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THE WONDERFUL OCEAN
A REPRESENTATION OF HUMAN IMPACT ON THE OCEANS

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1. INTRODUCTION

This document will serve as reflective piece of the creation of the data visualisation entitled "The Wonderful Ocean", as well as an exploration of data visualisation theory and their respective applications to *The Wonderful Ocean*. The key points that will explored is that of data driven storytelling, artistic data art and lastly the procedural rhetoric potential of data visualisation. The analysis of data driven storytelling will be supplemented by the chapter "*Storytelling in the wild*," from "*Data-Driven Storytelling*" by *Riche et al* [1]. Artistic data art will be supplemented by the paper "*Artistic Data Visualization: Beyond Visual Analytics"* by *F. Viégas* and *M. Wattenberg* [2]. Lastly, the procedural rhetoric of data visualisation will lend itself from *Ian Bogost's* book "*Persuasive Games*" [3]. This document will also serve as an exploration of the iterative design process, and its failures and successes. Due to the fact that the visualisation is interactable, for this paper; "game" and "visualisation" and; "player" and "viewer" will be used interchangeably.

2. OVERVIEW OF THE WONDERFUL OCEAN

The Wonderful Ocean is a data visualisation created using mainly p5.js, and numerous other plugins to create an in-browser experience without the need of external applications. In the visualisation, the player finds themself in control of a school of fish in which they can move up and down. The objective of the game is to survive as long as possible while surviving off the energy produced by the coral on the seabed keeps you flourishing. Intuitively, there is an immediate and direct understanding that the coral in the game supplies the fish'/player's livelihood, and in order to survive the existence of the coral is paramount. As the visualisation progresses the year that is presented will also increase, and this year correlates to the number of coral and fish present in the ocean at that time. Understandably, given the circumstances of

how the ocean is being treated, the number of fish the player controls will decrease, and so shall the number of coral. From this point when the game ends (i.e. when the fish run out of energy), the player will be taken to an end page screen where they will be shown graphs of the data used within the game, to contextualise the data and give them a better understanding of where it comes from.

3. INTENT

“Events do not arrive neatly boxed and labeled. We do that ourselves.” [1] Viégas makes an interesting point in the construction of data driven storytelling, in that the ‘events’, in this case the empirical data, is not preordained to be a story. The representation of the data itself, simply numbers spewed across a screen, do not create any elements of a story. The weaving of the data into a visualisation with a specific idea and “focusing on intent rather than surface aesthetics” [2] is the way to make a meaningful and compelling story. Both the theory of data art and data driven storytelling typically work in tandem. The intent of creating data art is typically a way of arranging the data into a coherent representation, which would, in turn, tell a story. An important thing to note is that even though there is a level of interactivity that makes the visualisation akin to a game, the intent is not to make a ‘fun’ piece of work. The visualisation is meant to invoke a sense of dread and emotion; the visualisation is more of an experience, while also being an educational piece.

In the case of *The Wonderful Ocean* the intent was to create an environmental statement, without the use of conventional data visualisation techniques (i.e. bar graphs, pie charts, etc.), but to rather use theories of representation to elicit an emotional response from the player interacting with the visualisation. The same idea could have been achieved with these conventional data visualisation techniques, however, the emotional response is lost on the viewer. Without telling the player the intent of *The Wonderful Ocean* the player is still able to figure out the story being told without direct explanation. The exploration of the visualisation innately does that for them. This is in some parts due to the fact that the representation of the data is done by using real world representations of the data, and there is no obscure symbolism. For example, the number of fish represented from the data set are represented by varying amounts of fish in the visualisation, with the same being done for the coral. Abstract art is not used in the visualisation, but instead their real world counterparts are. This allows the viewer to instantly grasp the representation of the data, which is very much needed, because this visualisation does not focus primarily on the representation of the data, but rather why and how it is being represented. While having these formal aspects would elicit some sort of emotional response from the viewer, it is one thing to view a data visualisation, it is another

thing to make the player the controller of the data set, to tie them more closely to the subject matter.

4. INTERACTIVITY

> *But meaning in videogames is constructed not through a re-creation of the world, but through selectively modeling appropriate elements of that world. Procedural representation models only some subset of a source system, in order to draw attention to that portion as the subject of the representation. Interactivity follows suit: the total number and credibility of user actions is not necessarily important; rather, the relevance of the interaction in the context of the representational goals of the system is paramount. Videogames offer a particularly good context for this selective interactivity.* [3]

Ian Bogost focuses heavily on analysing the art of persuasion by rule based representations and interactions, rather than spoken word. This is exactly the underlying theme of what an interactive data visualisation should be. To contrast this idea, in modern data visualisation pieces (both conventional and otherwise), interactivity is often used as a tool to alter the representation of the data. This type of interaction is very skin deep. In these cases, the interactivity is often used to sort, delete, arrange, group or otherwise change the arrangement of the data. The interactivity is not tied to the intent, it is only used as a tool that is disconnected from the story.

For *The Wonderful Ocean* the interactivity is paramount in delivering the emotional response and the ‘persuasion’ of the piece. By inserting the player into the representational space, a link has been created between the data set and the player. The player is now *experiencing* the data, rather than simply being an observer that can fiddle with it. In this sense, the visualisation starts to delve into the realm of being a game, and thus Ion Bogost’s analysis has an application to it, due to the interactivity.

The reason interactivity in data visualisation is so important is purely by the fact that, besides games, no other medium incorporates interactivity. “The only significant kind of computer art, within the context of the history of art, will be the type that could not have been made without the computer” [6]. In this case Roger Malina posits that unless computer art is able to accomplish something that no other medium is able to, it is insignificant in the grand scheme of the history of art. This statement does not fully apply to data visualisation by itself, as non-interactive data visualisations are accomplishable without the use of a computer. However, by incorporating interactivity into the core of the data visualisation, it now transcends other mediums, as being a tool that could never be achieved in another medium.

5. SUBVERSION FOR STORYTELLING

"Most visualization stories begin with some kind of question that orients the viewer to the topic and context within which the data is most meaningful. This can be done explicitly or implicitly, but the context must be clear. The question contains the premise and introduction to the story, and leads us up to the point at which the data can take over the storyline." (Beautiful Visualisation, Julie Steele)

A common literary technique is the subversion of expectations of the audience. Conventions are set in place, and the subversion of these conventions is a tool that can be used to deliver a profound emotional response. As Julie Steele in her book *Beautiful Visualisation*[4], these tropes exist themselves in data visualisation. Instead of completely subverting this convention, it is rather used as a method of re-aligning what the conventional wisdom would tell the user the visualisation will be about. In *The Wonderful Ocean*, it is never mentioned or even hinted to what the intent of the visualisation is until the very end. Players will typically start the game thinking that it would be a typical side-scrolling game in which you play as a fish, and in actual fact, that is the lie the visualisation sells the player in the beginning. The game starts off very easy, and staying alive is rudimentary even to non-avid gamers. But, as the game progresses, it slowly starts to set in that the game is getting harder and harder, and the scene is getting sparser and sparser until, inevitably, the scene is empty and the player can no longer survive, no matter how hard they try. It is directly this contrast between the start and end of the game which elicits the emotional response to the player. The shift from an easy fun game, to an impossibly hard one. The shift from a beautifully coloured environment, to a barren abyss. It is that type of shift which reinforces the tragedy of the oceans, and again, by putting the player in the position of the fish, they experience the shift through the mechanics rather than just watching it happen with no connection.

6. USE OF COLOUR AND SPACE

The use of colour and space was used specifically to relate to the intent of the data visualisation. Specifically in this visualisation, the actual colour chosen is inconsequential, but rather the amount of colour used for the key features is of importance. "Colours, when used correctly, can guide the viewer's eyes to what's important" [5]. In figure 1, the most striking visual elements are the fish, the control, and the small orange balls of energy that the player must collect. In the beginning of the game the screen is heavily populated by these objects, and as a result the space is very colourful. In terms of ludology, this also conveys to the player the most important aspects of the scene. To contrast this, in figure 2, towards the end of the game, there is almost no colour, apart from the ocean. In this part of the game, as a result of the

dataset, there is just a sole fish swimming in the empty abyss. The reason this shift is so striking is due to the fact that the screen is less populated, but even more important, is due to the lack of colour that was found in the beginning of the game. This reinforces the idea that the beginning of the game is the more preferable state to be in, which again ties back to the fact that coral coverage and fish species are collapsing as the years progress. “[Colour] can also be used to change the mood of the scene entirely” [5]. Without explicitly telling the player that the coral and fish population are decreasing, they are instinctively able to infer that information, mainly because of the loss of colour, and the openness of the space.

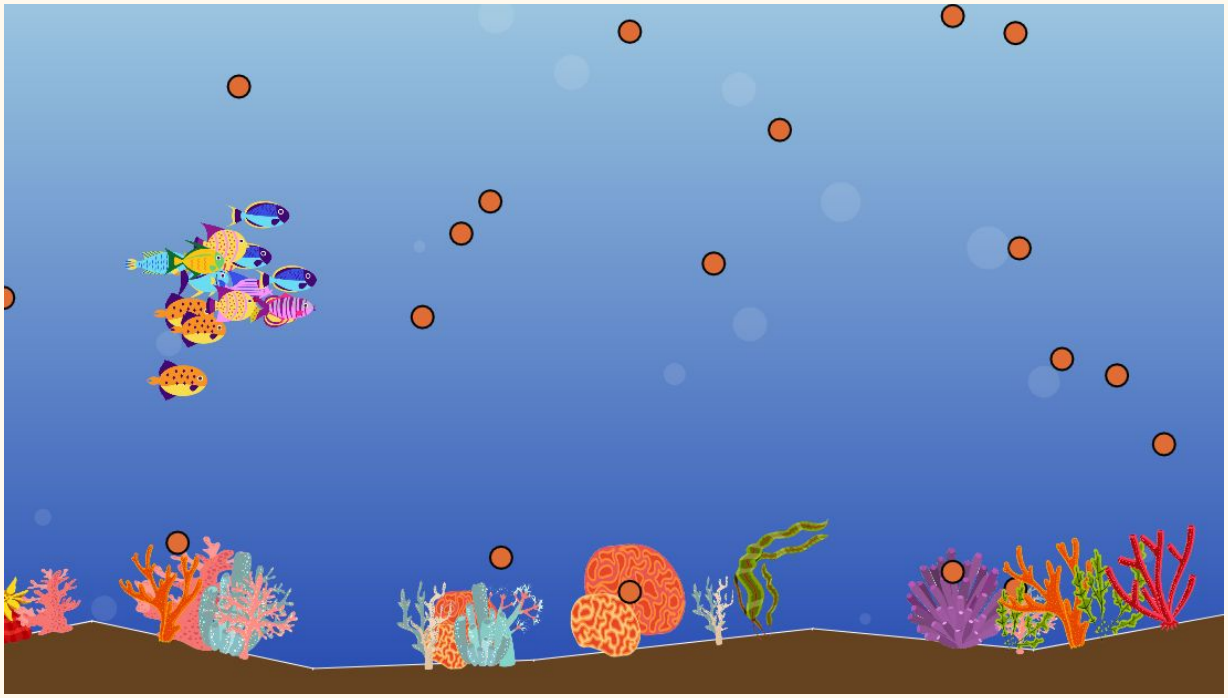

Figure 1: Beginning of the game

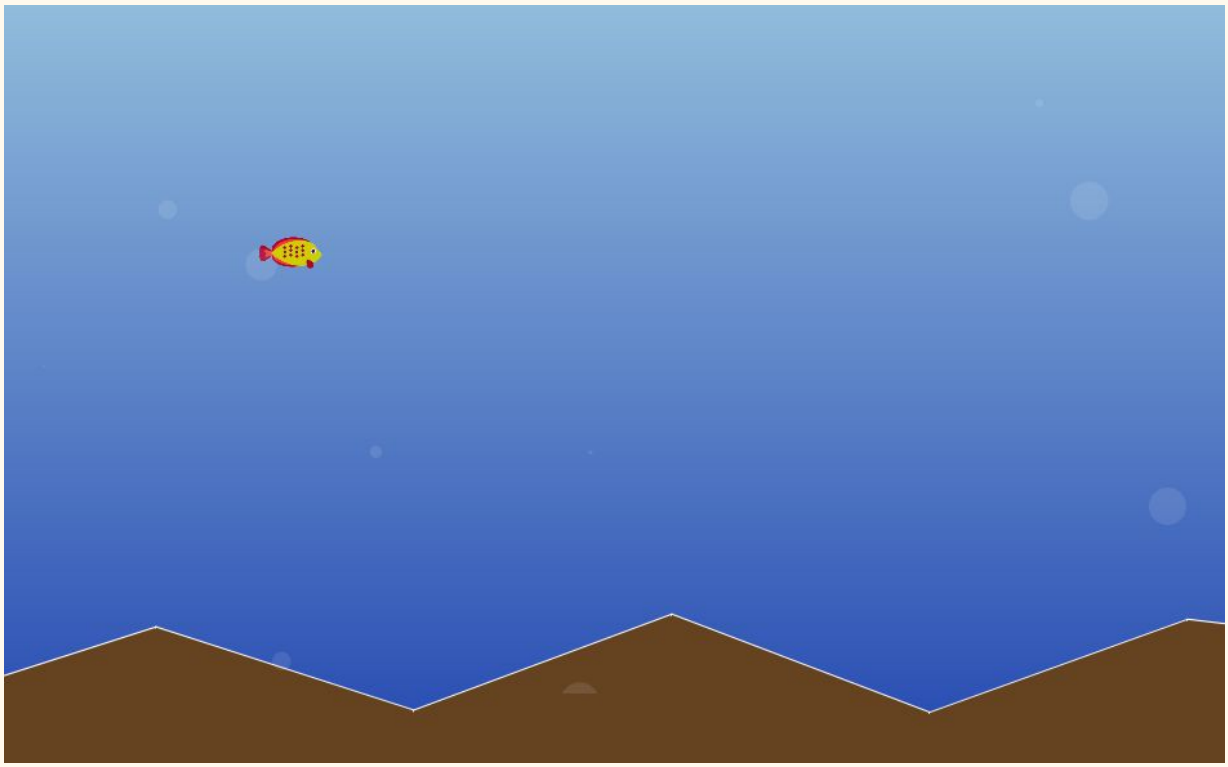

Figure 2: Near the end of the game

7. END GAME SCREEN

While the main part of the visualisation is meant to elicit an emotional response, the end game screen is there to inform the player, but also provide references to where the data set came from. This page, while not the crux of the visualisation, is of utmost importance, as where the data came from is what gives weight to the visualisation. Having the visualisation by itself will still relay to the player the loss of coral coverage and collapse of sea life, but this screen is able to directly display the information used to bring about it. The player is now able to view the statistics, see where the statistics came from and also check the validity of the data. Refer to figure 3 the display of the end game screen. This page also contains a link to the credits for everything sourced through the game, including libraries, plugins and sprites. The player also has the option to restart the game, however, the game does not offer much in the realm of replayability.

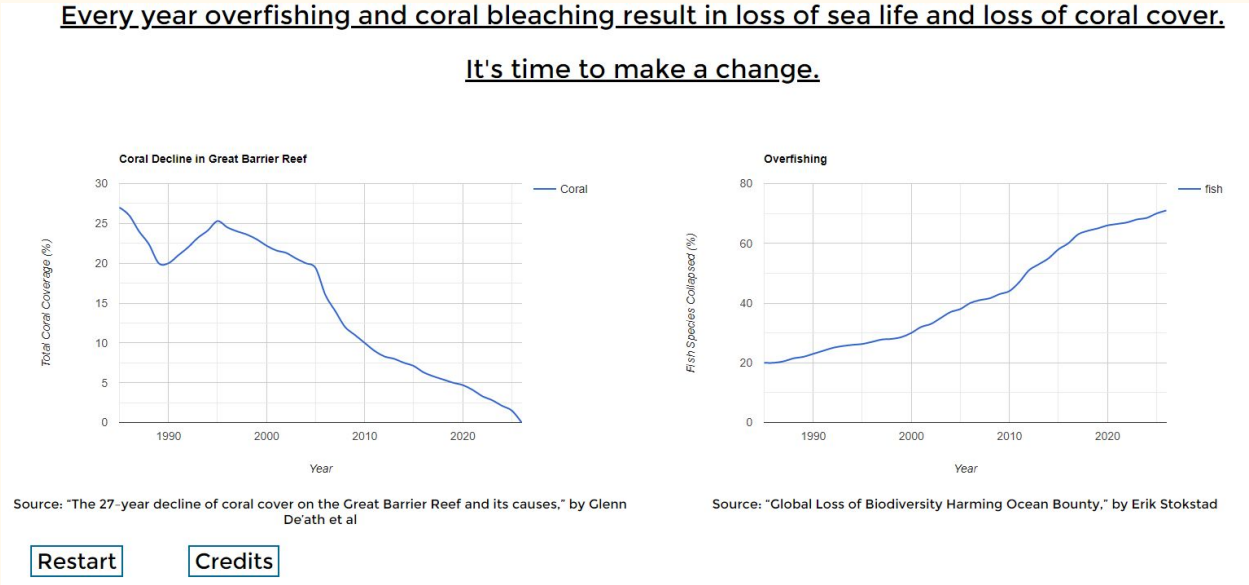

Figure 3: End game screen of the visualisation

8. ITERATIVE PROCESS

This section will detail the iterative process and individual aspects that went into making *The Wonderful Ocean.*

1. Object sprites

Initially the objects in the scene (coral and fish) were made using 2D primitives with p5.js. The issue with this method was that in order to make detailed shapes, multiple vertices, lines and fills would need to be used. In order to get an adequate level of detail almost 500 vertices would need to be used (especially for round shapes in the coral). This was not only heavily time consuming, but it what not feasible given the limitations of p5. The shapes ended up looking very cluttered, but also the frame rate would suffer dramatically when more than 50 objects were being drawn. As a result, the fish and coral shapes were replaced by sprite images which saw a drastic increase in performance and readability.

2. Consistency

One of the hardest parts about creating a visualisation that has so many elements that have varying size, colour and shape is maintaining a consistency between all the elements. As mentioned before, sprites were used which made it easier to avoid a feeling of clutter within the scene. But then the issue came about of consistency between the sprites, and the sprites and

the canvas. In order to avoid this, the fidelity and style of the sprites would need to be similar. Eventually enough sprites were found that maintained the same fidelity, which avoids jarring the player with inconsistent visual styles.

3. Balancing

Given that the interactive data visualisation relates more so to a game, game design balancing principles were needed to balance the mechanics of the game. Most of the considerations were time based, i.e. how long should year intervals be set apart, how quickly should coral coverage deplete based on the data set and how quickly should the player's fish disappear based on the dataset. The reason that the time is the only mechanic taken into consideration in terms of balance is simply because the difficulty is inconsequential. The game is meant to be lost, so it is just a matter of when and how slowly the loss should be eased into. Through the course of playtesting it was found that a couple of minutes are more than enough to engrain the intent into the players mind, and any more than that was irrelevant to the player. Other small mechanical tweaks were made, such as the fish's movement, but, as said before, most of these facets were inconsequential as the game is meant to be lost and has no win condition.

4. Object Orientated Programming

One problem that was seen to be prevalent at the beginning of the project was the fact that anything drawn on the canvas using p5.js has no reference inherently referenced to it after it has been drawn. The drawing is simply nothing but pixels on the screen, and it has no ID or tag to be located and operated by. After this was realised, it became apparent that all objects being drawn to the screen would need to have superficial references coded for them in the IDE. Using OOP would not necessarily be necessary for most data visualisations, but because the objects in my game would need references to the positions of other objects, and vice versa, these states would need to be constantly and consistently tracked. This resulted in everything being segmented towards an object in an object in an object. The energy is created by the coral, therefore a reference to all the energy must be coral in the energy array on the coral. The coral is on the ground, therefore the same thing applies to that. Even higher up the ground is part of the seabed. What you're left with is a seafloor object, with reference to an array of ground, each ground with an array of coral and each coral with an array of energy. While this may seem time consuming, this allowed every object in the game to locate one another and make the game possible using p5.js.

5. Randomness

An important feature that was added was randomness to almost every facet of the game, while still maintaining a similar game loop for each playthrough. The coral position, coral size, coral sprite, energy spawning, fish size, fish position, fish idle animation, fish sprite and ground shape are all randomised slightly when the visualisation begins. While this does not change the mechanics of the game all that much, it allows for a slightly different visual experience for anyone who plays the game more than once. Because of the use of OOP, the addition of these random characteristics was easy to implement. Simply inputting a random offset to a constructor value allowed the object to be slightly tweaked in their respective characteristics.

6. Mixing frameworks

An amazing facet of the Javascript language is the abundance of plugins, libraries and frameworks available to the user. Even more interesting is that the libraries have their own plugins and vice versa. Using these capabilities many different languages and frameworks were incorporated into the project. HTML for the setup, CSS for the style, Javascript for the computation, p5 for the drawing, particles for the environment, Google charts for the graphs and finally JQuery for implementation with Google charts. Initially, p5 was the only plugin to be used in the project, simply because mixing all these different facets might have become too overwhelming. But the bigger and bigger the project became, the more the implementation of these different frameworks was necessary. This resulted in a large amount of time of the project being dedicated to learning them and also learning their incorporation with everything else, leading to a cohesive amalgamation of frameworks that created a pipeline, resulting in the end product; *The Wonderful Ocean*.

7. Analysis of p5

After dealing with p5 extensively in working with this project and other projects, it was determined that p5's benefits outweigh its shortcomings. The ability to edit elements in HTML, in real time is quite impressive and the fact that no external application is needed to make it work is a big benefit. However, the limitations which include; badly optimised performance with the HTML5 pipeline, no reference to drawing on the canvas, limited adaptive display, limited functionality with 3rd party plugins, no built in visual mathematical transforms (besides javascripts') and an overall low framerate from complex visualisations. In order to achieve the most desired results, a lot of shortcuts and workarounds need to be made in order to achieve functionality. If one helpful thing can be said about the p5 library, is that it makes sure the programmer is using OOP, because if not, working with it is nigh impossible.

9. DATA SOURCES

One of the most significant parts of the project was obtaining reliable data sets to create the visualisation. It is common knowledge that overfishing and coral bleaching has been a pertinent issue regarding the ocean, but the exact figures have not been as well documented. However, there have been extensive studies done on the issues. An extensive study entitled "The 27–year decline of coral cover on the Great Barrier Reef and its causes," by De'ath et al, was able to track the percentage of coral coverage throughout the Great Barrier Reef, but also the coverage in each of its parts. The second study, "Global Loss of Biodiversity Harming Ocean Bounty," by Erik Stokstad was able to track the percentage of fish species collapsed as a result of human influence, going back as far as 1950. The former was published in the *Proceedings of the National Academy of Sciences of the United States of America's* weekly issue and the latter published in the *American Association for the Advancement of Science's* weekly issue. Both these sources are reputable, and there has been no controversy in the scientific community about the validity of the empirical data obtained from each respective source. Using their findings a JSON file was able to be constructed, which detailed the loss of coral coverage as a percentage and the number of fish species collapsed as a percentage from 1985, as this is the year both datasets date back to. Using the data, the data set can also be extrapolated to the year 2026, using a mathematical model. This extrapolation is consistent to projected models, and is accurate if the trends continue on their path. The year 2026 was chosen, as this is the projected year that the Great Barrier Reef's coral coverage will reach 0.

10. POSSIBLE IMPROVEMENTS

Given that *The Wonderful Ocean* is meant to be a simple exploration of how minimal interactivity can deepen the connection between a data user and a user, any more interaction would only serve to artificially inflate the experience rather than adding anything more meaningful to the experience. That being said, in terms of allowing for a more complete overall experience, the addition of more communication to the player would have helped. Currently, the year from the dataset is displayed in the top right corner, and it was found that players would sometimes not notice the year at all. Also, the communication of players picking up energy could have been enhanced by an effect that quickly plays to alert the player of what has happened.

The addition of sound could have enhanced the experience. A simple, melancholic sound consisting of mainly piano would have been an apt addition to the experience.

One idea that would completely change the dynamic would be to change the visualisation into a 3D environment. This wouldn't necessarily enhance the experience, but it would be interesting to explore that environment from a programming point of view.

11. CONCLUSION

The Wonderful Ocean is a data visualisation that aims to tell a story using an empirical dataset. The use of interactivity allows the user to more deeply immerse themselves within the space of the dataset, allowing the dataset to directly impact their emotions of the dataset. By subverting their expectations, and with the use of colour and space, the visualisation is able to elicit an emotional response due to the subversion and contrast of the beginning and end states of the visualisation. The data sources have been deemed reliable, but have also been included in the visualisation so that the user may draw their own conclusions on the reliability of the source. *The Wonderful Ocean* is able to lead the player through an artificially constructed landscape, built solely on a dataset that consists of numbers, but still have a meaningful impact on them about the state of the ocean, and the impact of human influence.

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