

Some of our preliminary analyses of satellite images have shown that between 1994 and 2000, urban (+58%) and agricultural (+16%) cover increased while forest (-8%) cover decreased, which may be associated with higher nutrient and sediment loads into the wetland, alteration of plant community composition, and ultimately degradation of wildlife habitat in the wetland. Although forest cover declined overall, using spectral mixture analysis we observed an increase in the green vegetation fraction on forested slopes near the city of Shangrila and Napahai Wetland. This suggests that the logging ban is being enforced within the sphere of influence of the Forestry Bureau (i.e., near the city and nature reserve), but may not be strictly enforced farther from institutional centers. These and further land-use analyses will assist in elucidating the drivers of change in the watershed and inform the development of restoration plans. For example, interdisciplinary teams could investigate how the 1998 logging ban has altered local timber harvesting practices, how the urbanization of Shangrila has influenced the livelihoods of villagers surrounding Napahai Wetland and their use of wetland resources, and how locals perceive changes in wetland and water quality over time and their desire and ability to restore ecological function.

Implementation of an effective restoration plan at Napahai needs to account for the interconnected nature of wetland habitat, local livelihoods, and governance. Understanding these relationships will yield context-relevant results that will facilitate the development of sustainable restoration and management strategies. Ultimately, restoration of black-necked crane habitat could enhance the biological integrity of Napahai and promote sustainable livelihoods for those living near this globally important wetland.

Acknowledgments

We would like to thank the University of Wisconsin-Madison Biodiversity Conservation and Sustainable Development IGERT program for funding this preliminary work. We appreciate the guidance and support of Tian Kun, Yang Bo, Yang Xiaojun, Yang Yongping, Josh Posner, and Joy Zedler during this project.

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Bay Scallop Restoration in New York

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Natural populations of commercially important bivalve mollusks have declined in many parts of the world during the past century due to overfishing, habitat degradation, disease, and other environmental perturbations. Attempts to augment or restore bivalve populations and fisheries to former levels have benefited from advances made in aquaculture methodology and technology, but these restoration efforts have met with mixed success. One of the most successful programs has sustained the Japanese scallop (*Mizuhopecten yessoensis*) fishery through large-scale production and planting of hatchery-reared animals (Sekino 1992); this is the template for much of the work we describe here.

In the United States, the commercially important bay scallop (*Argopecten irradians*) has declined in most of the Atlantic and Gulf coastal areas where it was abundant in the twentieth century. Bay scallops are particularly susceptible to population fluctuations because they usually live for only 18–22 months and reproduce once. On Long Island, New York, populations of the northern subspecies (*A. irradians irradians*) were nearly extirpated due to direct mortality and recruitment failures during “brown tide” (*Aureococcus anophagefferens*) algal blooms from 1985 to 1987.

Bay scallop restoration in the Peconic Bays (Figure 1) was initiated soon after the first brown tide with the goal of planting juveniles (0+ yr) that would spawn at maturity (ca. 1 yr) and help repopulate the bays. External fertilization is followed by a 1–2 week larval period during which dispersal is effected by tidal currents. Reproductive potential is very high in bay scallops, with a single individual

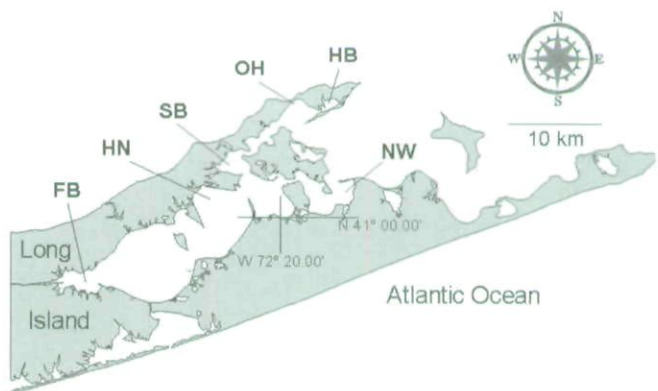


Figure 1. Map of the Peconic Bay system in eastern Long Island, New York, showing the restoration site (Orient Harbor) and other sites monitored for larval settlement to mesh bag spat collectors and/or abundance of juvenile and adult scallops on the bay bottom. OH = Orient Harbor (longline system), HB = Hallock Bay, SB = Southold Bay, HN = Hog Neck Bay, NW = Northwest Harbor, FB = Flanders Bay.

capable of producing over 5 million eggs, so even though survival of transplanted natural and hatchery-reared scallops from the time of planting in the fall until spawning in early summer was less than 12 percent in the late 1980s–early 1990s (Tettelbach and Wenczel 1993), these plantings did contribute to an increase in Peconic Bay scallop populations (Krause 1992).

A severe brown tide in 1995 again decimated populations, but despite the absence of brown tides since then scallop populations have not recovered naturally. Commercial harvests since 1995 have remained at 1%–2 % of pre-brown tide levels (NYSDEC 2008), and population densities in most areas are very low (< 0.1 individuals/ m^2). We have postulated several explanations, including a possible decline in water quality and the observed loss of eelgrass (*Zostera marina*), the preferred habitat of juvenile and adult bay scallops. However, our primary hypothesis for the lack of recovery is that local bay scallop densities and numbers have been too low to permit high rates of successful fertilization of eggs (Liermann and Hilborn 2001). Experiments with other invertebrates exhibiting external fertilization (such as sea urchins, sea squirts, and hydroids) have shown that fertilization success drops sharply as distance between spawning males and females increases to more than 1 m or population density drops too low (Levitan and Petersen 1995). In turn, larval supply becomes limiting (Peterson et al. 1996). Under these circumstances, populations may not be able to rebuild unless natural mortality rates decline (e.g., by reducing the numbers of predators) or spawning stocks are boosted above some critical threshold.

Most of our early restoration work involved free-planting scallops to the bay bottom by dispersing them by hand from boats that transit back and forth across a demarcated area. These plantings were done at low densities (≤ 10 ind/ m^2) after Japanese methods and to avoid attracting large numbers of crustacean and gastropod predators.

In our current work, we are attempting to “jump-start” bay scallop populations by planting large numbers of hatchery-reared individuals at high densities to ensure a high probability of fertilization success upon spawning. Our change in approach was prompted by the recent literature on fertilization dynamics (noted above) and our own recent observations of up to 50% survival, from early spring until the initiation of spawning in summer, of scallops free-planted at densities of about 100 ind/ m^2 . In our current work we are free-planting at comparable densities, but our major emphasis is deploying scallops in thousands of lantern nets suspended in midwater from subsurface lines—again following Japanese methods. Scallops are thus protected from predators and are concentrated at the time of spawning, since nets are stocked at densities of 190–200 ind/ m^2 and are spaced about 1 m apart on 200+ m long lines. We have stocked from 250,000 to over 500,000 scallops in this system each fall, 2006–2008, at a single site in Orient Harbor (Figure 1), which formerly supported a

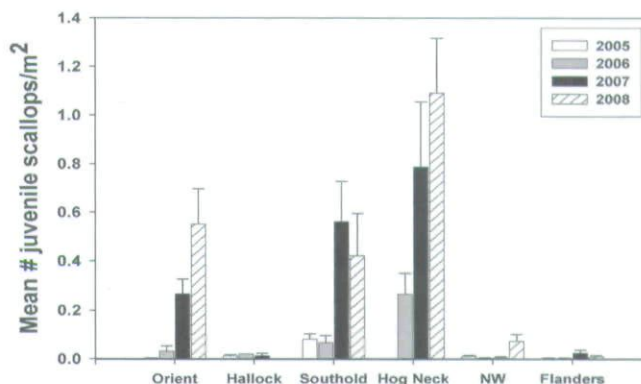


Figure 2. Mean density (± 1 SE) of juvenile (0+ year) scallops in six embayments in eastern Long Island NY during 2005–2008. Orient = Orient Harbor, Hallock = Hallock Bay, Southold = Southold Bay, Hog Neck = Hog Neck Bay, NW = Northwest Harbor, Flanders = Flanders Bay. Data were collected via transect surveys in the fall of each year or spring of the following year (e.g., Fall 2005/Spring 2006).

robust scallop population. Our efforts represent the largest bay scallop restoration project of its kind yet attempted in the United States.

While survival of our free-planted scallops from fall until the following summer has been low ($\leq 7\%$), the higher survival (36%–50%) of scallops in our lantern nets has yielded many more spawning adults at higher densities than we witnessed in our restoration efforts in the 1980s. Consequently, the numbers of scallop larvae produced by our current stocks should be much higher; this has been confirmed by our 2005–2008 field monitoring.

Levels of larval recruitment to “spat” collectors (mesh bags suspended above the bay bottom), as well as abundance of juvenile and adult scallops on the bottom of Orient Harbor, are markedly higher than in the two years prior to the start of our current restoration work. Larval recruitment at most of our eight monitoring sites in Orient Harbor in 2007 and 2008 increased 3–13 times over respective levels in 2005 and 2006 (data not shown). Overall densities of juvenile (0+ yr) scallops significantly increased (Figure 2, Dunn’s test $p < 0.05$, following Kruskal-Wallis test $p < 0.001$), and the spring 2008 estimated juvenile population, based on the area-density method, was 13.5 times higher than that seen in the two years before spawning of our planted scallops. Overall adult scallop densities in fall 2008 were three times higher than in 2005.

In addition to Orient Harbor, we have monitored larval recruitment and/or juvenile scallop densities in other areas where natural population levels were very low (Figure 1), as they were in Orient Harbor in 2005–2006 prior to our plantings; our surveys in these areas (Hallock Bay, Northwest Harbor, Flanders Bay) have shown that juvenile densities have remained at less than 0.1 ind/ m^2 (Figure 2). These results strongly suggest that spawns of scallops in 2007 and 2008, which we planted in 2006 and 2007, respectively, have contributed to the increased population sizes in the Orient Harbor area.

Two other unplanted areas that we have monitored (Southold Bay and Hog Neck Bay) have more than quadrupled in abundance of juvenile scallops since 2005 (Figure 2). At Southold Bay, where we have monitored adult abundance for the longest period, numbers of adults increased sixfold from 2005 to 2008, possibly due in part to larval dispersal from spawning Orient Harbor stock (Siddall et al. 1986). Population densities at Hog Neck Bay may have been high enough since 2006 to sustain themselves.

Results to date suggest that the bay scallop population is increasing in the vicinity of our longline system in Orient Harbor, and we anticipate a measurable increase in bay scallop commercial fishery landings in this area in fall 2008. We have recommended limited area closures to protect juveniles during landings, and we plan to continue our current planting efforts at the same high densities and numbers and are hopeful that these efforts will continue to boost populations toward a level at which they may become self-sustaining, at least 1–2 ind/m² by our estimates.

Acknowledgments

We gratefully acknowledge funding support from the Suffolk County (NY) Water Quality Protection and Restoration Program as well as the Coastal Management Program of New York State Dept. of State. We thank Kevin Cahill, Jeff Chagnon, Mike Patricio, Kim Tetrault, Gregg Rivara, Neal Stark, Josh Clauss, Alli Dinargo, and Ken Birmingham for their tireless work in growing and maintaining bay scallop stocks and the assistance of Bradley Peterson, Scott Hughes, Dennis Bonal, Andrew Weinstock, Chelsea Fitzsimons-Diaz, John Carroll, Jason Havelin, and Richard Ames with field monitoring.

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The New Mexico Forest Restoration Principles: Creating a Common Vision

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Millions of hectares of ponderosa pine (*Pinus ponderosa*), mixed conifer forests, and piñon-juniper (*Pinus edulis*–*Juniperus* spp.) woodlands in the southwestern United States are in crisis, owing to past logging, grazing, and fire suppression practices. Historic surface fire regimes have been all but eliminated, and today many areas are dominated by dense stands of small-diameter trees, leaving these forests vulnerable to destructive crown fires. As in many western states, New Mexico's forests are predominantly on federal lands. Decades of controversy over logging practices have left many skeptical of forest management. “People don't trust government . . . and increasingly they don't trust experts” (Cortner 2003). Critics question whether fuel reduction treatments are just traditional timber sales by another name when they remove larger trees and whether creating stands of uniformly spaced trees for fire protection can in any way be considered restorative. Without other avenues to influence management, disagreement has often been expressed through litigation and administrative appeals. Collaborative resource planning with interest groups has been gaining popularity to reduce conflicts in forest management. In this paper, I describe a collaborative group in New Mexico working to accelerate forest restoration at a state-wide scale through a set of guiding ecological principles.

Several recent events created conditions supporting collaborative approach to restoration. In 2000, the Cerro Grande Fire severely burned nearly 18,000 ha and 400 homes in the Jemez Mountains of northern New Mexico around Los Alamos, causing the evacuation of 18,000 people. Soon thereafter, the Community Forest Restoration Act of 2000 (Title VI, Public Law 106–393) established the Collaborative Forest Restoration Program, or CFRP (www.fs.fed.us/r3/spf/cfrp/) to manage cost-share grants to private organizations or communities for forest restoration projects on federal, tribal, or state lands. These projects must include diverse stakeholders and address several objectives, including wildfire threat reduction, reestablishment of historic fire regimes, preservation of old and large trees, and increased utilization of small-diameter trees. In the last seven years, over 100 CFRP projects have been funded through a consensus process involving representatives from federal and state agencies, forest industry, local communities, tribal interests, academic research, and environmental groups. Participation in the CFRP has engaged a significant number of people and organizations in the state in on-the-ground projects.

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