Application of downscaled climate models to the Florida Keys and Florida Bay Marine Ecosystems

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Climate change and coral reef ecosystems

- Climate change may impact coral reef ecosystems by:
  - Increasing water temperatures, leading to increased coral bleaching events, and changes in species ranges, especially where species already exist near thermal limits
  - Changes in precipitation, and riverine discharge
  - Changing oceanic circulations and larval dispersal
  - Loss of coastal habitat through flooding
- Current global climate models suggest that the western central Atlantic Ocean will experience a 2.0 to 2.5°C increase in surface temperatures by the end of the 21st century

Current models of climate change

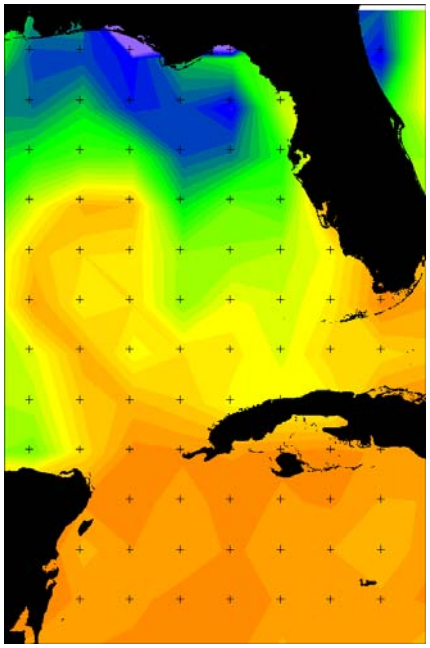
- There are **21** global climate models, derived from the IPCC 4th Assessment Report (AR-4)
- These models have a spatial resolution of ~100km, and thus cannot be used for regional predictions
- Global climate models must therefore be downscaled to the scale of the region of interest, using either:
  - *Statistical downscaling*
  - *Dynamical-physical downscaling*
  - A *coupled ocean-atmosphere model*

Downscaling climate models for the western central Atlantic Ocean

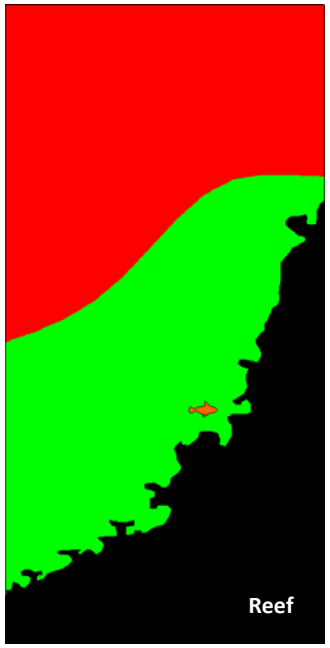
- We are currently in the process of downscaling global climate models using a high-resolution (10km) regional ocean model
- Once this is complete, we will further refine our results with a coupled atmosphere-ocean model
- This tool will output water temperature and salinity through the water column, and current speed and direction, at decadal intervals through 2100
- This will allow us to assess a range of climate change impacts on coral reef ecosystems, and habitats of highly migratory pelagic species

Coral reef bleaching

- Coral reef bleaching events may increase in spatial and temporal extent under climate change conditions
- A downscaled model will output high resolution predictions of temperature through the water column, at decadal intervals through to 2100
- These predictions can be integrated into existing coral reef bleaching models (e.g., NOAA's Coral Reef Watch), in order to predict future bleaching events

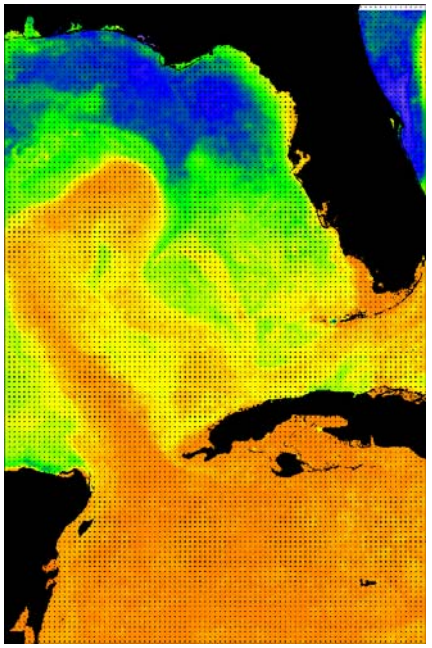


Horizontal resolution:
Global climate models

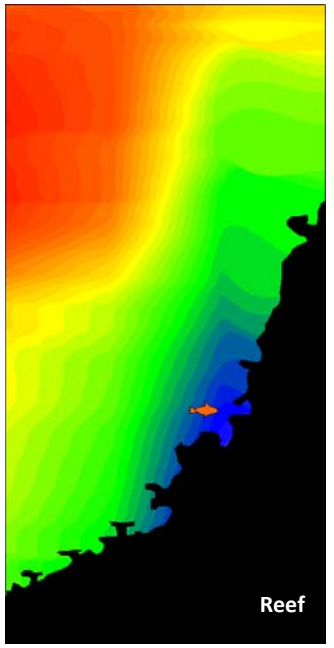


Vertical resolution:
Global climate models

Downscaling process



Horizontal resolution:
Downscaled model



Vertical resolution:
Downscaled model

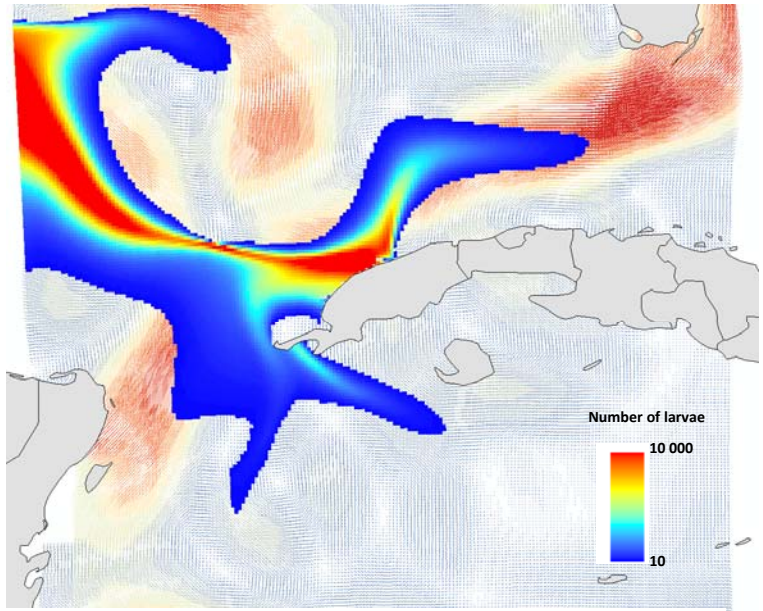
Larval dispersion and transport

- Climate change conditions may influence the strength and direction of ocean circulation patterns. This is turn will affect larval dispersion and connectivity pathways
- A regional ocean model driven by climate change predictions will allow us to quantify changes circulation, and to identify which regions of interest (reefs, MPAs) may lose or gain connectivity with each other in the future

Spawning habitat information

Regional ocean model

Climate models



Estimates of larval dispersal under climate change conditions

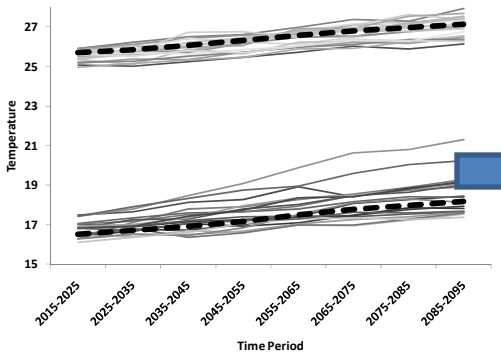
Applicability to the Florida Keys ecosystem

- Florida Bay and the Florida Keys are strongly influenced by water temperatures, water salinities, and freshwater inflow
- In addition, connectivity mechanisms between other ecosystems, such as the Mesoamerican reef, are potential sources of larval recruitment
- Both these mechanisms may be strongly affected by climate change, leading to changes in water quality, species composition, and persistence of habitat types

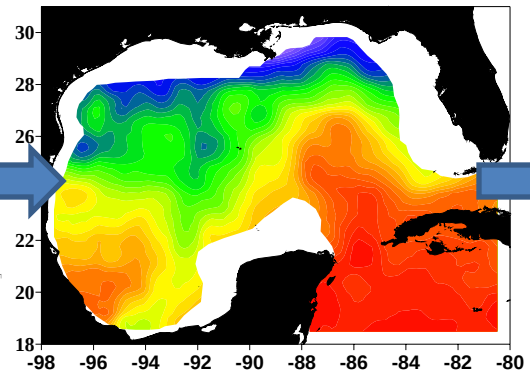
An example:
Using climate models to predict changes in spawning habitat

- Spawning of bluefin tuna in the Gulf of Mexico is highly temperature-dependent, due to physiological constraints on adult fish
- Using existing models of spawning habitat, we predicted the future extent of spawning activity in the GOM using predictions from climate models
- Results show that conditions within the existing spawning season may become progressively less suitable under climate change conditions

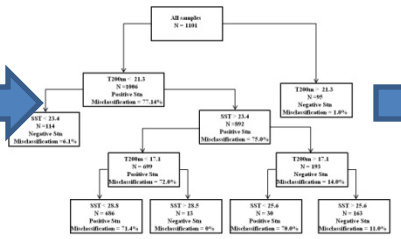
1) Weighted mean predictions of temperature at the surface, and 200m depth



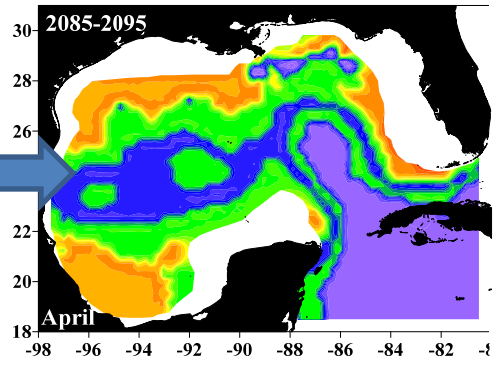
2) Temperature maps of the Gulf of Mexico at decadal intervals



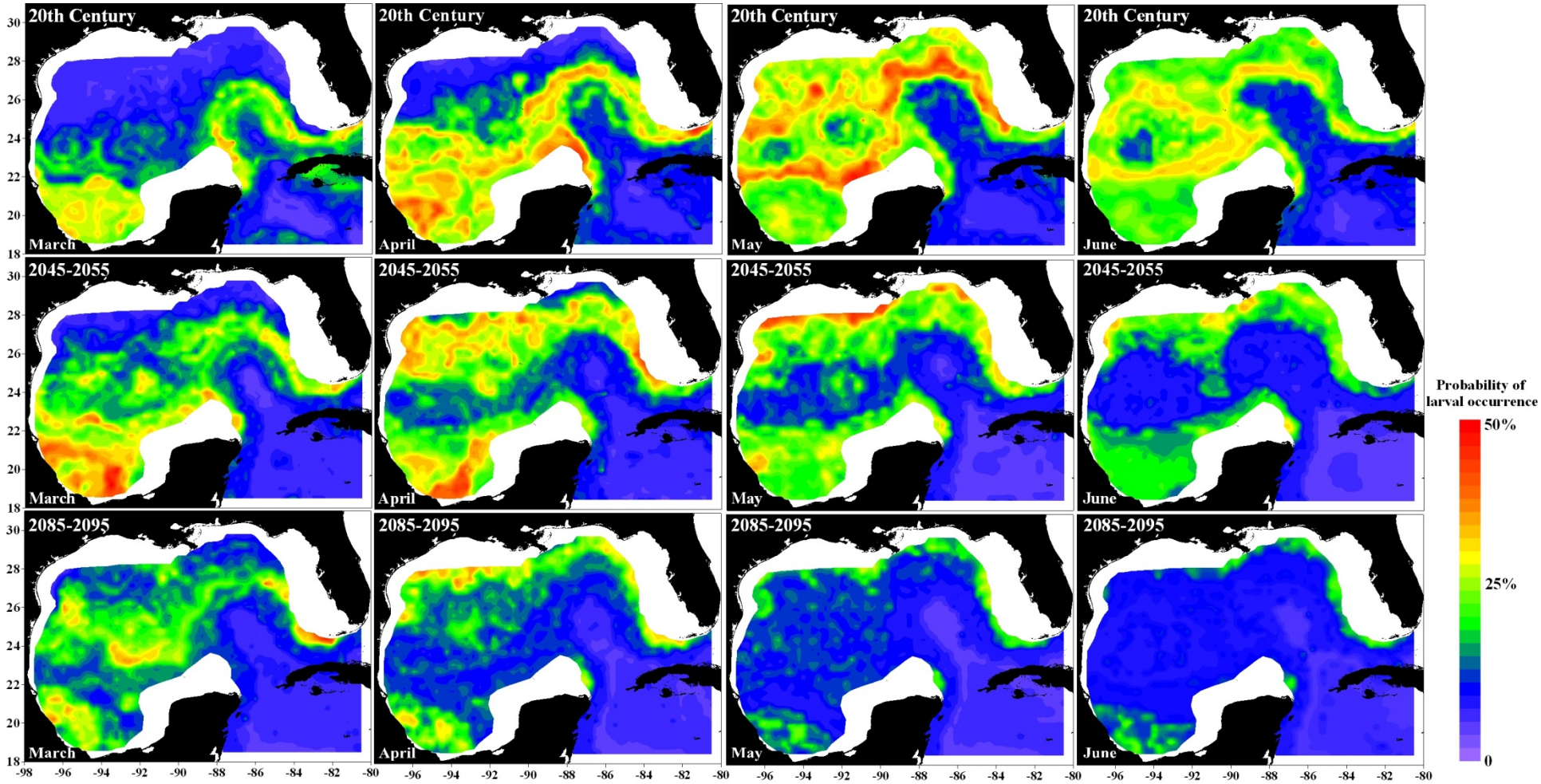
3) Data run through a classification tree built from archival CTD data and larval occurrences



4) Habitat suitability maps for April, May and June at decadal intervals



Predicted probabilities of larval occurrence



Conclusions and future collaboration

- Climate change has high potential to impact the Florida Keys ecosystem, and the wider central western Atlantic
- Once the downscaled climate model is complete, we will be able to assess changes in temperature, coral bleaching rates, and larval connectivity
- Preliminary results suggest that spatial and temporal extent of spawning habitat of temperature-dependent species may be strongly affected by climate change
- Future work over the next few years will allow us to quantify impacts relevant to coral reefs, including the FKNMS