

# Dolphin Deaths: A Case Study in Environmental Toxicology

by

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## Part I – Strandings

“This weather would be great for a stroll on the beach. The sun is so bright and warm, and that breeze feels amazing,” News Channel 9 reporter Amy Carter said to the film crew while setting up. “Too bad this dolphin stranding has really brought down the mood. Why is this happening again?” Amy sighed and prepared to break the bad news to her regular coastal viewers. “Why does it have to be a dolphin? At least when sea turtles strand, they often go to the turtle hospital and recover, and then there’s a happy story when they get released. Dolphin recovery stories are rare.”

She took a deep breath before the camera started filming. “Sad news on the beach out here today. Another dolphin washed ashore dead this morning. As you can see behind me, researchers are working quickly to take tissue samples to test for signs of a suspected morbillivirus infection and remove the carcass so beachgoers can get back to enjoying the beach. Scientists with the National Oceanic and Administrative Association (NOAA) Fisheries have described the recent die-offs as an “unusual mortality event.” This is a phrase defined in the Marine Mammal Protection Act as “unexpected, significant die-offs of a marine mammal population” (NOAA Fisheries, 2014). Some states on the east coast have reported upwards of 200 more dolphin strandings this year than usual. I spoke with some visitors who saw the dolphin on the beach today and here is what they had to say.”

A montage of beach visitors followed. Amy turned to a tall, athletic man and asked, “What are the factors you think could be involved in the dolphin die-offs? Are you concerned?”

He responded, “It just isn’t right. I’ve jogged on this beach regularly in the mornings for the past ten years and I see them out close to shore, playing and swimming around. Never before this year have I seen one wash up, and this year there’s already been three here. There’s got to be something seriously wrong. It’s scary.”

A retired man visiting the beach with his wife had a different viewpoint. “It’s sad, but I mean it’s probably just nature taking its course; you see dead crabs and fish wash up all the time and that’s considered normal. I’m not too worried.” Amy nodded, thinking he made a good point.

A mother standing with her two kids responded with, “I don’t feel safe taking my kids to the beach when this happens. I don’t want them to catch whatever the dolphins have.” Amy mentioned that scientists have stated that morbillivirus does not pose a threat to humans, but the interviewee replied, “Scientists have been wrong before and I’m not taking any chances.”

A young man who seemed to have made up his mind about the cause of the die-offs chimed in, “Who is there to blame besides us? Between seismic testing for oil and the nasty chemicals factories pour into the oceans, I think I’d be



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washing up sick too if I lived in the ocean. They can only take so much. Regulations like the Clean Water Act are out of date and we need to make having a clean, safe planet a higher priority in this country.”

Amy turned back to the camera. “With a mix of emotions, it appears that people do not really know what to think of these increased dolphin strandings along the east coast. Morbillivirus is not new to dolphins, but the unusual increase in deaths is making many wonder why it could be having a greater impact now. Due to health and safety concerns from locals, the city will be holding a public hearing on Friday this week at 6:00 pm to clear up confusions and discuss what is responsible for these tragic deaths occurring to our dolphins. From News Channel 9, this is Amy Carter.”

As Amy headed up the beach to rinse off her feet, she kicked a plastic bottle that washed up. She picked it up and said to herself, “People can’t even recycle bottles. If pollution really is a factor in these die-offs, maybe we need to be more concerned about what we’re putting in our oceans...”



### *What Do I Know?*

Sorting out the factors involved in this complex dolphin die-off event will be aided by creating a *KWL* chart. This is a chart with three columns: *K* (what I *know* or think I *know*), *W* (what I *want* to know), and *L* (what I *learned*). Complete 5–10 statements for the *K* column of the chart as homework. These statements can come from the reading or from your prior knowledge about any of the topics mentioned in Part I. You will collaborate with classmates during the next class period to create a class chart.

Here are some guiding questions to help you get started:

- What do you know about dolphins?
- What do you know about the effects of pollution (on individuals, populations, or the environment)?
- What do you know about the sources of pollution?
- What do you know about viruses?
- What do you know about immune responses to viruses?

<b>K</b> <i>What I Know</i>	<b>W</b> <i>What I Want to Know</i>	<b>L</b> <i>What I Learned</i>

Figure 1. Example KWL Chart.

## Part II – Preparing for the Public Hearing

Shortly after the news clip aired on TV, a mass email announcing the public hearing circulated through the city, starting out as follows:

Notice is hereby given that a public hearing on the Dolphin Unusual Mortality Event (UME) occurring on the Atlantic coast of the US will be held this Friday at 6:00 pm at City Hall.

In July, 2013, a UME as defined in the Marine Mammal Protection Act was declared for bottlenose dolphins and continues into 2014. Due to a number of recent dolphin stranding events locally, the city council would like to address concerns from local residents about the overall health and safety of citizens and the environment. Dolphin morbillivirus is suspected to be causing the deaths of many of these dolphins, and this virus is not perceived as an immediate health threat to humans. The city council wants input from local residents, businesses, organizations, and government agencies on the actions, if any, which need to be taken regarding this event.

*Any person wishing to speak to the council about this issue may do so at the public hearing.*

### *The Ecologist*

“Hmmm... I should probably go to this,” mumbled Richard Greene, a local ecologist for the Department of Natural Resources who began his career during the environmental movement in the 1970s when Rachel Carson’s *Silent Spring* was first published. Despite the changes in the regulation of pesticide use sparked by her book, Richard had always found it unfair that companies can cause detrimental impacts to the environment for their own profit. As Richard scrambled through his calendar, his secretary chimed in, “What is that?”

“They’re holding a public hearing about the current dolphin die-offs in the Atlantic on Friday. Of course anything to do with dolphins appeals to the general public,” Richard sighed, “but I hope people realize that there is more than just dolphins to be concerned about. Ecosystems are interconnected in so many ways and changes in top-down control by apex predators can be just as devastating as losing key prey species at the bottom of the food web.”

“People need to care about environmental degradation playing a role in dolphin health because many pollutants biomagnify through food chains. So, at the top of the food chain, dolphins are getting the most concentrated doses of these chemicals. Humans are also at the top of the food chain.” Richard saw the young secretary getting even more confused. “Organisms low on the food chain like plants absorb chemicals like pollutants that are in their environment, whether in the soil, water, or air. When a fish comes by and eats that plant, he’s eating the pollutants inside the plant too. Eating a lot of plants containing pollutants means the fish bioaccumulates those pollutants and stores them in its body. Then an even bigger fish comes around and eats the small fish and all of its buddies...”

Richard’s secretary interrupted him, “So since the small fish ate lots of plants, it has more pollutants in its body than the plant, right? And the even bigger fish is going to be eating a larger dose of pollutants?”

Richard smiled, “Exactly! And larger doses of a chemical put an animal at greater risk of problems like endocrine disruption. That’s what a lot of people fear with pollution—if we continue to pump more and more chemicals into our environments we may pass certain thresholds that body systems can no longer handle, so immune function decreases, hormones are all out of whack, and general health goes down. In fact, dolphins are considered animal sentinels for environmental health because of their long lives, local residences, and role as apex predators.”

“Do you think that’s what is happening with the dolphins?”

Richard shrugged. “It’s really hard to tell, you know. Wild animals aren’t exactly lab mice where you can control all of the environmental factors they are exposed to. But lab tests have shown that common household chemicals, like the flame retardant chemicals called PBDEs (polybrominated diphenyl ethers), cause neurotoxicity and thyroid hormone disruption in lab animals, so it’s definitely something to consider when looking at wildlife health. Some of these chemicals have such long half-lives that they will persist in the environment for years to come even if they have already been banned. I like the idea of the Precautionary Principle— if there’s reason to believe an action could seriously harm the environment or even us, even without full proof, we should not be doing it. If our dolphin populations start to tank, then every level below them on the food chain is going to be affected. I think it’s time to really look at what chemicals we are allowing companies to include in our everyday products. Companies need to be held more accountable for the pollution they produce.”

### *The Immunologist and Virologist*

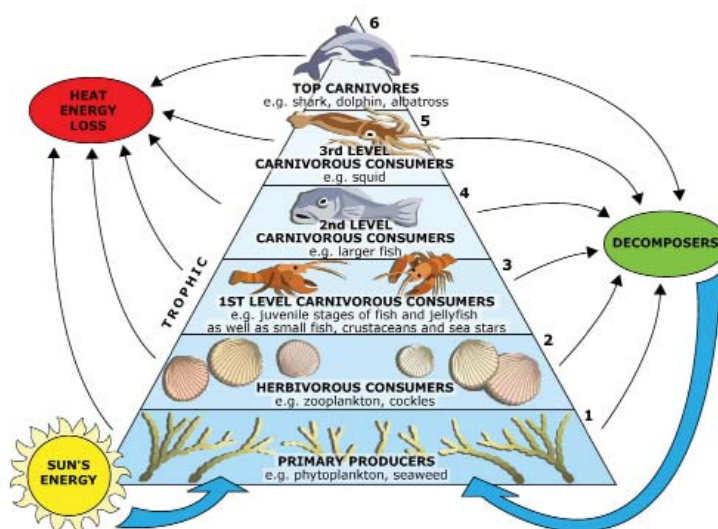
Meanwhile, some medical researchers at a local hospital brought up the same topic while having lunch together. “Did you see the email about the dolphin meeting they’re having downtown this week?” asked Jenny Albertson, an immunologist.

Will Hernandez, a well-known virologist, took a bite of his sandwich and shook his head. He swallowed and asked, “What is it about?”

"I guess they're going to be discussing the factors involved with the increase in dolphin strandings they're noticing on the east coast. I think it's some sort of virus." Jenny had a feeling that Will would know what she was talking about. Despite working in a human-focused field at the hospital, Will maintained a strong interest in wildlife epidemiology and kept current in the field.

“Morbillivirus? There was an outbreak of that in dolphins in the Atlantic when I was in graduate school the late '80s. It's similar to a measles virus in humans or canine distemper in dogs. It's a negative-sense single-stranded RNA virus. It buds from out of the host cell's membranes so it's enveloped too.”

Jenny grinned at being able to predict her colleague so well. “Yeah, that was it. It sounds like the dolphins aren’t staying current on their vaccines.” Jenny chuckled, and she also thought more seriously about the role the secondary immune response could be playing in these outbreaks. “Of course maintaining a nutritious diet and keeping cortisol levels low would



*Figure 2. Marine Trophic Pyramid.* Being at the top of the trophic pyramid, dolphins are susceptible to the effects of biomagnification. They prey on species that have already bioaccumulated contaminants from lower levels of the food chain. *Source:* ©The University of Waikato, <http://sciencelearn.org.nz/Contexts/Life-in-the-Sea/Sci-Media/Images/Marine-trophic-pyramid>, used in accordance with site policy.

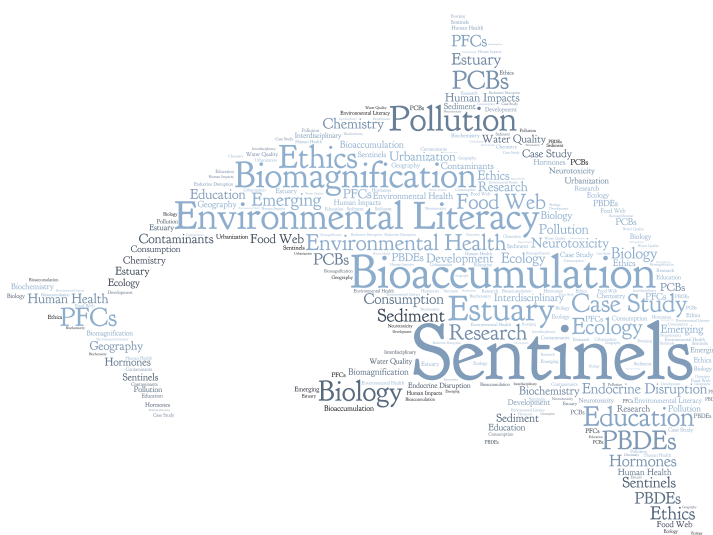


Figure 3. Dolphin Word Cloud. Dolphins are sentinels of environmental health.



also help out the innate immune response. Too bad many people probably think an antibiotic would be the cure for morbillivirus-infected dolphins, like they think when they get a cold,” Jenny said to her colleague who nodded his head in agreement. She often had to explain to people why you cannot treat the flu or a cold with antibiotics. Antigens, antibodies, antibiotics, antidotes—these similarly sounding words with very different meanings seemed to get mixed up in people’s minds as the same thing. Jenny asked Will, “Do you think morbillivirus is sort of like the flu? Where new strains formed from genomic recombination lead to increased virulence?”

“That’s a great question, Jenny. I know multiple marine mammals like seals and whales catch morbillivirus, so it’s very possible it is zoonotic. Being zoonotic would allow the virus to spread between different species more easily. This could especially impact migrating dolphin populations since they would be more likely to encounter other species throughout their migration routes. That could be why it is a successful emergent virus.”

“The announcement also mentioned environmental degradation possibly being a factor in the die-offs. I wonder if they’re hinting at immunosuppression being a factor.” Jenny looked down at her watch and realized lunch break was almost over. “Do you want me to forward you that announcement about the hearing? I think I’ll be going.”

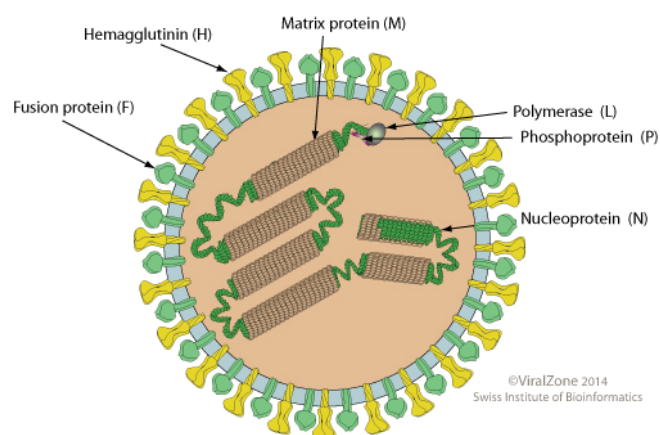
“Absolutely, I can’t wait to see what the public brings up at this meeting. Thankfully since most people like dolphins there shouldn’t be any suggestions for a mass culling to control morbillivirus. Bats are another story...” Will shook his head, “People are so afraid of bats carrying diseases that they think killing them all is the solution. The host species are not what we should be fearing.”

Jenny agreed, “I wonder if there is a reservoir host for morbillivirus that could be causing these outbreaks. It might not be feasible to vaccinate dolphins, but maybe vaccinating another species could help the problem.”

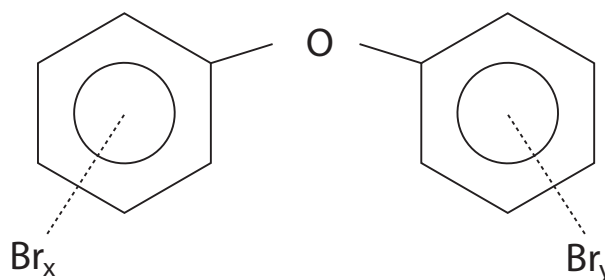
### *The Endocrine Physiologist*

At the local university across town, a physiologist named Susan Bernard had also planned to attend the meeting. With a specialization in hormone research, she wanted to know everyone’s take on the possibility of endocrine disruption in this event. Having studied persistent organic pollutants (POPs) before, Dr. Bernard was aware that these flame retardant chemicals had been detected in marine mammals, including in samples of dolphin blubber. The lipophilic properties of many of these contaminants resulted in their being stored in high-fat areas of the body, making a mother’s milk another place they ended up. The transfer of contaminants from a mother’s milk to her offspring is termed maternal offloading.

“Endocrine disruptors like the pesticide atrazine cause drastic physiological changes where male frogs start developing female reproductive organs,” Susan mentioned to a graduate student working in her lab. The graduate student was going to attend the public hearing with her, and Dr. Bernard recommended some peer-reviewed literature for him to



*Figure 4. Morbillivirus.* The structure of cetacean morbillivirus is similar to that of measles. It is a negative-sense single-stranded RNA virus. Multiple different strains have been observed in dolphins. *Source:* ViralZone: [www.expasy.org/viralzone](http://www.expasy.org/viralzone), Swiss Institute of Bioinformatics, used with permission.



*Figure 5. PBDE.* There are 209 possible combinations of bromine atoms on this base structure of a PBDE compound. They are similar in structure to thyroid hormones, causing concern for endocrine disruption. PBDEs have been used as flame retardants on electronics, textiles, and furniture to name a few of their widespread uses.

read over before the meeting. “But the endocrine system is made up of so many different and vital chemical messengers, secreted from many different organs. It would be a mistake to think that only sex hormone production can be altered by the environment. This dolphin event could really be an opportunity for research to show how overall health and body systems like the immune system may be impacted by changes in hormones.”

“PBDEs are shaped like the thyroid hormones T3 and T4, aren’t they?” asked the graduate student. Dr. Bernard was excited that her student seemed so invested in this study. While steroids are usually the lipophilic hormones and amino acid derivatives and polypeptides are hydrophilic, the thyroid hormones are amino acid derived hormones that are lipophilic, just like PBDEs.

Dr. Bernard reached for a paper by Dr. Patricia Fair at NOAA and her colleagues on contaminants found in dolphin blubber and handed it to the student to read. “The juvenile dolphins and males are definitely a concern. They have higher levels of PBDEs than females because the females transfer their contaminant loads to their young. Companies have stopped using PBDEs in the US but they are persistent organic pollutants. And even though they recently stopped using these chemicals, e-waste is loaded with flame retardants. Even e-waste recycling facilities can be a major source of PBDE pollution if they do not follow strict pollution control standards.”

Her graduate student then added, “Biomarkers, mechanisms of action, and negative feedback loops... there sure is a lot to think about. I think there really needs to be greater regulation on e-waste recycling. With computers and cell phones becoming obsolete every other year, we really need to figure out safe ways to dispose of these products. Look at how many flame retardant chemicals are already being found in dolphins alone! What will our wildlife look like a decade from now?”



### *What Do I Want to Know?*

As a beginning biology student, you may not know or understand many of the terms or concepts that the scientists have been discussing. An important aspect of preparing for this public hearing is to review these concepts so you can be confident in your argument. Based on the dialogues of these scientists, what topics do you need to explore to have a better understanding of factors involved in these die-offs? What are some scientific concepts that were mentioned in their conversations? Construct 5–10 statements for the W column of the *KWL* chart to share with your classmates to develop the class chart.

### *Time to Prepare...*

Attendants at a city council public hearing typically only get three minutes to state their opinions before their turn is over and the next person who wants to speak is up. Each of these scientists needs to prepare what they plan to say in order to make an impact on those who are listening. You will assume the role of one of these scientists preparing for the meeting. Before attending the public hearing, all four of these professionals prepare by reading some popular news articles about the dolphin strandings and brushing up on some of the literature in their respective fields. They all want to be prepared to speak at this hearing to clear up any misunderstandings the general public has about the basic science concepts this meeting may cover. The local newspaper is also holding a series of Op-Ed pieces this month. With all of the uproar the dolphin die-offs have created locally, it’s almost as if the piece could write itself... but first, the public hearing.

### *Questions*

1. Why does studying pollutants in dolphins give a better representation of pollution’s impacts on an ecosystem than studying marsh grasses?
2. If a large portion of the bottlenose dolphin population were to die-off in the Atlantic, what are some of the ecological effects that you might expect?

3. How might the timing between the last morbillivirus-caused die-off event and this dolphin die-off event be related to the immune function of dolphins?
4. Do you think mothers or offspring are at higher risk of endocrine disruption from PBDEs or other environmental contaminants? What about adult males versus adult females?
5. Why are lipophilic chemicals of greater concern when it comes to endocrine disruption? What parts of the endocrine system are more likely to be affected by these?
6. What are some of the factors that could be causing the sudden outbreak of morbillivirus in dolphins?
7. Some dolphin populations are year-round residents, while others migrate over seasons. How can migration impact morbillivirus outbreaks?
8. What are some possible solutions to the dolphin die-offs?

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Some of the literature and news articles the scientists reviewed included the following.

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## Part III – The Public Hearing

News reporter Amy Carter was not going to miss this public hearing. She listened to the council read aloud the information they received from NOAA Fisheries. “From July to February this year about 10 times as many dolphins have stranded along the east coast than compared to the same time period last year. Most of the dolphins sampled have tested positive for morbillivirus, the same virus that struck dolphin populations on the east coast in the late ’80s. The most common concern that we would like to address is that cetacean morbillivirus poses no threat to humans. The human equivalent of morbillivirus is measles, which can be prevented through vaccination. Dolphins do not have vaccines so that is why their ‘measles-like’ disease for them is so deadly.” Amy agreed that it made sense that a lack of immunity could be causing the dolphin fatalities. *Maybe it’s just a natural cycle*, Amy thought.

She looked around the room to see that all of the seats in the room were full and more people were standing along the walls. Once the council members opened the floor to public comments, some collective themes emerged.

A concerned nurse and mother of two was not convinced that everyone was safe. “So do we need to protect ourselves from morbillivirus at all? Is this going to be like bird flu where the virus jumps from birds to us? I don’t think we can ever be too safe when it comes to public health. Scientists don’t know for sure that morbillivirus is the only thing affecting the dolphins, so who is to say that there isn’t something more dangerous going on?”

“There really isn’t anything that we can do at this point. These animals are highly social, and just like with colds in people, viruses spread much quicker and easier in social settings,” stated a recent college graduate who majored in biology. Amy noticed that Drs. Albertson and Hernandez exchanged a glance of pleasant surprise that this young graduate brought up a point that they were both thinking themselves.

Amy took note of common questions the city council could not answer, including “Where did this virus appear from?” and “How can we help the dolphins?”

A tall, lanky, retired fisherman who was a lifetime native of the area said, “I think everyone is overreacting to this event. Whether it’s kayaking, boating, or fishing, I’m out in the water a lot and there is always an abundance of dolphins out and about. Even if more than usual are dying right now, there are still plenty of them out there and we need to calm down.”

After a long night of comments, each of the four scientists got their chance to express what they believed was going on. Having captivated the crowded room, and giving Amy a lot to think about, each hoped that they had cleared up some public confusion.

*What is it that each scientist said?*

Complete a concept map of key terms about your topic with your expert group members and elaborate on how they relate to this case study. After the concept map is complete, prepare your three minute speech to present back to your original jigsaw group on your topic.

## Part IV – Writing to the Editor

As a citizen who was up-to-date on this event and had heard all of the different scientist perspectives at the public hearing, Channel 9 reporter Amy decided to write an Op-Ed letter to the local newspaper about the many factors that could be contributing to the dolphin strandings. Some questions she considered were: *What are the factors involved in the dolphin die-offs? What actions does society need to take on this issue, if any? Why or why not?*

In your jigsaw groups, construct an outline of Amy's opening paragraph. You will use the outline to help you write your own independent Op-Ed letter to the editor. Op-Ed pieces are typically around 750 words so your goal is to cover the four "expert" topics presented in your argument fully in a succinct letter. Op-Ed articles are opinion pieces, so be sure to back up your argument with science concepts.

### *Guides for Writing Op-Ed Articles*

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