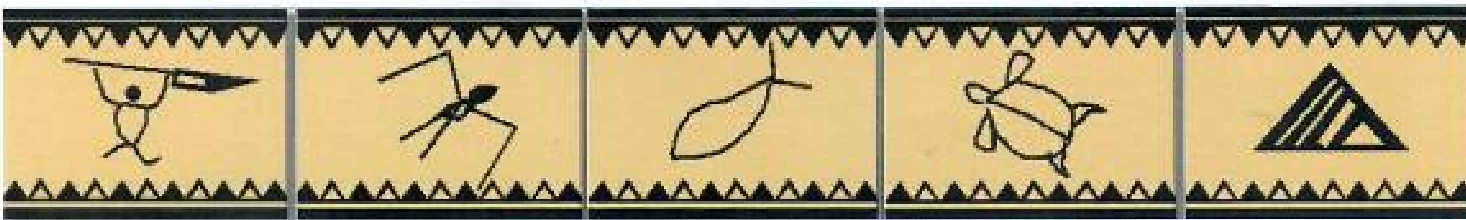


HONOLULU FIELD STATION

A newsletter of the Honolulu Field Station, part of the USGS-National Wildlife Health Center in Madison, WI

The National Wildlife Health Center (NWHC) celebrates 40 years

National Wildlife Health Center in Wisconsin.

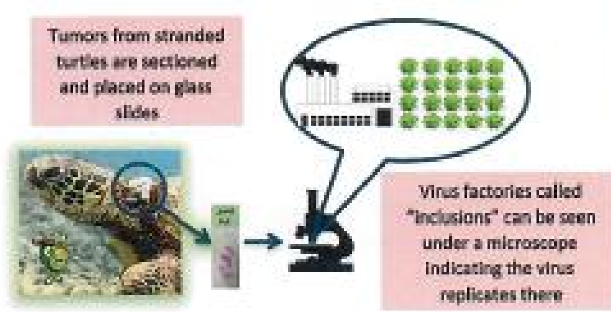
The NWHC was established in Madison, Wisconsin in 1975 to serve the US and its territories on wildlife health related issues. In the 1980s and 1990s, the NWHC did groundbreaking research on waterfowl diseases like avian botulism, avian cholera, and lead poisoning, the latter of which led to nationwide bans on use of lead shots. Recently, the NWHC has branched out to wildlife health issues of conservation or public health concern such as white nose syndrome in bats, chronic wasting disease of deer, avian influenza, and sylvatic plague. Although times have changed, the NWHC remains committed to national leadership to safeguard wildlife and ecosystem health through dynamic partnerships and exceptional science.

Supershedders may be involved in transmission of tumor viruses in sea turtles

Sea turtles in Hawaii are affected by fibropapillomatosis (FP), a disease that causes unsightly tumors on the skin and internal organs of green turtles. FP is closely associated with a herpesvirus, and the virus is found in large amounts in tumors but not in normal tissues. To date, no one has been able to grow the virus in the lab, so the best evidence we have that this virus causes FP is the association between presence of virus and tumors.

Viruses and transmission: Herpes viruses can cause tumors in other animals including chickens and even humans. A big mystery is how such viruses are transmitted. For instance, in humans, it is known that herpesviruses that are associated with tumors are often secreted in saliva, and that is a potential means of transmission. In the case of turtles, other than knowing that the virus is present in tumors, we really do not know the dynamics of virus transmission. Knowing how viruses are transmitted is important because this allows one to better target disease management or surveillance strategies.

Microscopy to the rescue: Because herpesviruses are quite large, we can often actually see them under the microscope. Typically, the viruses are seen in the skin where they presumably slough off and move from one animal to the next. We used this to our advantage and examined the skin from a large numbers of tumors from several green turtles to see whether presence of virus depended on tumor size or individual animals. The findings were surprising.

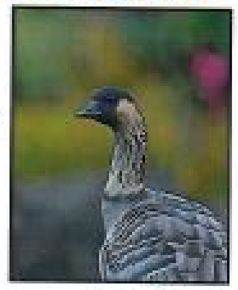


Virus shedding: It turns out that only about 20% of turtles with tumors actually shed herpesvirus in the skin, and those that do have many tumors shedding virus. In addition, smaller tumors shed more virus than bigger ones. The phenomenon of few animals being responsible for a majority of disease transmission in animal populations is not new, and such animals are referred to as "supershedders".

One in five tumored turtles has multiple tumors where the virus is actively replicating

A good example in humans is Typhoid Mary, a single person who was responsible for many salmonella (a bacterial disease) outbreaks in the 1800s. The finding of more virus in smaller tumors is also useful information because it allows investigators to target particular tumors for attempts to grow the virus in the lab. **This of course leads to new questions.** How often do supershedders contact susceptible turtles? How efficiently are viruses transmitted from supershedders? Do smaller tumors really increase our chances of isolating the herpesvirus? It is these kinds of things that make investigation of wildlife disease so fascinating. *Work TM, Dagenais J, Balazs GH, Schettle N, Ackermann M (2014) Dynamics of virus shedding and in-situ confirmation of chelonid herpesvirus 5 in Hawaiian green turtles with fibropapillomatosis. Veterinary Pathology.*

Starvation and Trauma are Major Causes of Death in Endangered Hawaiian Geese



Hawaiian goose or Nēnē. Photo credit © Dan Clark

A 30-year review conducted by the HFS found that the most common causes of death in the Hawaiian goose or Nēnē (in decreasing order of importance) were starvation, trauma, and infectious disease. Of the infectious diseases, the parasite Toxoplasma gondii was a prominent player. This parasite is transmitted by feral cats and has played an important role in extirpation of native Hawaiian crows from their native range. Toxicoses played a minor role in causing Nēnē death and comprised mainly lead poisoning and more rarely botulism. While some of the causes are difficult to prevent, others such as vehicle collisions and toxoplasmosis are preventable if proper management tools are implemented (feral cat control and traffic speed reduced/increased road signage). This is another example where understanding causes of death aids in the management and recovery of endangered birds. *Work TM, Dagenais J, Rameyer R, Breeden R (2015) Mortality patterns in endangered Hawaiian geese (Nene; Branta sandvicensis). J Wildl Dis 51:688-695.*

Necropsy Files Update

The identity of the parasite, Toxoplasma gondii, suspected of having caused the death of a purple-capped fruit dove in American Samoa (see Newsletter 2), was confirmed. This is the first case of this parasite killing native wildlife in that territory.

Recent HFS visiting Scientists

Isabela Domiciano (Brazil), January thru July 2015

A candidate for a PhD in Brazil, Isabela interned at the HFS for 6 months, working on identifying latent herpesvirus gene expression in sea turtle tumors, histopathology of tumors in turtles from Paraná state, Brazil and worked toward developing tools in order to better understand tumor biology. RNA extractions, RT-PCR, agarose gel electrophoresis, SDS-PAGE, western blotting and immunohistochemistry are some of the techniques she acquired. Isabela also performed sea turtle and bird necropsies, and assisted HFS staff with various tasks pertaining to wildlife diseases. We wish her the best of luck in obtaining her doctoral degree!

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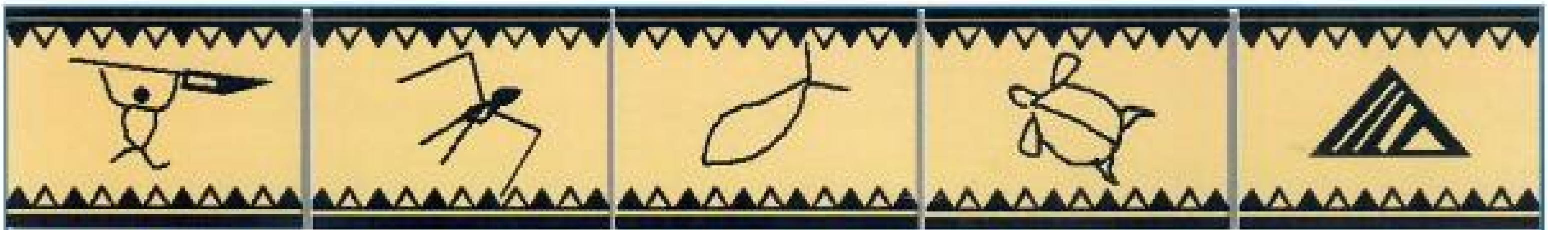


HONOLULU FIELD STATION

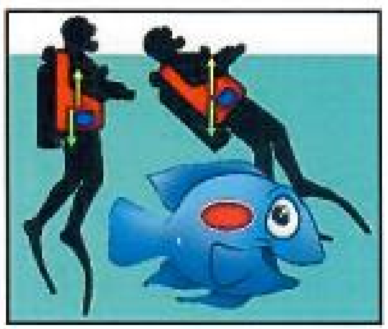
A newsletter of the Honolulu Field Station, part of the USGS-National Wildlife Health Center in Madison, WI

Pufferfish Mortality Explained!

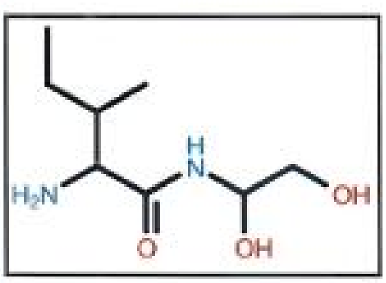
From June to October 2010, the HFS received reports of Stripebelly pufferfish either puffed up in the water, floating unable to submerge, or washed up on the beach. There were also reports of puffers biting each other (photo) and even attacking divers. At necropsy (autopsy for animals), fish had massively swollen livers and hyper-inflated gas bladders. A bit of collaborative sleuthing by HFS and the National Oceanic Atmospheric Administration's Marine Products Chemistry laboratory in Charleston, SC revealed *that **the fish likely died from ingesting a natural toxin.** (1)*

How did we figure this out?

Understanding causes of wildlife mortality requires knowing about the animal, the causative agent, and the environment where the two interact. Here are some key points we learned.

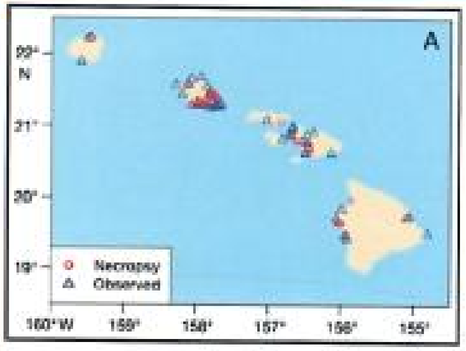


Animal: Fish have a special organ called a **gas bladder** that they use to maintain neutral buoyancy, kind of like a buoyancy compensator used by a SCUBA diver. Fish fill the gas bladder by regulating the acid-base balance (or pH) in their blood. The **liver** is important in maintaining **acid-base balance**. Because the fish had liver failure, they could not control their blood acid-base, the swim bladder overinflated, and fish could no longer remain submerged. This explains puffed up fish floating on the surface. The puffing was a response to stress; when puffers are stressed, they fill their stomach with water and swell up (hence the name pufferfish).



Agent: Using a deductive approach, we were able to rule out infectious disease as cause of death. **Microscopic examination** of tissues suggested a poison (toxin) might be responsible. Laboratory tests revealed the presence of a small chemical compound in pufferfish tissues that was toxic to cells. We suspect that fish somehow **ingested the toxin that led to liver failure** and subsequent clinical signs seen in the field.

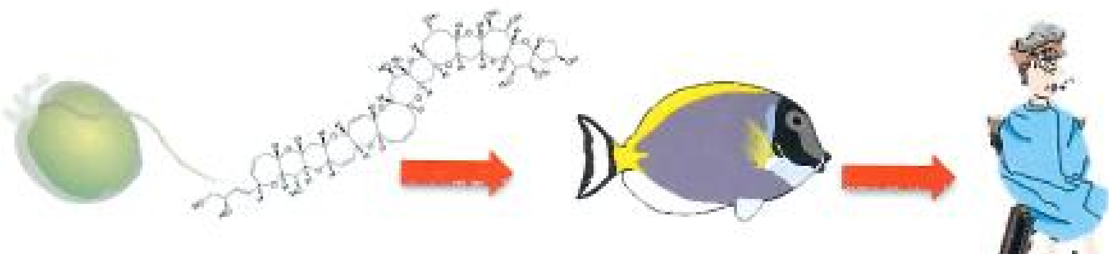
(1) Work TM, Moeller PD, Beauchesne KR, Dagenais J, Breeden R, Rameyer R, Walsh WJ, Abecassis M, Kobayashi DR, Conway C, Winton J. 2017. Pufferfish mortality associated with novel polar marine toxins in Hawaii. Dis Aquat Organ 123: 87-99.



Environment: Pufferfish were seen dying in all the main Hawaiian Islands suggesting that the cause was **geographically widespread** (e.g. not likely something like point source pollution). Interestingly, the mortality affected mainly **one species of pufferfish** (Stripebelly) which tends to be most commonly seen on reefs and thus more detectable.

Marine Toxins

As part of their defenses, numerous marine organisms make chemicals that are toxic when eaten. The most common examples are **toxins produced by microscopic algae that bioaccumulate** in fish or shellfish. **Ciguatera** poisoning is a good example in the tropics. We think the same thing happened to the pufferfish. We do not yet know the source of the toxin.



Ciguatera is produced by a unicellular alga that is eaten by reef fish where the toxin accumulates. People get poisoned by eating fish.

In the case of the pufferfish, something produced the toxin that was then ingested by the fish leading to liver failure and death. What the fish ate to become poisoned is still a mystery.

Discovering new marine toxins like we did is a tedious time consuming process. Figuring out how to do this more efficiently in the future is important because, as discussed above, some of those toxins could have human health implications.

NWHC-HFS

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Climate Change and Wildlife Health: Direct and Indirect Effects

Climate change will have significant effects on the health of wildlife, domestic animals, and humans, according to scientists. The Intergovernmental Panel on Climate Change projects that unprecedented rates of climate change will result in increasing average global temperatures; rising sea levels; changing global precipitation patterns, including increasing amounts and variability; and increasing midcontinental summer drought (Intergovernmental Panel on Climate Change, 2007). Increasing temperatures, combined with changes in rainfall and humidity, may have significant impacts on wildlife, domestic animal, and human health and diseases. When combined with expanding human populations, these changes could increase demand on limited water resources, lead to more habitat destruction, and provide yet more opportunities for infectious diseases to cross from one species to another.

Awareness has been growing in recent years about zoonotic diseases— that is, diseases that are transmissible between animals and humans, such as Lyme disease and West Nile virus. The rise of such diseases results from closer relationships among wildlife, domestic animals, and people, allowing more contact with diseased animals, organisms that carry and transmit a disease from one animal to another (vectors), and people. Disease vectors include insects, such as mosquitoes, and arachnids, such as ticks. Thus, it is impossible to separate the effects of global warming on wildlife from its effects on the health of domestic animals or people (fig. 1).

Climate change, habitat destruction and urbanization, the introduction of exotic and invasive species, and pollution—all affect ecosystem and human health. Climate change can also be viewed within the context of other physical and climate cycles, such as the El Niño Southern Oscillation (El Niño), the North Atlantic Oscillation, and cycles in solar radiation that have profound effects on the Earth's climate. The effects of climate change on wildlife disease are summarized in several areas of scientific study discussed briefly below: geographic range and distribution of wildlife diseases, plant and animal phenology (Walther and others, 2002), and patterns of wildlife disease, community and ecosystem composition, and habitat degradation.

Geographic Range and Distribution of Wildlife Diseases

In the Northern Hemisphere, global warming has likely played a role in geographic shifts of disease vectors and parasitic diseases that have complex life cycles. For example, the black-legged tick, which carries and transmits Lyme disease and several other tick-borne zoonotic diseases in North America, has been expanding north into southern Ontario (fig. 2) and western Ontario and Manitoba (Ogden and others, 2006), and, more recently, into Quebec and the Canadian Maritime Provinces (Ogden and others, 2005, 2009, and 2010).

Figure 2. Surveillance for the black-legged tick identified a single resident population in 1991 (yellow arrow). Between 1991 and 2003 additional resident populations were reported (black arrows) showing the expanding distribution of the tick in southern Ontario. The red line shows the approximate current temperature limits for the black-legged tick (Ogden and others, 2005). Adapted with permission from the Ecological Society of America and D.H. Ogden, Public Health Agency of Canada.

In Europe, a similar northward expansion of the European castor bean tick, which also carries and transmits Lyme disease, tick-borne encephalitis (TBE), and other diseases, has been reported in Norway (Hasle, 2009) and Sweden (Tälleklint and Jaenson, 1998; Lindgren, 2000). On both continents, migrating birds carrying feeding ticks are likely the source of long-range expansion of the tick vectors (Ogden and others, 2008; Hasle and others, 2009; Brinckerhoff and others, 2011), and increasing environmental temperatures have likely permitted the ticks to become established in larger geographic areas (Lindgren, 2000).

Figure 1. Ecosystem health reflects environmental quality, an important factor in the well-being of humans, domestic animals, and wildlife. Prevention of disease occurring at the interface between these components requires a holistic approach of "one health" for the benefit of all (Friend, 2006). (Drawing by John Evans)

forests in Costa Rica in part through the effect of climate change on the humid leaf litter microhabitat of the forest floor (Whitfield and others, 2007). Weather conditions also significantly affect the microclimates for nests and burrows. For example, in sea turtles, elevated temperatures may lead to altered sex ratios or loss of nesting beaches secondary to sea level rises. Temperatures outside the range of those that turtles can tolerate result in the death of the developing sea turtle embryos (Morreale and others, 1982).

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By Erik Hofmeister, Gail Moede Rogall, Kathy Wesenberg, Rachel Abbott, Thierry Work, Krysten Schuler, Jonathan Sleeman, and James Winton.

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WHISPers—Providing Situational Awareness of Wildlife Disease Threats to the Nation—A Fact Sheet for the Biosurveillance Community

By Bryan J. Richards, Kimberli J. Miller, and C. LeAnn White

Biosurveillance and Wildlife Disease Event Data

Factors such as global trade and travel, urbanization, and agricultural intensification have increased the interactions among diverse wildlife populations, domestic animals, and humans, which have promoted opportunities for the spillover of diseases that can be shared between humans and animals (zoonoses). Today, over 70 percent of emerging zoonotic diseases worldwide originate in wildlife (Jones and others, 2008).

Solutions for emerging infectious disease and bioterror threats can be improved by incorporating integrated biodefense strategies, including improved surveillance for animal and zoonotic diseases, strong national leadership (The White House, 2012), and effective management tools. Active biosurveillance for disease events is key to early detection, warning, and overall situational awareness and enables better communication, coordination, decision making, and data-driven responses. The national biosurveillance infrastructure has well-established channels for human and domestic animal health data through the Centers for Disease Control and Prevention and U.S. Department of Agriculture, and State, county, and local authorities. Wildlife disease information, however, has been more challenging to acquire and access, in part, due to the comparatively small infrastructure and resources dedicated to wildlife health and also because regulatory authority for wildlife and wildlife health is split among Federal, State, Tribal, and indigenous natural resource authorities. To address these issues, the Wildlife Health Information Sharing Partnership-event reporting system (WHISPers; https://whispers.usgs.gov) was developed by the U.S. Geological Survey (USGS) National Wildlife Health Center (NWHC) to promote collaboration and sharing of wildlife health information and to provide situational awareness and timely information about wildlife disease

U.S. Geological Survey and U.S. Department of Agriculture employees partner to investigate and respond to an event of Newcastle disease to minimize its effect on wildlife, domestic animals, humans, and the environment. Photograph courtesy of Paul Wolf, U.S. Department of Agriculture.

Designed surveillance sampling of wildlife allows for early detection of pathogens, such as *Pseudogymnoascus destructans*, the fungus that causes bat white-nose syndrome. Wildlife Health Information Sharing Partnership-event reporting systems contains information on white-nose syndrome mortality and surveillance dating back to 2010. Photograph by Katrien Werner, U.S. Geological Survey.

Beyond Wildlife Disease

WHISPers is a secure, extensible platform the biosurveillance community can use to monitor wildlife disease outbreak information shared by State, Federal, Tribal, and indigenous wildlife health professionals. This unified data stream provides value to the biosurveillance community by creating an understanding of the immediate potential for wildlife related disease risks to humans, domestic animals, and other wildlife. Documenting where disease occurs, which species carry it, its impacts, and changes to the disease over time are also vital to understanding factors that create resilience in wildlife populations. NWHC and other collaborators plan to use WHISPers data to better understand drivers of disease, which is necessary to develop predictive tools and risk mitigation strategies. Long-term WHISPers goals include developing the ability to capture active, targeted surveillance data (in addition to morbidity and mortality data), creating mobile applications and advanced search and data visualization tools, and continuing further development of a national and international partner network to share data about priority pathogens. WHISPers is an integral part of the NWHC strategic science plan for advancing wildlife health science for the benefit of animals, humans, and the environment. To learn more about how WHISPers and the NWHC can be beneficial to your mission, visit our website at https://whispers.usgs.gov/home or contact us at WHISPers@usgs.gov.

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