harvest – (these are the things managers can control)
         1. This is where managers can influence stable state
         2. Also where managers can change/maintain a stable state as a direct result of harvest/catch (basically, this is where you can deal with whatever people did, which may not have been ideal)
            1. Here, I am thinking we could talk about how managers have control over changing undesirable states created through human impacts
3. Here we explore this second pathway, direct human influence on an ecosystem, through a modeled recreational fishery to show why understanding the complex interactions between species is necessary to either maintain or rehabilitate an ecosystem.
4. This shows how managers, with an understanding of the hysteresis and stable states in their system, can purposefully manage their systems to maintain stable states
   1. Also that this multi-species/multi-level approach is important in maintaining ‘desired’ ecosystem function

Another version where we narrow to aquatic systems earlier, and fisheries later

1. Ecosystems often can exhibit multiple stable states, aquatic ecosystems have provided classic examples of this
2. The transition between these states is often non-linear and may come with little warning
3. Because of this, keeping ecosystems in a safe operating space is crucial to buffering against disturbances and preventing regime shifts to undesirable states
4. Ecosystems transition between stable states resulting from changes in community dynamics. This can occur either through slow moving changes to underlying abiotic factors that favor some species over others (nod to Hansen climate change work) or through direct impacts by humans on the species themselves.
   1. Fisheries are a prime example of this kind of system where humans impact the system directly through fishing and indirectly through climate change
      1. Indirect ways example (climate change Hansen work) – these are hard to manage
   2. Talk about how both the ways in which humans directly alter species interactions can play a role in reinforcing or changing the stable state.
      1. Harvest, catch and release – (thinking these are the things the average person controls)
         1. This is more of an emergent thing – people do not really think about the stable state when they do this, they are thinking about catch rate, etc.
      2. Stocking, limiting harvest – (these are the things managers can control
         1. This is where managers can influence stable state
         2. Also where managers can change/maintain a stable state as a direct result of harvest/catch (basically, this is where you can deal with whatever people did, which may not have been ideal)
            1. Here, I am thinking we could talk about how managers have control over changing undesirable states created through human impacts
5. Here we explore this second pathway, direct human influence on an ecosystem, through a modeled recreational fishery to show why understanding the complex interactions between species is necessary to either maintain or rehabilitate an ecosystem.

Start off talking about biotic interactions

1. Interspecific interactions play a large role in shaping the stable state of aquatic ecosystems
2. Aquatic ecosystems transition between stable states due to changes in the community dynamics. This can occur either through slow moving changes to underlying abiotic factors that favor some species over others (nod to Hansen climate change work) or through direct impacts by humans on the species themselves.
   1. Fisheries are a prime example of this kind of system where humans impact the system directly through fishing and indirectly through climate change
   2. Talk about how both the ways in which humans alter species interactions can play a role in reinforcing or changing the stable state.
      1. Harvest, catch and release – (thinking these are the things the average person controls)
      2. Stocking, limiting harvest – (these are the things managers can control
3. As we seek to protect or rehabilitate aquatic systems we must consider these dynamics when making management decisions.
4. Here we use a simple model of a 2 species fishery to show how species interactions can lead to counterintuitive management action when trying to maintain or change the stable state.
5. Ecosystems are difficult to manage, aquatic systems, and fisheries in particular, provide examples of this. Counterintuitive responses by fish populations to management have shown that in many cases a linear, single species focused view of these systems can lead managers to make decisions that, in hindsight, are ineffective or even detrimental to these systems
   1. Describe the problems (baby) that arise from these counterintuitive responses
      1. Ecosystem service loss
      2. Economic loss
6. Pine et al. (2009) review some fishery examples of the erroneous predictions based on simple ecosystem models that have had negative consequences. A central theme of these incorrect predictions is a failure to consider interactions between multiple species and life stages in these systems.
   1. What can’t species interactions be overlooked?
      1. Other species are also impacted by humans in various ways
         1. Harvesting
         2. Habitat loss
      2. Slow moving abiotic changes to the systems underlie species interactions too
   2. Because of the above reasons these systems often behave in complex, non-linear ways
      1. Cultivation – depensation shout out here?
7. Non-linearity poses a problem for management that is often based in linear, single species views/strategies.
   1. Managers are also limited in what they can and can’t directly control
      1. Talk about safe operating spaces
      2. This gives rise to unexpected outcomes
8. We use an example two-species fisher to explore how limited management levels and a linear view can lead to counterintuitive responses by fish populations to management intervention. We then show how adopting a non-linear approach that considers community interactions helps.
   1. Hypothesis – Hysteresis plays an important role in determining the appropriate management action.
      1. Prediction – Taking a multi-species, non-linear view of fisheries leads to more positive and stable outcomes
         1. Cost effective too