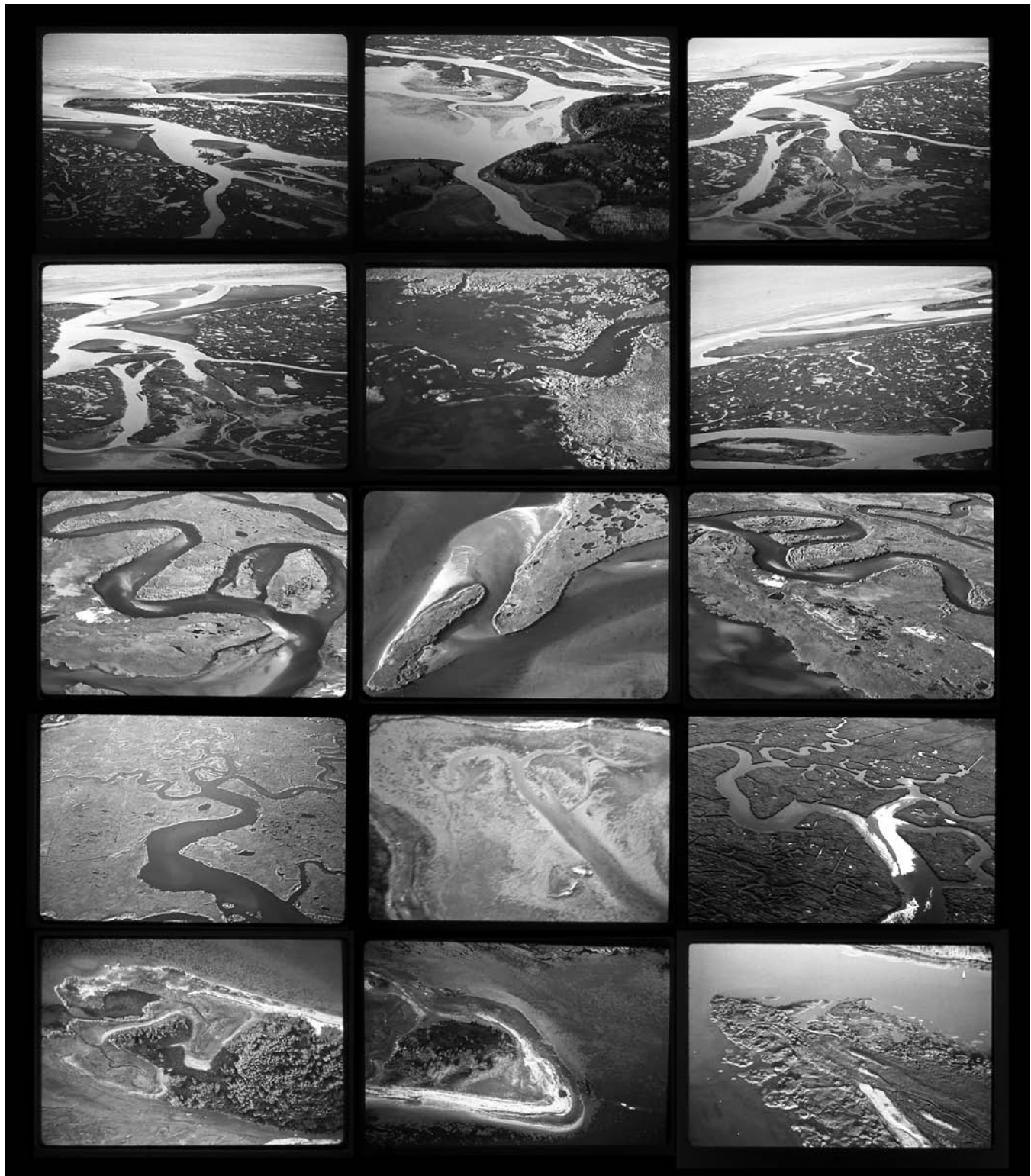




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Salt Marsh Landscape Mosaic, aerial photography, 2006. (© Joseph E. Ingoldsby) Aerial photographs capture the pattern and coloration of the Cape Cod salt marsh, including images of inundation, barrier beach dissolution through storm damage and flooding of the salt marshes in an additive and subtractive process of water, wind and tide.

Vanishing Landscapes: The Atlantic Salt Marsh

Joseph Emmanuel Ingoldsby

This elegy for coasts and estuaries in a changing world must be told. There is an urgency to the storytelling. By 2100, at current rates of warming, the seas are projected to rise 24 inches along most of the U.S. coasts [1]. The increase in air temperature caused by a rise in CO₂ concentrations and other greenhouse gases will increase the snow and ice melt [2]. If the polar ice caps should disappear, the sea level is estimated to rise 60–70 m higher than at present [3]. Mountain glaciers make up 1% of the volume of land ice. Their potential contribution to sea level rise is about 1 m, should their melt-water flow to the sea [4].

SALT MARSHES

The rising seas will impact the salt marsh, which rings the shore and transitions and arbitrates between the land and the sea (Article Frontispiece). The salt marsh of an estuary is one of the most productive zones on earth. The mixing of the tidal and fresh waters and the input of nutrients feeds a host of species, which depend on it for food and cover. The salt marsh is tough yet fragile. It withstands extremes of temperature, freezing and thawing, saturation and drought. The plants of the salt marsh are uniquely adapted to life on the edge of the sea.

Salt marshes (Fig. 1) can be differentiated into distinct zones, which correspond to increasing elevation and decreasing durations of submergence. The lowest zone is vegetated by a variety of drifting or attached algae and eelgrass, *Zostera marina* of the sub-tidal zone. As Fig. 1 shows, a tall form of *Spartina alterniflora* may be found growing along the edges of

channels, creek banks and ditches, marking a change of elevation.

The next highest zone is the intertidal area from mean low tide to mean high tide. This is the Low Marsh or *Spartina alterniflora* zone. *Spartina alterniflora* dominates the low marsh, where it forms dense, continuous stands. The Low Zone is generally submerged with each flood tide, depending on the degree of tidal exchange between the marsh and coastal waters. *Spartina alterniflora* is uniquely adapted to this Intertidal Zone. These plants can pump oxygen from air passages on their leaves to air chambers in their hollow roots through diffusion. This allows the plants to respire and to extract nutrients by converting the iron sulfide in the anaerobic soils to iron oxide. The soil around the *Spartina* roots is often surrounded by rust red soils. *Spartina* exude excess salt from special glands on their leaves to preserve their osmotic pressure; *Spartina* stomata open at low tide and close during high tide [5]. The Aerenchymal tissue (Fig. 2) allows *Spartina* to exchange gases, even when surrounded by an anoxic soil. The tissue, illustrated in the Fig. 2 photograph, is visible as a series of circular passageways around the periphery. Plants cannot use nutrients efficiently without oxygen, so this tissue allows a connection between the aerobic leaves and the stems, which are usually surrounded

ABSTRACT

The author, trained in art and landscape architecture, utilizes observation of nature and culture as a central focus in his art. The work involves research, scientific collaboration and examination, documentation, analysis and synthesis using art, science and technology for environmental advocacy. The focus for these works has been on the coastal landscape of New England, the imprint of humans on land and sea, and the impact of climate change on the marine landscape and fisheries of New England.

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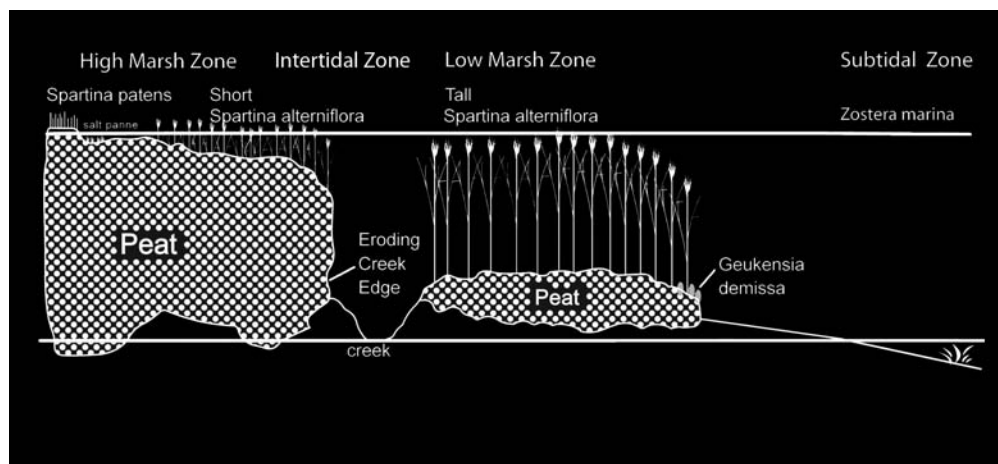


Fig. 1. Schematic cross-sectional view of a salt marsh with creeks. (© Joseph E. Ingoldsby) *Zostera marina* (eelgrass) dominates the sub-tidal zone. The tall form of *Spartina alterniflora* tends to live adjacent to creek edges, which are bathed in the nutrient-rich water of the intertidal zone. The short form lives in higher sites away from creek edges. *Spartina patens* (salt hay) carpet the High Marsh zone, which is flooded by spring and storm tides.

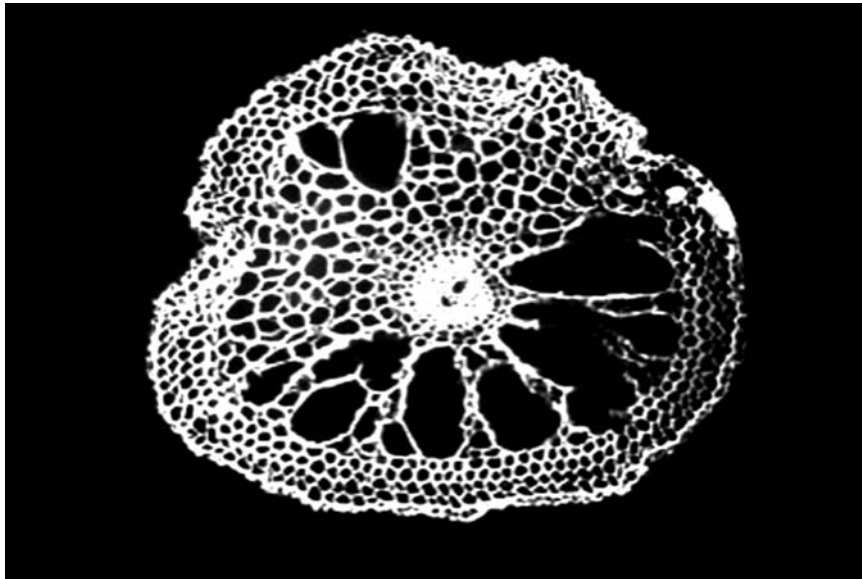


Fig. 2. Cross-section of Aerenchymal tissue. (Photo © Irv Mendlessohn) The Aerenchymal tissue allows *Spartina* to exchange gases, even when surrounded by anoxic soil. The tissue in this photograph is visible as a series of circular passageways around the periphery. Plants cannot use nutrients efficiently without oxygen, so this tissue allows a connection between the aerobic leaves and the stems, which are usually surrounded by anoxic water.

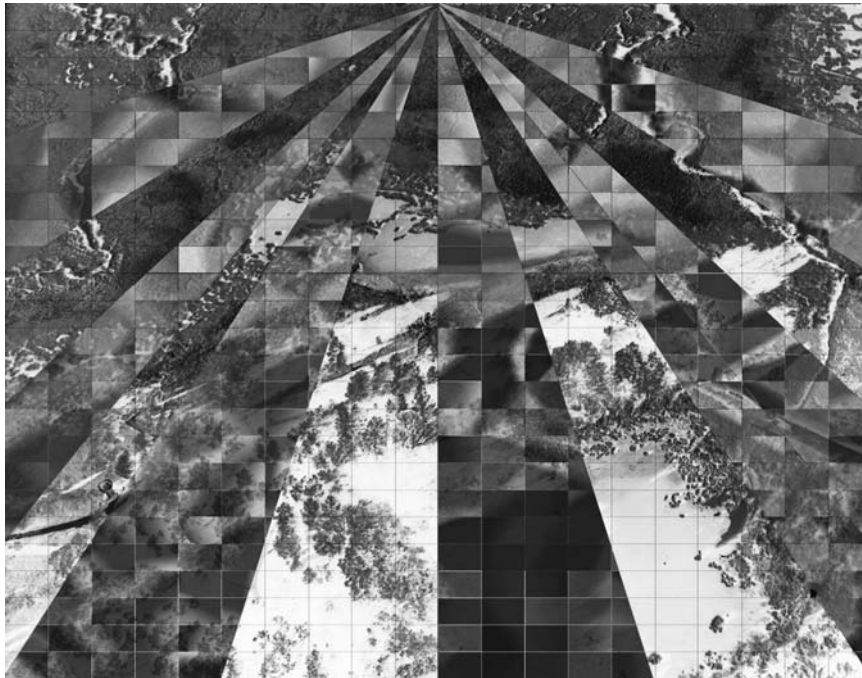


Fig. 3. Salt Marsh zonation radiant perspective: aerial photography, computer graphics and projection. (© Joseph E. Ingoldsby) Overview of the Wellfleet salt marsh, abstractly illustrating the different zones of the salt marsh.

by anoxic water [6]. *Spartina alterniflora* can withstand submergence longer than most other plants of the salt marsh. However, extended continuous inundation will suffocate the *Spartina* plants, since they are unable to breathe under water. This phenomenon has been documented at Jamaica Bay, New York, where the tall form of *Spartina alterniflora* is drowning in a combination of sea level rise and lack of marsh accretion, reducing the low marsh to barren mudflats [7].

The High Marsh is the uppermost zone of the salt marsh and is usually only centimeters higher than the Low Marsh. However, this elevation difference is enough to restrict the tidal intrusion to spring flood tides and storm tides. The lower edge of this zone may include the short form of *Spartina alterniflora* mixed with *Spartina patens*. *Spartina patens* (salt hay) dominates the High Marsh, where it mixes with other grasses, including *Distichlis spicata* (spike grass). *Juncus*

geraldi (black rush), often indicating freshwater intrusion into the salt marsh, marks the next increase in elevation, with High Marsh forbs to the *Iva frutescens* zone. In New England, the salt marsh is often framed by a forested terrestrial edge that demarcates the saltwater zones from the freshwater zone (Fig. 3). Each zone's plant palette represents an adaptation to degrees of salinity, submersion and elevation [8].

That narrow ribbon of marsh between land and sea is dying. What is killing the salt marsh is still not fully known. The stress of climate change, sea level rise, warming trends, drought and salinity change, together with coastal development, pollution and a constricted growing area often lead to the development of stress-related pathogens and opportunistic predation, which infect, attack and kill the salt marsh grass [9]. The *Spartina* marsh is stripped bare, leaving the hollowed out memory of the marsh grass roots, which erode with each high tide as the rising tides move steadily inland, inundating the High Marsh. *Spartina patens* and *Distichlis spicata* of the High Marsh cannot adapt or migrate quickly enough to counter the effects of sea level rise, and so the High Marsh of Cape Cod is slowly drowning [10]. Climate change also affects species composition. There is scientific documentation that the southern Sassafras crab has established a beachhead at Wellfleet Bay, Massachusetts, where the crab is eating the low marsh *Spartina alterniflora* to bare mud, slowly stunting and killing the marsh grasses [11]. The trophic cascade of predator and prey is out of balance. Salt marsh dieback is not a local problem. Scientists report salt marsh dieback from Maine to Louisiana. The end result is a loss of coastal protection, habitat, estuarine landscape and sustainable fishery.

ART AND THE ENVIRONMENT

The public seems oblivious to the impending, incremental changes that reflect an imbalance in nature. Art can be used to arbitrate and communicate concerns of climate change and environmental degradation to the general public outside the confines of the gallery or museum. Often my installations involve collaboration with scientists, governmental agencies, environmental organizations and the community.

Spartina Winter Ice (Fig. 4a,b) is the first in a series of environmental advocacy works I created that focus on the vulnerability of the U.S. Atlantic coastline to sea level rise. The installation documents the melting of winter ice from the *Spartina*

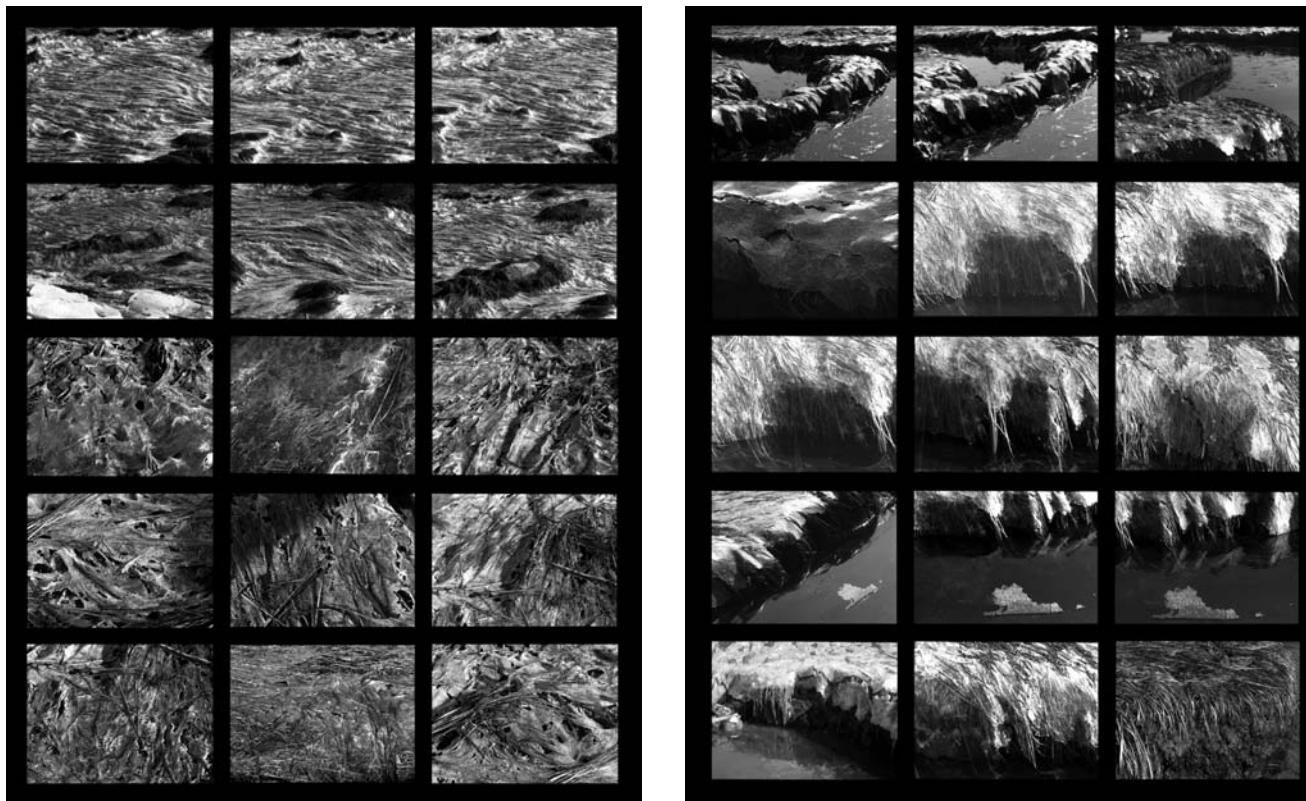


Fig. 4. *Spartina Winter Ice*, photographs and projection, 2004. (© Joseph E. Ingoldsby) Grid of time-lapse photographs of the last day of winter on the Spartina marsh, when the ice melts and the tides rise up and flood the High Marsh. The sequence projects as 15 panels, which scroll down while accompanied by a soundtrack of an incoming wave of seawater. Between the images of land and sea are projections of the sunrise from dawn to high noon. The projections are designed as a template to match a screen of 15 handmade Spartina salt marsh paper panels set in a grid on a scrim of sheer linen. The layered projection panel installation size is 10 ft wide by 12 ft high by 3 ft deep. The layering allowed a play of opacity, translucency and transparency as the work progressed to reveal the coarse fibers and salt hay on the back wall beyond the scrim.

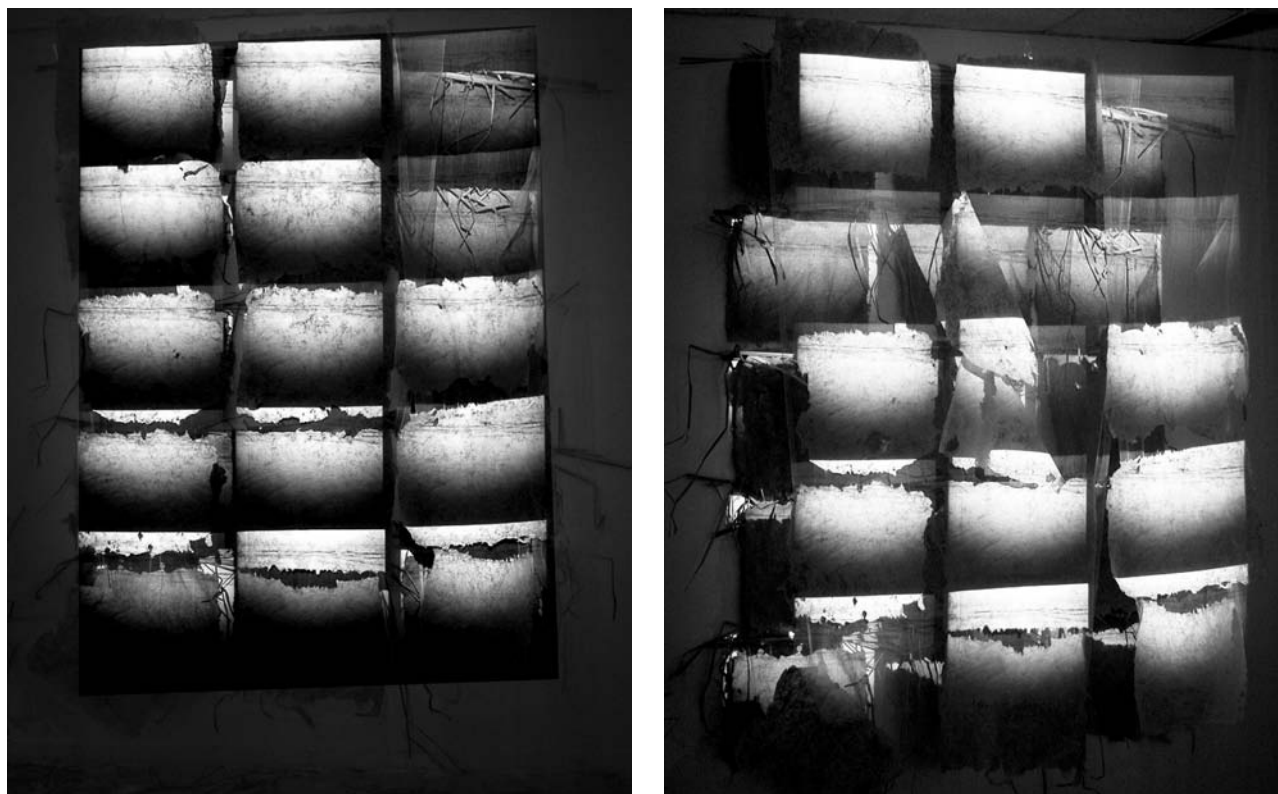


Fig. 5. (a) *Spartina Winter Ice*, installation, 2004. (© Joseph E. Ingoldsby. Photo © Andy Zimmermann.) As the sun reaches high noon, the spring tide rises up and over the Spartina patens High Marsh. Sheets of ice break off and fall into the rising waters. In the installation the effect is simulated with the slow-motion drop of Spartina paper panels from the installation onto the sheer linen scrim, shimmering like water on the floor below. (b) Detail. (© Joseph E. Ingoldsby. Photo © Andy Zimmermann.) Side view of the installation showing the multiple layers of handmade paper simulating ice being shed as the sun rises, the atmosphere warms and the ice melts. The final images are of paper adrift in the shimmering scrim with photographs of sky reflected on water, projected on the back panels of coarse salt marsh grass paper.

patens marsh and the rising tide washing over the salt marsh on the last day of winter. The event, documented in *Spartina Winter Ice*, began at first light. The *Spartina* grasses of the High Marsh had been covered with the tide the night before, which froze, encasing the grasses in a thin sheet of ice. The ice echoed the flow of the water and the texture of the grasses encased beneath the frozen tide. As the sun rose the ice became luminous and glowed like the sun. The rising sun illuminated the marsh grasses, which are gold with blue shadows beneath the ice. As the sun warmed the morning air, the sea began to rise with the tide. Plates of ice shattered and fell into the rising tide and floated away. As the sun rose and the light became more intense, the ice melted, revealing the golden marsh grasses and green algae below. Soon the rising spring tide would cover the *Spartina* patens salt marsh in seawater.

Spartina Winter Ice is an animation of gridded projections, which capture images of the sunrise on the marsh and the sea level rise, from first light to high noon. The work is projected onto a corresponding grid of handmade salt marsh fiber sheets fixed to a scrim of sheer linen. The wall behind the scrim is set with a corresponding grid of coarse salt marsh fiber panels flanked by salt marsh grasses gathered from the site (Fig. 5a,b).

The projections are sequenced to project from the top panels down and are synchronized with the recorded sound of the waves washing over the shore. Each change in the time sequence of the sun rising on the marsh follows a projection of the sky at that moment in time. As the work progresses, the white salt marsh panels begin to fall from the scrim, echo-

ing the shedding of ice from the salt marsh on the last day of winter (Color Plate B). The final projection is that of water flowing over the coarse salt marsh panels set with salt marsh grasses on the backing wall. *Spartina Winter Ice* presents a microcosm of global concerns as rising temperature, polar ice cap melting and global sea level rise accelerate with each passing year.

Yet, for all of its utility, few see the beauty of the salt marsh. Remember it. Soon it will be gone. For many years, I have visited the marsh and relished its seasonal change of color and pattern. My work *Landscape Mosaics* has charted that change over time. Through methodically charted color palettes, the work traces the growth of the marsh through the seasons using color change. This change is based on a number of scientific principles and plant physiology, including the quality, intensity and duration of light allowing for photosynthesis. I installed hundreds of color panels, which I called *pixel panels* (Fig. 6a,b), representing the color projection of the marsh below [12]. The colors were charted using Pantone colors held directly to the plants at fixed times of the day to reflect the altering of color with the degree of light and the span of time. The Pantone colors were then matched to custom-mixed acrylic paints applied to primed panels set into the salt marsh on thin, neutral-colored stakes. The color panels appeared to float above the sea of grass. I added additional color panels as the seasons progressed, until the landscape was pixilated with hundreds of colored squares representing the mosaic of the salt marsh landscape through the seasons. Now I must add another color palette to the series—that of death.

REQUIEM FOR A DROWNING LANDSCAPE

Requiem for a Drowning Landscape can be described as a meditation on the loss of a landscape. The work follows the themes of Remembrance, Recollection and Retelling.

Remembrance

Within a darkened gallery is a series of light box panels. Each panel is set with iconic photograph(s) of color transformation in the salt marsh, representing seasonal change, and with the color palette representing the seasonal timeline each image represents. Imagery and text explain and illustrate the process from dormancy, emergence, growth, reproduction and senescence to death (Fig. 7).

Recollection

This installation interprets the seasonal progression of the salt marsh using projected colored light in a color meander representing the staggered intervals of seasonal growth and decline in an experiential way (Fig. 8). The installation traces out the color change from the slow breaking of dormancy in spring with the lengthening of daylight hours to a rapid state of pure, luminous, green chlorophyll. By summer, the maturation of growth deepens the color. Seeding occurs in late summer into autumn, and with it the marsh transforms into a kaleidoscope of colors. The colors become muted with the shortening of daylight and the cooler night temperatures as the plants become dormant with the onset of winter. These color projections were installed along a creek meander of the tidal North River in Scituate, Massachusetts, as

Fig. 6. (a) *Landscape Mosaic—Spartina Color Mosaic Study*, 40 × 50 in, 2005. (© Joseph E. Ingoldsby) Plein-air graphite drawing overlaid with digital color palette of the *Spartina* salt marsh. (b) *Landscape Mosaic*, installation, Wellfleet, Massachusetts, 2003. (© Joseph E. Ingoldsby) Color panel installation of salt marsh pixel panels, based on field-charted colors within the salt marsh at the Sanctuary at Wellfleet Bay.

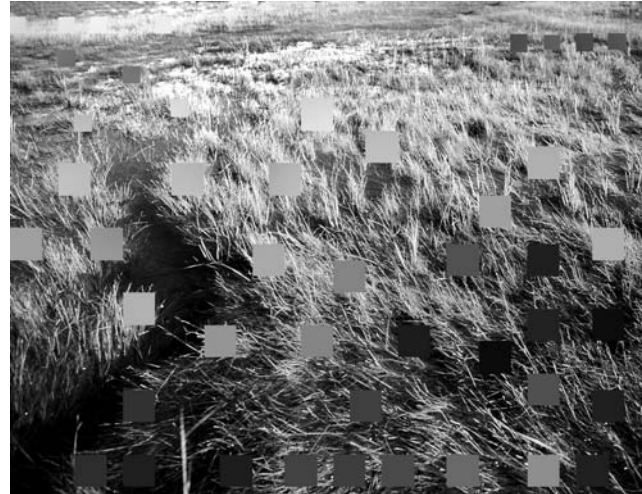
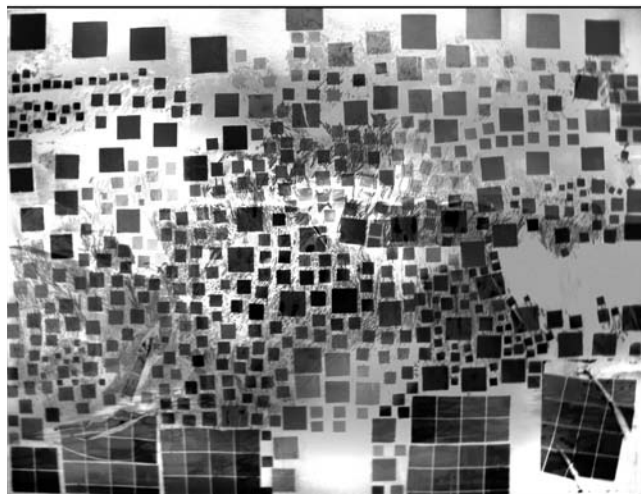


Fig. 7. *Requiem for a Drowning Landscape—Remembrance*, 2008. (© Joseph E. Ingoldsby) Model of the *Requiem for a Drowning Landscape* installation, tracing the life and death of the salt marsh.

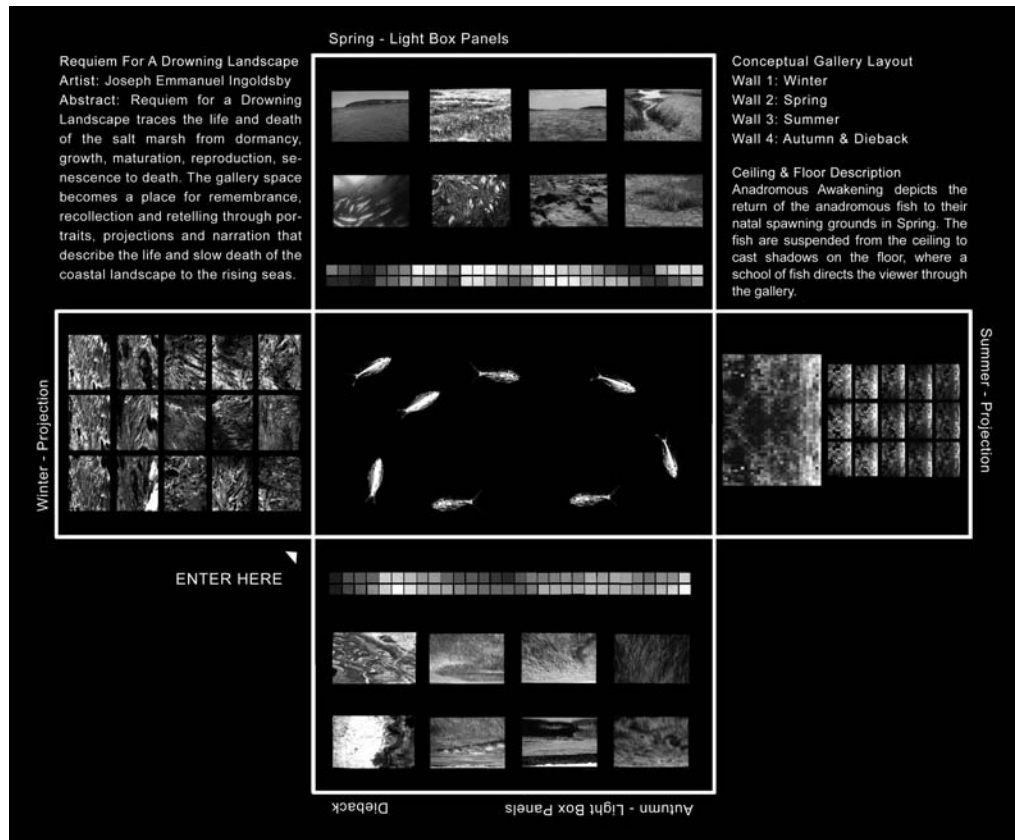


Fig. 8. *Requiem for a Drowning Landscape—Recollection*, 2008. (© Joseph E. Ingoldsby) Digital graphic depiction of a gallery installation of the sequence of seasonal color in the marsh, using light beams and programmed color animation. The color time line with staggered intervals of growth and decline is to be projected to create the colors of each season in an experiential way.

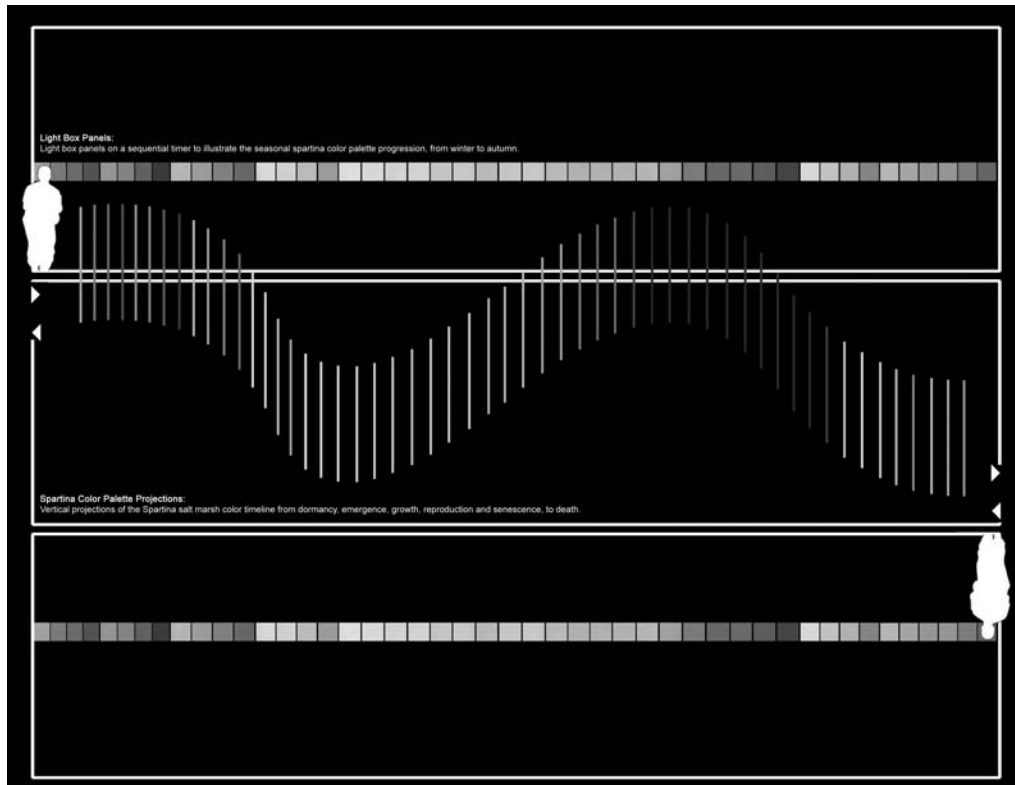
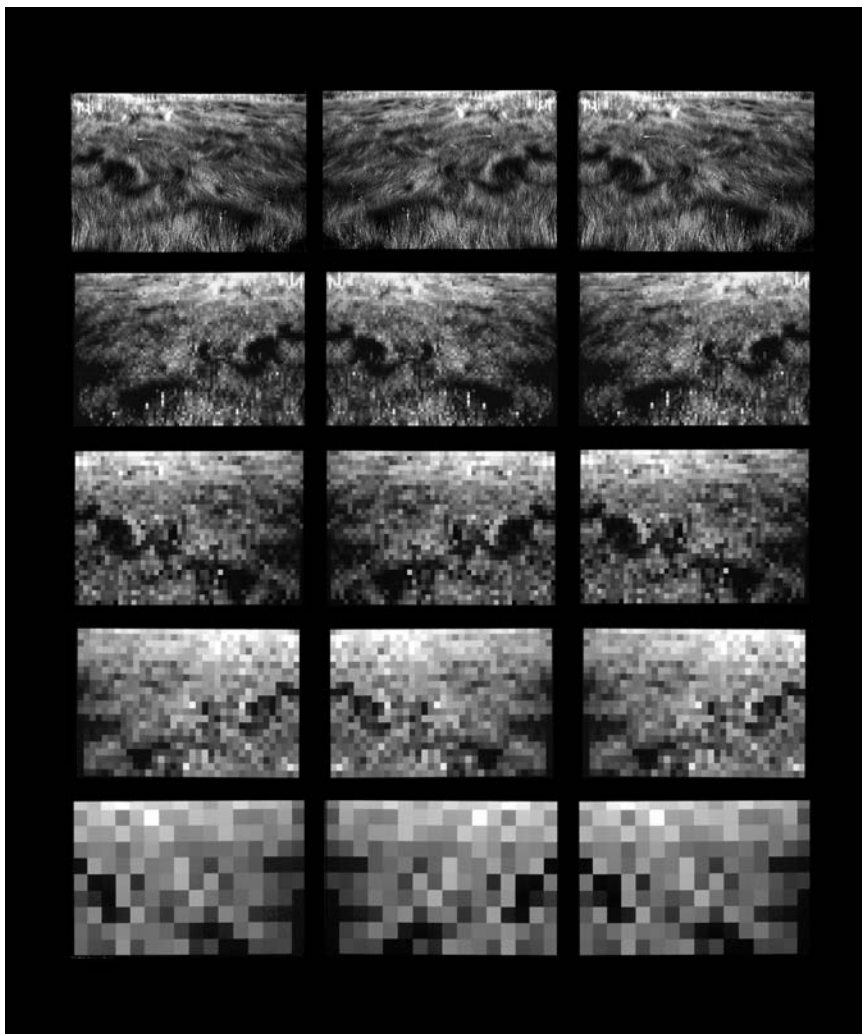




Fig. 9. *Requiem for a Drowning Landscape—Recollection*, site installation, North River, Scituate, Massachusetts, 2003. (© Joseph E. Ingoldsby) Kinetic display of color representing the time line of growth, seeding and senescence in the *Spartina* salt marsh.

Fig. 10. *Requiem for a Drowning Landscape—Retelling*, 2004, 2008. (© Joseph E. Ingoldsby) Digital Flash animation projection (10 × 12 ft) of late summer seeding coloration shifts in the *Spartina patens* salt marsh. The work scrolls in sequence from left to right and top to bottom of the panel.



part of a Cyber Arts Festival in Boston. Fifteen hundred vertical posts were primed and painted with custom-mixed acrylic paints with the help of high school students and installed into the High Marsh after community and environmental reviews and permitting. The colored posts marked the seasonal progression of color and time in the salt marsh and were reflected in the waters of the rising spring lunar tides, which inundated the High Marsh (Fig. 9). There is a science to the transformation and adaptation to light.

Retelling

Retelling is reminiscent of the vibrant life of the fertile marsh seeding, retold and repeated in projections of panels and a color time line in a Flash format presentation with audio. I mirror-joined my photographs of the marsh in late summer and applied a fine grid over the image. Each square of the grid has been digitally altered to shift the color palette of the seeding cycle through a color blending process. The animation reflects the wind blowing across the grains of marsh grass, shimmering in the summer sun (Fig. 10).

CONCLUSION

My work looks at sensitive landscapes and endangered species using art, science and technology to interpret complex ecological ideas for a broad cross section of the public, beyond the walls of a museum or gallery. My installation *Anadromous Awakening* (Fig. 11) depicts the return of the anadromous fish to their natal spawning grounds in spring. The illuminated fish are suspended from the ceiling to cast shadows on the floor, where a digitally printed school of fish directs the viewer through the gallery. The suspended handmade riverine fiber fish are a fragment of a site-specific celebratory work I installed on a tidal river. Waves of anadromous smelt, herring and shad return from the sea to spawn in their freshwater natal streams, renewing a cyclical process of life, death and rebirth, unseen by the general public. The species were installed in small schooling groups marking the passage of the fish upstream to make visible the invisible migration of anadromous fish in nature. Today, the fisheries are in trouble. Overfishing, loss of habitat, pollution, invasive species, ocean warming and acidification have taken their toll on the fishery [13]. We can only recall the estuary, schooling with fish. Warming water, current changes, salinity and acidification have already altered the historic spawning and

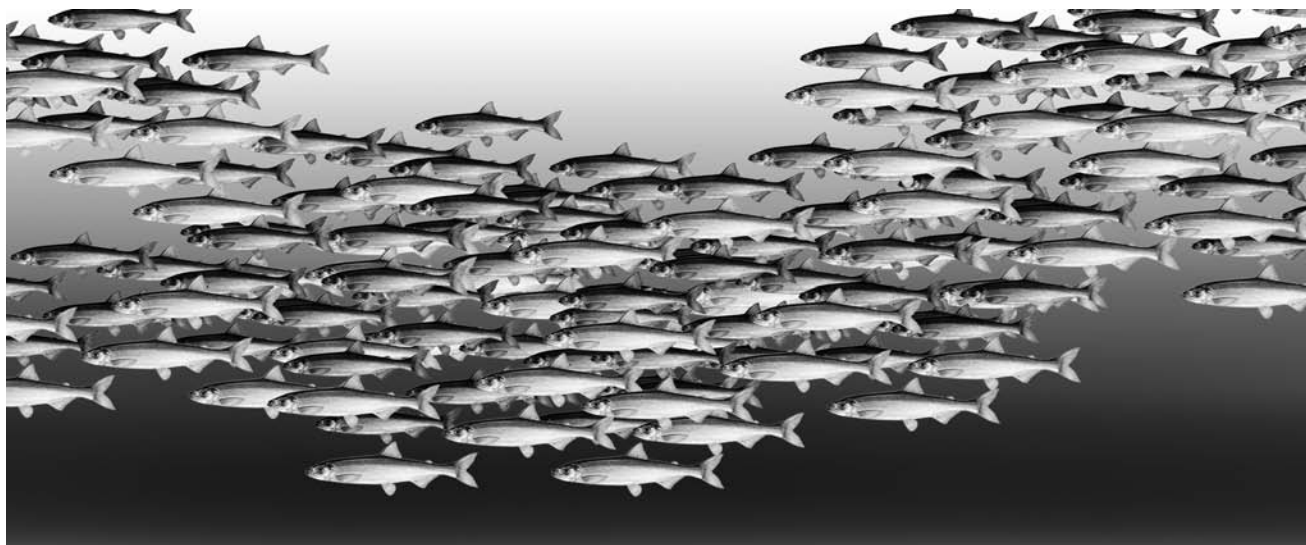


Fig. 11. *Anadromous Awakening*, graphic depiction of installation, 2005, 2007. (© Joseph E. Ingoldsby) The sea is rising and the rivers are overflowing as the fish swim over former marshes and fields.

schooling grounds for many species of fish and shellfish. Ocean temperature rise and saline dilution will further alter the makeup of the fisheries in the future. Tales will be told and retold of the inexhaustible fertility of the ocean, but they will be historical recollections of and a eulogy to a vanishing landscape.

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Joseph E. Ingoldsby learned to design with nature with Ian McHarg at the University of Pennsylvania. He is a member of the American Society of Landscape Architects, the Coastal Estuarine Research Federation and Art & Science Collaborations, Inc. Recent work of his has been shown at the New York Hall of Science (Requiem for a Drowning Landscape, 2008–2009) and the University of Wisconsin-Madison Arboretum (Vanishing Landscapes and Endangered Species, 2009). He is currently producing Fish Tales of the Last Generation.