Fisheries

ISSN: 0363-2415 (Print) 1548-8446 (Online) Journal homepage: http://www.tandfonline.com/loi/ufsh20

Round-the-Coast: Snapshots of Estuarine Climate Change Effects

Karin Limburg, Randy Brown, Rachel Johnson, Bill Pine, Roger Rulifson, David Secor, Kelly Timchak, Ben Walther & Karen Wilson

To cite this article: Karin Limburg, Randy Brown, Rachel Johnson, Bill Pine, Roger Rulifson, David Secor, Kelly Timchak, Ben Walther & Karen Wilson (2016) Round-the-Coast: Snapshots of Estuarine Climate Change Effects, Fisheries, 41:7, 392-394, DOI: 10.1080/03632415.2016.1182506

To link to this article: http://dx.doi.org/10.1080/03632415.2016.1182506

Published online: 29 Jun 2016.

Round-the-Coast: Snapshots of Estuarine Climate Change Effects

Karin Limburg
Department of Environmental and Forest Biology, SUNY College of Environmental Science and Forestry, Syracuse, NY. E-mail: klimburg@esf.edu

Randy Brown
U.S. Fish and Wildlife Service, Fairbanks, AK

Rachel Johnson
Southwest Fisheries Science Center, National Marine Fisheries Service & Department of Animal Sciences, UC Davis, Davis, CA

Bill Pine
Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL

Roger Rulifson
Institute for Coastal Science and Policy, and Department of Biology, East Carolina University, Greenville, NC

David Secor
Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD

Kelly Timchak
Lower Rogue Watershed Council Coordinator, Gold Beach, OR

Ben Walther
Department of Life Sciences, Texas A&M University, Corpus Christi, TX

Karen Wilson
Department of Environmental Science and Policy, University of Southern Maine, Portland, ME

ALASKA

Recent declines in Arctic Ocean summer sea ice constitute one of the most tangible effects of climate change anywhere. Notable environmental effects are increased water temperature, solar exposure, and freshwater inputs, which have led to enhanced primary production and a distributional shift north for many marine organisms including fish. Adult Pacific salmon *Oncorhynchus* spp. are occasionally captured along the north coast of Alaska and northwest Canada, and there is a widespread public expectation that they will become an abundant resource over time. However, winter still falls on the land and sea, and few northern rivers maintain adequate flow and temperature for successful spawning and egg incubation. If young are produced in northern rivers, they would smolt into the Beaufort Sea, where they would face a long migration against prevailing currents into the southern Bering Sea before winter sea ice covers the ocean. Temperature under sea ice drops to about −1.7°C, which is too cold for salmonids. Eventually, the Arctic region may warm enough that the entire Pacific salmon life cycle will work and colonization will be successful. In the meantime, small numbers of Pacific salmon will continue to probe the northern limits of available habitat.

–R. Brown

ROGUE RIVER, OREGON

The city of Gold Beach and much of Curry County, Oregon, depend economically on the lower Rogue River and its estuary and the fish, wildlife, and recreation values they impart. The estuary is the vital interface between ocean and freshwater that is critical to the health and survival of threatened anadromous species such as Coho Salmon *O. kisutch* and Chinook Salmon *O. tshawytscha*, Green Sturgeon *Acipenser medirostris* and White Sturgeon *A. transmontanus*, steelhead *O. mykiss*, and Pacific Lamprey *Lampetra tridentata*. Climate change affects salmon throughout their life stages and poses an additional stress. As more winter precipitation falls as rain rather than snow, higher winter streamflows scour streambeds, damaging spawning nests and washing away incubating eggs. Earlier peak streamflows flush young salmon from rivers to estuaries before they are physically competent for the transition, increasing a variety of stresses including the risk of being eaten by predators. Lower summer streamflows and warmer water temperatures create less favorable summer stream conditions for salmon and other coldwater fish species in many parts of the Northwest. To help brace against the effects of climate change, the Lower Rogue Watershed Council is working to restore freshwater and tidal wetlands, floodplain connectivity, and streamflow regimes to increase habitat diversity and population resilience.

–K. Timchak

SAN FRANCISCO ESTUARY

San Francisco's estuary, the largest on the U.S. West Coast, provides habitat to 14 imperiled migratory or estuary-resident fishes (e.g., Delta Smelt *Hypomesus transpacificus*, Chinook Salmon) and marine species supporting fisheries (e.g., dungeness crab *Metacarcinus magister*). The freshwater region of the estuary supplies water to 25 million people and irrigates economically important farmland. Floods and droughts are part of the historical ecology of the estuary and its 163,000 km^2 watershed. Yet, there is growing concern that large-scale loss and degradation of diverse aquatic habitats due to land- and water-use practices will compromise the ability of species to respond/adapt to climate change. Projections suggest that the region will become warmer and drier with increased environmental variability, placing the ecosystem into novel regimes. California's current four-year drought, exhibiting low freshwater outflow and record air and water temperatures, together with anomalously warm ocean conditions, foreshadows these conditions. Record low abundances of native pelagic fishes and poor survival of endangered juvenile salmon appear to have been exacerbated by the drought. Warm, dry conditions likely favored nonnative resident fishes (e.g., centrarchids), nonnative aquatic vegetation, and harmful algal blooms. Threats of sea level rise and armored shorelines further reduce shallow marsh habitats, already in short supply. Managing fish populations in a highly degraded and diminished natural habitat and changing climate will likely further constrain California's limited water supply, providing daunting challenges for resource managers.

–R. Johnson

TEXAS GULF COAST

In Texas estuaries, the watchword is "drought." The region has a long history of interannual aperiodic cycles of freshwater inflow, but rising average temperatures coupled with intensifying droughts drive estuarine dynamics in worrying directions. Reduced inflows lead to hypersalinity in systems enclosed by barrier islands, a characteristic of many Texas estuaries. The most recent statewide drought in 2015 exceeded the intensity and duration of the record drought in the 1950s. The effects of aperiodic inflow variation on estuarine-dependent organisms are of great concern, although clear relationships between inflow dynamics and biotic responses are elusive. A central question is whether Texas populations of estuarine-dependent species have sufficient tolerance to withstand hypersaline regimes given the historical propensity for drought in the region or whether inherent tolerance thresholds will be exceeded if droughts intensify. These dynamics will be further shaped by range expansions of tropical species (e.g., black mangrove *Avicennia germinans*) that may alter nursery habitats for important fishery species. Understanding these altered biotic interactions along with threshold tolerance responses to hypersalinity will be crucial for unraveling the multifaceted effects of climate change.

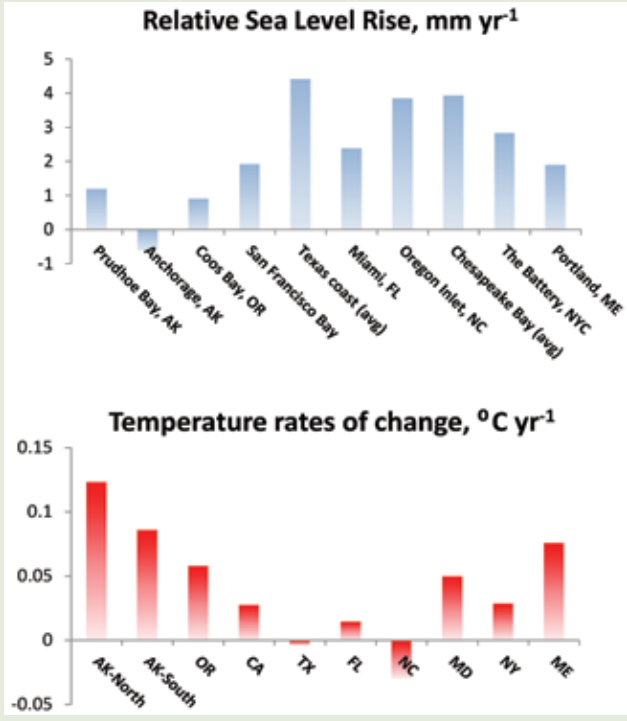
–B. Walther

FLORIDA

Estuaries in Florida provide key economic and ecological benefit to a state highly dependent on natural resources to drive the tourism, agriculture, and development segments of the economy. With more than 2,100 km of coastline and a human population of over 20 million people (and growing by about 1,000 people a day), climate change is important to every citizen and visitor to the Sunshine State. In the highly developed southeastern corner of Florida, climate change–related sea level rise is contributing to increases in coastal flooding of metropolitan areas, such as Miami Beach during spring and fall high tides. Lesser known, yet equally dramatic, impacts to marshes and estuaries are also occurring throughout the state including the sparsely developed "Big Bend" region in the northeastern Gulf of Mexico, where estuaries are squeezed by rising sea levels and changes in freshwater inputs contribute to die offs in coastal vegetation and loss of oyster reefs. Between 60% and 90% of the key commercial and recreational fisheries in Florida are dependent on estuaries for some part of their life history necessitating protection of these habitats for these resources to remain viable. Addressing climate change and the related impacts to coastal Florida is likely one of the biggest challenges ever faced by the state.

–B. Pine

Concerns in estuaries include the rates of sea level rise and temperature warming. We examined data sets for trends in our geographic areas. Sea level rise is variable; highest rates occur mostly in the central Gulf of Mexico coast, but even off the Atlantic coast, there are hot spots of rise. West Coast rates tend to be lower, and in southern Alaska they are negative because of isostatic rebound. On the other hand, increases in temperature show a latitudinal gradient. To make this comparison, we restricted our data sets to be as consistent as possible; that is, from 1995 to 2015. In this case, highest rates are observed in Alaska and lowest rates at more southerly latitudes. This is in accordance with climatological predictions. Knowledge of such trends provides managers with broad guidance for planning.



Sources

Sea level rise: Data are from the National Oceanic and Atmospheric Administration (NOAA) Center for Operational Oceanographic Products and Services (CO-OPS) Sea Level Trends display (co-ops.nos.noaa.gov/sltrends/sltrends.html; see also NOAA 2001, 2009). These are based upon observations of a minimum 30 years from the National Water Level Observation Network.

Water temperature: Annual temperature trends (1995–2015) were gathered from a variety of sources. National Estuarine Research Reserve (NERR) data were summarized for Maine (Wells), Florida (Apalachicola), and Oregon (South Slough) NERRs (NERR Centralized Data Management Office, cdmo.baruch.sc.edu). Data for the Hudson River were collected at Poughkeepsie, New York, by the U.S. Geological Survey (monitoring station 01372058) and the Chesapeake Biological Laboratory Pier and for the Neuse River basin by the Albemarle–Pamlico National Estuary Program (compiled by M. Chad Smith, received from Roger Rulifson via personal communication). The NOAA CO-OPS' PORTS data product (tidesandcurrents.noaa.gov/ports.html) was used to obtain water temperature data for Galveston Channel (station 8771450) and Sabine Pass North (station 8770570) in Texas, Port Chicago (station 9415144), Suisun Bay, California, and Port of Anchorage, Alaska (station 9455920). Finally, data were used from the Kuparuk River on the Alaskan North Slope; these were collected by the Arctic Long Term Ecological Research program and are described in Kane and Hinzman (2013). Data for each site mentioned may be found at catalog.ioos.us/datasets/filter and entering corresponding the station number.

NORTH CAROLINA

The largest barrier island system in North America provides North Carolina with large expanses of lagoonal estuaries and estuarine habitats and offers important habitats for spawning and nursery for many commercially and recreationally important finfish and shellfish species. Alewife *Alosa pseudoharengus* is at the southern limit of its range and appears to be losing ground as temperatures warm. Striped Bass *Morone saxatilis*, which historically overwinter off the Outer Banks and provide a popular winter surf fishery, have moved northward over the past decade to waters off Chesapeake Bay. The Bull Shark *Carcharhinus leucas* is now using habitats in Pamlico Sound as pupping grounds since about 2010; the previous known northern habitat for pupping was in northern Florida. Sea level rise over the next 100 years will cover large expanses of coastal counties that currently flood routinely; saltwater intrusion has poisoned significant expanses of agricultural lands, which are extensively ditched for freshwater runoff. Tough regulations regarding bulkheading and beach hardening may allow marsh systems to migrate landward more easily than in other states with minimal hardening regulations.

–R. Rulifson

CHESAPEAKE BAY

"America's estuary" serves as the dominant source of recruits for Atlantic Menhaden *Brevoortia tyrannus*, blue crabs *Callinectes sapidus*, and Striped Bass. Winter weather sets the clock for nursery conditions of these and other living resource species within the Chesapeake. Cold, wet conditions favor Striped Bass and other anadromous species; warm winters favor blue crab, Bluefish *Pomatomus saltatrix*, and other coastal spawning fishes. Recent, modest declines in Striped Bass recruitment coincide with a period of warm winters. Striped Bass now spawn earlier in the Potomac River, which may affect the foraging and thermal environments that offspring encounter. Resident Striped Bass avoid summertime hypoxic conditions by occupying warmer surface habitats in which they grow poorly. Anglers now encounter sickly or diseased stripers. Warmer conditions could broaden the window of successful recruitment by menhaden, which move from the shelf into the Bay's tributaries. Warming will allow blue crab juveniles a longer growing season before hunkering down for the winter, yet this applies also to their cannibalistic larger siblings. Increasingly, drums (Sciaenidae) are making a toe-hold in both the lower and upper Chesapeake Bay segments, including Atlantic Croaker *Micropogonias undulatus* and Red Drum *Sciaenops ocellatus*, consistent with poleward range expansion for this warmwater family.

–D. Secor

NEW YORK

In the 250-km Hudson River estuary, we began to notice warming in the 1980s, when Rainbow Smelt *Osmerus eperlanus*, at its southern range limit, began to get scarce. The last individual was observed in 1998, and Rainbow Smelt became the first known climate-based extirpation. Since then, Atlantic Tomcod *Microgadus tomcod* are barely holding their own, whereas tropical marine strays are increasingly observed. Additionally, earlier onset and shorter duration in spawning phenology appear to be the case for anadromous American Shad *Alosa sapidissima* and river herring (*A aestivalis* and *A. pseudoharengus*). One of the biggest impacts of the more energetic climate is the increased frequency of powerful storms. The Hudson River estuary witnessed three within a 14-month period: Hurricane Irene followed by Tropical Storm Lee in 2011 and Superstorm Sandy in 2012. Irene and Lee deposited several centimeters of fine sediments, burying submersed macrophytes; five years on, recovery of this critical habitat is just beginning. Sandy rearranged habitats lower in the system, but the main impacts were likely financial rather than ecological, given the heavy urbanization. With rising sea levels, managers are concerned for wetlands that have little space to move in this largely rock-bound estuary.

–K. Limburg

MAINE

Almost all of Maine's estuaries are long "drowned river valleys" stretching many kilometers inland and, as in most estuaries, the position and extent of the mixing zone are highly dependent on both tides (ranging from 9 to 11 ft) and freshwater input. Changes in the intensity and timing of storms and spring meltwaters are expected to affect these already dynamic patterns. Warming Gulf of Maine waters are bringing new species north and allowing "old" invasives, such as the European green crab *Carcinus maenas*, to flourish. At the same time, Maine's warmer interior estuaries harbor warmwater organisms such as the horseshoe crab *Limulus polyphemus* and the eastern oyster *Crassostra virginica*; these species may find expanded habitat with warmer marine temperatures. Although species such as smelt are still hanging on in Maine, populations are declining. In contrast, river herring are increasing in numbers, particularly in the Kennebec and Penobscot rivers, where dam removals increased access to spawning grounds and stocking have resulted in millions of returning spawners. The use of the Penobscot estuary by juvenile river herring has increased dramatically since dams were removed in 2012 and 2013, and Shortnose Sturgeon *A. brevirostrum* were documented moving upstream into potential spawning habitat this fall for the first time in over 100 years.

–K. Wilson

REFERENCES

Kane, D. L., and L. D. Hinzman, 2013. Climate data from the North Slope Hydrology Research project. University of Alaska Fairbanks, Water and Environmental Research Center. Available: ine.uaf.edu/werc/projects/NorthSlope. (March 2016).

NOAA. 2001. Sea Level Variations of the United States 1854-1999. Technical Report NOS CO-OPS 36. Available: tidesandcurrents.noaa.gov/publications/NOAA_Technical_Report_NOS_COOPS_036.pdf. (June 2016).

——. Sea Level Variations of the United States 1854–2006. NOAA Technical Report NOS CO-OPS 53. Available: tidesandcurrents.noaa.gov/publications/Tech_rpt_53.pdf. (June 2016). AFS