MEP Linked Watershed Embayment Model

Scientific Peer Review Panel

Preliminary Findings

November 16, 2011

Peer Review Panel Members

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  Estuarine Water Quality Modeling
- Peter Shanahan, Ph.D., P.E.
  Groundwater Modeling
- Lawrence E. Band, Ph.D.
  Soils Science & Nitrogen Transport
- Billy H. Johnson, Ph.D., P.E., D.WRE
  Estuarine Hydrodynamic Modeling
- W. Judson Kenworthy, Ph.D.
  Estuarine Biology
- Paul E. Stacey, M.S.
  TMDL Policy & Regulatory Issues

Background

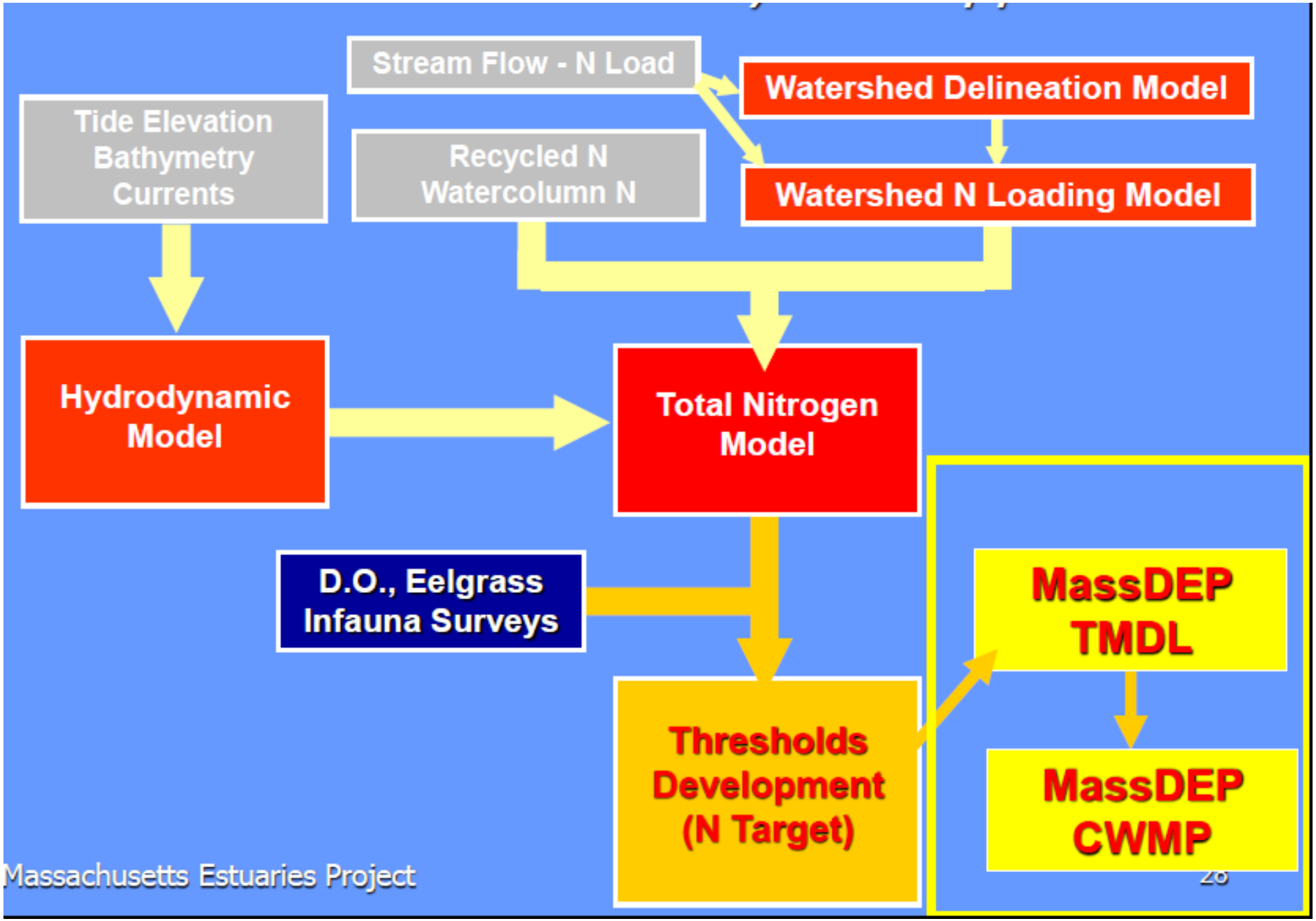
Nitrogen Enrichment and Eutrophication of Coastal Marine Systems

- Nitrogen enrichment is a widespread problem leading to eutrophication of coastal ecosystems worldwide
- Eutrophication is a condition caused by excessive nutrient loads, leading to increased algal growth, reduced dissolved oxygen, and ecological impacts
- Nitrogen delivery to Cape Cod estuaries is dominated by septic sources delivered to local waters through groundwater transport

Total Maximum Daily Loads (TMDLs) and Nitrogen Sources

- Chesapeake Bay
  - Delivered by surface inflows
    - Agricultural
    - Wastewater treatment plants
    - Urban
  - Atmospheric sources
- Long Island Sound
  - Wastewater treatment plants
- Cape Cod
  - Septic sources are local and delivered through groundwater transport

MEP Modeling Approach


Stream Flow - N Load
Watershed Delineation Model
Tide Elevation
Bathymetry
Currents
Recycled N
Watercolumn N
Watershed N Loading Model
Hydrodynamic
Model
Total Nitrogen
Model
D.O., Eelgrass
Infauna Surveys
MassDEP
TMDL
Thresholds
Development
(N Target)
MassDEP
CWMP

Components of MEP Hybrid Approach

- Directly computed by models
  - Watershed nitrogen loads to the estuaries
    - Distributed sources
    - Groundwater transport
  - Estuarine nitrogen concentrations
    - Linked hydrodynamic-water quality model
- Determined by observed data
  - Water quality
    - Chlorophyll
    - Dissolved oxygen
  - Ecological responses
    - Benthic animals
    - Eelgrass

Linkages in MEP Hybrid Approach

- Model-Based
  - Nitrogen loads from the watershed linked to computed nitrogen concentrations in the estuaries
- Data-Based
  - Observed data for water quality and ecological responses linked to observed data for nitrogen concentrations in the estuaries to derive thresholds
- TMDL
  - Uses MEP models to link threshold nitrogen concentrations in the estuaries back to nitrogen loads from the watershed

Charge Question 1

Is the MEP modeling approach scientifically defensible and functionally adequate to be relied upon in the development and implementation of appropriate nitrogen TMDLs for the estuaries and embayments of Cape Cod in support of the state's Comprehensive Wastewater Management Planning and EPA Clean Water Act requirements and in developing overall wastewater and nutrient management plans for Cape Cod to meet the TMDLs?

The Panel Finds that the MEP Modeling Approach is Scientifically Defensible

- It is consistent with the best understanding of existing conditions for Cape Cod estuaries, based on available data
- The component models are well-known, documented and tested
- Watershed nitrogen loads are data-driven and quantitatively linked to estuarine nitrogen concentrations

The Panel Finds that the MEP Modeling Approach is Functionally Adequate

- It explicitly considers nitrogen loads from septic systems
- It is designed for groundwater dominated systems
- The component models are compatible with the available data and project resources
- The approach is consistent with existing nationwide TMDL practices
- It can be used to evaluate alternative scenarios and inform nutrient management plans

Charge Question 2

To what level of accuracy will the MEP linked model predict the effect of alternative nitrogen load planning scenarios and/or the prospective water quality in the affected estuaries and embayments and what is the degree of error in those predictions?

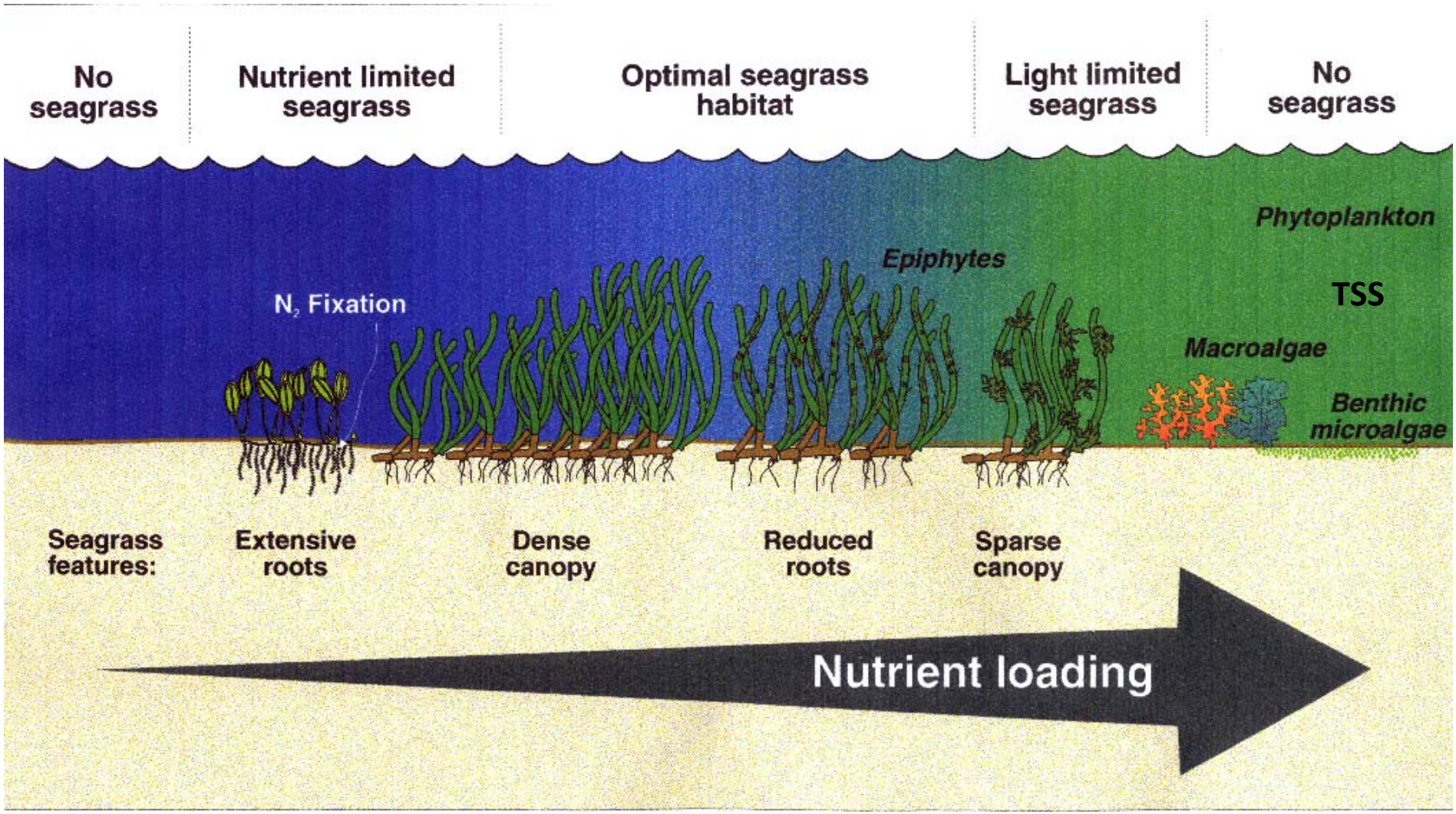
What is Known with Certainty (1)

- Water quality and ecological conditions have been declining and continue to decline in the bays and estuaries of Cape Cod
- Increasing loads of nitrogen are a major cause of these declines
- Most of the nitrogen loads from the watershed are delivered through groundwater transport

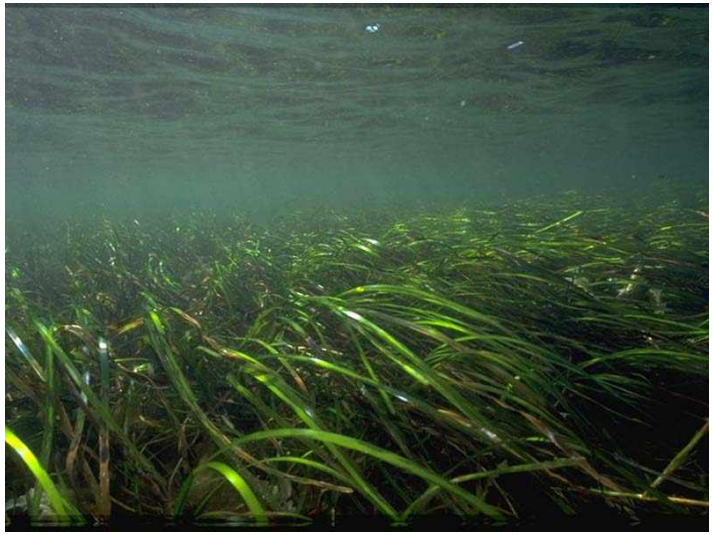
What is Known with Certainty (2)

- Eelgrass is a particularly sensitive indicator of ecological health
- Monitoring data show the area of eelgrass to be declining by an average of 3.4 percent per year in Cape Cod's southern bays and estuaries
- Increases in nitrogen loads from the watershed are closely linked with declines in eelgrass

Seagrass Decline



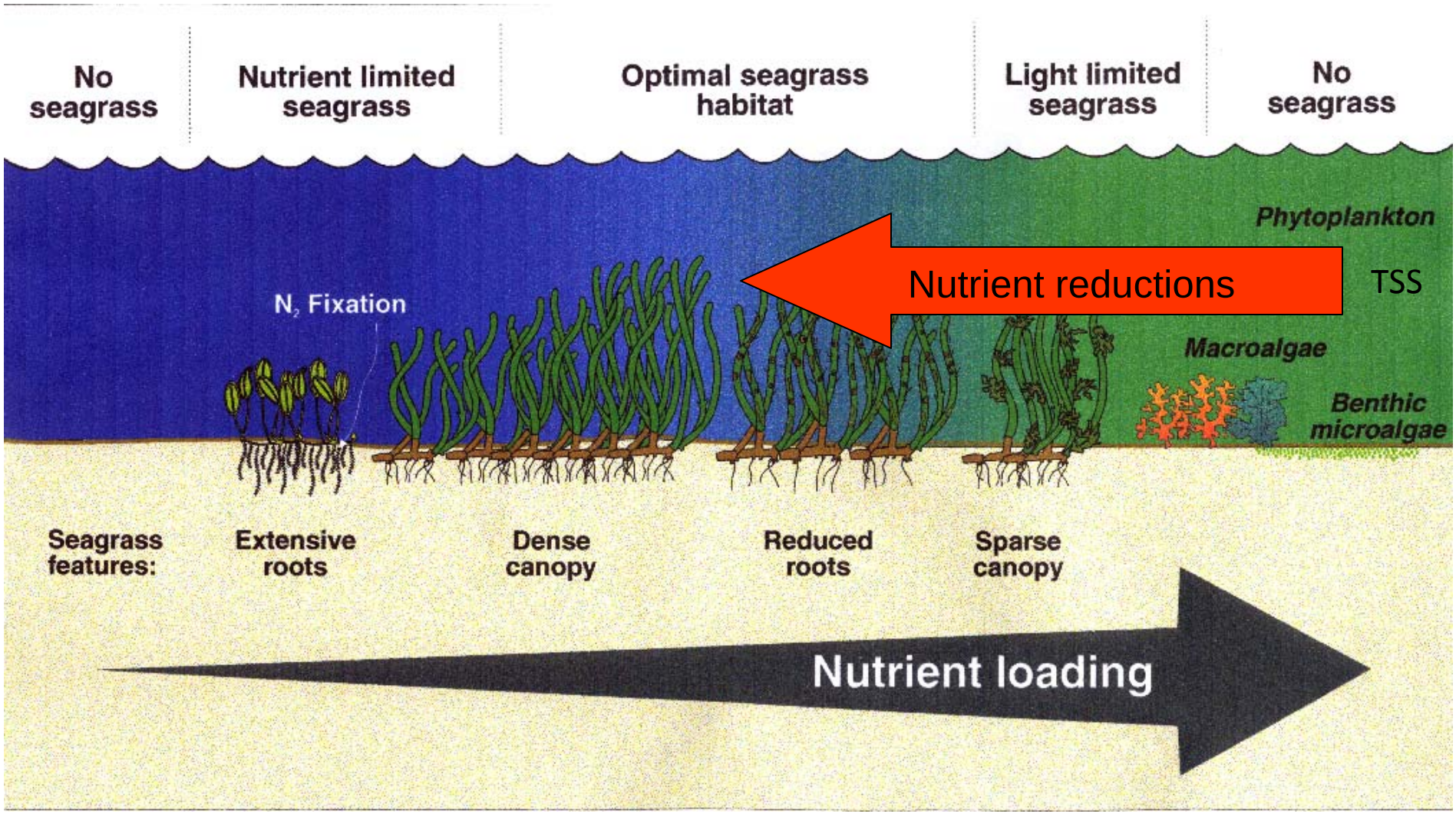
Seagrass Decline



What is Known with Certainty (3)

- Further increases in nitrogen loads will lead to further declines in water quality and ecological health
- Decreases in nitrogen loads will result in improved water quality and ecological health
- Reductions in nitrogen loads from wastewater discharges to Boston Harbor, Gloucester Harbor, and New Bedford Harbor have been followed by increases in the areas of eelgrass

Seagrass Recovery



Areas of Uncertainty in MEP Approach

- Delivery of nitrogen loads to Cape Cod estuaries through groundwater transport is more complicated than in systems with major wastewater discharges
- In response to nitrogen load reductions on Cape Cod:
  - Reductions in estuarine nitrogen concentrations computed by the MEP approach are relatively certain
  - Degrees of improvement in DO and chlorophyll concentrations inferred from the MEP approach are less certain
  - Location and areal extent of eelgrass recovery inferred from the MEP approach are uncertain, as is the timing of the recovery

Path Forward

- We recommend an integrated monitoring, data analysis and modeling process
- We recommend an adaptive management program for controlling watershed nitrogen loads
  - To ensure that TMDL implementation is not compromised due to a lack of information
  - To ensure progress while gathering new information to improve upon initial TMDL plans

Benefits of Path Forward

- Gain better understanding of the controlling physical, chemical and biological processes in Cape Cod watersheds and estuaries
- Reduce uncertainties in:
  - Relationship between nitrogen loads from the watershed and estuarine nitrogen concentrations
  - Relationships between estuarine nitrogen concentrations and impairments
    - Water quality (DO and chlorophyll)
    - Ecological (benthic animals and eelgrass)
- Take immediate steps to control further load increases
- Optimize expenditure of resources