PRODUCING A FILM ON OIL SPILL RESEARCH FOR THE PUBLIC

Emma Barnes, B.S.

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APPROVED:

Aaron Roberts, Major Professor
Edward Mager, Committee Member
Andrew Esbaugh, Committee Member
Jyoti Shah, Chair of the Department of Biological Sciences
Su Gao, Dean of the College of Science
Victor Prybutok, Dean of the Toulouse Graduate School

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The Deepwater Horizon oil drilling rig exploded on April 20, 2010, off the coast of Louisiana in the Gulf of Mexico. Following the spill, British Petroleum, leaser of the rig, set up a funding institution known as the Gulf of Mexico Research Initiative (GoMRI) to support research and understanding of the spill on the environments and peoples of the gulf. This outreach project was created alongside research of the RECOVER consortium, funded by GoMRI, to communicate what is happening within research labs around the country to understand the effect that the spill had on fish in pelagic and coastal regions of the gulf. The outreach project is composed of a short film (*Deepwaters: The Science of a Spill*, 18 min) and related outreach materials posted to Instagram (@FishandOilSpills).

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CHAPTER 1

BACKGROUND AND ANALYSES

Reasoning

This film was created to fill a gap in the way scientific knowledge is presented to the public from the Deepwater Horizon spill. Video is one of the most work-intensive forms of outreach media to produce and as such, video is not often seen from a researcher's perspective. As a graduate researcher, I was in the unique position to learn about the in-progress research of several laboratories from within and then gather that knowledge together into a film. I have long been interested in working with science outreach and using a visually-appealing medium to do so. As a member of a university, I had access to a huge amount of information through published papers and journals as well as software and hardware that allowed me to produce an accurate and attractive film at low personal cost. This outreach project can be used not only to highlight the work of the RECOVER Consortium but also the greater work being done from the Deepwater Horizon (DWH) spill, and educate the public on the general ecosystems of the Gulf of Mexico.

Inclusion of Research

Throughout the filmmaking process, I was determined to ensure that all the information I was gathering was the best and most up-to-date that I could find. From researching how fish and other aquatic organisms moved through water, to how the Gulf loop current moves, why oil is in the Gulf, and what exactly happened to cause the DWH drilling rig to explode, I made sure to present the correct information to the public not only through the narration but also

with the visuals. I also wanted to focus on the research that I was working on and experiencing every week as a part of a research lab. Throughout the 3 years I worked on this project, I was a part of behavioral, cardiac, visual, and cellular level studies involving 4 different fish species. This information is included as it is not only more personal, but was also very accessible for me to study. This allowed me ample time to think about the best way to visually represent it.

I focused on the research that has been recently published and built upon by the RECOVER consortium. RECOVER focuses on the impact of oil exposure on a pelagic (open-water) and a coastal fish species native to the Gulf of Mexico: Mahi-mahi (*Coryphaena hippurus*) and Red Drum (*Sciaenops ocellatus*). Both of these species lay eggs that float on the surface of the water, allowing RECOVER scientists to understand realistic impacts of oil across the life cycle of these species. Multiple studies reported that naturally weathered oil, sitting on the surface of the water, causes increased toxicity to coastal and pelagic organisms compared to source oil, if the oil supply is replenished.(Esbaugh et al., 2016) Increased toxicity occurs on the water's surface because as smaller and lighter oil molecules are lost to the atmosphere and larger, heavier, and consequently more concentrated, molecules are left behind.(Esbaugh et al., 2016) Additionally, fish embryos that float when spawned have a greater toxicity response to crude oil, likely due to having a greater length of interaction with the oil on the surface during development.(Irie et al., 2011) The toxicity of the oil on the floating eggs manifests as a range of problems in the brain, heart, nervous system, and on fin, eye, and spine development.(Incardona et al., 2014)

Across development, cardiac performance is one of the primary focuses of study for RECOVER as it is vital to foraging, predator avoidance, and migration.(Mager et al., 2014) There

are several markers used to study cardiac health in fish. Cardiac edema is one of the clearest biomarkers of cardiac toxicity, when fluid fills the area within the heart, impacting its ability to function. Mahi embryos exposed to oil, compared to non-exposed embryos, saw the occurrence of edema increase by 4.5 times while the area of the edema increased by close to 2 times.(Mager et al., 2014) Swim performance (essentially putting fish on an underwater treadmill) is also used to understand the heart as it is closely linked to cardiac function. Juvenile Mahi, exposed to oil as embryos, were tested for swim performance and saw a 37% decrease in swim performance. Juvenile Mahi, exposed as juveniles, also saw a 22% decrease in swim performance but at a higher concentration. The tested concentrations are within values seen in the Gulf, but even when exposed to oil concentrations below what would have been encountered during the DWH spill, cardiac stress via poor swim performance is observed.(Mager et al., 2014) At the multicellular and organ level, cardiac function appears to be the main target of the tricyclic group of oil compounds known as polycyclic aromatic hydrocarbons, or PAHs (the most prevalent size in DWH weathered crude oil(Esbaugh et al., 2016)) and may be affecting potassium or calcium channels or targeting gap junctions, vital to muscle contractions, within the heart.(Mager et al., 2014)

Vision through life stages is another area of focus for crude oil toxicity in fish development for RECOVER. RECOVER transcriptomics work have been very important to establish a starting point for vision research. Transcriptomics involves studying how an organism uses the information within its DNA and RNA molecules to make cells function and react to interferences, such as oil. Studies with Mahi-mahi suggested downregulation (turning off) of vision proteins such as rhodopsin (used for low-light vision) after oil exposure.(Xu et al.,

2016) To follow up on that study, fish embryos were exposed to oil and then had their vision behaviorally tested and histologically sampled, to study anatomy, upon developing into larvae.(Magnuson, Martinez Bautista, et al., n.d.; Magnuson, Khursigara, Allmon, Esbaugh, & Roberts, n.d.) These studies (in submission) supported the transcriptomics work and found that oil does have a negative effect on eye development and also impacts cardiac function through separate pathways.(Magnuson, Martinez Bautista, et al., n.d.; Magnuson, Khursigara, et al., n.d.) This information is particularly valuable to know, not only because it shows that both cardiac and vision are valuable areas of study, but also because Mahi-mahi and Red Drum were both in the midst of their spawning seasons during the spill, so embryos were likely to have come into contact and been quickly effected by oil, even if they were able to move away after hatch. This information and research was a great resource to have access to. The results were coming out in real time while I was working on the film so I was sure to have the most accurate and recent data possible.

Target Audience

The target audience of this film is all age ranges of the public, particularly those who are open to learning more about how the environment and research works. I see this project being shown in a science museum where children and their families can watch together. Although some concepts may go over the heads of younger viewers, they can still appreciate the beauty of the Gulf of Mexico and the organisms that reside within it. I want to inspire viewers to care about what lives under the ocean and understand why science is important to keeping those creatures safe and protected.

Future Intentions

I am interested in applying to film festivals and science-specific outreach events that can show the film to a wide audience. Associating with other outreach components created by the RECOVER consortium is also of interest. RECOVER has created iPad applications for classrooms to do simulated lab work on fish hearts and eyes. By introducing these topics first through the film, the students can reach a richer understanding of what they are working on and why it is being pursued. Eventually, I would also like to upload this to a public video service (YouTube or Vimeo) either in three parts (Gulf and Spill, Science, Future Gulf) or in whole to allow people around the world to understand what is going on with the Deepwater Horizon spill 8+ years on.

Using Instagram for Outreach

The Instagram account that I started, @FishandOilSpills was put together after taking a documentary pre-production course. I first began posting on the account on July 15th, 2016 with the intention to post photos of my research and how I was making my film. While initially posting three times weekly over the summer, that schedule shifted to just once a week once classes began. I found that I got the best audience attention on Tuesday and Thursday afternoons between 1-3pm CST and so always tried to hit one of those days and time brackets. As I posted more, I settled on a specific look for my page to garner better follower increases after posting. I decided to do 3-set color series, where for three weeks I posted images with a blue color focus and then alternated with three weeks of black and white posts. Instagram pages show feeds in threes so my page looked more organized and appealing when new people checked it out.

Inspired by the RECOVER logo, I wanted a simple graphic that expressed what I was working on. What resulted was a logo made up of the outline of the three fish that I had worked on, Mahi-mahi, Red Drum, and Sheepshead Minnow, circling a camera. Having a "brand" logo that I could use on business cards and throughout other posts to represent myself was very useful and is one of my most popular Instagram posts.

As Instagram updated in the last two years, they also introduced stories and saved stories. Short, fifteen second photos or videos can be posted straight from a phone camera to show day-to-day activities in a more causal way than stylized permanent posts. I created an Instagram story one morning showing the step-by-step process of setting up an experiment and then was able to permanently save it to my Instagram page through the saved story function (otherwise the posts would disappear after 24 hours). This gives uses a more in-depth understanding of what my daily life in the lab involves. I also posted occasional non-permanent stories to my page when working on research or when I experienced wildlife around me.

Through interacting with other Instagram pages, implementing useful hashtags so that new people can find my page, and by talking about my Instagram at conferences, I've gathered a variety of followers. From National Geographic photographer Thomas Peschak, to scientists (Dr. C M Lee), science communicators (Veronique Koch, Save.our.plankton, Richard Wylie, and more) and also more specialized users for fishing, and even oil drilling promotion pages, it was exciting to see it grow to new audiences. Over the course of two years I've garnered over 100 followers with fluctuations occurring as I missed post weeks or was less active.

Instagram Statistics

From July 15 2016 to July 3 2018, I posted 84 posts: 58 photos and 26 videos (Fig. 1).

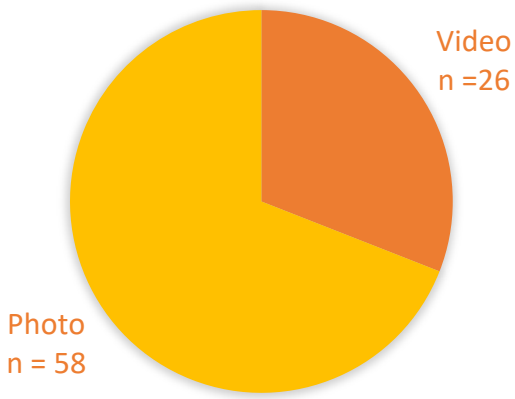

Figure 1: Ratio of post type across 84 Instagram posts to the account FishandOilSpills. Updated 9 July 2018.

Photos outnumbered videos about 2:3 (Fig. 1). I tended to post more photos because they were easier to edit for Instagram and required less editing and file manipulation prior to posting online.

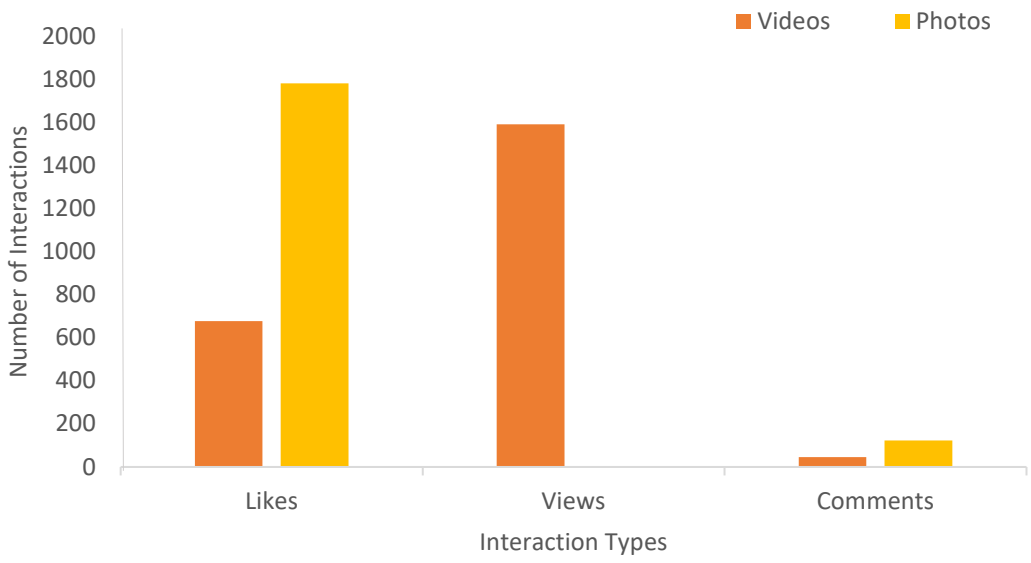

Figure 2: Sum of content statistics across 84 Instagram posts to the account FishandOilSpills. Updated 9 July 2018.

On average and in total, videos tended to get less interaction compared to photos (Figs. 2 and 3). While I did get quite a few views on videos, it was less likely that those viewers would click “like” compared to photos. This is a trend that I saw across Instagram and I don’t believe that it is indicative of the types of videos that I posted on my page. Instagram does not offer me information on how many views photos receive so I couldn’t compare views from video to photos.

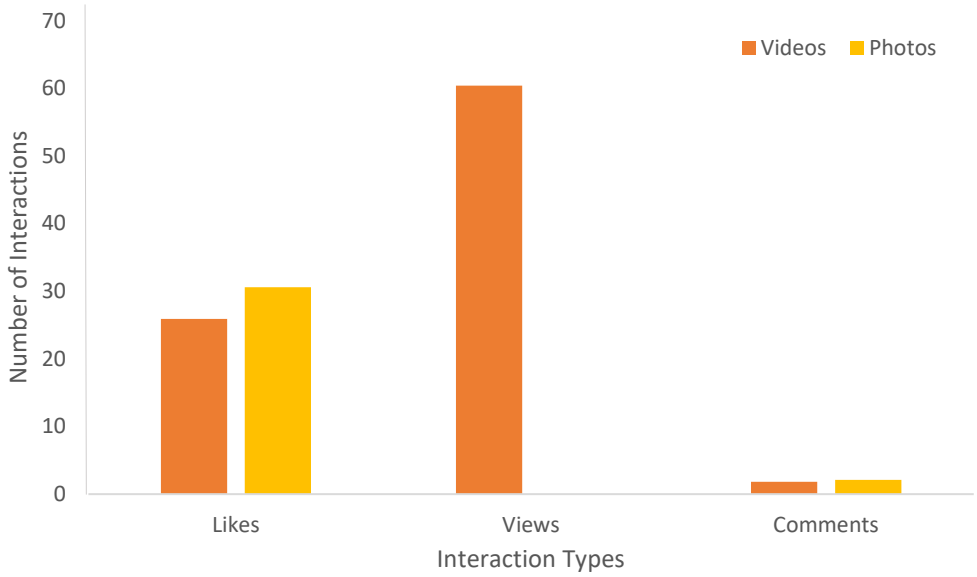

Figure 3: Average of content statistics across 84 Instagram posts to the account FishandOilSpills. Updated 9 July 2018.

My most popular posts from each interaction type all prominently feature fish, either live or drawn. This is a trend that I did notice and made sure to focus on in future posts so fish were clearly visible in the photo or the cover frame of the video. My most viewed video is of feeding sheepshead minnow by hand (100 views, https://www.instagram.com/p/BR_VM9DDtiB/?taken-by=fishandoilspills). My most liked post is the photo of my FishandOilSpills logo (57 likes, https://www.instagram.com/p/BVp4uOvlqiQ/?taken-by=fishandoilspills). The post with the

most comments is an image of several different fish sketches (10 comments, https://www.instagram.com/p/BLg2pBejxcF/?taken-by=fishandoilspills). The Instagram Story that I posted and saved has 33 views (https://www.instagram.com/fishandoilspills/). These top posts were most popular as of July 9th, 2018 and are all subject to change, as Instagram is a live and dynamic social media platform.

I averaged around 100 followers from 2017-2018. These followers are a blend of people from the general public, scientists, and companies (Fig. 4). Public is the largest category of followers, followed by scientists, and then accounts run by companies (e.g. stores, organizations, films). If a profile that follows me is locked from my viewing, I assumed that they were a part of the general public unless otherwise stated in their information section at the top of their page.

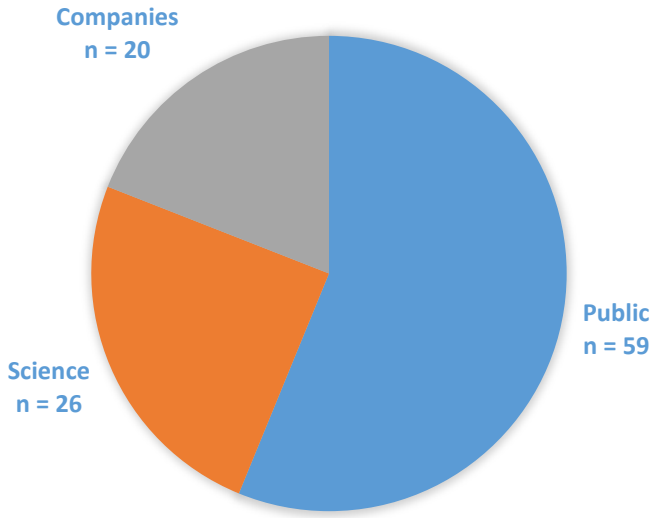

Figure 4: Ratio of general types of followers to the FishandOilSpills Instagram account. Updated 9 July 2018.

I also grouped followers into sub-categories (Fig. 5). There is often overlap between the sub-categories of interests (e.g. science communicators are also fishermen and researchers) so I

chose their category by the most prominent type of content that they posted to their page, or if I knew them personally and had a more informed way to categorize them. The largest group is still the general public, but I was able to break out groups that interact in specific ways to the environment, such as wildlife photographers, science communicators, and fishermen. The "other" group is composed of users that have specialized pages not necessarily associated with anything else (oil drilling companies, art-focused pages, and pages that just share other people's posts). The newest 5-10 followers tends to fluctuate week to week as bots follow/unfollow or people who are just looking for follows back only follow temporarily.

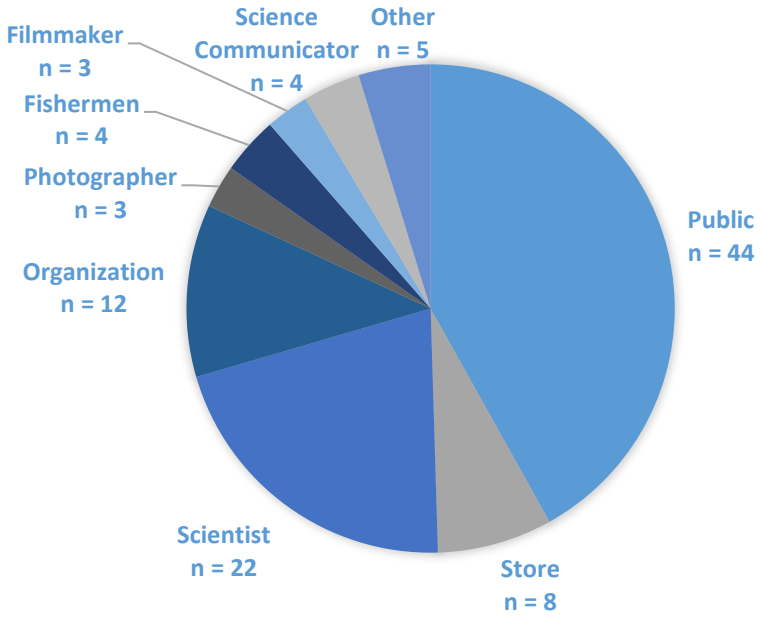

Figure 5: Ratio of followers to the FishandOilSpills Instagram account broken down into sub-categories as informed by available information on each user's page. Updated 9 July 2018.

When a few typical types of posts are broken out and further examined, there are some differences in the types of users I have interacting with my posts. Three posts: a science post (https://www.instagram.com/p/Bcshri-FAyF/?taken-by=fishandoilspills), an art post (https://www.instagram.com/p/Bd3FEXRlRri/?taken-by=fishandoilspills), and a fish art post

(https://www.instagram.com/p/Bc-RvB_FFz7/?taken-by=fishandoilspills) were selected as samples of the types of posts I usually made (table 1). By pulling out who "liked" each post, it appears that the public is the most likely to interact with my post overall followed by companies and scientists, who go back and forth in which post type is more popular to each group (table 1). While I did enjoy hearing from other scientsts on Instagram and looking at their outreach choices, having primarily non-scientists interacting with my posts was encouraging as it was the type of audience I targeted.

Table 1: Breakdown of what type of Instagram user "likes" different types of posts on the FishandOilSpills Instagram.

	Science		Art		Fish Art	
	n	%	n	%	n	%
Scientist	5	16%	9	29%	2	5%
company	11	35%	6	19%	12	28%
public	15	48%	16	52%	29	67%
count	31		31		43	

Compared to the whole consortium's Instagram page (https://www.instagram.com/recover_gomri/), I did have fewer followers at about 100, compared to RECOVER_GoMRI's about 360. RECOVER also had more posts as they've been posting for about 3 years and so also have more total interactions on their posts (Table 2).

However, the number and type of interactions between the two are very similar on average (Table 3). The breakdown of followers between FishandOilSpills and RECOVER are also very similar when separated into the three overarching categories. RECOVER has a slightly higher percentage of public followers and lower scientist followers but only within a few percentage points (Table 4). So, despite having a smaller base of followers and less postings,

the followers I do have interacted just as much, if not more than, followers on the Instagram page for the entire consortium.

Table 2: Sum of user interactions on Instagram accounts FishandOilSpills (9 July 2018) and RECOVER_GoMRI (8 August 2018)

	Quantity	Likes	Views	Comments
		Video Posts		
FishAndOilSpills	26	677	1592	46
RECOVER	35	982	3346	23
		Photo Posts		
FishAndOilSpills	58	1781	N/A	123
RECOVER	156	4534	N/A	94

Table 3: Average of user interactions on Instagram accounts FishandOilSpills (9 July 2018) and RECOVER_GoMRI (8 August 2018)

	Quantity	Likes	Views	Comments
		Video Posts		
FishAndOilSpills	26	26.04	61.23	1.77
RECOVER	35	28.06	95.60	0.66
		Photo Posts		
FishAndOilSpills	58	30.71	N/A	2.12
RECOVER	156	29.06	N/A	0.60

Table 4: Types of followers on Instagram accounts FishandOilSpills (FaOS, 9 July 2018) and RECOVER_GoMRI (8 August 2018) in total and as a percentage

Interest	n		%	
	FaOS	RECOVER	FaOS	RECOVER
Public	59	224	56.2%	60.7%
Science	26	74	24.8%	20.1%
Companies	20	71	19.0%	19.2%
Total	105	369		

Instagram Conclusions

Instagram was a great way to practice short-form science communication and to see how other science communicators (the primary type of page I follow) interacted on the app. Instagram is the second most popular social media platform, with 35% of US adults and 71% of US adults aged 18-24 using Instagram, 60% of those users logging into Instagram at least once a day.(Smith & Anderson, 2018) Social media use is also growing, with logins to Instagram increasing from 51% to 60% daily (of total Instagram users) in the past year (2017-2018) and overall use (of US population) increasing from about 28% in 2016 to 35% in 2018.(Smith & Anderson, 2018) Clearly, this is a growing platform and is well suited to my science communication efforts. While I certainly did not use Instagram to its full potential during this project, and did end with a small following, it is encouraging that my user interaction was comparable to the overarching RECOVER consortium page that does outreach on a much broader scale. The most valuable part of using Instagram aside from interacting with other users was to try out different types of communication. From photos, to illustrations, videos, and animations, the short-form format of Instagram allowed me to very easily view and judge engagement. Using Instagram in this way really encouraged me to further develop my illustration and animation skills. The art posts were often some of my most popular and without the encouragement of social media, it's likely that I would have much less of that type of content, which became my favorite, in my film.

CHAPTER 2

FILM

Film Description

Part I

The film opens on the Gulf of Mexico and the pelagic zone. A variety of pelagic fish species and other organisms swim and interact in the backdrop of the open water. We move from open to coastal waters. The coastal zone has some species overlap, but also new species of fish, plants, and other organisms that are adapted to life in shallower water. The Gulf of Mexico is also home to industry like fishing, shipping, and crude oil. Oil drilling is possible because the gulf has formed over 150 million year old swamps that have been pressurized to become crude oil. Oil drilling can become a dangerous operation if protocols and safety regulations are not observed or are too lax. In 2010, the Deepwater Horizon oil rig, leased by British Petroleum (BP), exploded due to a series of mechanical malfunctions from user error. Eleven men died and crude oil gushed from the bottom of the gulf for 4 months following the explosion, leaking 10 times the amount of oil that spilled in the Exxon *Valdez* spill in 1989. Spill clean-up was intense, and because of the length and type of spill, huge areas of the gulf and coasts ecosystems were affected.

Part II

Following the spill, BP set up a funding institution, the Gulf of Mexico Research Initiative (GoMRI) to understand the impact on the gulf ecosystems. There had previously been very little research done on the gulf, so the $500 million fund set up through GoMRI allowed a huge

amount of new science to be published. One of the consortia groups that was funded was RECOVER (Relationships of Effects of Cardiac Outcomes in Fish for Validation of Ecological Risk). RECOVER focuses on the oil's effect on pelagic and coastal fish development, specifically cardiac and visual systems, among others. Crude oil is toxic to many different species, including humans, because of specific chemicals, often shaped like hexagons. If UV rays from the sun hit these chemicals, they become even more toxic and cause even greater damage. These chemicals will soak into fish embryos and cause larvae to be behind in vision development. It can also cause fluid to fill the area around a fish's heart and yolk, resulting in problems with keeping blood pumping around the body.

Part III

Eight years after the spill, it is still being studied and funded by GoMRI. The gulf's health appears to be on the mend in many areas. Oil is no longer found in the open ocean and organisms caught for seafood are healthy. The deep sea and coastlines have had a longer recovery. Remotely operated robots are still sending back images of oil in the deep sea, where the spill originated, and scientists aren't sure when or if it will ever be fully free of the Deepwater Horizon oil. The shoreline is still degrading where oil washed up and tarballs of degraded oil are still present. The gulf is an important resource for all kinds of industries and environments and there are many environmental issues that can damage all of these areas. However, as more renewable energy sources become more affordable and available, and more research is done on preventing these problems and learning about this vast and complex area, we can better protect the gulf in the future.

Film Script

The following is the narration of *Deepwaters: The Science of a Spill*. It was recorded by one narrator.

Part I (~6 mins)

- Introduction

  Eight years ago the largest oil spill in US history occurred, resulting in an unknown amount of damage. Let's travel back to before the spill to see what was at stake…

- Pelagic

  Welcome to the Gulf of Mexico, home to tourism, industry, and a huge variety of plants, and animals across depths and environments.

  The largest part of the gulf is taken up by miles of open water. This area is known as the pelagic zone and it's a tough place to live. Finding food, avoiding predators, and finding mates is a challenge when there isn't anything to hide behind or any end in sight!

  The basic food of this zone, and most water bodies, are plankton. They include some of the smallest animals in the sea, only millimeters in size, but also include jellyfish like this big sea nettle! They all float along with the open ocean pelagic currents and are hunted by each other and…

  Other predators like this small bait ball of menhaden, the largest shark in the world, the whale shark, who survives purely on those little plankton, and green sea turtles, one of the five different species of turtles that call the Gulf of Mexico their home.

  The next meal up the food chain are those menhaden. They attract mahi-mahi, oceanic whitetip sharks, and bottlenose dolphins. They need to be fast to survive, but they'll have a hard time escaping some of the fastest fish in the world, yellowfin tuna and swordfish!

- Coastal

  The gulf isn't only made up of wide open ocean. There are over 1,600 miles of coastline along the US bordering the Gulf of Mexico! Just like species that are adapted to live in the open ocean, there are many species that excel in living in the shallower seagrass filled waters of the coastal zone.

Red drum spend their whole lives in this area, growing up in inland estuaries before moving out to more open water along the coast.

Along with other fish like speckled seatrout and gafftopsail catfish, drum cruise along the seabed hunting for bait fish… like these anchovies which form schools just like the open ocean menhaden.

Mollusks like this lightning whelk, and echinoderms like the green sea urchin move much slower along the sea floor looking for algae and other planktons to scrape up.

Meanwhile, pipefish hide from predators in sea grasses.

Turtles, like the green sea turtle also like seagrass, but as a snack, when they come in from the pelagic zone before laying eggs on the beach.

- Industry

All these species and more help to make the Gulf of Mexico a thriving and dynamic environment. But the gulf isn't just a natural wonderland.

It serves as a resource for several large industries. Industrial shipping and commercial fishing both bring in billions of dollars to the US.

But neither can compare to the huge amount of wealth brought in by the oil drilling industry. Oil rigs cover the coastline and far out past the continental shelf, bringing in more money than the shipping and fishing industries combined.

Oil is bountiful in the depths beneath the gulf because marsh plants and bacteria died 150 million years ago as water flowed in and out of the gulf basin. This caused thousands of feet of salt to be left behind, burying the organic material. Then, the Rocky Mountains formed and the Appalachian Mountains eroded, causing displaced dirt and sediment to wash overtop the salt. Eventually, the weight caused heat and pressure to build up and turn the plants and bacteria into oil which is now being tapped by oil rigs in modern day.

- The Spill

That leads us up to 2010. The Deepwater Horizon oil rig, leased by British Petroleum, was located in the deepwaters off Louisiana at a site known as the Macondo Prospect.

On April 20th, after a series of errors and malfunctions, oil unexpectedly started flowing up the closed pipeline. Pressure increased at the top of the closed pipe until oil and gas forced its way out. The rig then exploded.

Many men and women working on the drilling platform were injured in the explosion. Eleven lost their lives

After the explosion and subsequent sinking of the rig, a remotely operated vehicle (a robot) sheared off the pipe in an attempt to seal the leak. This failed and tons of crude oil spilled into the Gulf of Mexico for 4 months.

Oil spread throughout the north gulf and into the coasts of Florida, Alabama, Mississippi, Louisiana, and Texas.

Cleaning up the oil while the spill was still occurring was a huge undertaking. Workers spent months using various techniques: burning or collecting oil off the surface of the water, and in some areas, adding dispersant to the water to break up the oil into smaller droplets to hopefully make eventual breakdown by bacteria, like these, faster and to prevent so much oil from washing up onto the coast.

Still, many gallons of oil made its way onto beaches where crews had to shovel and cart it away.

Part II (~7 mins)

- Research Groups

The spill was unprecedented in size for the US. To learn more about this impact, BP set up an independent funding institution to grant over $500m to research studies for 10 years following the spill known as the Gulf of Mexico Research Initiative, or GoMRI.

In 2015 a consortium known as RECOVER was funded under GoMRI, joining together 7 research labs from 4 universities across the country to study cardiac and related effects of oil on mahi-mahi and red drum, two of the most popular sports fish in the gulf.

- Labs

Hatcheries at the University of Miami, Florida keep mahi-mahi adults, who are voracious feeders. Mahi embryos hatch in only 48 hours making them also beneficial for studying development

At the University of Texas Austin in Port Aransas, hatcheries keep adult red drum, known for their distinctive drumming. Drum embryos also develop even faster, hatching in just 24 hours

Zebrafish are also raised as a model species (a smaller fish that compares accurately to the development of larger species) but take longer to hatch, about 4 days.

Fish are carefully raised and maintained so that they can be studied as adults. When they spawn, their offspring can also be studied as they develop.

At the start of experiments, eggs are carefully moved into their dishes and monitored until they hatch out as larvae.

The different developmental stages of fish, from embryo through adult can be studied in the lab.

After spawning, development happens rapidly. From just one cell, division quickly takes over until the head and tail forms, the heart begins to beat and blood flows around the body, and soon, the fish is ready to hatch! These fish still have a way to go in development before they'll have full use of their eyes and mouth but they are prepared enough to be able to move and escape from predators

- Chemistry

The timing of the spill was also prime time for fish to meet and spawn. Mahi-mahi and red drum both spawn eggs that float on the surface of the water until they hatch, forcing them to intermix with the oil spill during the crucial early development period.

The oil collected during the spill, from the surface and from the broken pipeline, is used to understand how it could have impacted fish development and behavior.

Oil is primarily made of carbon and hydrogen molecules that look like variations on this:

The oil coming straight from the ocean floor is a smooth liquid. When it reaches the surface, the small molecules float off into the atmosphere, leaving behind bigger and heavier oil particles that are beaten down by waves, bacteria, and transformed by UV rays in sunlight until a thicker, peanut butter-like texture forms.

Let's go to the lab to learn more -

To understand the oil's toxicity to all life stages of fish, oil from the spill or individual chemicals are carefully measured and mixed into water at varying concentrations.

- Cardiac

The heart is one of the biggest targets of oil, so cardiac health is a major focus of study. We can't take a fish to a cardiologist but we can think about fish hearts by comparing them to human hearts.

Human and fish hearts work in the same way. The heart pumps oxygen around the body through blood. For humans, we take in oxygen from our lungs. Fish hearts are simpler than human hearts but they still take in oxygen, just from gills

If the balance of pressure, blood volume, and strength is off, the heart can't pump effectively and this impacts the rest of the body. A major sign of heart problems is

edema, or when areas of the body fill with fluid. In humans, heart problems can result in edema in the lungs.

For larvae, a big indicator of cardiac health can be found right next to the heart, in the yolk! Young fish have yolks just like chicken eggs that provide them with nutrients until they're ready to feed on their own

In these larvae, the area around the heart, the pericardium, and the yolk can have edema as a result of oil exposure. This puts more pressure on the heart and makes it harder to function. Fewer heart beats per minute means that less oxygen is moving around the body to keep the fish healthy and growing.

Other physical problems show up after oil exposure as well. Spinal curvature, and fin deformities are commonly seen alongside edema in oil-exposed fish.

Treadmills are a common test for cardiac health in humans but they can also be used to look at fish cardiac health! Older fish can be put in an underwater treadmill to understand how oil exposure affects the heart!

Just like a cardiac workout in humans, these fish will push against different current speeds until they are too tired to continue. Different types of measurements can be taken to understand how heart health changes with oil and how quickly the fish will become exhausted. Oil-exposed fish have a harder time keeping up with the currents for long periods of time compared to unoiled fish.

- Eyes

Eyes and vision are another big target of oil exposure. But once again, we can't take a fish to an ophthalmologist and ask them what they see.

Eyes are vital to many organisms, including ourselves; vision is used for processing huge amounts of information that help us navigate our daily lives

Our eyes work by taking in all the light and color around us and sending it to the occipital lobe in the back of our brain to process into images.

Fish, like mahi-mahi, are very dependent on their vision to find food and mates in the huge expanse of the Gulf of Mexico.

From the biggest adults, to the smallest larvae, food is vital to their continued survival and success.

This dependence means that their eyes function very similarly to humans' but are designed for living under water. They have no eyelids but still send light from their eyes to the optic lobe in their brain.

If you've ever laid back watching fan blades spinning around, you might notice that it gets to a speed where you can't follow a distinct blade anymore. This same concept is used to understand fish vision in the lab!

A fish is placed in a tube that is circled by stripes. It will start to follow one of the black stripes as it spins around but once it spins too fast, the fish can't see an individual stripe anymore and will stop swimming.

The development and growth of the eye can then be measured. Fish exposed to oil don't follow those stripes as well and have a smaller and less developed eye compared to fish that were in clean water. Each layer of the eye functions in different ways meaning that oil can have a range of effects.

Part III (~3 mins)

- Mahi Papers

  Hearts and eyes are just some of the paths studied by the RECOVER consortium. All aspects of a fish, from the whole life cycle, to hearts, to embryo and larval development under different oil conditions, and all the way down to the DNA and RNA level are being studied.

- Red Drum Papers

  And not just mahi-mahi. Red drum as well as other pelagic, coastal, and model species are being studied. Oil in a variety of weathered forms with UV and dispersant does impact many aspects of these species. By continuing to further our knowledge of how the spill affected these animals, we can be more prepared if another spill were to occur in the future in how to inform clean-up crews and local communities.

- Gulf Progress

  After the months of oil spilling into the gulf, the broken pipe was finally fully sealed in September of 2010.

  With help from the clean-up crews, and bacteria, much of the oil was removed from the surface of the water. Federal waters were all fully cleared and re-opened a year later in April 2011.

  And fishing returned to the gulf, along with tourism and shipping.

However, the gulf is not completely Deepwater Horizon oil free. Oil is still found on beaches in the form of tar balls, getting brought up by waves and then buried in the sand.

And oil is still found at the bottom of the gulf, where there is less breakdown activity.

The gulf is a valuable resource for industry and tourism but also holds important ecosystems that are vital to hundreds of different organisms. Not only do protections need to be considered for industry workers and local communities, but also the gulf environments, all of which can be impacted by oil spills.

Other environmental issues such as dead zones and algae blooms, increased hurricane forces and frequency, and sea level rise can also seriously affect all the functions of the gulf, especially as the climate warms.

To combat this, there is a rise in alternative energy sources, from natural gas, to wind and solar power, more protections in place to limit oil rig disasters, and a wide-range of research learning how to best mitigate climate change and it's wide reaching effects.

By performing research on the impacts of disasters such as the Deepwater Horizon spill, even 8 years later, we learn more about the value of these efforts and protections and about the whole ecosystem from the pelagic whale shark, to the coastal pipefish.

Production Process

The concept for this film grew from my interest in science and natural history filmmaking prior to committing to a master of science degree at UNT in fall 2015. Upon joining the Roberts' lab as a graduate researcher on the Deepwater Horizon spill, I decided that I wanted to make a film about the Deepwater Horizon spill and the work I was doing on juvenile vision behavior. Of course, over the last 3 years there have been many changes to the research and the film. I learned how to illustrate and animate digitally, swapped research between four different fish species and 2 different ages, and moved on from vision and feeding behavior, to cardiac toxicity before deciding for focus all my efforts on creating this film.

Starting my degree at UNT, I had no experience in either toxicology or filmmaking. So, alongside toxicology classes, I took a documentary pre-production course in spring 2016 and followed it up with an independent study in spring 2017 to learn about production, post-production and editing software programs. The pre-production course involved drafting ideas, learning storytelling techniques, watching films, understanding planning, budgeting and promotion, and different production roles. By the end of the semester I drafted my first film proposal focused on specific occupations that could lend insight into the spill and its aftermath (chef's, opthomalogists, fishermen, etc.). One of the main takeaways from the course, for me, was to think about an internet presence in promoting my film. Inspired by social media work that had been done by other films, I began an Instagram account over the summer of 2016. Having the account pushed me to think more about the visuals that I wanted to include in the film and helped me to practice in small scale a lot of skills that I would later use extensively. With a MacBook Air from UNT installed with all the applications of Adobe Creative Cloud, I began playing around with digital illustration. However, it wasn't until spring 2017 during my film independent study that I really developed a skill-set for the programs.

As I further developed my digital illustration and animation skills, I was approached by Dan DiNicola, the outreach coordinator from our research consortium (RECOVER), to make some fish-swimming animations surrounding the vision research that I had been working on in the summer of 2017. It was this animation that really showed me how far I could take my Illustrator and After Effects knowledge to use much more heavily in the film than I had previously considered. This resulted in another rethink of the film. I tossed out the idea of interviews after struggling to find experts on the fields I was interested in, instead focusing on

my own knowledge of the spill and resultant research. From these different changes, I began developing more animations and putting together footage that I had gathered and that had been gathered by Dan. In the midst of this shift, I attended the Jackson Hole Wildlife Film Festival in September 2017. This trip really shaped my film into its final product. I had the opportunity to view a huge variety of different documentaries from professional and student filmmakers and it opened my eyes to the directions that I could take my own film. I began to embrace a style of animation over a live-footage background that I really connected with and felt comfortable shaping into the final film product.

The style I have settled on is very simple, clean, and cartoony illustrations. I wanted the drawings to be accurate, but only to the point where they are easily recognizable (e.g. as a heart, eye, fish embryo) and not overly detailed. The film is roughly half animation, half real footage and about 18 minutes in length. One of the challenges of storytelling has been figuring out how much to include myself in the film. While I wanted to show the research that I'm working on, I didn't want it to just become a film about myself. There is a much bigger picture to talk about with the BP spill and so I decided to show myself minimally, just in shots of my torso, arms, or hands, and do the voiceover for the project. I am very happy with the final film and look forward to sharing it with the greater public.

Film as an Outreach Tool

Science and nature has a long history of being shown on film and television with the popularity of classic environmental and science television hosted by Jacques Cousteau, Carl Sagan, Bill Nye, David Attenborough, Jane Goodall, and Steve Irwin. Showing educational

material on television is actually required in the United States by the Federal Communications Commission (FCC), stating that broadcast television stations in the US air some educational TV content every week.("Children's Educational Television," 2017) In spite of concerns from stations about this requirement, educational cartoons can be just as entertaining to children as non-educational films and educational documentaries can help to shift perspectives and understanding on particular topics, in both children and adults.(Fisch, Yotive, Brown, Garner, & Chen, 1997; Fortner, 1985) Learning also doesn't have to take place only in a classroom, Fortner (1985) found that a home-viewed documentary communicates as effectively as viewing the documentary or being instructor-taught in a classroom and that adults use TV as their primary information source on environment related topics.(Fortner, 1985) Visually communicating information can concrete ideas in memory as well as engage students, making them more empathetic with the film's message compared to just listening to a teacher or reading a scientific paper.(Fortner, 1985; Moura, Almeida, & Geerts, 2016) Documentaries that focus on nature and the environment not only can educate students, but can also increase their interest and empathy towards the environment.(Barbas, Paraskevopoulos, & Stamou, 2009) Although my film may not make it onto broadcast television, these studies give support to my own project and that science education can and should be done with visual assistance as I chose to do with this thesis project.

APPENDIX

PRODUCERS BOOK

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Visuals

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Materials Used

Hardware

- GoPro Hero 4 Silver
- Joby GorillaPod Action Tripod
- MacBook Air
- Canon 80D with EFS 18-135mm lens and Macro EFS 35mm lens
- Slik 300G camera tripod
- Zoom H1 Handy Recorder microphone
- Wacom Intuos drawing tablet
- iPhone 6 and 8
- Seagate Backup Plus Portable Drive (1TB and 2TB)
- Transcend 8GB USB flashdrive
- SanDisk Ultra 32GB SD Card
- Samsung 64 EVO+ MicroSD Card
- 6 2GB MicroSD Card

Software

- Adobe Illustrator CC
- Adobe Photoshop CC
- Adobe Premiere Pro CC
- Adobe After Effects CC
- Adobe Audition CC
- Adobe Media Encoder CC
- Instagram

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