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Journal of Magazine Media, Volume 11, Number 1, Fall 2009, (Article)

Published by University of Nebraska Press

DOI: <https://doi.org/10.1353/jmm.2009.0003>

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**Information Recall of Internet News:
Does Design Make a Difference? A Pilot Study**

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Abstract

This study looks at the effect of the design of online news presentation on content recall. One of four versions of a story was read online. Results of a post-test showed that recall was significantly higher after students read the text only or abbreviated text with photos and captions options over photos with captions and videos or animated graphics. Participants over age 21 had significantly better content recall after viewing the photos with captions and video prototype.

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Patrick Tabatcher is a senior multimedia producer in Instructional Services at The University of Akron.

Introduction

The current economic environment has ravaged the newspaper industry. Unable to deal with continuing advertising cutbacks, reduced circulation and ever increasing production costs, publishing companies are looking for ways to control their mounting financial losses. Earlier this year, E.W. Scripps Co. opted to shut down the *Rocky Mountain News* in Denver after 150 years.¹

Detroit News owner MediaNews Group and *Detroit Free Press* owner Gannett turned to a new business model, emphasizing digital news and providing home delivery for the print product only on Thursday, Friday, and Sunday.² Hearst Corp. closed down its 146-year-old *Seattle Post-Intelligencer* in favor of an entirely digital news product.³ The Newhouse family's Advance Publications announced plans to close the 174-year-old *Ann Arbor News* in favor of a "web-focused news operation built from the ground up" (AnnArbor.com).⁴

Newspapers have long fostered a connection with the digital world. More than 25 years ago, the *Columbus Dispatch* became the first newspaper to go online with a CompuServe dial-up service.⁵ But it wasn't until the 1990s that daily newspapers got serious about introducing digital versions of their paper products. As Riley, Keough, Christiansen, Meilich, and Pierson explained, 1996 marked the beginning of a two-year growth spurt, when the number of newspapers having an online version went from 154 to 3,600.⁶

Yet what was happening in 2009 was different. As the *Seattle PI* and *Ann Arbor News* illustrate, newspapers were looking to the online world for their future. But what forms should those products take? What is the most effective way of communicating to the public—and have the readers remember what they read?

This pilot study was designed to begin to try to answer those questions in an experiment testing four versions of an online news story for content recall.

Literature Review

Content recall has long been the focus of scholarly research. For six decades, researchers from a variety of disciplines have analyzed content recall of news, information, and messages provided by the media. As each new medium was introduced—and widely adopted by the American public—researchers revisited the issue of content recall.

In 1949 the focus was on radio, news listening, and memory. In a study by Harrell, Brown, and Schramm,⁷ the researchers became one of the first—although certainly not the last—to point out the shortcomings of radio news with regard to content recall. The three reported the low rate of information recall, regardless of news format or repetition. According to the study, participants remembered items dealing with human interest or "spectacular stories of crime and disaster" as opposed to more substantive public affairs

news.⁸ The researchers equated this to sensational newspaper coverage, although newspapers were not included in their study.

Williams, Paul, and Ogilvie⁹ saw more promise in broadcast media in their study in 1957. In this experiment comparing television, radio, print, and “live” delivery of information, the researchers found participants exposed to television and radio scored the highest content recall—both short term and long term—compared to those exposed to print and/or “live” delivery of information. This experiment, however, did not deal with news reporting, nor did it include newspaper and/or magazine coverage. Nonetheless, the study seemed to keep the hope for broadcasting alive.

Tichenor, Donohue, and Olien¹⁰ held out that hope for television, too. In their ground-breaking work on the knowledge-gap theory and the mass media, the three found that the better educated retained more information from newspaper coverage of complex scientific topics than the less educated. The researchers were not sure if the findings could be extended to television. They speculated, “Since television use tends to be less correlated with education, there is a possibility that television may be a ‘knowledge leveler’ in some areas.”¹¹

Subsequent researchers¹² have shown that Tichenor, Donohue, and Olien were overly optimistic. Katz, Adoni, and Parness’ work¹³ is especially on point. In their examination of recall of radio and television news, the researchers found television more effective in information recall than radio—or “seeing the news”—was more effective than merely hearing it.¹⁴ However, neither television nor radio scored impressive content recall results. Moreover, television was not found to be the panacea that Tichenor, Donohue, and Olien hoped. As Katz, Adoni, and Parness concluded, their findings were consistent “with the knowledge-gap hypothesis, and does little for our expectation that television news would contribute most to the least well-off, informationally speaking.”¹⁵

Over the decades, researchers searched for an explanation for broadcasting’s information-recall shortcomings. Some suggested “contextual interference,” or viewers doing other things while they watched television,¹⁶ the trivialization of news,¹⁷ and the characteristics of television news itself.¹⁸

After the introduction of Gannett’s colorful, graphically intensive *USA Today* on September 15, 1982, dailies shifted their designs, using more color and graphics. The Society of Newspaper Design found that from 1984 to 1988 the percentage of dailies with graphics capability grew from 40 to 90 percent.¹⁹ The greater use of maps, charts, and three-dimensional graphs caused some researchers to study the link between graphics and information recall. A number of researchers found that tables, graphs, and maps enhanced reader performance and recall.²⁰

The widespread use of the Internet brought researchers back to familiar recall territory, examining the new medium—the computer—and its effect. These studies again took a comparative approach, this time looking at newspapers, radio, television, and the

computer to ascertain content recall. These studies have tended to come to similar conclusions. Newspapers scored the highest level in content recall, followed by computer, television, and radio.²¹ Cultural media tradition may influence content recall results, however. Facorro and DeFleur²² found that a nation's tradition of media use can influence content recall results. In Spain computer penetration is not as great as in America, and radio plays a greater role in informing the public. Thus, newspaper content recall was the highest for both American and Spanish groups. However, radio recall scored a close second for the Spanish group; television followed, and the computer scored a distant fourth.²³

As websites evolved, adding more multimedia elements, researchers returned to the issue of design and its influence on content recall. Researchers from the education discipline especially saw great benefits in interactive media and learning, emphasizing the deep comprehension for students working with interactive media²⁴ and the benefits of student control of the speed of learning through computer-based instruction.²⁵

Researchers from the communication field have not been as enthusiastic in their findings the interactive media. In 2000 Berry²⁶ reported on an experiment on Web-page design and content recall. Her study offered participants two options—text only and the other multimedia based. While the comprehension scores were low for both sites, Berry reported that the multimedia site had slightly better recall scores than the text-only site, but not statistically significant.

The Poynter Institute did the most comprehensive study dealing with the issue of design and recall to date. The “Eyetracking the News” report²⁷ looked at how different print (newspaper) and online designs influenced information recall. The researchers offered the participants three different versions of the same story. These options ranged from traditional, text-heavy stories to a very visual, graphics-laden presentation. Researchers reported that newspaper/broadsheet readers across the board had better information recall than online participants. However, the best information recall for both print and online was the graphics-laden presentation.²⁸

Although eyetracking research has been used as a tool to help gauge usability of website designs, the research method has been largely ignored by the newspaper industry. The Poynter Institute has been the forerunner in using the eyetracking devices in researching how newspapers and Web pages are read. Technological advances have produced eyetracking paraphernalia that is less cumbersome, less obtrusive, and more accurate, but measurement problems exist. Salvucci and Golberg noted that although there was general agreement that visual and cognitive processing do occur during eye fixations, “it is less clear exactly when fixations start and when they end.”²⁹

There is also the inherent problem of interpreting eyetracking data. Jacob and Karn note that there is a “lack of standard terminology and definitions for even the most fundamental concepts used in eyetracking data interpretation.”³⁰ Jacob and Karn also point

out, in discussing measurement, that using the eye as a computer input device can be a problem. "Moving one's eyes is often an almost subconscious act.... it is relatively difficult to control eye position consciously and precisely at all times. The eyes continually dart from spot to spot even when its owners thinks he or she is looking steadily at a single object."³¹

Hypotheses

H1: Recall will be greater for respondents reading text-plus graphics version (Appendix B—a page with the edited story plus photos and captions and video) than text alone (Appendix A—the longest version of the story with no photos or video or graphics).

H2: Recall will be greater for respondents reading graphics-rich version with no text (Appendix C—no text, only photos and captions and video) than text-plus graphics (Appendix B) or text alone (Appendix A).

H3: Recall will be least effective for respondents reading text-only version (Appendix A) and viewing the animated graphics³² version (Appendix D—static graphic and animated graphic only, no text or photos or video).

Method

In order to test these hypotheses, the researchers developed four different versions of a story for online presentation that encompassed a variety of presentation alternatives. The four alternatives were:

1. Text only (see Appendix A).
2. Abbreviated text with photos and captions and video (see Appendix B).
3. Photos and captions and videos (no text) (see Appendix C).
4. Animated graphics (see Appendix D).

The materials provided in each of these versions were based on the series "Altered Oceans," which appeared in the *Los Angeles Times* from July 30 to August 3, 2006.³³ The researchers specifically used content from part one of that series, "A Primeval Tide of Toxins."

The researchers developed a pre-test of five questions, testing the respondent's prior knowledge of the subject matter (see Appendix E). Those same five questions were asked after exposure to one of the versions. Demographic questions were also asked after the post-test (see Appendix F). The four versions, pre-test, post-test, and demographic material were stored on a central server. Access to the central server was password protected so participants were affiliated with The University of Akron and no student could participate in the experiment more than once.³⁴

Each participant was presented with a screen explaining the study and allowing him or her to opt out. By opting in, participants were presented with a pre-test. After the pre-test, each participant was randomly assigned one of the four versions (text only; abbreviated text with photos and captions; photos and captions and videos—no text; and animated graphics). One communication class of 16 students participated while in the classroom. The remainder of the participants viewed the stories outside of a classroom setting—wherever they were most comfortable or they had access to a computer.

Participation was voluntary in all instances. There was no time limit placed on how long a participant could spend reading, viewing or interacting with the content. Videos and animations could be replayed multiple times. However, the participants could not return to the version they had viewed once they began the post-test.

Participants in this study, students at The University of Akron, were enrolled in a range of classes across campus, including communication, women's studies, and environmental studies, during the spring 2009 semester. In all, 146 college students—77 men and 69 women—participated in the study. Undergraduates and post-secondary students represented the largest number of participants ($N=137$); only eight graduate students participated, and one fit into neither category. Respondents were also asked their age; 66 were under 21, and 66 were over 21; four did not report an age. The largest number of the participants reported that they were arts majors, which included communication ($N=87$); followed by business majors ($N=24$), and those from the science technology, engineering, and mathematics disciplines ($N=16$).³⁵

Results

H1, H2, and H3 all hypothesized the relationship between the content versions and information recall. An ANOVA and Bonferroni post-hoc test statistics were obtained. Full results can be seen in Tables 1, 2, and 3.

H1 argued recall would be greater for respondents reading text-plus graphics version than text alone. Results indicated that there is no significant difference in post-test scores for those who saw the text with photos and captions ($M = 3.70$, $SD = 1.311$) versus those who saw the text-only version ($M = 3.62$, $SD = 1.197$). *These two versions, however, had the greatest rate of content recall of the four tested.*

H2 hypothesized that recall would be greater for respondents reading the graphics-rich version with no text than text-plus graphics or text-alone versions. Surprisingly, the ANOVA results indicated that with the graphics-rich version—no text ($M = 2.58$, $SD = 1.232$), there was statistically significantly *less* content recall, $F(3, 121) = 7.362$, $p < .001$, than in the text alone ($M = 3.62$, $SD = 1.197$) or the text with photos and captions ($M = 3.70$, $SD = 1.311$) versions. There was no significant difference between the graphics-rich version with no text and the animated graphics ($M = 2.70$, $SD = 1.104$).

H3 hypothesized that recall would be least effective for respondents reading the text-only version and viewing the animated graphics version. Table 2 indicates that the most highly recalled mean occurred when the participants were given the text with photos and caption version ($M = 3.70$, $SD = 1.311$), followed by the all text version ($M = 3.62$, $SD = 1.197$). The less effective versions were the no text animated graphics prototype ($M = 2.70$, $SD = 1.311$) and the graphics rich with no text version ($M = 2.58$, $SD = 1.252$)

Table 1
ANOVA results for content recall based on content version

ANOVA Post-Test Score	Sum of Squares	df	Mean Square	F	Sig.
Between groups	32.522	3		7.362	.000
Within groups	178.166	121	1.472		
Total	210.688	124			

Table 2
Descriptive statistics for content recall based on the version viewed

Descriptives Post-Test Score	N	Mean	Standard Deviation
All text no video or photo	28	3.61	1.197
Text + three photos w/captions	33	3.70	1.311
8 photos w/captions + 3 videos No text	31	2.58	1.232
Animated graphics (3) No text	33	2.70	1.104
Total	125	3.14	1.303

Table 3 Post-hoc Bonferroni examination of the various methods of content delivery with content recall						
Multiple Comparisons						
Dependent Variable: Post-Test Score						
Bonferroni						
(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound
All text no video or photo	Text + three photos w/captions	-.090	.312	1.000	-.93	.75
	8 photos w/captions + 3 videos No text	1.026(*)	.316	.009	.18	1.88
	Animated graphics (3) No text	.910(*)	.312	.025	.07	1.75
Text + 3 photos w/captions	All text no video or photo	.090	.312	1.000	-.75	.93
	8 photos w/captions + 3 videos No text	1.116(*)	.304	.002	.30	1.93
	Animated graphics (3) No text	1.000(*)	.299	.007	.20	1.80
8 photos w/captions + 3 videos No text	All text no video or photo	-1.026(*)	.316	.009	-1.88	-.18
	Text + three photos w/captions	-1.116(*)	.304	.002	-1.93	-.30
	Animated graphics (3) No text	-.116	.304	1.000	-.93	.70
Animated graphics (3) No text	All text no video or photo	-.910(*)	.312	.025	-1.75	-.07
	Text + three photos w/captions	-1.000(*)	.299	.007	-1.80	-.20
	8 photos w/captions + 3 videos No text	.116	.304	1.000	-.70	.93

* The mean difference is significant at the .05 level.

Discussion

The year 2009 may be remembered as the beginning of the shift of emphasis of the news industry from print to online. With the *Seattle Post-Intelligencer* leading the way as the largest circulation newspaper to become an online-only news product and the announcement of other newspapers planning to follow suit, questions about presentation of information arise. Where should resources go? Should news online veer more toward graphic presentation and away from the text heavy stories?

No one project can answer those important questions. Our research studied different formats as it relates specifically to information recall. It did not address the issue of preference—allowing the respondent to select the format—which might influence the amount of information that was recalled. There was the attempt to allow the participant to view the story in his or her natural setting, with all the distractions that are the norm. With this approach we were not able to keep all conditions constant as we would in an artificial setting and, therefore, cannot as confidently attribute the results to the differences in the versions of the story.

Although research is not abundant concerning the format of news online and recall, studies on the subject are mixed. Berry gave participants only two options—text and multimedia—and her results showed no significant difference between the two options. The Poynter Institute's Eyetrack studies have been the most comprehensive. The 2004 Eyetrack study found that recall was better for text information than for multimedia—audio with photo and caption³⁶. However, in the 2007 Eyetrack study, which looked at both print and online using three prototypes of news presentation, two of which relied on “text blocks and visual storytelling” and a third that “displayed no narrative, with the story told through an explanatory map, a Q&A, a numbers chart, and more” found that the graphic-intense information in both print and online provided the greatest recall.

The results of this study indicate, contrary to the latest Poynter study, that text alone or text with photos is best in presenting news online based on recall. The recall of news after reading the text version or reading the text version with photos and caption and video was significantly higher than the version with only photos and captions and video and the version with animated graphics only. Both recall means of the text and text with photos options were high (3.62 and 3.70 respectively out of 5). However, all the options we presented showed good recall of the information, highlighting the fact that people are acclimated to reading news online and remembering what they read. Obtaining the information through the multimedia version—photos with captions and video—scored worst on our recall (2.58 mean score) and was not significantly lower than the animated graphics version (2.70 mean score).

The difference between our results and Poynter's may be related to the fact that our format differed markedly from any of the studies conducted thus far. We looked only at news online. Also, we presented four versions rather than two or three, with each of our prototypes distinctly different from the others. No other study has presented a graphics option without text. Both of Poynter's print and online graphic presentations in the 2007 study did not include narrative, but the prototypes were text intensive. Their online versions provided no video or graphic-only scenario.

Further Research

There are many factors facing editors of news organizations in their decisions concerning how news should be delivered online. Providing information that enhances the understanding of a subject or issue is one of the objectives. This pilot study is the beginning of an approach we believe will ultimately help news organizations better judge how to deliver news. More study is planned that will not only expand the number of students responding and the disciplines of those students but will also include the general adult population. We need to look at the different educational and socioeconomic backgrounds of news readers in different parts of the country as a means of revisiting knowledge-gap research. Will the explosion of information online help narrow that gap or can presentation have an effect? We will also increase the number of questions in both the pre- and post-test. Related research should be initiated that looks at the way information is presented in graphics. Is animation better than graphics that utilize more text-heavy approach in the presentation?

Also, we have not addressed a reader's preference in how news is presented. Although people might say they want to get their information through video or graphics, when the time comes to choose the format, will they return to a text-rich presentation? With these approaches we can come closer to identifying where resources should be used and understand the realities of online news readership.

Conclusion

These results could have an impact for news organizations writing stories for the Web. If, as the data suggest, text alone or text with photos or graphic elements combined are the best methods for presenting information, news organizations—which are looking at ways to trim resources yet provide information—should focus on what they do best—write news stories and provide photos and/or graphics that illustrate them. That has been the substance of the news industry for 200 years, and although more research is needed, this study suggests organizations should continue that course as they move resources to presenting news online.

Appendix A

Content Recall

Welcome, Survey Participant

Exit

Altered Oceans

A Primeaval Tide of Toxins

MORETON BAY, AUSTRALIA — The fieweed began each spring as tufts of hairy growth and spread across the seafloor fast enough to cover a football field in an hour.

When fishermen touched it, their skin broke out in searing welts. Their lips blistered and peeled. Their eyes burned and swelled shut. Water that splashed from their nets spread the inflammation to their legs and torso.

When they spoke up about their condition, authorities dismissed their complaints — until a bucket of the hairy weed made it to the University of Queensland's marine botany lab.

Samples placed in a drying oven gave off fumes so strong that professors and students ran out of the building and into the street, choking and coughing.

Scientist Judith O'Neill put a tiny sample under a microscope and peered at the long black filaments. Consulting a botanical reference, she identified the weed as a strain of cyanobacteria, an ancestor of modern-day bacteria and algae that flourished 2.7 billion years ago.

O'Neill, a biological oceanographer, was familiar with these ancient life forms, but had never seen this particular kind before. What was it doing in Moreton Bay? Why was it so toxic? Why was it growing so fast?

The venomous weed, known to scientists as *Lyngbya majuscula*, has appeared in at least a dozen other places around the globe. It is one of many symptoms of a violent jax on the world's oceans.

In many places — the azils of the Pacific, the shrimp beds of the Eastern Seaboard, the fjords of Norway — some of the most advanced forms of ocean life are struggling to survive while the most primitive are thriving and spreading. Fish, corals and marine mammals are dying while algae, bacteria and jellyfish are growing unchecked. Where this pattern is most pronounced, scientists evoke a scenario of evolution running in reverse, returning to the primeval seas of hundreds of millions of years ago.

Jeremy B. C. Jackson, a marine ecologist and paleontologist at the Scripps Institution of Oceanography in La Jolla, says we are witnessing "the rise of slime."

Over time, the accumulation of environmental pressures has altered the basic chemistry of the seas.

The causes are varied, but collectively they have made the ocean more hospitable to primitive organisms by putting too much food into the water.

Industrial society is overdosing the oceans with basic nutrients — the nitrogen, carbon, iron and phosphorous compounds that curl out of smokestacks and tailpipes, wash into the sea from fertilized farms and cropland, seep out of septic tanks and gush from sewer pipes.

Modern industry and agriculture produce more fixed nitrogen — fertilizer, essentially — than all natural processes on land. Millions of tons of carbon dioxide and nitrogen oxide, produced by burning fossil fuels, enter the ocean every day.

These pollutants feed excessive growth of harmful algae and bacteria.

At the same time, overfishing and destruction of wetlands have diminished the competing sea life and natural buffers that once held the microbes and weeds in check.

Many of the same forces have wiped out 80% of the corals in the Caribbean, despoiled two-thirds of the estuaries in the United States and destroyed 75% of California's kelp forests, once prime habitat for fish.

Jackson uses a homespun analogy to illustrate what is happening. The world's 6 billion inhabitants, he says, have failed to follow a housewife's rule of thumb: Be careful what you dump in the swimming pool, and make sure the filter is working.

Around the world jellyfish populations are growing because they can. The fish that used to compete with them for food have become scarce because of overfishing. The sea turtles that once preyed on them are nearly gone. And the plankton they love to eat are growing explosively.

As their traditional catch declines, fishermen now haul in 450,000 tons of jellyfish per year, more than twice as much as a decade ago.

This is a logical step in a process that Daniel Pauly, a fisheries scientist at the University of British Columbia, calls "fishing down the food web." Fishermen first went after the largest and most popular fish, such as tuna, swordfish, cod and grouper. When those stocks were depleted, they pursued other prey, often smaller and lower on the food chain.

In California waters, for instance, three of the top five commercial catches are not even fish. They are squid, crabs and sea urchins.

Overfishing began centuries ago but accelerated dramatically after World War II, when new technologies armed industrial fleets with sonar, satellite data and global positioning systems, allowing them to track schools of fish and find their most remote habitats.

The result is that the population of big fish has declined by 90% over the last 50 years.

Pauly said the oceans are being transformed into a "microbial soup."

Jellyfish are flourishing in the soup, demonstrating their ability to adapt to wholesale changes — including the growing human appetite for them. Jellyfish have been around, after all, at least 500 million years, longer than most marine animals.

Federal scientists tallied a tenfold increase in jellies in the Bering Sea in the 1990s. They were so thick off the Alaskan Peninsula that fishermen nicknamed it the Slime Bank. Researchers have found teeming swarms of jellyfish off Georges Bank in New England and the coast of Namibia, in the fjords of Norway and in the Gulf of Mexico. Also proliferating is the giant nematode found off Japan, a jellyfish the size of a washing machine.

Of the 2,000 or so identified jellyfish species, only about 10 are commercially harvested. The largest fisheries are off China and other Asian nations. New ones are springing up in Australia, the United States, England, Namibia, Turkey and Canada as fishermen look for ways to stay in business. Pauly, 60, predicts that future generations will see nothing odd or unappetizing about a platter of these gelatinous blobs.

The dark water spun to the surface like an undersea cyclone. From 80 feet below, the swirling masses of partially treated sewage spewed from a 5-foot-wide pipe off the coast of Hollywood, Fla., dubbed the "poop chute" by divers and fishermen.

Fish swarmed at the mouth — blue tangs and chubs competing for particles in the wastewater.

Maine ecologist Brian Lapointe and research assistant Rex "Chir" Baumberger, wearing wetuits and breathing air from scuba tanks, swam to the base of the murky tunnel cloud to collect samples. The effluent meets state and federal standards but is still rich in nitrogen, phosphorus and other nutrients.

By Lapointe's calculations, every day about a billion gallons of sewage in South Florida are pumped offshore or into underground outfalls that seep into the ocean. The wastewater feeds a green tide of algae and bacteria that is helping to wipe out the remnants of Florida's 220 miles of coral, the world's third largest barrier reef.

In addition, fertilizer washes off sugar cane fields, livestock compounds and citrus farms into Florida Bay.

Government officials thought they were helping in the early 1990s when they released fresh water that had been held back by dikes and pumps for years. They were responding to the recommendations of scientists who, at the time, blamed the decline of ocean habitats on hypersalinity — excessively salty seawater.

The fresh water, laced with farm runoff rich in nitrogen and other nutrients, turned Florida's gin-clear waters cloudy. Seaweed grew fat and bushy.

It was a fatal blow for many struggling corals, delicate animals that evolved to thrive in clear, nutrient-poor seawater. So many have been lost that federal officials in May added what were once the two most dominant types — elkhorn and staghorn corals — to the list of species threatened with extinction. Officials estimate that 67% of them are gone.

Sewage and farm runoff kill corals in various ways.

Algae blooms deny them sunlight essential for their survival.

The nutrients in sewage and fertilizer make bacteria grow wildly atop corals, consuming oxygen and suffocating the animals within.

The ancient seas contained large areas with little or no oxygen — anoxic and hypoxic zones that could never have supported sea life as we know it. It was a time when bacteria and jellyfish ruled.

Nancy Rabalais, executive director of the Louisiana Universities Marine Consortium, has spent most of her career peering into waters that resemble those of the distant past.

On research dives off the Louisiana coast, she has seen cottony white bacteria coating the seafloor. The sulfurous smell of rotten eggs, from a gas produced by the microbes, has seeped into her mask. The bottom is littered with the ghostly silhouettes of dead crabs, sea stars and other animals.

The cause of death is decaying algae. Fed by millions of tons of fertilizer, human and animal waste, and other farm runoff rising down the Mississippi River, tiny marine plants are rot, die and drift to the bottom. Bacteria then take over, in the process of breaking down the plant matter, they suck the oxygen out of seawater, leaving little or none for fish or other marine life.

Years ago, Rabalais popularized a term for this broad area off the Louisiana coast: the "dead zone." In fact, dead zones aren't really dead. They are teeming with life — most of it bacteria and other ancient creatures that evolved in an ocean without oxygen and that need little to survive.

Continue

Appendix B

Content Recall

Welcome, Survey Participant
Exit

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At the same time, overfishing and destruction of wetlands have diminished the competing sea life and natural buffers that once held the microbes and weeds in check.

A *Tichodysmus* bloom off the coast of Australia. Moreton Bay Marine Park rangers are often summoned by boaters who mistake such blooms for an oil spill.

Many of the same forces have wiped out 80% of the corals in the Caribbean, despoiled two-thirds of the estuaries in the United States and destroyed 75% of California's kelp forests, once prime habitat for fish.

Also around the world jellyfish populations are growing because they can. The fish that used to compete with them for food have become scarce because of overfishing. The sea turtles that once preyed on them are nearly gone. And the plankton they love to eat are growing explosively.

As their traditional catch declines, fishermen now haul in 450,000 tons of jellyfish per year, more than twice as much as a decade ago.

Daniel Pauly, a fisheries scientist at the University of British Columbia, said the oceans are being transformed into a "microbial soup."

Jellyfish are flourishing in the soup, demonstrating their ability to adapt to wholesale changes – including the growing human appetite for them. Jellyfish have been around, after all, at least 500 million years, longer than most marine animals.

Pauly, 60, predicts that future generations will see nothing odd or unappetizing about a plateful of these gelatinous blobs.

In Florida fertilizer washes off sugar cane fields, livestock compounds and citrus farms into the water. The fresh water, laced with farm runoff rich in nitrogen and other nutrients, was released into the ocean and turned Florida's gin-clear waters cloudy. Seaweed grew fat and bushy.

It was a fatal blow for many struggling corals, delicate animals that evolved to thrive in clear, nutrient-poor saltwater. So many have been lost that federal officials in May added what were once the two most dominant types – elkhorn and staghorn corals – to the list of species threatened with extinction. Officials estimate that 97% of them are gone.

Sewage and farm runoff kill corals in various ways.

Algae blooms deny them sunlight essential for their survival.

The nutrients in sewage and fertilizer make bacteria grow wildly atop corals, consuming oxygen and suffocating the animals within.

The ancient seas contained large areas with little or no oxygen – anoxic and hypoxic zones that could never have supported sea life as we know it. It was a time when bacteria and jellyfish ruled.

On research dives off the Louisiana coast, Nancy Rabalais, executive director of the Louisiana Universities Marine Consortium, has seen cottony white bacteria coating the seafloor. The sulfurous smell of rotten eggs, from a gas produced by the microbes, has seeped into her mask. The bottom is littered with the ghostly silhouettes of dead crabs, sea stars and other animals.

The cause of death is decaying algae. Fed by millions of tons of fertilizer, human and animal waste, and other farm runoff racing down the Mississippi River, tiny marine plants run riot, die and drift to the bottom. Bacteria then take over. In the process of breaking down the plant matter, they suck the oxygen out of seawater, leaving little or none for fish or other marine life.

Years ago, Rabalais popularized a term for this broad area off the Louisiana coast: the "dead zone." In fact, dead zones aren't really dead. They are teeming with life – most of it bacteria and other ancient creatures that evolved in an ocean without oxygen and that need little to survive.

Continue

Instructions: To play the video, click on the "play" button below.

Lab Users: This video includes audio. Please use headphones if viewing this video in a computer lab.

Instructions: To play the video, click on the "play" button below.

Lab Users: This video includes audio. Please use headphones if viewing this video in a computer lab.

Jeremy Jackson, a marine scientist with the Scripps Institution of Oceanography in San Diego, swims through a small canyon in Discovery Bay while surveying what was once a colorful coral reef, riddled with staghorn and elkhorn corals. Overfishing and disease have allowed algae to smother the coral.

A *Tichodysmus* bloom off the coast of Australia. Moreton Bay Marine Park rangers are often summoned by boaters who mistake such blooms for an oil spill.

Partially treated sewage flowing from a pipe off Hollywood, Fla., is sampled by Brian Lapointe of Harbor Branch Oceanographic Institution in Fort Pierce, Fla., and his assistant Hans "Chip" Baumbarger. Although sewage treatment plants reduce bacterial levels, they do not remove nutrients that feed explosive growth in marine algae.

Appendix C

Content Recall

Welcome, Survey ParticipantExit

Altered Oceans

A Primeaval Tide of Toxins

Partially treated sewage flowing from a pipe off Hollywood, Fla., is sampled by Brian Lapointe of Harbor Branch Oceanographic Institution in Fort Pierce, Fla. and his assistant Rex "Chip" Baumberger. Although Sewage treatment plants reduce bacterial levels, they do not remove nutrients that feed explosive growth in marine algae.

Lapointe inspects what scientists suspect is a mixture of algae and bacteria, similar to enormous balls of muckage found in the northern Adriatic Sea. This one is floating near Looe Key, Florida where Lapointe has been documenting detrimental changes for more than 20 years. "It rips my heart out," says Lapointe. "It's like coming home and seeing burglars have ransacked your house and everything you cherished is gone."

A fleshy alga grows atop a soft coral in the Florida Keys and begins to smother the sunlight-dependent organism. Algae are taking over the Keys due to a combination of overfishing and nutrients flowing into Florida Bay from sugar-cane fields, citrus orchards, and hundreds of millions of gallons of partially treated sewage.

A Trichodesmium bloom off the coast of Australia. Moreton Bay Marine Park rangers are often summoned by boaters who mistake such blooms for an oil spill.

Jeremy Jackson, a marine scientist with the Scripps Institution of Oceanography in San Diego, swims through a small canyon in Discovery Bay while surveying what was once a colorful coral reef, filled with staghorn and elkhorn corals. Overfishing and disease have allowed algae to smother the coral.

A moray eel among some bleached coral in Discovery Bay. Coral reefs face many kinds of stresses, including sewage and other nutrients that fuel bacterial growth, spread viruses and disease.

Martha Newman, a Scripps doctoral student, holds two types of fleshy algae that are smothering the coral reefs in Discovery Bay, Jamaica. On the left is Sargassum, on the right, Lobophora.

Strands of Sargassum grow in Jamaica's Discovery Bay, where once-healthy reefs have been decimated in places by a shaggy overgrowth of fleshy algae.

Continue

Instructions: To play the video, click on the "play" button below.

Lab Users: This video includes audio. Please use headphones if viewing this video in a computer lab.

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Appendix D

Content Recall

Welcome, Survey Participant Exit

Altered Oceans

The birth of a 'dead zone'

Coastal waters can go into toxic shock from an overdose of basic nutrients that cause algae to grow explosively, making the water inhospitable for nearly all sea life except bacteria and jellyfish. *Click on each step below.*

1. Nutrient-rich runoff: Fresh water laced with nitrogen and other nutrients from farms, animal feedlots, sewage pipes, smokestacks and auto tailpipes flows into the ocean.

2. Thermal zones: The plume of nutrient-rich water enters a warm surface layer over denser, colder saltwater. The layers don't mix, inhibiting the flow of oxygen.

3. Algae blooms: Nutrients fuel blooms of microscopic plants, or algae, which turn coastal waters soupy green.

4. Organic rain: As the algae die, the mass of cells and other detritus sink to the seafloor. Bacteria break down this organic matter, consuming most of the oxygen in the water.

5. Flee or die: Without enough oxygen, sea stars, corals, snails and other shellfish suffocate. Fish and shrimp swim or scuttle away, if they can.

Sources: Louisiana Universities Marine Consortium, Woods Hole Oceanographic Institution, National Council for Science and the Environment, Science Museum of Minnesota. Graphics: Reporting by Cheryl Brownstein-Bartelge. Graphics by Leslie Carlson, Los Angeles Times.

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Content Recall

Welcome, Survey Participant Exit

Altered Oceans

Ancient bacteria with a bite

Lyngbya majuscula, a strain of cyanobacteria, blankets Moreton Bay, Australia, and other subtropical waters, plaguing wildlife and fishermen. *Click on each step below.*

Life Cycle

- Spores in sediment sprout tufts, eventually covering the seafloor.
- Protein release produces bubbles of oxygen that lift the bacteria to the surface. Thick mats clog boat motors and foul beaches.
- Decaying *Lyngbya* sinks to the bottom, scattering spores anew.

Hazards

- It emits toxins that are harmful to sea life and humans. It can cause rashes on contact, as well as respiratory distress, nausea and dizziness.
- Lyngbya* swallows prime fishing grounds, blocking sunlight to sea grasses, driving away other sea life and rebelling fishermen of their catch.

Why it's unique

- It spreads rapidly, about 100 square meters a minute.
- It makes its own food, stripping nitrogen out of the air to spur growth. *Lyngbya* can also feed on itself, using nitrogen released into the seawater as earlier growth dies and decays.

Sources: University of Queensland, University of Maryland, University of South Florida, Virginia Institute of Marine Sciences, University of British Columbia, Memorial University and Carleton University Partnership. Graphics: Reporting by Cheryl Brownstein-Bartelge, Tom Landry. Graphics by Lorenz Higgins, Pascal Rafoux, Leslie Carlson Los Angeles Times.

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Content Recall

Welcome, Survey Participant Exit

Altered Oceans

Slow suffocation

Low-oxygen "dead zones" are spreading as fertilizer use and deforestation grow, and coastal populations boom.

Dead zones

Oxygen's ebb

The number of "dead zones" is nearly doubling every decade

Documented zones of oxygen depletion

Decade	Number of zones
1950s	3
1960s	14
1970s	19
1980s	27
1990s	43

Fish catch declines

More fishing boats are plying the oceans, chasing fewer fish

Total tonnage of fish caught*

* Figures adjusted for overfishing and natural fluctuations

[Previous](#) 2 of 3 [Next](#)

Appendix E

Pre-test

Content Recall

Welcome, Survey ParticipantExit

Pretest

Select the option that best answers each question.

1. The oceans:

☐ A. are in trouble

☐ B. are thriving with hundreds of species of fish

☐ C. might be in trouble in a few years, but fish that are healthy today are not having problems.

2. Excessive harmful algae and bacteria are growing in our oceans because:

☐ A. there is an abundance of nutrients being dumped into the oceans

☐ B. there are fewer jellyfish species that feed off of algae and bacteria

☐ C. raw sewage is being dumped into the oceans and is killing fish

3. The algae and bacteria are:

☐ A. helping to wipe out coral, which makes up reefs around the world

☐ B. consuming oxygen and suffocating animals that live in the oceans

☐ C. neither a nor b

☐ D. both a and b

4. The so-called "dead zones" in our oceans are:

☐ A. really alive with fish and other sea animals

☐ B. really alive with bacteria and other creatures such as jellyfish

☐ C. completely devoid of any organism

5. An ancient form of water plant, *Lyngbya majuscula*, is appearing around the world and it is:

☐ A. a toxic plant that caused fishermen to break out in welts when they touched it.

☐ B. a benign plant that is found near many of the world's coral reefs.

☐ C. a plant that is provided much-needed nutrients for the dwindling populations of sea turtles and certain types of fish.

☐ D. being harvested for use in fish farms around the world.

Reset Answers

Continue

Appendix F
Post-test

Content Recall

Welcome, Survey ParticipantExit

Posttest

Select the option that best answers each question.

1. The oceans:

☐ A. are in trouble

☐ B. are thriving with hundreds of species of fish

☐ C. might be in trouble in a few years, but fish that are healthy today are not having problems.

2. Excessive harmful algae and bacteria are growing in our oceans because:

☐ A. there is an abundance of nutrients being dumped into the oceans

☐ B. there are fewer jellyfish species that feed off of algae and bacteria

☐ C. raw sewage is being dumped into the oceans and is killing fish

3. The algae and bacteria are:

☐ A. helping to wipe out coral, which makes up reefs around the world

☐ B. consuming oxygen and suffocating animals that live in the oceans

☐ C. neither a nor b

☐ D. both a and b

4. The so-called "dead zones" in our oceans are:

☐ A. really alive with fish and other sea animals

☐ B. really alive with bacteria and other creatures such as jellyfish

☐ C. completely devoid of any organism

5. An ancient form of water plant, *Lyngbya majuscula*, is appearing around the world and it is:

☐ A. a toxic plant that caused fishermen to break out in welts when they touched it.

☐ B. a benign plant that is found near many of the world's coral reefs.

☐ C. a plant that is provided much-needed nutrients for the dwindling populations of sea turtles and certain types of fish.

☐ D. being harvested for use in fish farms around the world.

6. Please indicate the level of your interest in this article.

Very Interested ☐ ☐ ☐ ☐ Not At All Interested

7. Please indicate how useful you felt the information in this article was.

Very Useful ☐ ☐ ☐ ☐ Not At All Useful

Demographics

We'd like to ask a few more questions about you. Please be assured that all the information we are collecting is held in confidence – the information collected in this survey is used only for statistical and classification purpose in aggregated or summary form and is NOT shared, sold or used on an individual basis.

What is your gender?

☐ Female

☐ Male

What is your age?

What category best describes your current educational status?

☐ Attending High School

☐ Attending College (working toward Associate's or Bachelor's degree)

☐ Attending Graduate School

☐ Other

If you are currently enrolled in college, which of the following categories best describes your major?

☐ Arts (including Communication, Visual, Performing)

☐ Business (including Management, Marketing, Accounting)

☐ Education (including Primary and Secondary)

☐ Humanities (including English, History, Anthropology)

☐ Science, Technology, Engineering, Mathematics

☐ Social Sciences (including Psychology and Sociology)

☐ Other

☐ Undeclared Major

Which of the following categories best describes your career plans?

☐ Arts (including Communication, Visual, Performing)

☐ Business (including Management, Marketing, Accounting)

☐ Education (including Primary and Secondary)

☐ Humanities (including English, History, Anthropology)

☐ Science, Technology, Engineering, Mathematics

☐ Social Sciences (including Psychology and Sociology)

☐ Other

☐ Undeclared Major

What is the highest education degree that your father completed?

☐ Elementary School

☐ High School

☐ College (Associate's or Bachelor's degree)

☐ Graduate School

☐ Don't know

What is the highest education degree that your mother completed?

☐ Elementary School

☐ High School

☐ College (Associate's or Bachelor's degree)

☐ Graduate School

☐ Don't know

What is your current marital status?

☐ Single, never married

☐ Married/Domestic Partnership

☐ Widowed, divorced, separated

Which of the following categories best describes how you took this test?

☐ In Class

☐ Outside of class, at home

☐ Outside of class, not at home

Do you regularly read the newspaper?

☐ Yes

☐ No

Do you regularly read newspapers online or print?

☐ Online

☐ Print

☐ Don't read the newspaper

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³³ This series, written by Kenneth R. Weiss and Usha Lee McFarling with photos and video by Rick Loomis, went on to win the George Polk Award and the Pulitzer Prize for explanatory journalism. The series was used with permission from the *Los Angeles Times*. The full series appears online at <http://www.latimes.com/news/local/oceans/la-oceans-series,0,7842752.special>.

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