Penny Howell's notes from Jan. 18 Long Island Sound Study Science Teachers' webinar

TEACHING CLIMATE CHANGE –Close to Home Right Now
Key Concepts

Global vs Local Context: Energy Flow

1. One of the most important factors determining the extent of climate effects within an ecosystem is energy flow (in ecology, energy flow is the movement of energy around an ecosystem by biotic and abiotic means. Ecological pyramids (food chains) are where a sizable percentage of energy is held, where organisms in the chain supply an energy source to other organisms and so forth). In an ecosystem, the greater the flow, the greater potential effects. Ecosystems that have high rates of energy flow include the Earth's two poles and tropical rain forests, but one of the highest rates of energy flow on the planet is in Estuaries, and Long Island Sound is right nearby!
   A. Estuaries are mixing zones for riverine freshwater and oceanic saltwater which create large nutrient pulses, resulting in what is called 'coupled systems' that balance all comings and goings ("fluxes") and, in doing so, maximize biological production in a very small area.
   B. Estuaries are 20 times more productive (=more energy flow) per square kilometer than the open ocean and 10 times more productive than coastal seas.

2. CLIMATE CHANGE must be measured by statistically significant trends in long term patterns of production (=energy flow) and/or biomass (= numbers of plants and animals) so natural variability (aka 'the local weather') can be separated from true shifts due to climate which result from global forces affecting local production and abundance.

Which data are useful? How much do you need to draw meaningful and reliable conclusions?

Measuring TRENDS in a changing environment - **Temperature**

3. Physical Data: Focus on measurements that have the least extraneous controlling factors (e.g. bottom water temperature versus surface water or air temperature) and are consistently recorded for at least 3 times the life cycle of biological processes of interest (usually ~20-30 years minimum).
   A. Use long term data to find trends within the system's historic variance. Average of annual readings can show a clear persistent trend if the focus is on the historic observed range. Graphs can deceive: set the Y-axis to fit the data.
   B. Seasonal averages are more relevant to biological processes that tend to show strong seasonality.
   C. A clearer illustration of these trends is to express each annual or seasonal average as the difference from the long-term average of the entire data set (= each year's deviation from the series mean). However, watch out for a 'moving baseline' effect – for example: the local "long term mean" in bottom water temperature in Long Island Sound increased ~2% 1976 to 1991, so deviations from a 40-yr average will be larger than from a more recent 20-yr average but the trend would be similar.

4. Biology: Different species respond differently to changes in temperature.
   A. For many animals the actual temperature doesn't matter as much as the extent & duration of temperature above or below a stress threshold. Consider change in both location and timing or duration, both are important & synergistic. [Look up lab studies or distribution data for specific species].
   B. Best presentation of data: change in relation to a mean or median value; percent of a maximum value or biological threshold.

C. Climate 'models' incorporate all temperature and other relevant physical data available and map them with species distributions to get 'spatial temperature profiles' over years to show geography of change: where climate effects are greatest; where and when change may occur in the future if TRENDS continue.

5. Community Interactions: Grouping species based on their thermal tolerances (or other common physical response) can minimize unimportant variation and emphasize trends [example: seasonal plots of abundance of all cold-adapted versus warm-adapted species shows temperature effect]
6. Species richness (='biodiversity'= average number of species captured in each sample) is a very good measure of community stability, especially as a trend over time. A diverse community, made up of species that are generalists, specialists, and using different food sources, is more stable and has a greater likelihood of withstanding disturbances than one with only a few species. A community with high and sustained diversity indicates that the many habitats within the ecosystem are productive.

SUMMARY:

- Use long term data to find trends within the system's historic variance
- Highlight change by expressing data deviations from average or from baseline values
- Look for biological thresholds
- Consider change in location, timing or duration; all are important & synergistic
- Identify sensitive or reactive species = 'bell weathers'
- Grouping species with similar biological response may emphasize larger scale trends over time
- The total or average number of species present is a good indicator of community stability

Cold adapted animals aren't dying because of increasing temperature; they just can't thrive without the competitive advantage of cold water. And when cold-adapted species abundance declines, warm-adapted animals take advantage of the open niche. Winners and losers

Climate change predictions developed by Columbia University/New York City Panel on Climate Change for the greater New York region:

- **Temperatures: 1.5 – 3ºF increase by 2020s, 3 – 5ºF by 2050s and 4 – 7.5ºF by 2080s.**
- **[LIS annual increase since 1991 = 1.9ºF (1.0ºC); since 1976 = 2.8ºF (1.6ºC)]**

- **Precipitation: 0-5% increase by 2020s, 0-10% by 2050s, and 5-10% by 2080s.**
- **Sea level rise: 2-5 inches by 2020s, 7-12 inches by 2050s and 12-23 inches by 2080s.**
- **Frequency of extreme weather events (heat waves, droughts, intense precipitation, storm-related flooding) are all likely to increase.**

Climate alternations that are anticipated to have the largest effect on near-shore habitats are:

- **Increasingly large areas of elevated water temperature which persist for longer time periods**
- **Decreasing dissolved oxygen levels associated with persistently higher water temperatures**

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- **Precipitation and wind events that are more severe and sporadic instead of minor and seasonally consistent**

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