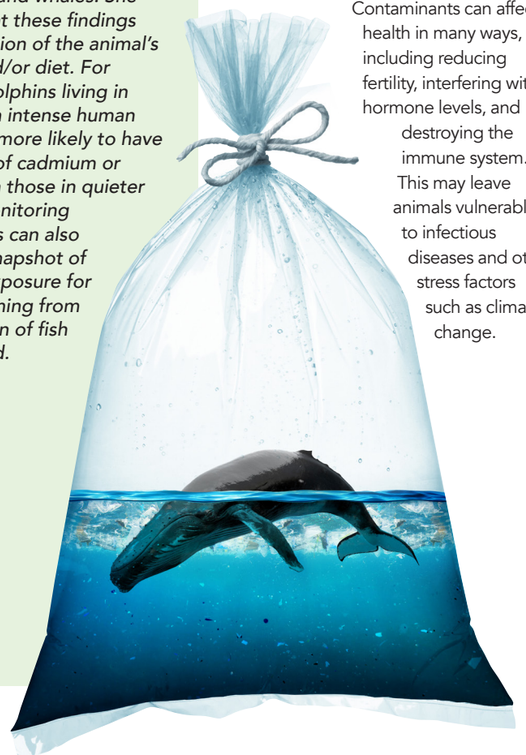
Biology | Annie Page-Karjian

Dolphins and whales are exposed to human-sourced contaminants in the water

Marine pollution is the introduction of contaminants, either deliberately or accidently, into our oceans. Oil, chemicals, and plastics are all examples of marine pollution and can cause harm to many marine species. Dr Annie Page-Karjian, based at Florida Atlantic University's Harbor Branch Oceanographic Institute, carried out extensive analysis revealing bioaccumulation of heavy metals and toxic compounds in dolphins and whales. She believes that these findings are a reflection of the animal's location and/or diet. For example, dolphins living in an area with intense human activity are more likely to have high levels of cadmium or arsenic than those in quieter regions. Monitoring these values can also provide a snapshot of potential exposure for humans coming from consumption of fish and seafood.

The oceans are so vast that up until recently, we didn't worry about how much trash and chemicals we dumped into the water. We are becoming increasingly aware that we cannot continue like this. Many artificial chemicals, such as pesticides, fertilisers, and industrial compounds, don't degrade quickly and will stay for years or even decades in the marine environment. These pollutants in particular affect long-lived marine mammals, like dolphins and whales, by accumulating in their bodies or passing down to their offspring during gestation and lactation.

Contaminants can affect health in many ways, including reducing fertility, interfering with hormone levels, and destroying the immune system. This may leave animals vulnerable to infectious diseases and other stress factors such as climate change.



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Plastics are a particularly harmful type of pollutant. These virtually indestructible products, which are mistaken for food by many different organisms, can contain a myriad of chemicals that can bioaccumulate and pose a real threat to wildlife.

Then, there's the long list of chemicals coming from human-made products that somehow end up in the water. Chemicals such as cadmium or arsenic, as well as bisphenol-A and triclosan can become toxic in high concentrations. The list continues and, worryingly, contains hundreds of new compounds whose impact on health hasn't yet been fully tested or documented, but nevertheless are used in many different products.

To further complicate the issue, exposure is rarely to a single contaminant. Animals are subjected to multiple toxic compounds and high levels of plastic at the same time. This can severely affect their health due to combined effects which may lead to decreased growth rates and long-term effects on the population.

After years of spewing trash, sewage, chemicals, and plastics into the water, we are finally beginning to understand the impact humans have on the ocean. Research groups around the world are working hard to understand better how specific pollutants can affect marine life.

One of the researchers working in this field is Dr Annie Page-Karjian, a veterinarian for the Marine Mammal Stranding and Population Assessment Program at Florida Atlantic University's Harbor Branch Oceanographic Institute in Florida, USA. Dr Page-Karjian is keen to promote wildlife conservation and coordinate emergency responses to sick, injured, distressed, or dead dolphins and whales.

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EVIDENCE FROM STRANDED ANIMALS

Gathering evidence from 83 dolphins and toothed whales found stranded in the southeastern United States between 2012 and 2018, Dr Page-Karjian and her team collected blubber and liver samples which were subsequently analysed for different toxic compounds, such as bisphenol-A, and heavy metals, including arsenic, cadmium, selenium, and zinc. Tissues from 72 animals were also collected for histopathological analysis, including to test for infectious diseases such as cetacean morbillivirus and brucellosis.

Several studies have done a similar analysis in free-ranging animals, using a variety of tissues, including blood, skin, blubber, liver, and brain. To date, however, this is the first time this has been conducted in certain lesser-studied species of stranded cetaceans. 'Our study is the first to report concentrations of toxicants in a white-beaked dolphin and in Gervais' beaked whales, species for which the scientific literature remains sparse', explains Dr Page-Karjian. 'Documenting toxicants in cetaceans is a critical step in tracing chemical contaminants within the marine food web and understanding their effects on biological systems.'

Monitoring concentrations of these and other contaminants in stranded dolphins can provide a relatively low-cost snapshot of the potential exposure risks in humans.

HEAVY METALS CAN BE DANGEROUS

Dr Page-Karjian found several differences in which chemicals were preferentially accumulated in dolphins and pygmy sperm whales, despite living in the same geographic region. Interestingly, whales showed higher levels of the heavy metals cadmium and arsenic compared to dolphins. The authors believe a contrasting taste in food could explain these differences. For example, pygmy sperm whales eat a diet rich in cephalopods and crustaceans, which

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Dr Annie Page-Karjian undertook extensive analysis revealing bioaccumulation of heavy metals and toxic compounds in marine species.

easily accumulate heavy metals, whereas dolphins prefer to hunt fish, where bioaccumulation is not so evident.

Nevertheless, dolphins stranded in Florida had higher levels of lead, mercury, and selenium compared to dolphins from North Carolina, USA. For the authors, this means that the prey accessible to the Florida dolphins – living in an area of intense human activity – is more likely to be exposed to contaminants. 'Inshore dolphins and those inhabiting areas adjacent to human activity are particularly susceptible to exposure to high concentrations of these contaminants as they enter the marine ecosystem via runoff and/or direct discharge', explained Dr Page-Karjian.

Whales stranded around the Florida area also had higher levels of arsenic, but in this case, it may be coming from natural phosphate mineral deposits that contain high levels of this chemical. Curiously, the team found a record-breaker Gervais' beaked whale in this area. The animal, which was stranded in Sebastian, Florida, in 2017, had the highest concentration of arsenic reported for any marine mammal to date.

Despite the potential health issues caused by heavy metals, the authors believe these species can tolerate high levels of mercury and cadmium. Heavy metals can be neutralised by binding with selenium, thus minimising the toxic effects of exposure. This protective mechanism may help limit some of the direct effects that can be seen with heavy metal toxicity, such as oxidative stress and increased cell death.

Selenium levels found in this study seem to corroborate this hypothesis, as concentrations of this essential element follow a similar pattern to mercury, cadmium, and lead in adult bottlenose dolphins and pygmy sperm whales. It is likely that this mechanism is only triggered up to a certain threshold, which means juveniles are protected, at least for a while, against high levels of mercury exposure. In practical terms, this means they have a lower mercury/selenium ratio compared to adults.

The Florida research team also unveiled an interesting relationship regarding levels of chemicals found in mothers and their offspring. Chemicals like arsenic, cadmium, and mercury tended to accumulate more in mothers, while their offspring had higher levels of copper, lead, and zinc. This likely reflects the pattern of chemical transfer during gestation and lactation and whether the contaminant bioaccumulates with age. 'Maternal transfer of toxicants during gestation and lactation to rapidly developing offspring may put young cetaceans at greater risk for adverse health effects, including immune and endocrine system dysfunction', explains Dr Page-Karjian.

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Curiously, males showed higher levels of iron than females, which led the authors to suggest that the risk of bioaccumulation is higher in males for some contaminants, whereas females can offload their stores during gestation and lactation.

TOXIC COMPOUNDS

Levels for some of the toxic compounds, including Aroclor-1268, atrazine, and triclosan, were higher in pygmy sperm whales than dolphins. The authors believe this is probably influenced by the animals' body condition at the time of stranding. About half of bottlenose dolphins stranded in good body condition, and only a few were emaciated. In contrast, a high proportion of pygmy sperm whales were very thin. In fasting or emaciated animals, increased lipolysis results in the release of toxic compounds into the bloodstream, which may contribute to morbidity and possibly even death.

CONTAMINANTS EXPOSURE AND CETACEAN HEALTH

Many lesions observed by Dr Page-Karjian's team were non-specific and likely to be a direct consequence of being stranded. These included, for example, pulmonary oedema, sunburn, hyperthermia, and multi-organ failure. Some lesions, however, such as respiratory problems or inflammation, were more likely to be due to chronic conditions caused by stress, starvation, or infections.

Some of these issues may also be affected by prolonged or repeated exposure to certain toxic compounds such as mercury, cadmium, and lead. While this is difficult to confirm, Dr Page-Karjian suggests that these contaminants should not be overlooked in cases of stranded animals. 'By examining toxicant concentrations alongside histopathological changes in specific tissues, we can begin to better understand some of the potential health impacts that exposure to these compounds can have on vulnerable and understudied species like cetaceans.'

Dr Page-Karjian is quick to point out that the benefits from this work extend to more than just protecting dolphins and whales. Many of the aquatic species that are eaten by these cetaceans are also on the menu for humans. According to the researcher, 'monitoring concentrations of these and other contaminants in stranded dolphins can provide a relatively low-cost snapshot of the potential exposure risks in humans and other organisms that feed at the upper trophic levels'.


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Behind the Research

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Research Objectives

Annie Page-Karjian's research investigates marine pollution and its effects on bottlenose dolphins and other marine species.

Detail

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References

Page-Karjian, A, Lo, CF, Ritchie, B, Harms, CA, Rotstein, DS, Han, S, Hassan, SM, Lehner, AF, Buchweitz, JP, Thayer, VG, Sullivan, JM, Christiansen, EF, and Perrault, JR, (2020). Anthropogenic Contaminants and Histopathological Findings in Stranded Cetaceans in the Southeastern United States, 2012–2018. *Front Mar Sci*, 7:630. doi:10.3389/fmars.2020.00630

Personal Response

What is next for your research?

"Our team continues to respond to stranded cetaceans, conduct necropsies, and lead ongoing research into threats to their health. We have now incorporated routine toxicological monitoring into all of our post-mortem investigations. By evaluating cetacean health in the context of regional population assessment and environmental data, we can begin to appreciate how anthropogenic impacts affect their behaviour, population demographics, and survivorship."

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