Long Island Sound Synthesis Volume

Co-editors: R. Lawrence Swanson (SBU), Charles Yarish (UConn), Corey Garza, (NOAA, Long Island Sound Office)

Steering Committee (Chapter Section Leaders)

Oceanic Circulation, Mixing, Geomorphology and Physical Forcing: Jim O'Donnell (UConn), Bob Wilson (SBU)
Biogeochemistry: Carmela Cuomo (UNH), Kirk Cochran (SBU)
Pollutant Sources, Magnitudes and Trends: Johan Varekamp (Wesleyan), Anne McElroy (SBU)
Ecological Processes: Bob Whitlatch (UConn), Glenn Lopez (SBU)
Biological Conditions: Gerry Capriulo (St. Mary's College), Bill Wise (SBU), Hans Dam (UConn)

Theme for Long Island Sound Synthesis Volume

To date a comprehensive reference volume synthesizing the body of research that has been conducted in and around Long Island Sound has not been readily available to the local research and management community. The proposed volume would bring together a body of environmental data collected by researchers from the academic and agency communities as it applies to understanding the environmental dynamics of Long Island Sound. Throughout the synthesis, an emphasis will be placed on summarizing our current knowledge of the physical and biological processes in an encyclopedic format that can serve as a primary reference volume for scientists conducting research in Long Island Sound. In addition to the data summaries, chapters would also be included that discuss recommendations for synthesizing this body of knowledge into a comprehensive ecosystem based management strategy for Long Island Sound. The proposed document, would be developed primarily for a technical audience to guide both research and management activities.

1. Geological History of Long Island Sound

(Authors: R. Lewis, H. Bokuniewicz and C. Cuomo)

2. Socioeconomic History of Long Island Sound

(Author: M. Weigold, E. Pillsbury)

3. Physical Oceanography

(Contributors: F. Bohlen, M. Bowman, R. Lewis, K. Lwiza, J. O'Donnell, R.L. Swanson, M. Whitney, R. Wilson)

3.1. Introduction: basic characteristics of Long Island Sound as a large, temperate latitude, partially mixed estuary located on the US eastern seaboard.

- Basic hydrography and geomorphology: physical dimensions, geomorphology, principal connections to the ocean and New York Harbor, temperature, salinity, density and location of freshwater sources.
- Spatial structure of hydrographic properties.
- Meteorology: winds, heating, cooling, air-sea interaction: properties and seasonal cycles.
- Rivers and watersheds.
- Tides, tidal currents, resonance, tidal stirring.
- Gravitational circulation.
- Wind driven and tidal residual currents, mixing and surges.
- Tidal mixing and estuarine fronts.
- Surface waves.

3.2. Topics in Physical Oceanography and related effects

A. Significance of small bays/inlets to LIS oceanography and water quality (

- Do they export nutrients?
- Is there sediment accumulation?
- Is there an effect of constricting the entrance?
- Ground water input
- Water treatment plants in CT discharge into bays (Stonington) and we need to know the processing/trapping etc.

B. Proximity consequences of Metropolitan New York

- Point and distributed sources of contamination
- Sewage treatment and discharges into East River
- STP nitrogen and carbon concentrations and budgets
- Atmospheric contributions of nitrogen

C. Physical Processes influencing hypoxia (Suggested authors: K. Lwiza, R. Wilson, R.L. Swanson, J. O'Donnell)

- Seasonal vertical mixing rates
- Horizontal advection and dispersion of dissolved oxygen and nitrogen between regions
- Boundary exchanges between the East River, LIS and the ocean
- Water column stratification: insolation, fresh water runoff and tidal mixing variations
- Winds: seasonal patterns, storms, surges and mixing
- Climate variability

D. Impact of Severe Storms: Nor'easters and Hurricanes
(Suggested authors: M. Bowman, R. Wilson, F. Bohlen, Colle, Buonaiuto)

- Basic properties of hurricanes and nor'easters
- Storm surge and inundation (frequency and magnitude)
- Historical storm tracks
- Surge characteristics and timing
- Coastal pollutant transport

- Coastal and bottom erosion by storm waves

E. **Climate change and interannual variability** (Suggested Authors: R. Wilson, M. Bowman, M. Whitney)
- Water temperature and pattern
- Precipitation changes and river discharge
- Timing and magnitude of river fresher/salinity distributions
- Wind variability and direction
- Seasonal variation in stratification
- Links to NAO and other indices?

F. **Impacts of sea level rise** (Suggested Authors: M. Bowman, M. Whitney, J. Varekamp)
- Change tides
- Frequency of flooding
- Shore line erosion and salt mash impacts
- Change salt flux in East river
- Change the frictional dissipation distribution
- Strom surge barriers and tidal gates

3.3. Big Questions?

- What controls vertical mixing rates and variability?
- What controls the benthic exchange? (including sediment resuspension, transport, nutrients, radiotracers)
- What controls the:
  - Horizontal transport (salt, water, nitrogen, carbon) and exchange through the East River?
  - Horizontal transport (salt, water, nitrogen, carbon) and exchange through the Race?
  - Horizontal transport (salt, water, nitrogen, carbon) and exchange through the CT Rivers?
- What is the ground water flux?
- What is the surface heat and water flux?
- What is the surface momentum flux?
- ESTABLISH the sensitivity of SWEM to the simulation of physical processes by developing at least two additional models
- RECONSIDER the biogeochemical model
- UPDATE the biogeochemical coeffiecients

- Rivers & Watersheds

- Connecticut
- Housatonic
- Quinnipiac & Mill
- Thames

- East River
- Exchange with small bays
- Groundwater (Suggested Authors: K. Cochran, T. Torgersen in other chapter)

- Surface exchanges (water, heat, CO2 and O2), (Suggested Authors: Monahan, Edson)

B. Geology (Suggested Author: R. Lewis)
- the bathymetry and its evolution
- characteristics of the sediments
- sediment sources and transport mechanisms
-

G. Benthic Disturbances (Cables, Pipelines, Navigational Dredging (mechanical disturbance) and Dredge Material Disposal (Suggested Authors: F. Bohlen, R. Lewis)
- Turbidity modulation
- Bottom stress (current and waves)
- Circulation
- Bed sediment type and geomorphology
- TSS transport
- Tidal power
- Wind power

4. Biogeochemistry Modules (all subjects will be considered with regards to spatial & temporal trends)

A. Diagenesis Overview (Author: R. Aller)
B. Bioturbation/Bioirrigation – Quantity, Seasonal Variation, Benthic Faunal Links, Rates, Functional Groups (Authors: J. Aller, C. Cuomo, K. Cochran, D. Rhoads, R. Cerrato)
C. Carbonate Dissolution – Biomineral Cycling – Silica (Authors: R. Aller, M. Green)
D. Fluxes [O, Si, N, P, (CH4,Mn, S)], Organic Matter Remineralization, Sed-Water Column, Maps (Authors: R. Aller, M. Altabet, C. Cuomo)
E. Radionuclide-Sources, Inventories (Lateral Exchange of Particles) (Authors: K.Cochran, R. Aller)
F. [Water Column Nutrient Dynamics – oxygen to ecological conditions] – will include here if not being included in any other section
G. Pulses of Organic Matter – organic compounds, pigments (Authors: R. Aller, K.Cochran, M.Altabet)
H. Sulfur Cycling – Pore Water/Solid Phase, S Pools, S Fluxes (Authors: C.Cuomo, R. Aller, P. Visscher)
I. Redox-Sensitive Metals (Mn) (Authors: R.Aller, D.Wang)
J. Microbial Communities (Authors: J. Aller, C.Cuomo, P. Visscher)
K. Stable Isotopic Tracers of Nutrient Element Budgets (Author: M. Altabet)
L. Air-Sea Interface Exchange – CO2, O2
M. Coarse-Grained Sediments (Authors: K.Cochran,, T. Torgesen)
N. Water Column Metal Geochemistry (Authors: A. Beck, D. Wang)

5. Pollutant Sources, Magnitudes and Trends

A. Historical trends in contaminant loadings, geological to modern, as preserved in

sediment cores (Authors: M. tenBrink, J. Varekamp, G.. Benoit, K. Cochran, W. Fitzgerald)

- Data on sediment cores showing differences in contaminant accumulation rate (if available) or concentrations
- Methods of digestion/analyses
- Dating constraints, bioturbation
- Marsh cores - well dated records with atmospheric inputs + particulate bound compounds/elements
- Lake cores for atmospheric deposition records
- Climatic impacts on records
- Influence from point sources

Sources: USGS database, individual researchers

B. 30 year records - Contaminant sources of LIS
(Authors: J. Mullaney, P. Stacey, S. Anisfeld, B. Cotrell, T. Graedel, M. Liebman)

- Riverine inputs
- Atmospheric inputs nutrients and metals, sewage flux data
- Changes in land use – model fluxes related to these changes
- Submarine discharges

* Extrapolating to PCBs, S California sludge data set for trends in metals et al., PAHs from other areas,– industrial ecology? Tie in land-use data to loadings (LISS, Stacey). USGS database, for Nutrients, ambient monitoring, LI data? Region 1 EPA? Submarine discharge inputs USGS, Region 1&2 regional offices on sewage, 1993 to present nutrient data , NYDEP, N and P and Si, & TOC, ratios of N/P? Sergio data

C. Current inventory and recent trends in contaminants in space and time
(Authors: V. Breslin, M. tenBrink, B. Brownawell, P. Stacey, L. Poppe, R. Flood, A. McElroy)

- Surface sediments from LIS TOC data
- Water column concentration data (nutrients)
- Link to sediment deposition and transport, include water column nutrient.
- Dredging and disposal

Sources: NOAA, EMAP, REMAP, NCA, Mussel Watch.

D. Metal Budgets and Processes
(Authors: W. Fitzgerald, R. Mason, J. Varekamp, G. Benoit, V. Breslin, M. tenBrink)

- Metals – Hg, Cu, Cr, Pb, Cd, Sn, Ag

E. Organic contaminants (Authors: B. Brownawell, G. Benoit, A. McElroy, S. deGuise, R. Burgess)

- Legacy compounds, emerging contaminants
- PCB
- PAH
- Chlorinated pesticides
- PBDE
- PFOS

- PFOA
- EDC's
- Pesticides
- Nanotubes

F. Nutrients and Carbon (Authors: M. Altabet, P. Stacey, J. Varekamp, J. Mullaney, J. Kremer)

- N, P, Si, C – total inputs, spatial distribution of inputs, sediment sink, export with biota (lobster, fish), N-species, denitrification, remobilization fluxes from sediment, distinction between OC-marine and OC-terrestrial, tidal export.

G. Bioaccumulation and effects of contaminants on LIS biota
(Authors: A. McElroy, S. deGuise, B. Brownawell, R. Mason)

- Spatial and temporal trends
- Metals, organics,
- Mussel, Watch,
- Striped bass surveys, NCA REMAP

H. Other Issues (Authors: R.L. Swanson, M. Liebman)

- Plastics and other floatable debris,
- Bacteria, pathogens, viruses
- Antibiotic resistance
- Oil and grease

Sources: Save the Sound, The Littoral Soc.

I. Future trends (Authors: A. McElroy, M. ten Brink, J. Varekamp)

- Climate change
- Relaxation of hypoxia
- Major storms
- Sea level rise
- Changes in population and related energy use

6. Biological Conditions Component (Authors: G.M. Capriulo, W. Wise)

A. Food Web Considerations (Authors: G.M. Capriulo, G. Wikfors, B. Peterson, E. Thomas, C. Cuomo et al.)

- Alterations due to perturbations (natural & human-induced)
- Spatial (e.g. East to West) variations
- Hypoxia/anoxia formation (biological considerations)
- Effects of changing climate
- Key biological croups that impact conditions
  - Water-column
  - Benthos

B. Biodiversity (Authors: G.M. Capriulo, J. Carlton, G. Wikfors, R. Whitlatch, H. Weiss, R. Zajac, S. Warren, C. Pickerell, B. Peterson)

- Assessment of key groups
- Shifts due to human-induced & natural causes
- Changes in biological equilibria (permanent & transient)
- Introduced/invasive species
- Diseases of important organisms
- Seasonal dynamics of organism life cycles & pollutant impacts
- Toxic red tides & other toxic algal blooms
- Effects of changing climate

C. Habitats (Authors: G.M. Capriulo, R. Whitlatch, G. Lopez, C. Yarish, R. Zajac, S. Warren, C. Pickerell, B. Peterson)

- Water column (East to West variations)
- Benthos (mud, sand, gravel, rocks)
- Changing qualities
- Salt marshes and wetlands
- Bays, coves, harbors
- Water Acidification (pH shifts)

D. Fisheries and the Impact of Harvesting (Authors: W. Wise, M. Frisk, D. Simpson, D. Conover, P. Auster)

- Pelagic & demersal Fish
- Shellfish
- Lobsters
- Whelks & limulus

E. Wildlife (Authors: H. Weiss et al.)

F. Physiological Responses to Stressors (TBA)

7. Ecological Processes

7.1. Primary Production and Fate

The synthesis will attempt to cover both pelagic and nearshore areas.

Lead authors for pelagic work: H. Dam, Goebel, S. Lin, J. Kremer, W. Peterson, J. Varekamp; Lead authors for nearshore work: C. Yarish, S. Warren, C. Pickerell, B. Peterson)

* Data sets:

LISS/DEP monitoring programs (88-2007)
W. Peterson's (Central Sound 1985-88)
J. Kremer's (early 2000's)
Riley's study (50's)
Varekamp's (paleorecord)

A. What controls primary production

- Light
- Temperature
- Nutrients

- Is it primary producers
- Growth – respiration – biomass approach (equation)
  - dB/dT=growth-R-Grazing-Sink

B. Fate of production
- Quantity
- Identity

1) Have there been changes in the driving functions of primary production, and in the primary production in the last 50 yrs (since Riley) – Riley data is uncertain, we can't tell; Use other historical data ?
   i. How does it effect ecosystem community
      - Total
      - Water column
      - Benthic
   ii. Why?
      - Nutrients – other anthropogenic forcings
      - Physical

2) What are the spatial and temporal distribution, gradients in drivers of PP, biomass and PP?
- Are gradients reflected in productivity in different habitats (benthic, marsh)
- Not a lot of info on benthic production
- Reasonable info on marsh production
- Biomass level
- Links to management applications
- Projected changes related to climate change/how has it changed already

3) Has structure of primary producers changed - has there been a shift in community structure?
- What are the food web consequences of that?
- What controls the community structure – why and how?
- Rate of change (post disturbance)
- Changes in forcing factors

7.2. Trophic Transfers & Dynamics - Forcing Function Effects (Light, Temperature, Nutrients, Biological Agents) in the Pelagic and Benthic Realms (Authors: G.M. Capriulo, G. Lopez, R. Whitlatch, G. Wikfors, R. Zajac, R. Cerrato, E. Thomas, J. Kremer, P. Auster, H. Hayes, H. Dam)

A. What are the changes in the fate of the production?
- Role of primary production in driving hypoxia
- Exchange of biomass in production
- Changes in sinks
- Spatial variation
- Has ratio of grazing to sinking changed and is it spatially variable
  - Links fate to food webs
  - Hypoxia
  - Food availability for benthic and pelagic
  - Cloern – DO equation

B. Fate through food web links

C. Shifts in biological partitioning among key food web components in the pelagic and benthic realms via changes in species composition and related production outcomes
D. Horizontal & vertical trophic imports & exports
- Migrations
- Losses due to predation and subsequent predator movements
- Human-mediated transport
- Respiratory loss

E. Possible changes in grazing to sinking ratios of primary production
F. Dominance of grazer food webs vs. detrital food webs
G. Thresholds & physiological limits
H. Top down vs. bottom up controls

7.3. **Response to Disturbance (Diseases and Invasive)** (Authors: R. Zajac, R. Whitlatch, R. Cerrato, B. Allam, M. Fast, A. Whelchel, G. Lopez)

A. Disturbance regimes
- Natural
- Anthropogenic
- Sources and scales
- ACE
- Chronic vs emp
- Biological disturbances; invasions, disease
- Land use; armoring shoreline, breakwaters, marinas

B. Responses to disturbance: spatial and temporal
- Overall processes and responses; organism responses to different stressors
- Provide case studies: lobster, dredging
- organize around an ecological hierarchy
- Functional groups and threshold effects
- Effects of multiple stressors; additive
- Indicator species
- Timing of disturbance

C. Managing disturbance
- Dredging and pipelines
- Climate change: temp., sea level rise

8. Management Issues (Current and Future)

(Authors: M. Tedesco, C. Garza, L. Swanson, C. Yarish, A. Whelchel)