ARTISTIC PRACTICE: MIXING THE CURRENTS OF SCIENCE AND DATA

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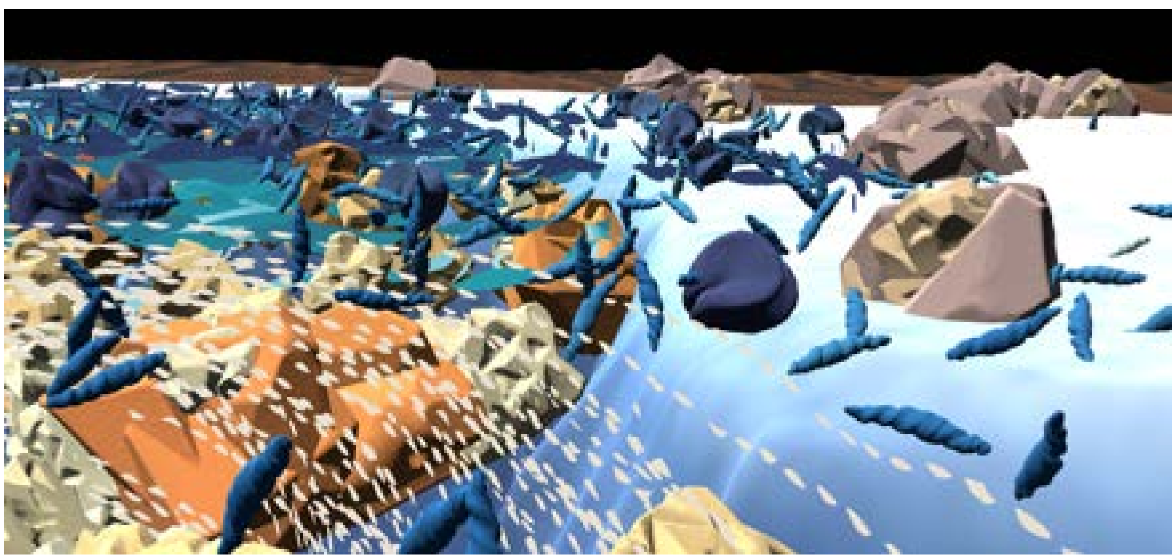
Abstract
Our work relies on the interplay of art, technology and science, and the dance of these disciplines as they augment one another to create an emotional connection between the audience and the data. Prior work focused on building out artistic vocabulary for clear, engaging science exploration and communication. Within this portfolio, we move through the steps of science inquiry and data representation, toward creating new layers of meaning and connection through affective visualizations.

Authors Keywords
Scientific visualization, art, climate science, affective visualization, artistic design theory

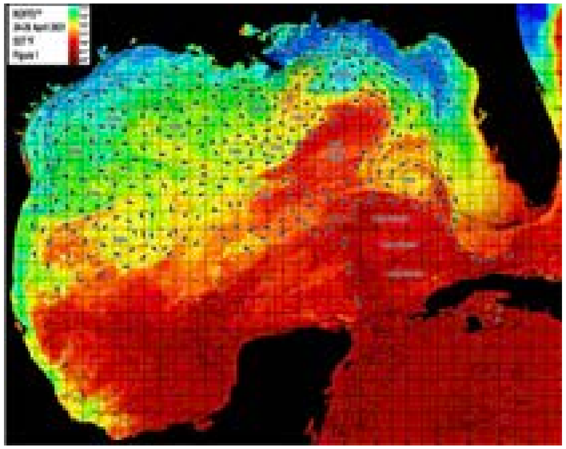
Images have been constructed from data, but created through artistic practice for emotional connection.



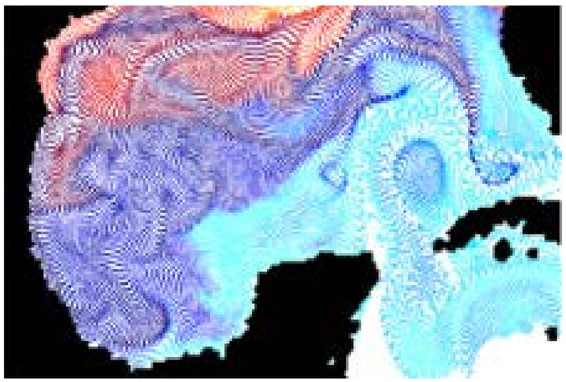
Throughout this portfolio we move through stages, beginning with a focus on science communication, and culminating in an emotional environment created via artistic practice. Section One demonstrates the application of vocabulary in service of science and engagement. Section Two combines the visualization with contextual entries to the work. Section Three, the focus of the portfolio, showcases a series of art-driven images.

VISAP'19, Pictorials and annotated portfolios.

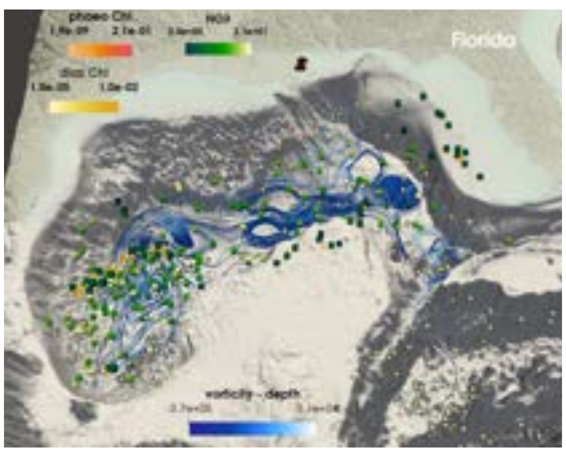
Art's ability to keep open the ambiguities, ambivalences, contradictions, and sometimes chaotic dimensions of reality, rather than leveling them into a coherent logical system, is seen as helpful when addressing the complexities of climate change (Kagan 2015).



Roff's Gulf of Mexico visualization, 2021 [3].



Currents in the Gulf of Mexico. Dutta et al [4].



Left: Nitrates and currents in the Gulf of Mexico compliments of Greg Abram.

Traditional Visualization Examples

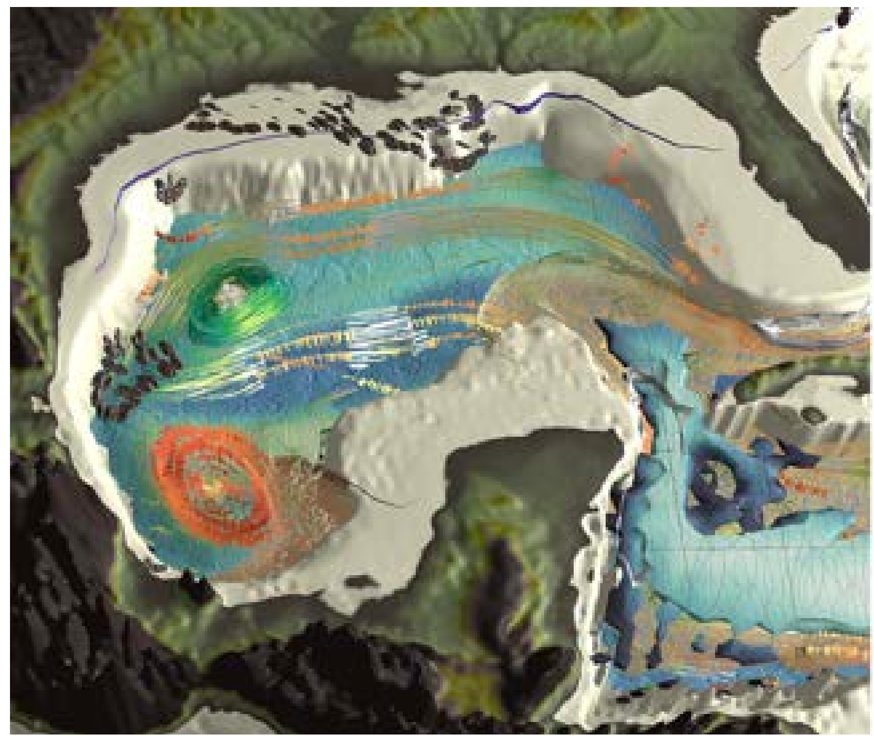
On the left are three examples of traditional visualization methods for the data shown throughout the portfolio.

Image 1 (top left) shows temperature and velocity. The colormap and glyphs represent the vector field. Here, only the surface is illustrated, making it difficult to follow what is happening with currents. This image represents the current standard visualization format for this type of data.

Image 2 (middle left) increases clarity, but the two-dimensionality of the visualization limits representation to surface currents.

Image 3 (bottom left) illustrates volume metric data of the Gulf, sampled by density and enabling visualization of the third movement of the currents.

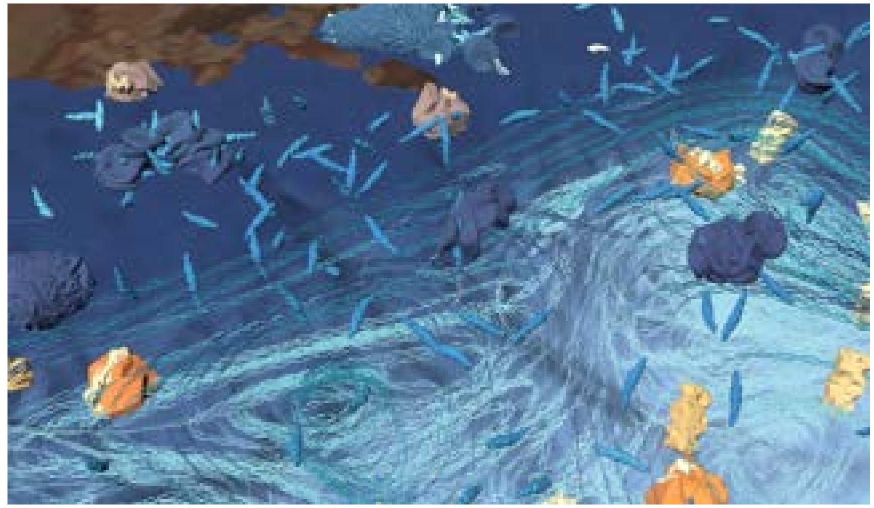
Note that the three approaches presented here rely on the same biogeochemistry simulation of the Gulf of Mexico, using the Energy Exascale Earth System (E3SM) coupled climate model [1].



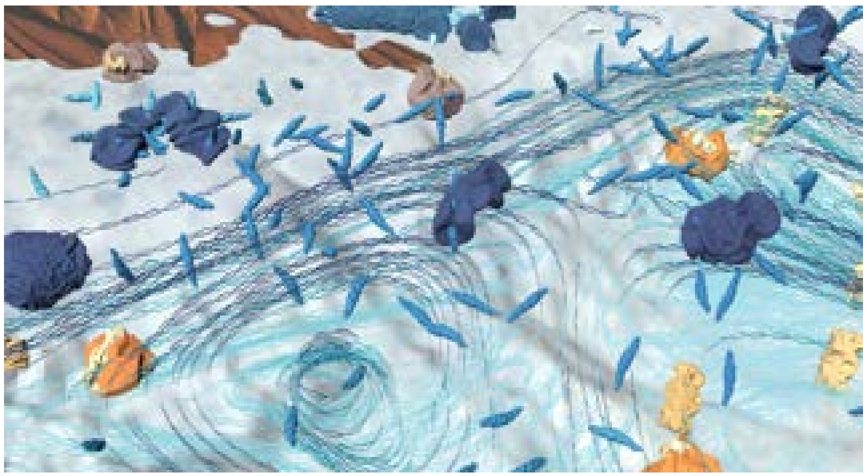
Early experimental visualization created with Artifact-Based Rendering[2].

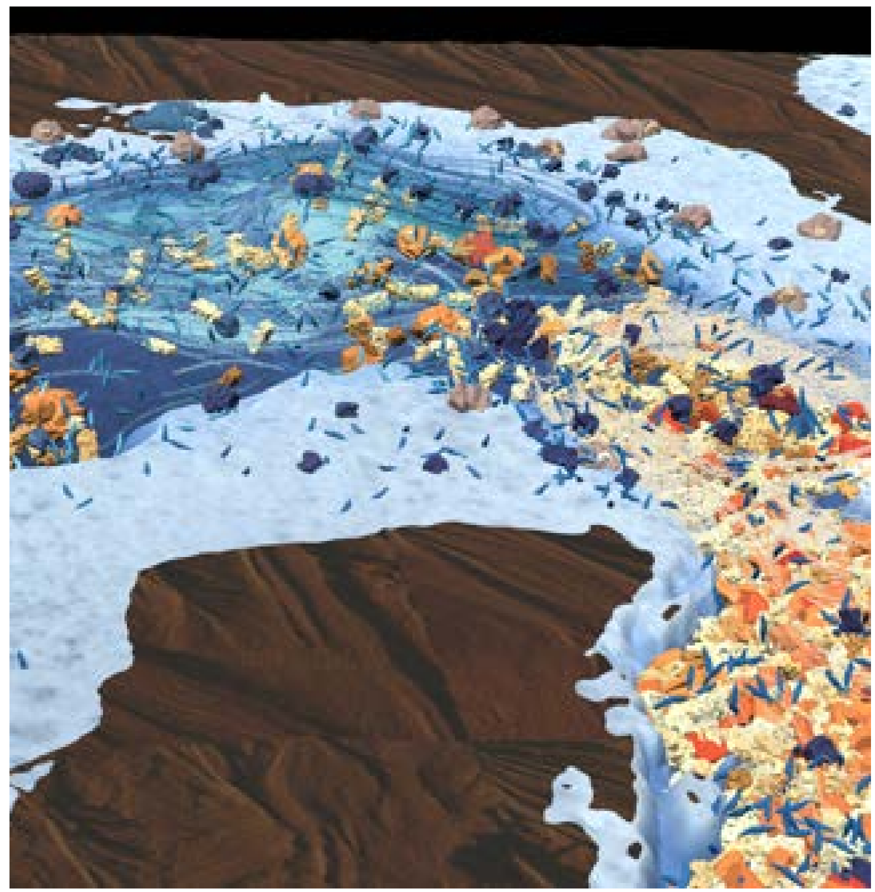
Currents, Eddies and Vertical Ocean Currents

Scientists study the nitrate levels stemming from Mississippi River runoff into the Gulf, which feeds phyto and zooplankton. Given an abundant food source, the plankton population grows until it absorbs most of the oxygen in the water, causing a deadzone.



The gulf is a dynamic environment inhabited by microbes, algae and nitrates, all being swept by currents.



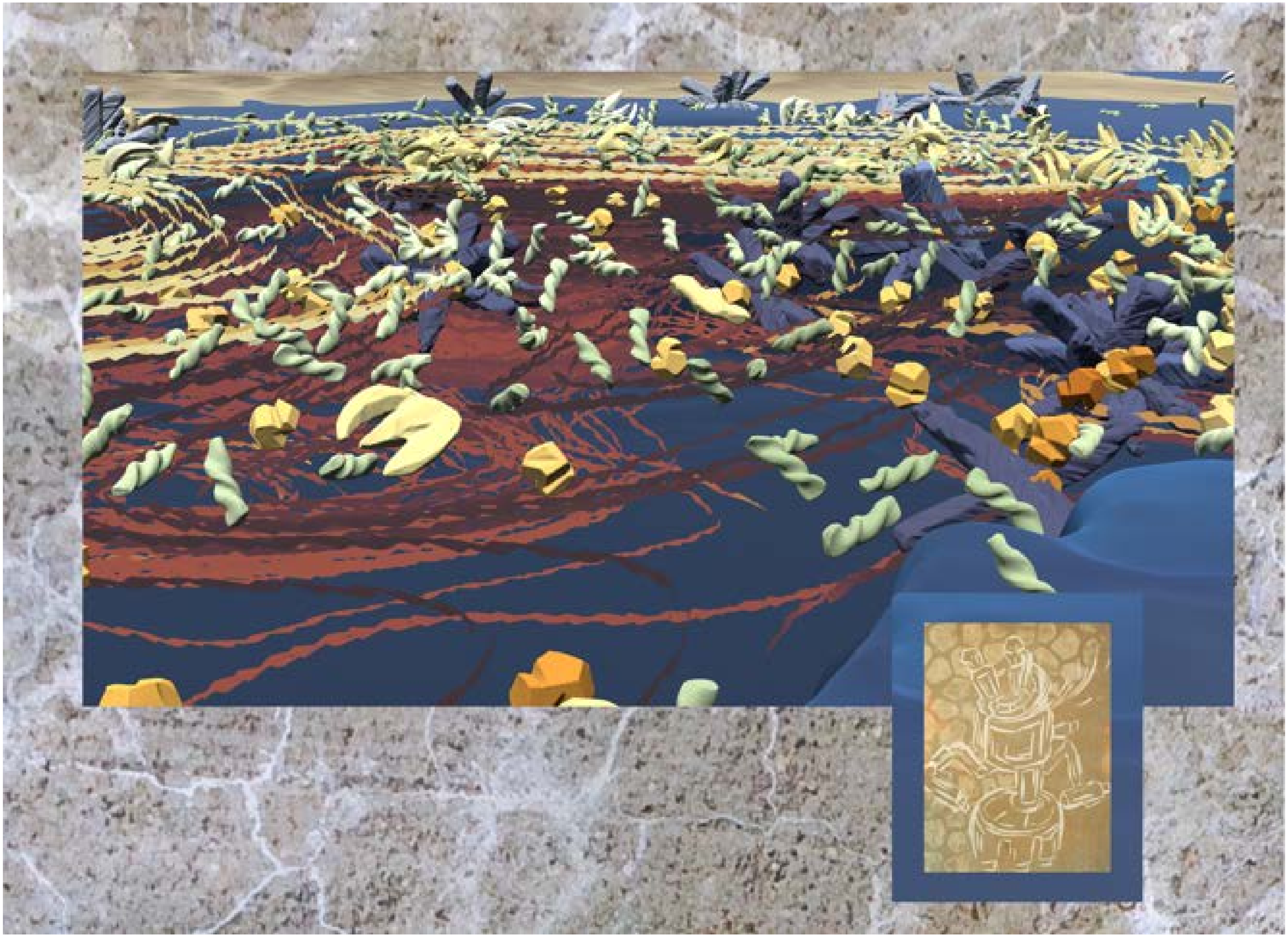


Vertical mixing pulls nutrients up from the deeper layers to the surface of the Gulf, where they can support the macroalgae population. Scientists working to quantify the level and sources of these nutrients are researching both strengths and locations of these vertical movements within eddies, shown here. The streamlines are colored by temperature and driven by depth. On the left, the vertical mixing is visible in the upper section, just south of the Mississippi Delta. The streamlines are assigned differing hues illustrating depth, as the waters are warmer at the surface and cooler at lower elevations.

These glyphs represent two categories of nitrates rendered in warm hues, and two categories of chlorophyll rendered in cooler hues. Scientists are interested in specific levels of nitrates and chlorophyll in order to identify where nutrients, temperatures, and currents are conducive to macroalgae cultivation to be converted into biofuel. Biofuel cultivation would absorb nitrates from agricultural runoff, mitigating the expanding dead zones in the Gulf.

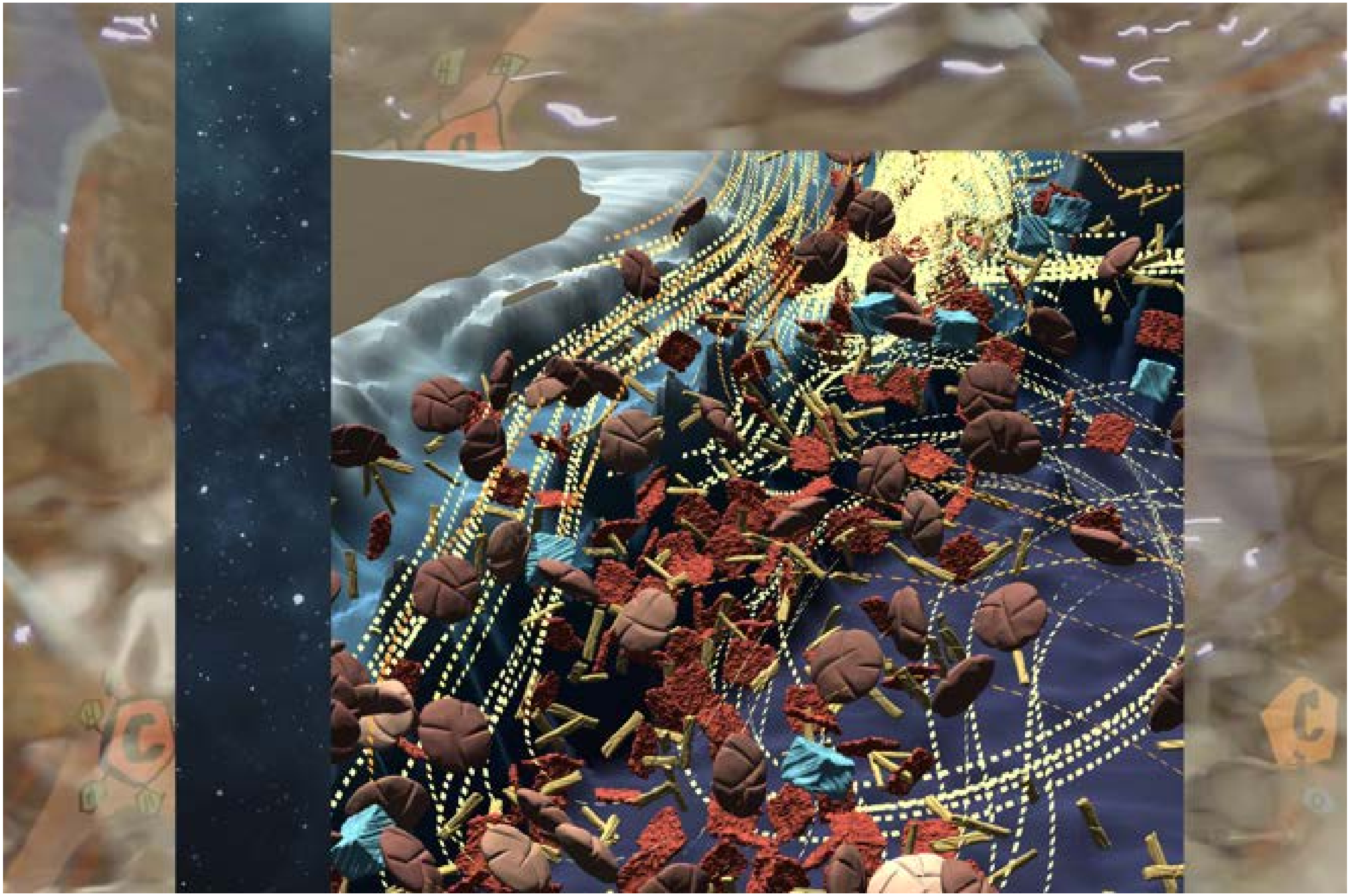
Concern over expanding dead zones has led to proposed research into cultivation of macroalgae, which would feed on the run-off from farmlands (the driver of the dead zone) while producing macroalgae for biofuels.

As context for this visualization, we incorporate contextual images pointing to the source of the problem: agricultural runoff from farmland in the midwest, draining into the Mississippi and flooding the Gulf of Mexico with nitrates..



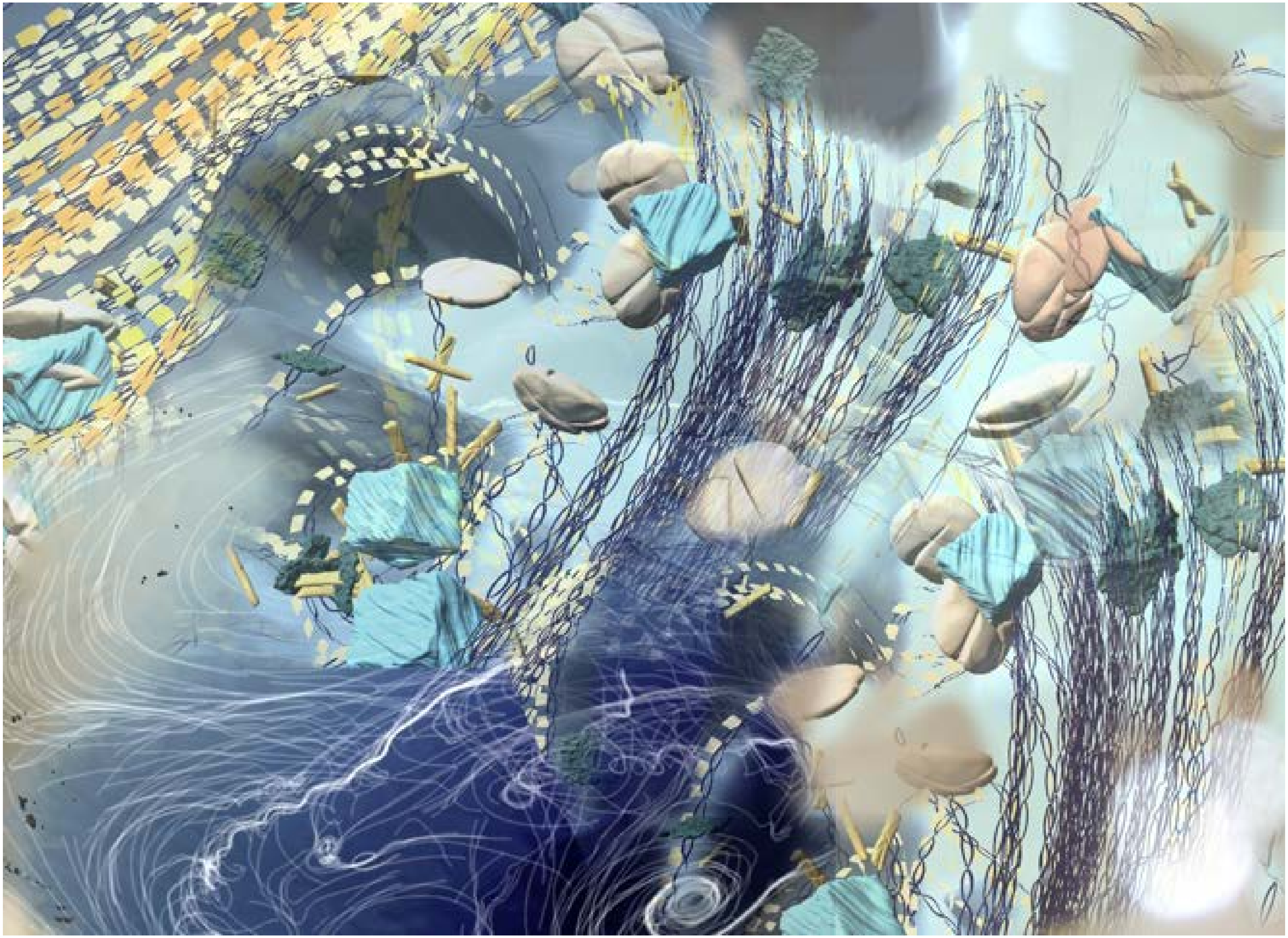
The Gulf of Mexico is teeming with aquatic flora and fauna, except in the regions where algae – having feasted on agricultural runoff – has depleted the oxygen levels to the point where life cannot be sustained. These growing dead zones impact regions far beyond their physical reach. The processes creating dead zones occur on a microscopic level, but have a macroscopic impact.

Here, we move away from describing the science and into the structure of the abstractions: variety of shape, size, density, and texture, as well as the tension between the calm and the threatening elements of shapes and palette.



The oceans are changing. Increasing levels of carbon and methane are moving into the air and ocean. The movement of these molecules is altering and amplifying weather patterns, driving oceanic currents, shifting temperature, and melting ice at the poles. This image stands as an acknowledgment of these death-dealing changes.

VISAP'19, Pictorials and annotated portfolios.

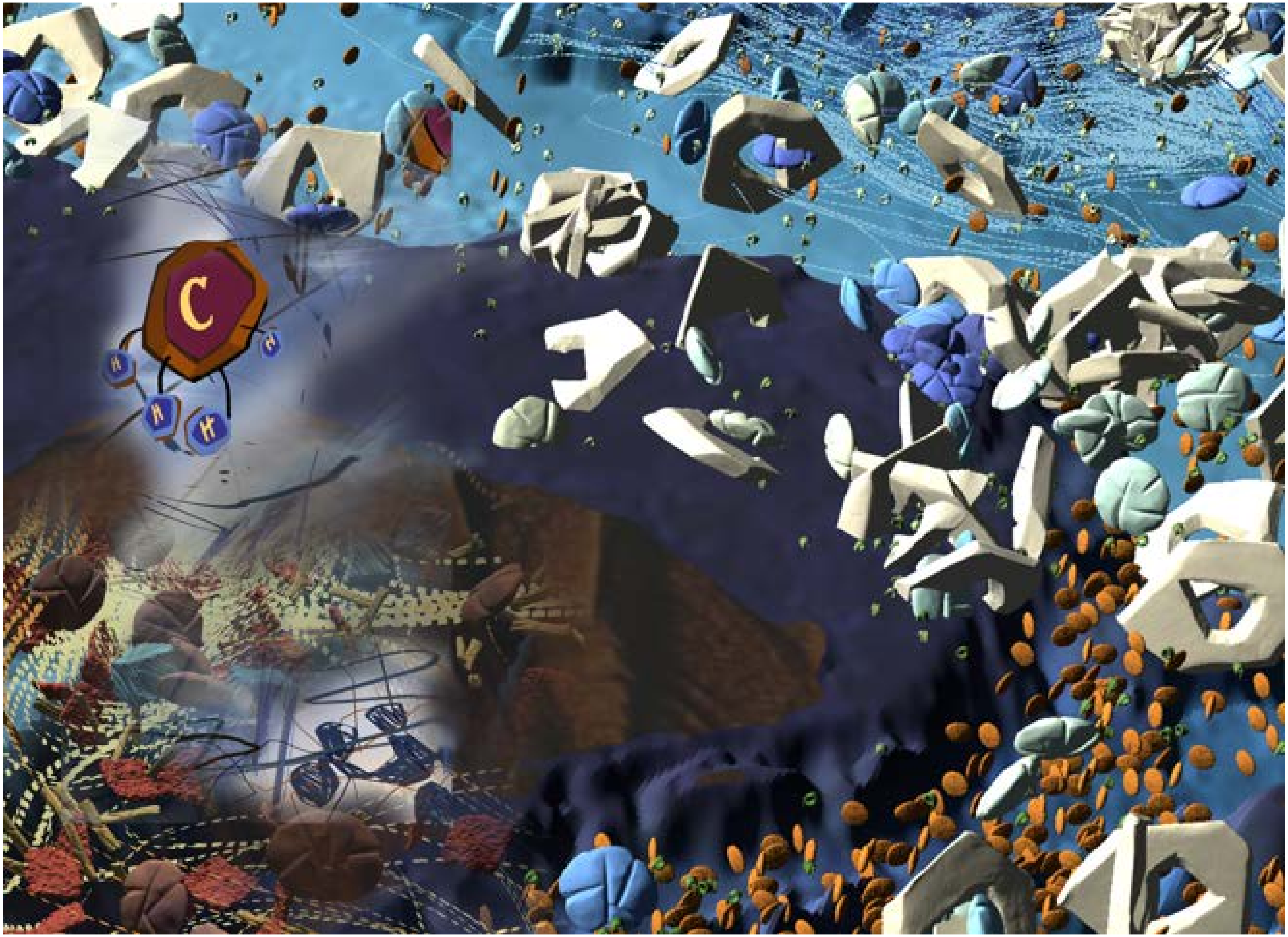


“Whirlwinds” speaks of the currents and activity within the Gulf and throughout the oceans: constant, tumultuous, and out of sight.

As with all of the visualizations in the portfolio, this simulation data is calculated within the MPAS-Ocean Model developed by the US Department of Energy. Variables of the data shown include biogeochemistry, temperature, salinity, and currents, which together enable scientists to assess the practicality of macroalgae cultivation for biofuels.

While many visualizations aim to provide a clearer rendering of this multiple-variable complexity, here we begin from the other side of the art-science collaboration, and develop the imagery from an artistic perspective.

The deadzones in the Gulf of Mexico impact life beyond the aquatic flora and fauna, including all the wildlife that depend on the aquatic ecosystem.

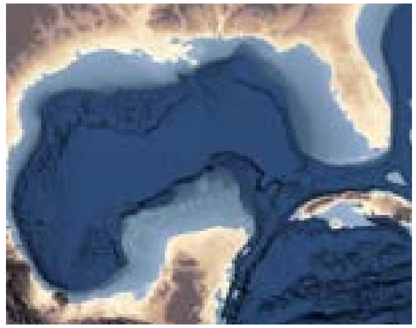


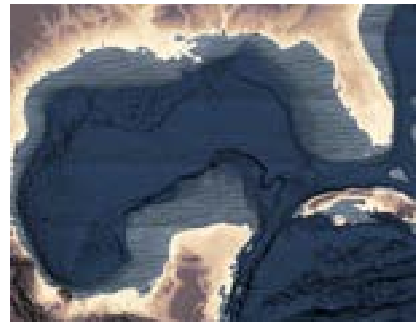
Presented here are steps from both sides of the bridge, the abstraction of the data to the physical world represented as shown above: a three-dimensional rendering of the same location, showing details of current flows as well as levels of nitrates and chlorophyll. This work relies on sampling algorithms to represent the volumetric data placed within.

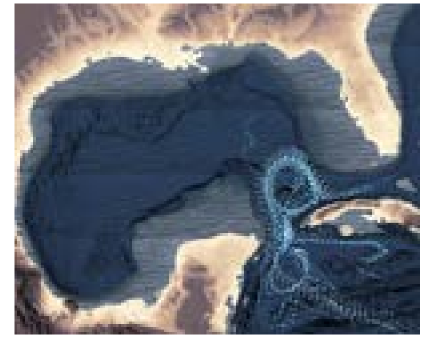
VISAP'19, Pictorials and annotated portfolios.

Constructing Visualizations Using Artifact-Based Rendering

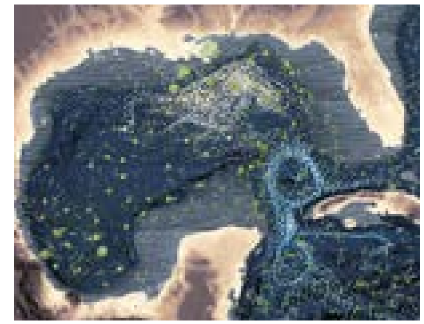
Building in ABR i[2] is designed to enable artists to render a full range of their own visual assets on data. The top row demonstrates the ability to apply custom textures to surfaces.

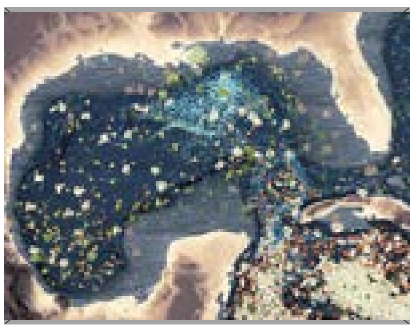


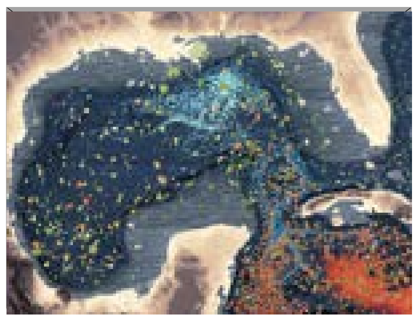




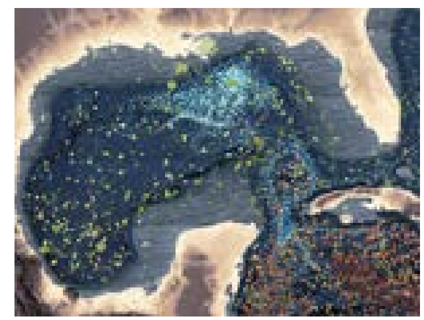
On the left, the currents are represented by the hand-drawn dotted line. On the right, two varieties of chlorophyll have been added. The volumetric data has been sampled by density to create the point distribution field on which the glyphs are placed.



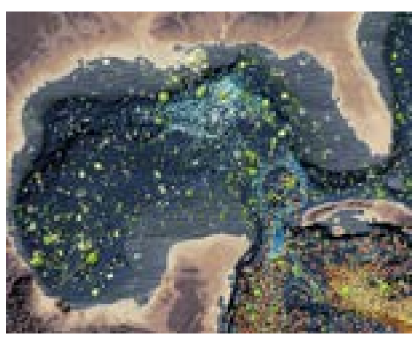


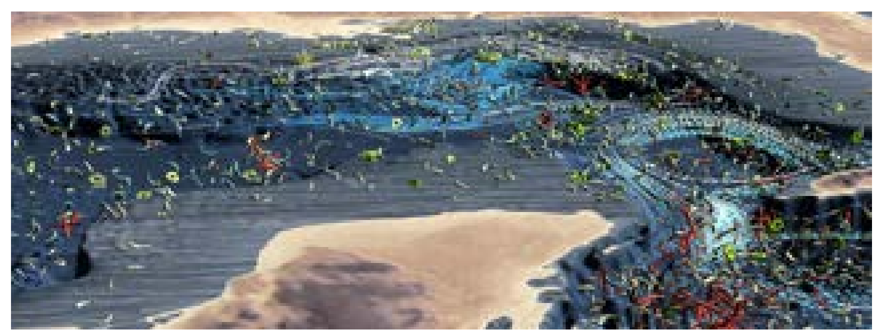


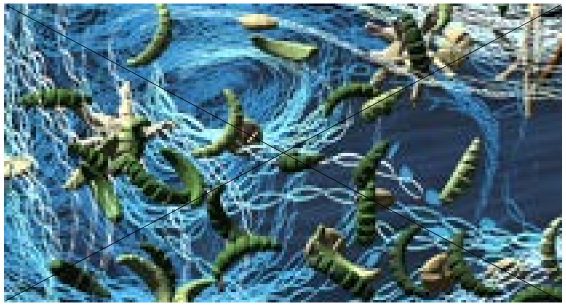
Changed the colormap on the upper set of streamlines inorder to simplify the color.
1. glyphs too big and the variable is incorrect
2. changed the glyph, corrected the variable, now too bold
3. selected a simpler glyph

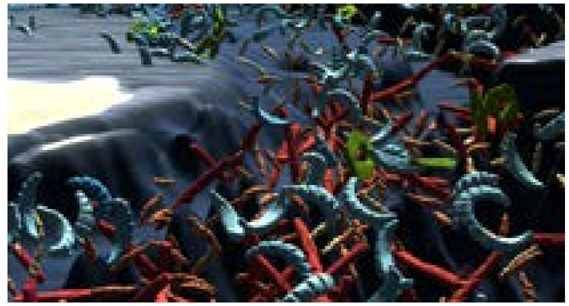


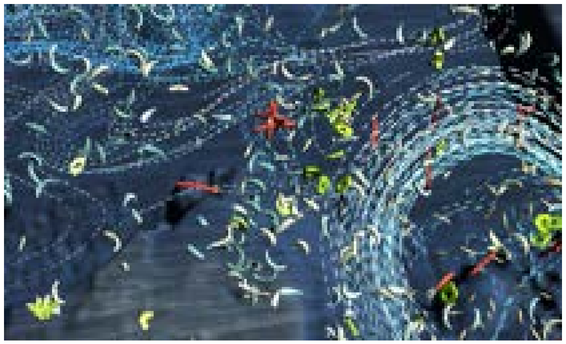
1. The chlorophyll appears to need more distinction
2. changed from a straight linear glyph to an arc glyph. Linear glyphs are clearer in dense areas. and the curvature provides distinguishion.
3. Lowered the sampling percentage on the nitrate cluster south of Cuba.





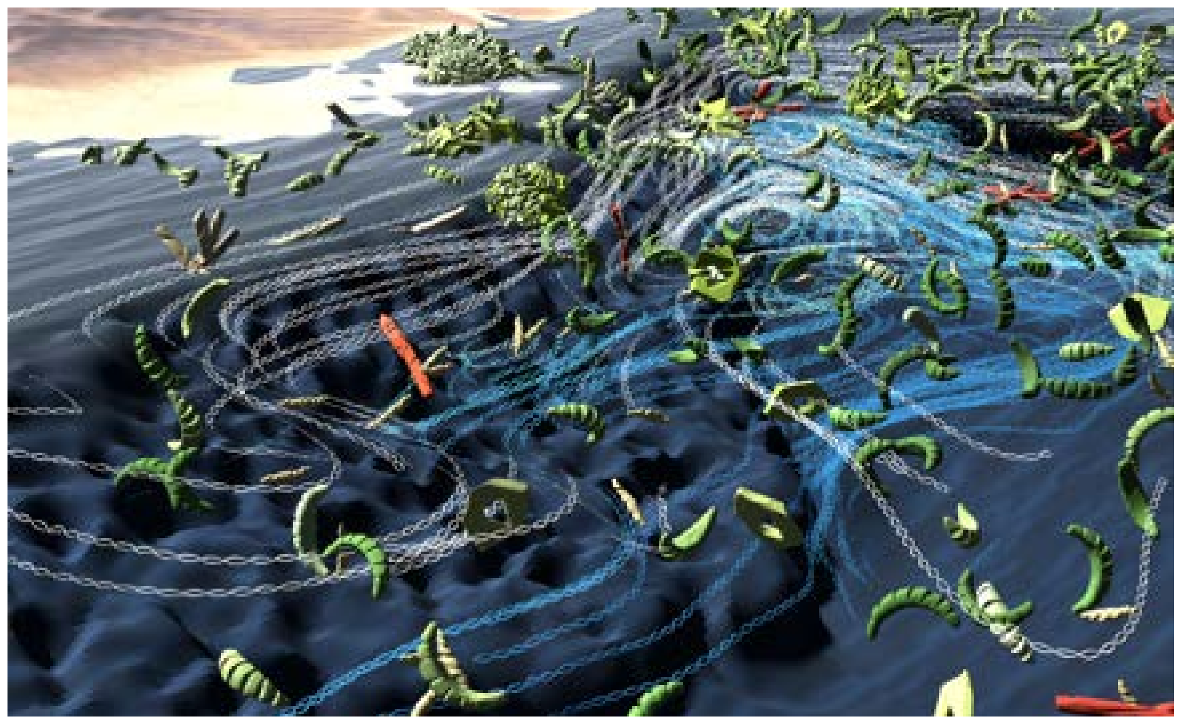


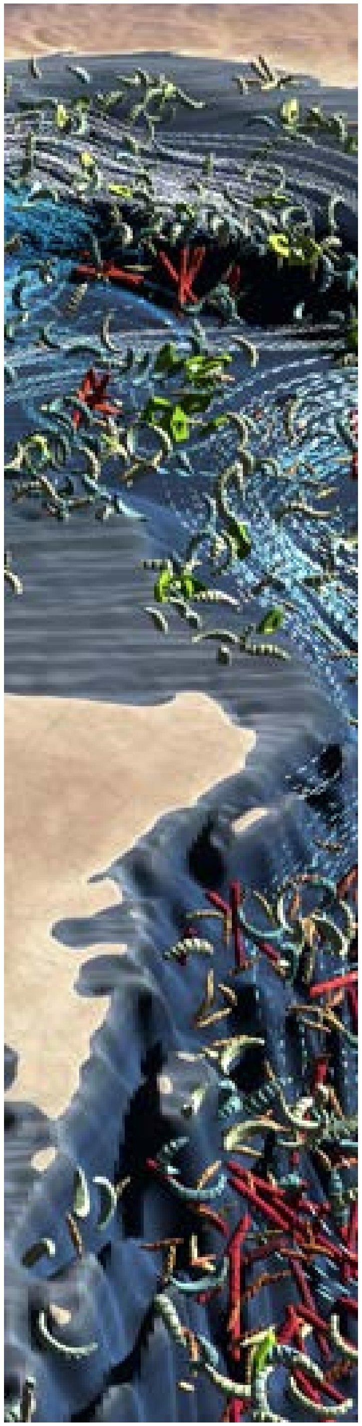


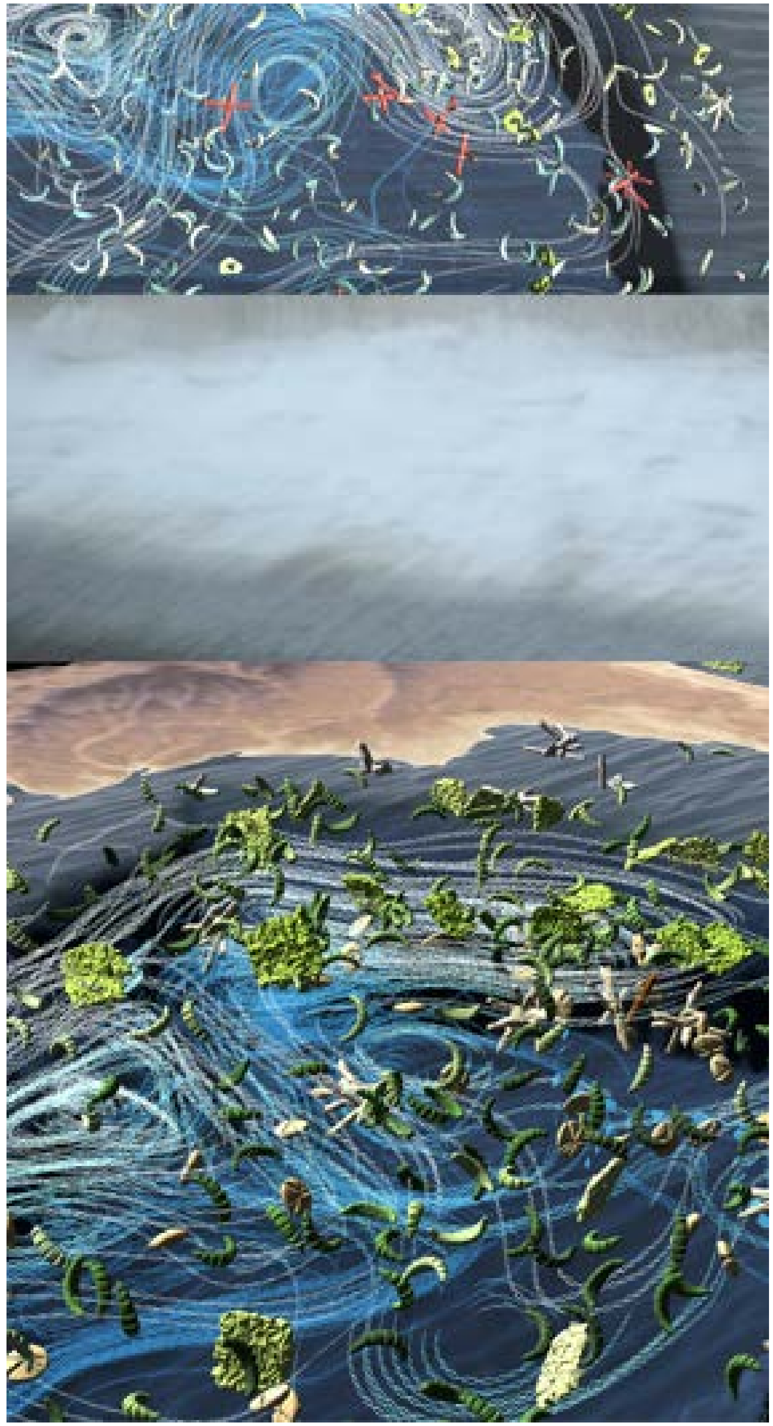


The beauty of work from the ABR system comes into focus as one zooms into the detail. The upper four images reveal the visual interaction between the viewpoints. The streamlines in the image below show the currents rushing out of the Mississippi Delta, carrying nutrients and algae into the Gulf of Mexico.

All of the work displayed here is made possible by the use of Artifact-Based Rendering [1]. Enabling the process, ABR provides the means to engage with large 3D data sets, and import .obj files, textures, drawing and colormaps. On the far left are examples of the artifacts constructed for the visualizations within this portfolio.







Acknowledgements

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References

1. Kagan, Sacha. The practice of ecological art. Journal Plastik. vol. 4, 2014
2. Seth Johnson, Francesca Samsel, Gregory Abram, Daniel Olson, Andrew J. Solis, Bridger Herman, Phillip J. Wolfram, Christophe Lenglet, Daniel F. Keefe, Artifact-Based Rendering: Harnessing Natural and Traditional Visual Media for More Expressive and Engaging 3D Visualizations, IEEE Transactions on Visualization and Computer Graphics, 10.1109/tvcg.2019.2934260, https://doi.org/10.1109%2Ftvcg.2019.2934260, 2019com/_CHINOSAUR/status/461864317415989248
3. Gregory J. Gawlikowski, COnditions Look Promising for teh Gulf of Mexico the Year, 2021, https///www.roffs.com/wp-content/uploads/2021/05/GofMFishingForecast2021FinalWeb.pdf
4. Dutta, Soumya and Brady, Riley X. and Maltrud, Mathew E. and Wolfram, Philip J. and Bujack, Roxana ,Leveraging Lagrangian Analysis for Discriminating Nutrient , 2019Origins, The Eurographics Association
5. Wolfram, P., Maltrud, M.., Riley B., Stevens B., Zhaoqing, Y., Tiaping W.: Multi-resolution, multi-scale modeling ofocean biogeochemistry for scalable macroalgae production. In Aquaculture 2019 (2019). LA-UR-19-22011. 2
6. Photo credit: Dominik Bartsch