Climate Variability and Fisheries Chapter

Guiding Principles:

- **For fisheries management purposes, focus on 1-30 year scope. We should consider to 100 years as important to climate change.**
- **Forcing functions outside the region are OK IF they impact variability. Focus on the South Atlantic region.**
- **Climate variability (vs. change) should be considered in a fisheries management plan.**
- **Fishery abundance related to climate variability**
- **Larval Fish abundance and 3D distribution related to climate variability (temperature, stratification, etc.)**
- **This is the basic, minimal outline. The writing team for each section should add on based on their experience.**
- **Commercial, recreational, fish, fisheries, and fishing communities need to be considered. (retailers, guides, suppliers)**
- **Err on the side of completeness in length - we can truncate/trim the document down later.**
- **We are striving for a 80% document for end of February 2016.**
- **If your statement needs to be referenced, please include the reference and link.**
- **No need to write more than a paragraph for each subsection. If more than a paragraph is needed- try to write no more than a page.**

1. **Introduction and Role of Climate Considerations** in Ecosystem-Based Fisheries Management. (***Roffer***, J. Ballenger, M. Reichert, Lora)

- Why to interject climate considerations into ecosystem based management: stock assessment and reference point development.

- Why this affects fisheries and fisheries management decisions.

- Is there an example that shows how this works/fails in SA? The lack of understanding in the apparent changes in abundance is requiring us to look at possible climate environmental drivers. (e.g., gray snapper, shrimp, king mackerel, spanish mackerel, large pelagics, menhaden, gag, cobia, anchovy, blueline tilefish, snowy grouper (as important prey spp.) (Jim, Claire)

- Stock Boundary - Habitat shifts - pelagic shifts and benthic shifts (Jim)

- NOAA has some slides that Pete will send - there is a document that covers the definition of progression - Jason' graphic.

- Look at NOAA's plan for statements that are useful

2. **Historical and Current Conditions/Characterization** (***G. Voulgaris***, R. He, Claire, R. Rykaczewski) characteristics of the SA system - baseline and linkages.

*Put scale of variability in each discussion in each section. Define it in the first section.

Scales of variability - multiple scales need to be considered (brief introduction) synoptic

   i. seasonal
   ii. interannual
      1. ENSO (through precipitation)

iii. decadal
    1. NAO / AO
    2. AMO
iv. climate-change scale (note that the next section addresses this scale)

a. Atmospheric Drivers
b. Oceanographic Drivers/Patterns
    i. Ocean forcing (temperature, oxygen, salinity, Gulf-Stream, inner-, mid-shelf circulation, upwelling, along-, across-shelf transport, upstream flow, mesoscale variability)
        1. Wholesale changes in system productivity (e.g., Lee et al. 1991; frontal eddies) (Claire)

b. Hydrologic drivers (Rua, Peter Sheng)
    i. Riverine inputs (precipitation spatial and temporal means and variability)
c. Ecosystem responses (lower trophic level) [Steve Arnott, Ryan]
    i. Biogeochemistry, Chlorophyll, phytoplankton, zooplankton (spatial and temporal means and variability, relationship to physical drivers where known)

3. **Future Changes** (Conditions in the South Atlantic (climatology, natural variability, and trends?) (over the coming 10-30 years) Put South Atlantic into global perspective (e.g. Burrows et al 2011, Poloczanska et al 2013 refs in basecamp), but also note reasons why this region differs from the global trends (e.g., main temperature gradients are onshore/offshore rather than north south, etc).
(G. Voulgaris, R. He, Claire, R. Rykaczewski, Peter O - as needed)
    a. Atmospheric forcing

    i. (radiative forcing, prevailing winds, frequency and intensity of hurricane/ tropical cyclones, winter extra-tropical storms)
b. Future Ocean forcing
    i. (temperature, salinity, Gulf-Stream, inner-, mid-shelf circulation, upwelling, along-, across-shelf transport)
    ii. Wholesale changes in system productivity (e.g., Lee et al. 1991; frontal eddies) (Claire)

c. Water Chemistry (e.g., ocean acidification, hypoxia)
d. Sea Level Rise - (Rua, Ken, and Peter Sheng)
    i. land subduction, sediment transport and coastal erosion,
    ii. loss of wetlands (into intertidal),
    iii. potential changes of functional habitats,
e. Regime shifts - have they occurred previously? They are important to consider in the plan. (Chesapeake example - Wood & Austin, 2009 ref in basecamp, Gulf of Alaska - Litzow 2006 ref in basecamp) [Steve Arnott, Claire]
f. Interactions among climate parameters: stationary and non-stationary
g. Changes in precipitation patterns
h. Cold/heat events Merge with “h” as “Temperature Extremes” [Steve Arnott]
i. Phenology [Steve Arnott]
j. Interaction of future climate change and variability with other anthropogenic impacts (potential changes in resiliency) e.g., onshore development and inability of habitats to migrate inland, other considerations (e.g., metal toxicity changes with pH)

4. **Climate Impacts on Fish, Fish Habitat and Fisheries (Arnott)**

*Explain the relationships in the Forcing parameters - ADMIT connections we know and don’t know- We have to be careful on hypotheses vs.

knowns. Emphasize of state of knowledge. Use confidence levels to provide possibilities - leading to research needs. Avoid term “uncertainty”. Relationship between groups of taxa and physical parameters (SST, SLP, MLD, mesoscale features, velocity). Multivariate community analyses?
* Be sure to address impacts of *both* climate variability and long-term climate change
* Useful to put regional changes in a global context (e.g., Burrows et al 2011, Poloczanska et al 2013)

i. Distributions of Temperatures, Salinity, turbidity, pH, chlorophyll, oxygen (Jim)

*Start with what we know, then what we don’t know - this leads to research needs.
Look at patterns of covariations in past data between environmental parameters and species abundance and distribution - indicative of regime shifts. Include consideration of the conceptual, mechanistic processes underlying these empirical relationships.

a. Habitat (in brief, impacts of climate variability on oyster, soft bottom, marsh, mangrove, reef, seagrasses, live bottom, deepwater coral, etc. [only mentioned where relevant]) (Jim)

*This should be brief and general terms - assume the other sections are handling the details. Could be a sentence long- Link to or reference other sections

b. Species and Stock Distribution (Jim)
    i. physiology: thermal envelopes
    ii. climate velocity and other processes
    iii. time-scales of responses
    iv. regional specifics/examples [Steve Arnott, J. Ballenger, M. Reichert]
    v. kinds of species most likely to be vulnerable (J. Ballenger)
c. Productivity (J. Ballenger)
    i. kinds of species most likely to be vulnerable

d. Spawning/Recruitment (Will, Mandy, J. Ballenger)
    i. survival rates and recruitment of the early life history stages
    ii. climate change impacts on spawning fishes and areas/habitats used by fishes during spawning.
e. Connectivity (Will White, Claire)
    i. Larval dispersal kernels
    ii. Ontogenetic connectivity across habitats
        1. species that rely on estuaries and other inshore habitats during part of their life cycle
    iii. connectivity networks (single species AND multispecies assemblages sharing connectivity patterns)
    iv. multi-species connectivity (Claire)
f. Inter and Intra Species Interactions
    i. Trophic interactions
    ii. Disease and parasites (possibly shrimp or crab examples? menhaden Neuse River example?)
g. Invasive Species (Jim)
h. Catchability (vulnerability and availability) (Roffer)
i. Interactions with other stressors (Will)
    i. Fishing and ability of populations to colonize new territory
    ii. Intraspecific diversity and robustness to climate variability (biocomplexity)
    iii. Age-structure truncation and sensitivity to climate variability (J. Ballenger, M. Reichert)
j. Impacts on people and fisheries (Malin)
    i. Infrastructure
        1. sea level rise
        2. market availability
    ii. Fishing opportunities
        1. location, travel time, jurisdictions
        2. Species composition and movement among fisheries (permit availability)

3. seasonal timing and phenology
4. time-scales of variability (extreme events, decadal variability, long-term trends)

iii. Management (note that Section 7 focuses specifically on SAFMC) - Food Web group will capture the stock assessment tools, models, etc. (J. Ballenger, M. Reichert)

1. ACLs and reference points
2. unit stock
3. coordination among Councils
4. allocation decisions

5.**Knowledge Gaps related to management needs** (this includes data, limited data and research)
Make some recommendation in possible indicators - this may be a research priority.

a. Climate Indicators - e.g., temperature (SST), species distribution, expansion range, wind pattern indicator, runoff, winter severity, upwelling, - are there correlations we can detect based on data exploration?
    i. modes of basin-scale variability
    ii. recommendations on readily available indicators (first order, e.g., used elsewhere)
    iii. process to develop full set of indicators
    iv. need to re-evaluate indicators regularly, as relationships between indicators and ecosystems conditions may change over time
b. Observation gaps (both in time and space) (Claire)
    i. large gaps on biological stuff (e.g., ichthyoplankton) v. physics
    ii. Mechanistic Understanding
    iii. dynamic management strategies in response to a variable environment (adaptive MPAs) (Will)

c. Species and habitat vulnerability to environmental change (Jim)
    i. Social impacts and fishery responses to climate variability
d. Quantitative catchabilities

6. **Research Priorities**

Note: Use the priorities from the Secoora Science Management Workshop in St. Pete as a ***starting point*** for this section 67 scientists prioritized research for the SA. This will be the starting point.

a. Derive or refine understanding
    i. relationships between South Atlantic fish, fish habitat and fisheries and marine environmental conditions in the current climate
    ii. Regional ocean climatology
    iii. variability in zooplankton and ichthyoplankton distributions in relation to hydrography (Claire)
    iv. physical-biological interactions (e.g., response to environmental signals, larval swimming/orientation capabilities) (Claire)
    v. etc.
b. Climate variability and species interactions ()
    i. impacts of climate on species interactions
    ii. impacts of species interactions on species responses to climate
c. Interactive impacts (nonlinear interactions, multiple stressors) (Will)
    i. among climate processes
    ii. between climate and other anthropogenic impacts (e.g., fishing)
    iii. relative importance of different stressors (e.g., SST, pH, changes in connectivity patterns) on population/ecosystem dynamics
d. Social-ecological coupling: human responses to climate variability, feedbacks to affect marine species and ecosystems

e. Modeling system development (physical state model, biogeochemical, biophysical, and ecosystem models, socio-economic models)
f. Regional downscaling of future climate scenarios
g. Management tool development
h. Deriving quantitative catchability
i. Updating species environmental vulnerabilities

7. **Links to SAFMC Management Decisions and EBFM, Lora)**
    a. Maintain robustness and resilience (options, diversity, monitoring, flexibility, reducing non-climate stressors) (e.g., Hilborn & Schindler 2015 Science)
    b. Stock assessments and Terms of Reference
    c. Spatial Management
        i. Stock boundaries and Spatial Allocations (e.g., New Fisheries, Loss of fisheries and Fisheries Operations)
        ii. Integrate into new System Management Plans (MPAs and (Spawning) SMZs)
        iii. tracking/analyzing fishers' movement
        iv.
    d. Long-term planning
        i.
    e. Short-term responsiveness (e.g., based on monitoring and indicators)
    f. Coordination with other management, research, and observational efforts (e.g., whole watershed, cumulative impacts, other Councils)

8. **Recommendations and Conclusions**
- General wrap up.
- Major points to remember/emphasize.
- This becomes the summary for the Executive Summary document.

9. **References**

Appendix A - Useful links on the web product to Other regional Efforts including, regional scale Fisheries Management efforts

a. Citizen Science
b. IOOS/SECOORA
c. NOAA Fisheries
d. Bonefish Tarpon Trust (http://www.bonefishtarpontrust.org/research-programs/research-programs.html)
e. Audubon
f. LLC Conservation Blueprint (http://www.southatlanticlcc.org/page/conservation-blueprint)
g. NSF CoastalSEES
h. NOAA ecological forecasting roadmap

- If other sections are done properly, a-i (above) already will be covered. Work in the current Climate Change and Variability Workshop recommendations into the body/text of the document, rather than listing separate efforts.