REstoration, COordination, VERification (RECOVER)

Northern Estuaries Hypothesis Clusters

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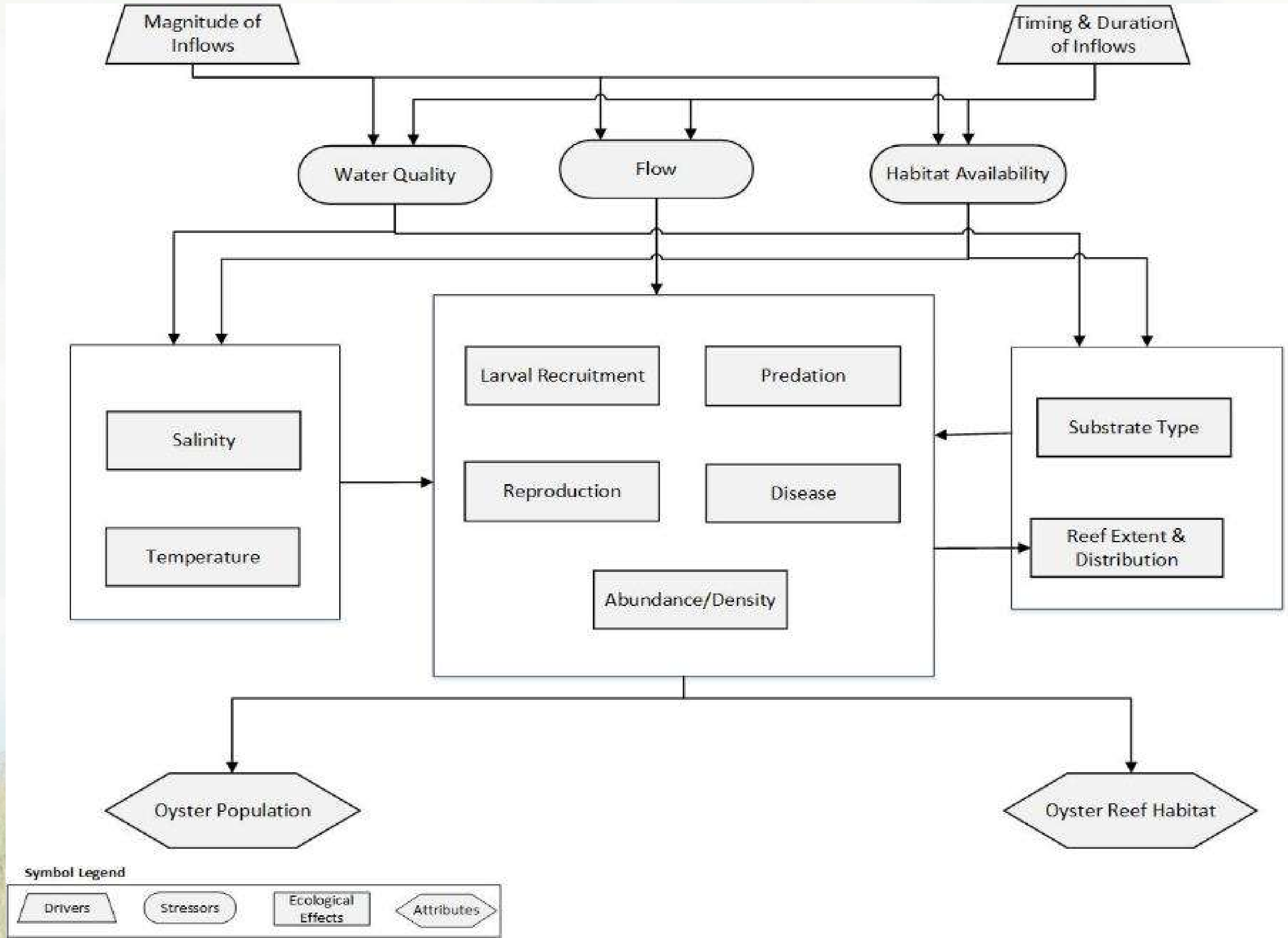
Northern Estuaries Oyster Hypothesis Cluster



Day 1 # 6 NE HC-Matin

Northern Estuaries Oyster Hypothesis Cluster

Working Hypotheses:

1. Heavy rainfall and large volumes of freshwater entering the estuaries rapidly decrease salinities below optimal levels for oysters, causing physiological stress and widespread mortality.

2. Large inflows of freshwater to the estuaries inhibit larval settlement by physically flushing the pelagic larvae out of the estuary.

3. Reduced freshwater inputs to the estuaries during the dry season or drought periods increase salinities above optimal levels for oysters, causing physiological stress and increased disease and predation rates.

4. Suitable habitat quality and substrate type will increase larval settlement success and encourage sustainable oyster populations.

MAP Monitoring:

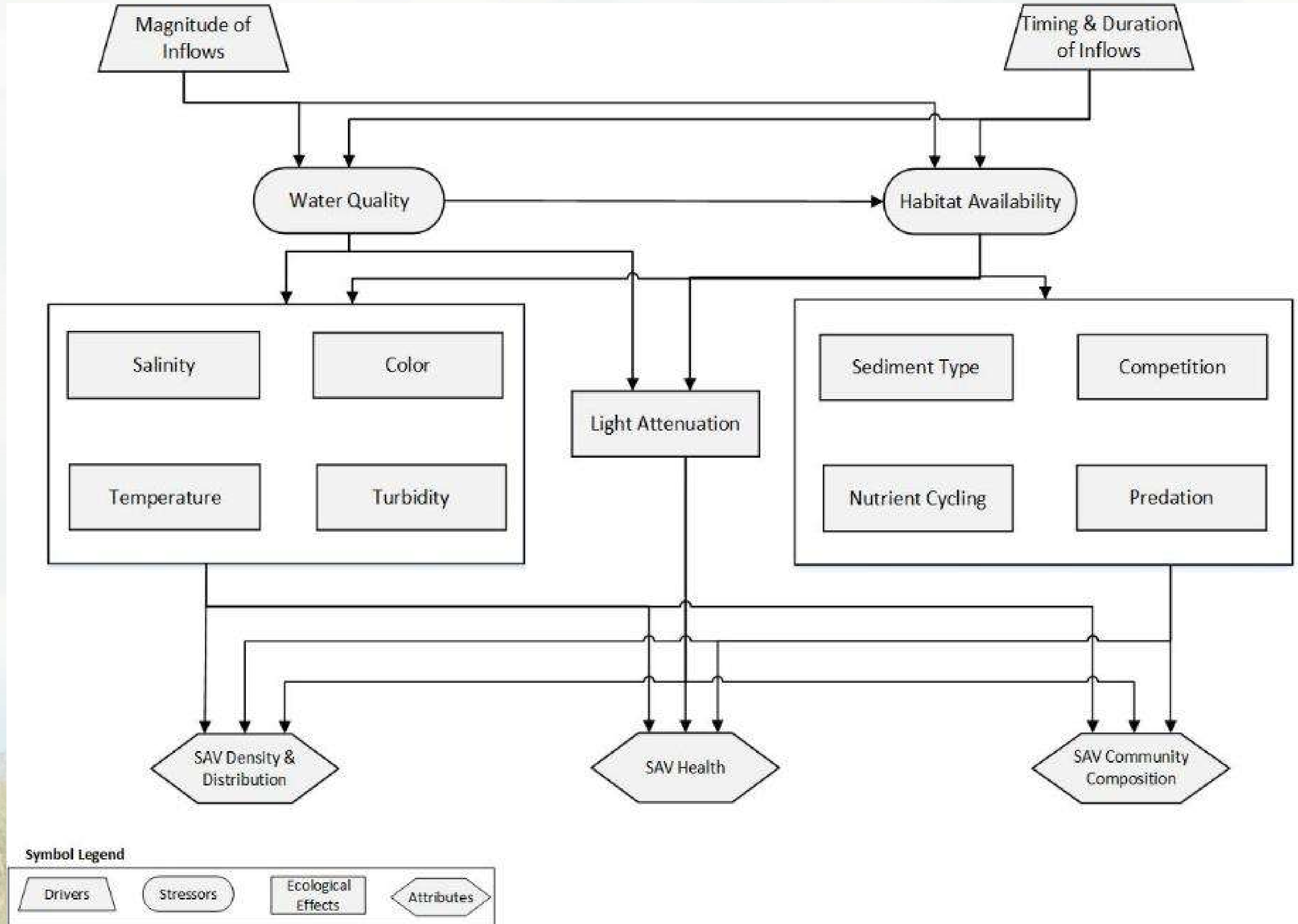
- Oyster density
  - twice a year, the number of living oysters is counted and compared among reefs
- Gonadal index (bimonthly during May-October)
- Spat recruitment (bimonthly during May-October)
- Juvenile oyster growth and survival
  - Juvenile oysters are deployed in mesh bags (open and closed) at all sites and monitored for growth/mortality every other month
- Disease monitoring
  - Total of 15 oysters per sampling condition are collected monthly
- Condition index
  - Ratio of meat weight to shell weight, completed with disease prevalence oyster collection

Northern Estuaries Oyster Hypothesis Cluster

Key Uncertainties:

1. Larval availability and connectivity for sustaining populations (endogenous vs. exogenous sources)
2. Substrate availability for larval settlement indicated through acoustic mapping and substrate classification efforts in the SLE and CRE, but uncertain for the LRE as efforts have not been made in recent years
3. Persistence of suitable settlement substrate after repeated mortality events
4. Resilience and ability of oysters to recover after a damaging event (e.g., will there be an exogenous larval source for recovery after a mortality event)
5. Impact of reduced "year classes" on oyster populations (i.e., decreased oyster life span due to disease and damaging water quality)
6. Impact of weaker and more porous shells on longevity of oyster and oyster population
7. Impact of increased water temperature/reduced seasonality on physiological health of oysters
8. Impact of sea level rise on distribution and health of oyster populations

Northern Estuaries SAV Hypothesis Cluster



Northern Estuaries SAV Hypothesis Cluster

Working Hypotheses:

1. *Increased magnitude and duration of freshwater inflows result in large salinity fluctuations in mid and lower estuarine regions reducing seagrass growth and density, diversity, and productivity.*
2. *Increased temperatures and reduced freshwater flows, particularly in the dry season, result in stress conditions (e.g., thermal, hypersaline) reducing SAV density, diversity, and productivity in the CRE and LRE.*
3. *High color (CDOM), increased turbidity, and the resuspension of muck due to high volumes and prolonged duration of freshwater inflows increase light attenuation in the water column and reduce SAV density, diversity, and habitat availability.*
4. *Increased sediment influx from high freshwater inputs elevates rates of deposition and resuspension of fine-grained sediments, reducing sediment quality and seagrass density, diversity, and productivity. Removal of muck should improve sediment quality and seagrass density.*
5. *High nutrient flux increases phytoplankton abundance, SAV C:N ratio, and sediment sulfide concentrations, reducing seagrass density, diversity, and productivity.*
6. *Increased benthic algal and epiphyte abundance reduces seagrass density, diversity, and productivity through light reduction, hypoxia, and competition for space.*
7. *Grazing or predation, impedes SAV recovery through the removal of above and below-ground biomass, disrupting sediment stability, SAV health, density, diversity, and productivity.*

Northern Estuaries SAV Hypothesis Cluster

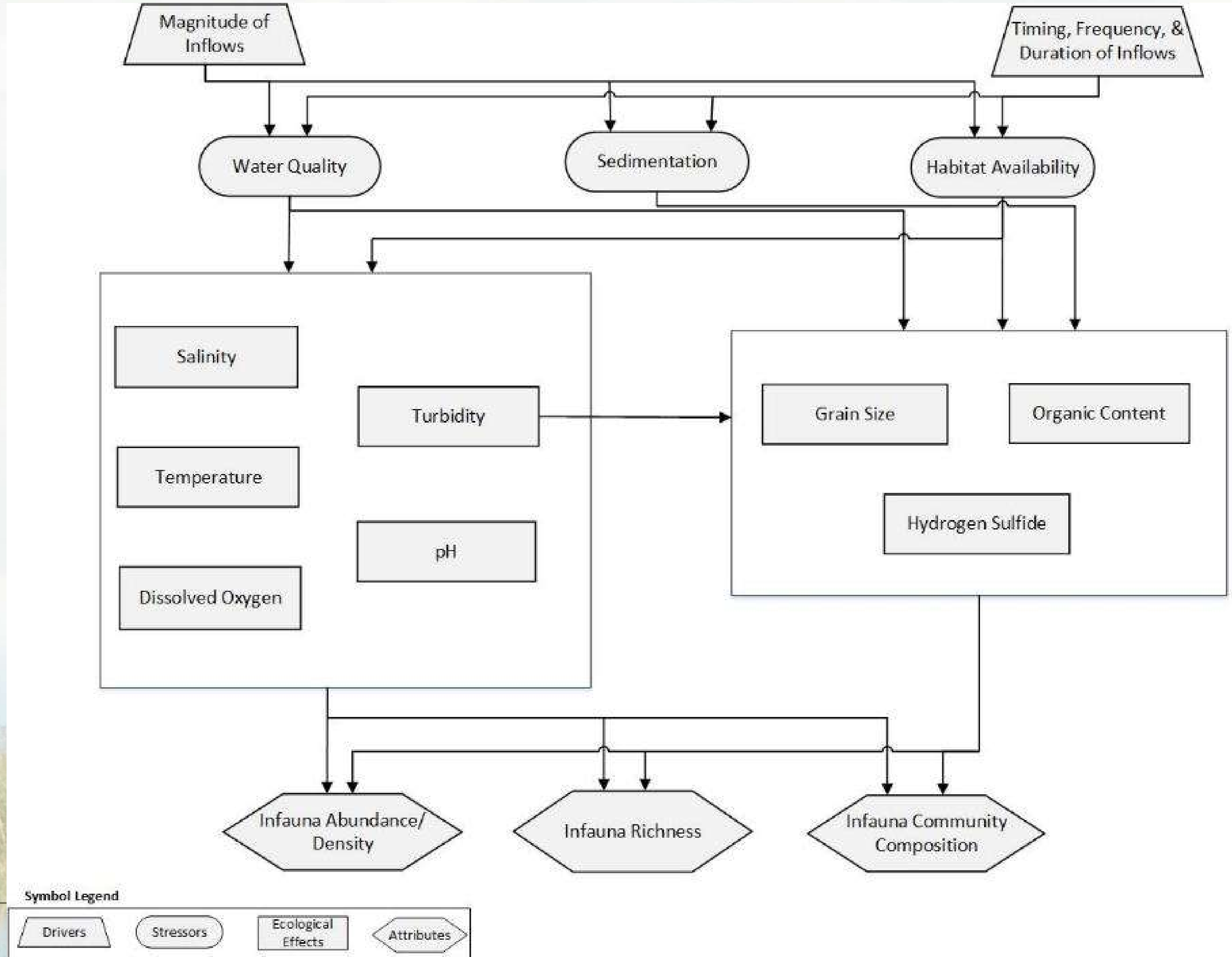
MAP Monitoring:

1. Patch scale- sampled every other month (i.e., haphazard sampling at a GPS location)
   a) Percent cover by species
   b) Canopy height
   c) Water quality parameters
   d) Ancillary parameters
2. Landscape scale
   a) Aerial photos (once every 5 years)
   b) SAV presence/absence recorded using same methodology as patch scale at specific site locations (i.e., transects))

Key Uncertainties:

- Sediment profile and quality to support colonization and patch expansion.
- Impacts of muck dredging on SAV due to prolonged residence times of fine organic particles.
- Impacts of wave attenuation in SAV areas on reproduction and recruitment success.
- Reproduction success and seed sources of the canopy forming species.
- Impact of increased water temperature and reduced seasonality on the physiology of the SAV.
- Impact of increased sea level rise on the distribution of and health of SAV.

Northern Estuaries Benthic Infauna Hypothesis Cluster



Northern Estuaries Benthic Infauna Hypothesis Cluster

Working Hypotheses:

1. *Heavy rainfall and large volumes of freshwater entering the estuaries rapidly lowers salinity reducing water quality and infaunal abundance, diversity, and alters community composition.*
2. *Increased duration and frequency of freshwater inflows create an oligohaline environment reducing water quality and infaunal abundance, diversity, and alters community composition.*
3. *Freshwater inflows increase the delivery and promote the accumulation of fine-grain sediments and organic material that can create unfavorable benthic habitat and reduce infaunal abundance, diversity, and alters community composition.*
4. *Removal of muck and reduction of the factors driving muck accumulation throughout the SLE and southern IRL will increase infaunal abundance and diversity and create healthy benthic habitats.*

MAP Monitoring:

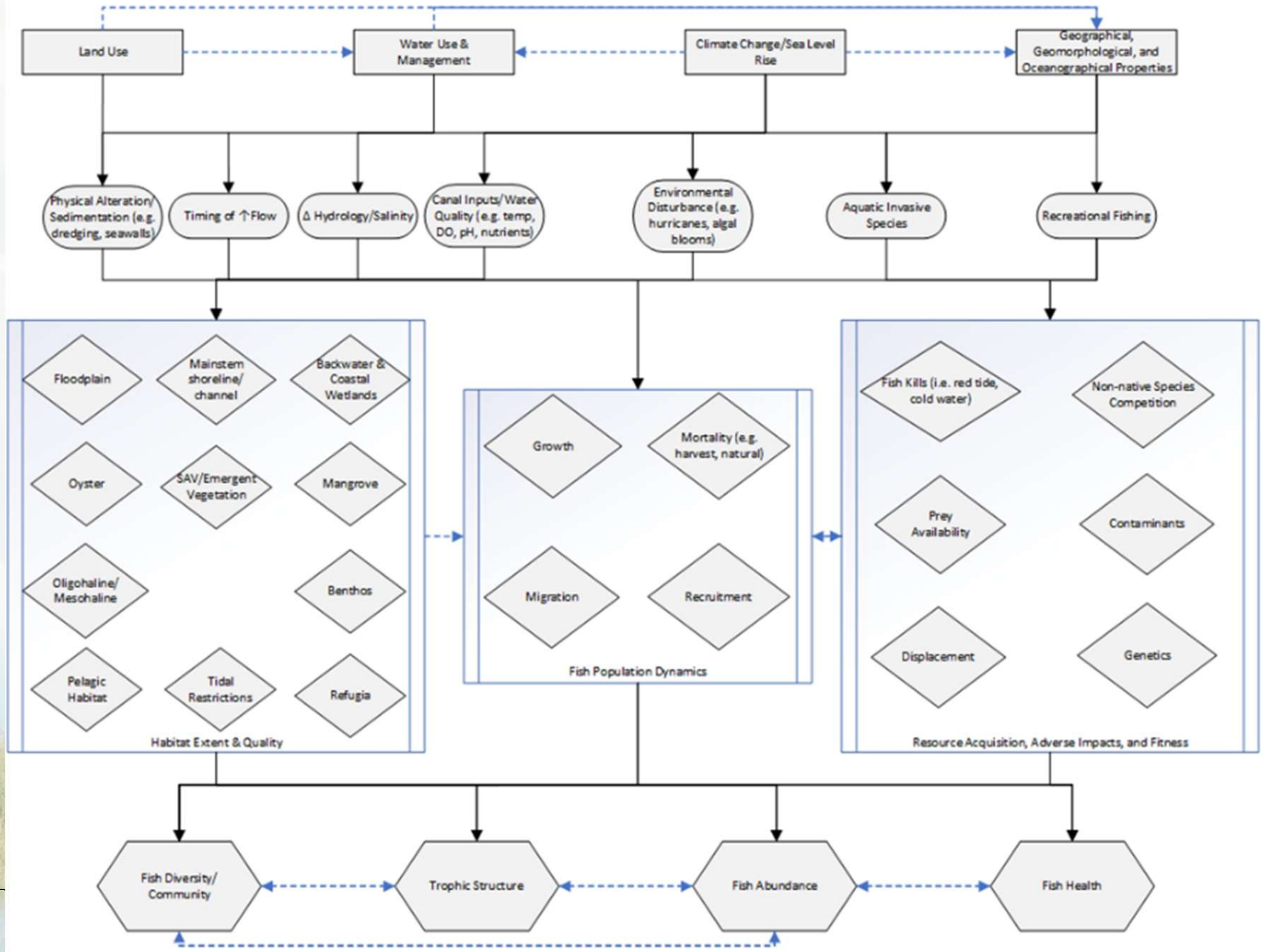
- Infaunal abundance and diversity (i.e., Shannon Index, Evenness, Species Richness)
- SAV (i.e., species and wet weights)
- Abiotic effects (i.e., water quality, flow, climatic conditions)
- Sediment (i.e., color, H_2S, % Water Content, % Organic Content, grain size)

Northern Estuaries Benthic Infauna Hypothesis Cluster

Key Uncertainties:

- Larval availability and connectivity for sustaining populations (endogenous vs. exogenous sources).
- Substrate availability for larval settlement.
- Persistence of suitable substrate after repeated high inflow events or storms that increase turbidity and deposit large amounts of fine-grained sediment.
- Resilience and ability of infaunal species to recover after a damaging event (e.g., the availability of an exogenous larval source for recovery after a mortality event).
- Impact of increased water temperature/reduced seasonality on the physiological health of infauna.
- Effects of predation – as altered by dietary shifts of predators, hypoxic/anoxic events, fish kills, etc. – on infaunal abundance and community composition.
- Environmental tolerance thresholds (e.g., salinity, temperature, grain size) of many infaunal taxa.

Northern Estuaries Fish Hypothesis Cluster



Day 1 #6 NE HC-Matin

Northern Estuaries Fish Hypothesis Cluster

Working Hypotheses:

1. *Maintenance and/or restoration of important nursery and essential fish habitat for juvenile and adult indicator species will promote productive fisheries and the rebuilding of depleted fish stocks.*
2. *Establishing a sufficient baseflow will aid in maintaining an oligohaline zone necessary for a healthy coastal ecosystem resilient to changes in regional controls (e.g., climate change, rainfall, sea level rise), thus ensuring that a productive native species-dominant oligohaline fish assemblage persists and that ecologically-meaningful isohalines are maintained downstream. Alternatively, rapidly changing salinity can adversely impact these fish assemblages.*
3. *Conserving the physical and biological processes affecting seagrass, which have been lost in many Florida estuaries, will provide habitat for economically-important fishes.*
4. *Maintaining and restoring productive biogenic habitats (i.e., oyster reefs, mangroves, and emergent vegetative habitats) will benefit fish assemblages and their prey, including indicator species such as Atlantic goliath grouper, common snook, and red drum.*
5. *Dredging, water releases, and water quality conducive to mercury resuspension and methylation will correlate with high environmental mercury concentration and biomagnification in the food web and result in fishes with higher than normal mercury in their tissues. The same is true for other toxicants like PAHs, PCB, and DDT. High levels of such toxicants are detrimental to fish populations and also to human consumers, and result in poor health conditions and abnormalities.*

Northern Estuaries Fish Hypothesis Cluster

Working Hypotheses:

6. *A normalized hydrologic condition coupled with habitat restoration will benefit the fish community to promote resilience to future disturbances. Normalized hydrological condition refers to clean water with low levels of nutrients and pollutants, a natural hydrograph rather than rapid unseasonal releases, optimum salinity and dissolved oxygen levels, greater tidal exchange, and floodplain connectivity.*
7. *Seasonal variation of freshwater inflow and flushing during key times of the year will change ichthyoplankton assemblages.*
8. *Nutrient enrichment alters water quality and results in red tide and other harmful algal blooms (HABs) causing fish kills, displacement or a shift in behavior, including movement rates and home ranges, in order to acquire sufficient resources (i.e. prey distribution changes as well).*
9. *Restoration of natural coastal habitats and maintaining freshwater/oligohaline zones will promote recovery of native species communities and will restrict many invasive fishes to upper reaches of the system.*
10. *Natural healthy soft sediments support healthy estuarine fish communities while excessive accumulations of anoxic muck can have a negative influence on the community.*
11. *Healthy freshwater emergent herbaceous vegetation has a direct relationship to oligohaline fish.*

Northern Estuaries Fish Hypothesis Cluster

MAP Monitoring:

- Fishery Independent Monitoring (FIM)
  - Identifying Fish Nursery Habitats in the St. Lucie River Estuary and Loxahatchee Rivers
  - Annual indices of abundance for several indicator species (i.e., spotted seatrout, common snook, and sheepshead, striped mullet)
  - Not available in the CRE

- SFWMD Fish Monitoring
  - Monitoring the impact of seasonal freshwater inflows to St. Lucie River Estuary on resource use and fish health using economically and ecologically important fish as indicator species
  - Evaluate and assess various performance measures in relation to freshwater inflows,
  - volume, and timing in South Florida's Northern Estuaries

Northern Estuaries Fish Hypothesis Cluster

Key Uncertainties:

- Long term effects from loss and/or alteration of habitat and nutrient pollution (i.e., magnitude and duration of impacts are unknown)
- Fish kills
- Varying effects from acute versus chronic disturbances (e.g., hurricanes vs water management)on fish community
- Biomagnification of mercury, pesticides, and other toxicants
- Amount and spatial extent of habitat needed for restoring fisheries
- Invasive fish species
- Elasmobranch nurseries

Northern Estuaries Fish Hypothesis Cluster

Key Uncertainties:

- Ecological linkage between estuaries and the coastal ocean
- Importance of certain fish habitats (i.e., seagrass, oyster reefs, mangroves, and salt marshes) to various fish species and to what degree
- Spatial extent of oligohaline habitat needed to maximize production and survival of low salinity fish indicator species