Challenges Facing the Cape Cod Aquifer Installment 5: Climate Change Effects on Waquoit Bay Water Shed

Since Waquoit Bay interacts with Nantucket Sound and the wider Ocean, it is impacted my multiple human stressors: warming waters; increased ocean acidity; eutrophication from "Nitrogen" enrichment; shifts in finfish and shellfish species in space and time; reduction in the productive capacity of eelgrass beds, oyster reefs, salt marshes; etc.

We discussed in Installment 2 the link between relative sea level rise and the height of the water table at the top of the Sagamore Lens on the Upper Cape. The general assumption of the Targeted Watershed Management Plans is that as we improve our wastewater infrastructure and reduce "Nitrogen" loading, the water clarity increase will be followed by return of the impacted habitats and recovery of the bay scallop populations (which have been harmed by loss of eelgrass beds and increased ocean acidity). In Nantucket Sound Summer flounder are arriving from the Mid-Atlantic and Winter flounder are moving into the Gulf of Maine. Coastal Embayments adjacent to Nantucket Sound will see blue crabs replace lobsters.

The Blue Communities Bill has been introduced in the Massachusetts Legislature to address some of these challenges of warming waters; "Nitrogen" loading from septic systems; increased ocean acidity; Summer hypoxia; salt marsh erosion; etc. which negatively affect aquatic wildlife and their habitats.

The lobster fishery south of Cape Cod is collapsing and it is moving into the Gulf of Maine/ St. Lawrence or further offshore into the deeper ocean. North Atlantic right whale mortalities have increased from ship strikes and entanglements in crab/lobster pot gear. We face the loss of our working waterfront on land which has negative implications for our "Blue Economy" on Cape Cod. Most of the environmental and socioeconomic consequences of climate disruption are ignored in the Barnstable County Climate Action Plan (CAP) and Massachusetts Ocean Management Plan (MOMP) which is under the jurisdiction of the Massachusetts Coastal Zone Management Program.

To address climate change effects, we need to integrate the planning and regulatory actions of the fishery management entities (NOAA Fisheries Greater Atlantic Regional Fisheries Office; Mid-Atlantic and New England Fishery Management Councils; Atlantic States Marine Fisheries Commission and Massachusetts Division of Marine Fisheries); ocean planning endeavors in state (MOMP) and Federal (Northeast Regional Ocean Plan) jurisdictional waters with the oversight by Massachusetts Coastal Zone Management & the Cape Cod Commission (CCC) on land.

Bills have been introduced in Congress (Blue Carbon for Our Planet Act; Ocean-based Climate Solutions Act of 2020) and the Biden/Harris Administration has issued Executive Orders to promote Marine Protected areas (30 x 30 initiative to

protect 30% of natural areas on land and in the ocean by 2030) and large scale ocean wind farms as a renewable source of electricity. A recent webinar discussed Falmouth's efforts to protect 30% of our land as conservation areas.

President Obama created the Northeast Sea Mounts and Canyons National Monument which is out at the edge of the Continental Shelf, while the Stallwganen Bank National Marine Sanctuary/Waquoit Bay National Research Reserve allow commercial and recreational fishing. Thus we lack any near shore "no take" marine reserves to implement the 30x30 goals. There is a gap in the Cape Cod Commission Regional policy Plan and the Massachusetts Ocean Management Plan (MOMP) between coastal embayments and state jurisdictional waters 0.3 miles offshore in regards to climate change that needs to be addressed. Fish and shellfish species are changing their locations in space and time due to warming waters inshore; increased ocean acidity and nutrient enrichment. This has implication for Essential Fish Habitat for Federally managed fish species in this gap region (eelgrass beds; oyster reefs;
Salt marshes). MOMP excludes fisheries management concerns and its boundary runs from 0.3 to 3 miles offshore (ignoring human activities in coastal watersheds).

The Upper Cape Water Supply Reserve occupies the northern 15,000 acres at JBCC and faces toxic contamination threats from Central Impact Area source area where removal of mortar and howitzer shells from the soil by mechanical means releases RDX; perchlorate and potentially PFAS chemicals into the groundwater. The proposed Army National Guard Multipurpose Machine Gun Range at Camp Edwards will remove 180 acres of pitch pine/scrub oak forests and have a 5000 acre buffer zone which includes portions of the CIA plume source areas. I served on the Community Working Group which came up with the compromise that military training at Camp Edwards had to be compatible with protection of the Upper Cape Water Supply Zone and conservation of the habitats for over 39 state-listed species. The Army National Guard Environmental Assessment of this project issued a Finding of No Significant Impacts (FONSI), so that no NEPA (Federal) or MEPA (state) Environmental Impact Statement will be required. In the fall of 2021 (?), the Environmental Management Commission and its Community and Scientific Advisory Committees will review the EA FONSI decision. Town Select Boards surrounding JBCC may hold public hearings on the ANG EA FONSI.

The State Environmental Management Commission was established in the state legislation Chapter 47 Act of 2002) which formalized this agreement for an oversite body. Environmental Performance Standard # 19 regulates Army National Guard training at Camp Edwards. There are numerous ENGOs and. Community of Faith entities which oppose the National Guard's approval of this EA ((with Rep. Keating and Senators Markey and Warren expressing reservations). Money has been authorized for this project in the 2019 National Defense Authorization Act approved by Congress and signed by President Trump. Thus construction of this project is imminent following potential approval by the EMC.

Over 200 people participated in the May 20 Virtual Public Hearing organized by the ANG on the Multipurpose Machine Gun Range EA and offered numerous reasons why this was not compatible with protection of the Upper Cape Water Supply Reserve and the Pitch Pine/Scrub Oak wildlife and habitat. The effects of climate change combined with military training on the Pitch Pine/Scrub Oak Forest in the northern 15,000 acres has not been mentioned in the ANG EA FONSI. The Bio4Climate ENGO and. Society for Ecological Restoration (SER) have material on climate change on naturally vegetated communities and the role the solid microbes/Fungi in water storage; biogeochemical cycling of nutrients (Nitrogen and Phosphorus); carbon storage in soil humus; etc.

Ashumet Pond itself experiences water quality and habitat challenges from "Phosphorus loading" from the sources of the Ashumet Valley Plume coupled with climate change effects on wildlife habitats similar to the situation in Waquoit Bay. Warming surface water overlays cooler bottom waters with the stronger stratification leading to hypoxia on the surface layer which has negative effects on aquatic plants and shellfish. This could exacerbate the methyl mercury generation that bio-accumulates in finfish and cyanobacteria toxin blooms which make shellfish unsafe to eat. More variable weather in the summer could affect the balance between rain and evapotranspiration which determines the groundwater recharge rate/Summer water usage restrictions.

An unknown component is how this will effect PFAS levels in finfish and shellfish and its health effects on wildlife and humans. There is a need for better monitoring on the effects of "P" loading on the wildlife habitats in the pond. Since most of the citizen monitoring efforts are focused on water quality in both Waquoit Bay and Ashumet Pond, it is likely that wildlife habitats will require active restoration efforts when the nutrient levels in the water column reach the target recovery levels. It is likely to take a long time for this problem to be fully resolved, since the ecosystems may return to a new "steady state" (i.e. like the Gulf of Maine and Cape Cod Bay). Thus we need to implement an adaptive, ecosystems-based management approach (EbM).

References:

1. Report on the Ocean Acidification Crisis in Massachusetts

2. NOAA Fisheries Definition of Ecosystems-based Management

Ecosystem Based Management is defined as: An integrated approach that incorporates the entire ecosystem, including humans, into resource management decisions, and is guided by an adaptive management approach.

NOAA's IEA supports EBM
for some years, NOAA has recognized the value and importance of moving towards EBM as an integrated way to meet the Agency's missions and mandates. NOAA's Integrated Ecosystem Assessment (IEA) program is developing and implementing a

collaborative, multidisciplinary approach to help advance EBM and to manage our Nation's trust marine resources in an ecosystem context.

EBM integrates humans as a component of ecosystems
An ecosystem-based approach to management (EBM) has at its core that humans are an integral component of ecosystems. Within EBM, human and ecological wellbeing are tightly coupled. Sustainability in both is only possible when they are addressed together.

EBM balances the diverse and interconnected needs of society and the environment
It is a management approach that addresses cumulative impacts and balances multiple, often conflicting, objectives across management objectives and/ or sectors. To this end, a primary goal of EBM is to balance the diverse and interconnected needs of society and the environment.

EBM manages ecosystem components as intrinsically linked
A fundamental principle of EBM is that individual ecosystem components (biological, physical, chemical, social, cultural, economic) are intrinsically linked to other components within a coupled socio-ecological system. Thus for management to be effective, it needs to consider the relationships between those components, as well as the trade-offs of potential management actions on components in addition to the target component or objective. For the same reason, i.e. that components are linked, EBM imparts enhanced effectiveness by considering the influence of components like environmental conditions or other human activities on other linked components residing in the same space. That is, the approach considers the whole ecosystem and how changes (human or natural) in one component might propagate through the system to influence the various other components in the system.

EBM is a stepwise process
EBM may seem too complex but by taking a stepwise process that is adaptive we can learn and incrementally move towards this holistic type of management. The first step is to consider all components of a system and the tradeoffs across them when making decisions. EBM does not supplant or replace existing management approaches but it builds on them so it does not require an immediate or drastic shift. Rather it seeks to broaden the scope of traditional resource management to bring a more holistic set of information to the table to inform decisions.

EBM can work on a continuum of management levels
An ecosystem-based approach can address single species, sector, or ecosystem service needs within a broader ecosystem context all the way to full multi-sector EBM. EBM is also not a "one-size-fits-all" framework. Though many may have the perception that EBM is only about supporting or achieving full multi-sector integration, and while this goal is important and potentially what ultimately we need to strive to achieve, there are steps in between we can to inform more traditional management approaches in an ecosystem context. Making decisions in an ecosystem context, really is what we might call an ecosystem-based management continuum or spectrum of levels of integration of information or assessment.

EBM has different meanings
There are many different definitions and perceptions of what EBM is. They all contain similar language with slight variations. Participants of the Atlantic Ocean Research Alliance Coordination and Support Action workshop are most associated with EBM.

3. NOAA Fisheries 2020 State of the Ecosystems Report

https://www.fisheries.noaa.gov/feature-story/noaa-fisheries-releases-key-reports-status-stocks-2020-and-fisheries-united-states

State of the Ecosystem Reports for the Northeast U.S. Shelf State of the Ecosystem reports are developed annually for the New England and the Mid-Atlantic Fishery Management Councils. They provide the current status of the Northeast Shelf marine ecosystems.

New England/Mid-Atlantic

State of the Ecosystem Reports

The State of the Ecosystem reports provide the current status of the Northeast Shelf marine ecosystems (Georges Bank, Gulf of Maine, and the Mid-Atlantic Bight). They are developed for the New England and the Mid-Atlantic Fisheries Management Councils. These annual, collaboratively produced reports inform the councils about social, ecological, and economic aspects of the ecosystem—from fishing engagement to oceanographic and climate conditions.

View the complete 2021 Mid-Atlantic report (PDF, 43p)

View the complete 2021 New England report (PDF, 43p)

2021 Updates

The Northeast U.S. Continental Shelf ecosystem showing the Gulf of Maine, Georges Bank and Mid-Atlantic bight regions as well as the dominant currents and oceanographic features.

The Northeast U.S. Shelf is one of the most productive marine ecosystems in the world. The ecosystem is changing and these changes are affecting the ecosystem services it provides. These reports synthesize ecosystem information to better meet fishery management objectives. The 2021 reports were restructured and organized into two sections:

- Performance measured against ecosystem-level management objectives
- Potential risks to meeting fishery management objectives such as climate change and other ocean uses, such as offshore wind development

Characterizing Ecosystem Change for Fishery Management

We use three overarching concepts in the report, all of which influence the structure and function of this complex ecosystem:

- Multiple system drivers
- Regime shifts
- Ecosystem reorganization

Physical, chemical, biological, and human factors comprise the **multiple system drivers** that influence each component of the ecosystem and the services it provides. Changes in those drivers can lead to **regime shifts**—large, abrupt, and persistent changes in the structure and function of an ecosystem. Regime shifts and changes in how the multiple system drivers interact can result in **ecosystem reorganization,** as species and humans respond and adapt to the new environment.

We are working to better characterize ecosystem changes and identify the early warning signs of future changes to understand the implications and improve management advice.

Multiple Ecosystem Drivers

Multiple competing factors cause change in an ecosystem. Numerous environmental drivers influence the quality and distribution of habitat in the ocean, which affects the amount and diversity of fish in the system. These environmental drivers, combined with social and economic drivers, influence the range of fishing opportunities and the seafood, recreation, and other services we derive from the ocean. Not all drivers are changing at the same rate, thus the effects on different parts of the ecosystem are not uniform. We are working to show both how systems are changing and what factors are driving those changes.

Regime Shifts & Ecosystem Reorganization

Ecosystem change can happen rapidly, resulting in large, abrupt and persistent changes in the structure and function of an ecosystem. It is important to identify these "regime shifts" because our historical knowledge of how the system works may not apply under the present conditions. Ecosystem reorganization occurs as species and humans respond and adapt to the new environment. Changing habitat conditions influence the range and distribution of resident species and create the conditions for new species to take up residence.

Performance Relative to Fishery Management Objectives

To evaluate fishery management performance, we examine indicators related to broad, ecosystem-level fishery management objectives. We also provide hypotheses on the implications of these trends—why we are seeing them, what's driving them, and potential or observed regime shifts or changes in ecosystem structure. Identification of multiple drivers, regime shifts, and potential changes to

ecosystem structure can help managers make changes to meet objectives and to prioritize for upcoming issues and risks.

Ecosystem-scale Fishery Management Objectives

Objective categories in bold and the indicators used to evaluate performance

Provisioning and Cultural Services

- **Seafood production:** landings; commercial total and by feeding guild; recreational harvest
- **Profits:** revenue decomposed to price and volume
- **Recreation:** days fished; recreational fleet diversity
- **Stability:** fishery and ecosystem diversity
- **Social & Cultural:** community engagement and reliance status
- **Protected Species:** bycatch; population (adults and juveniles) size; mortalities

Supporting and Regulating Services

- **Biomass:** biomass or abundance by feeding guild from surveys
- **Productivity:** condition and recruitment of managed species; primary productivity
- **Trophic Structure:** relative biomass of feeding guilds; zooplankton
- **Habitat:** estuarine and offshore habitat conditions