

**National Park Service Disease Outbreak Investigation Team Harmful Algal Bloom Investigation:
Report to Padre Island National Seashore Superintendent, Joe Escoto**

7 January 2010

Executive Summary

This report documents the harmful algal bloom (HAB) event that occurred at Padre Island National Seashore (PAIS) in October 2009, and describes the ongoing investigation conducted by PAIS personnel, the NPS Disease Outbreak Investigation Team (DOIT), and numerous collaborators to determine the causes and impacts of terrestrial wildlife and domestic animal mortality and morbidity. Numerous appendices provide additional details. Updates will be provided as additional information is obtained.

In early October 2009, a HAB event occurred along the Texas Gulf Coast. The HAB covered an extensive area and included the entire length of PAIS and beyond. The cause of this particular HAB was a dinoflagellate algae, *Karenia brevis*, which makes a potent neurotoxin (brevetoxin). As a result of the HAB and the associated brevetoxin, millions of dead fish washed ashore at PAIS on 14 October.

Between 4 November and 31 December, 11 coyotes and three domestic dogs died or were euthanized at PAIS or local veterinary clinics due to illness that may have been related to the HAB event. In addition, there were at least six reported sightings of “sick” coyotes along the beaches at PAIS. At least five domestic dogs became ill after visiting HAB-affected beaches; three were treated by veterinarians and recovered, and two recovered without veterinary treatment.

PAIS personnel initially contacted the NPS Wildlife Health Program (WHP) on 17 November for help in submitting coyote samples for diagnostic testing; frequent communications continued for the subsequent two weeks. As the number of potentially related cases increased, and as visitor pet health became a concern, it became apparent that a more extensive investigation was warranted. On 1 December, PAIS officially requested the assistance of the NPS Disease Outbreak Investigation Team (DOIT) to help investigate the unusual illnesses and deaths. The DOIT is comprised of personnel from the NPS WHP and NPS Office of Public Health (OPH), who work together using a One Health approach to investigate wildlife and human disease outbreaks. Core members of the DOIT are a medical epidemiologist and an environmental health specialist from the OPH, and a wildlife veterinarian from the WHP. Additional team members may be recruited from a variety of NPS disciplines as the situation dictates.

Through the collaborative efforts of PAIS personnel, the DOIT, and state personnel (primarily from California, Florida, and Texas), the following results were obtained and actions were taken.

Key Results:

- Coyotes and domestic dogs continued to be affected long after the HAB-related fish kill of 14 October; the most recent coyote carcass was found on 29 December, and a dog apparently became ill on 18 December.
- All of the animals observed prior to death exhibited neurological signs, including tremors, severe weakness or paralysis, and seizures. Additional signs often included anorexia, vomiting and drooling.
- Two coyote carcasses and one domestic dog carcass were submitted for necropsy and ancillary tests; a third coyote carcass has been submitted for necropsy, which will be conducted on 7 January.
- Coyote and dog samples contained very high concentrations of brevetoxin, which was likely the cause of death.

- The most likely route of brevetoxin exposure is via ingestion of dead fish, water, or sea foam; other potential routes include ingestion of sand/sediment, trash, or other beach items, however testing of these items has not been conducted.
- Ancillary tests for infectious disease (including rabies and distemper), other toxins, and heavy metals were negative, with the exception of one coyote liver sample, which contained a high mercury concentration.
- Large-scale die-offs of other terrestrial vertebrates were not reported.
- Analyses are pending for additional environmental and biological samples collected by PAIS personnel during and after the HAB event, including samples collected on 29 December. Those samples will provide information regarding the environmental persistence of brevetoxin.
- Besides initial cases of respiratory, nasal, and eye irritation reported among PAIS employees in October, no other PAIS-associated clusters of human illness have been reported to the park or to local/state health departments. The direct human health risks associated with this canid mortality event appear to be low.

Key DOIT Actions:

- Conducted a field investigation at PAIS to:
 - Gain a better appreciation of the geography, topology, and habitat types present at PAIS that might help explain the observed patterns of morbidity and mortality.
 - Meet with local veterinary and public health officials to exchange information and enhance collaborative efforts.
- Helped PAIS establish or strengthen communications and collaborations with a number of local, state and other entities, including:
 - Texas HAB Response Program
 - Texas State Veterinarian, Region 5
 - Cameron County, TX, Department of Health and Human Services
 - Nueces County, TX, Department of Health and Human Services
 - Texas A&M University HAB Researchers
 - Florida Wildlife Conservation Commission HAB Researchers
 - VCA Oso Creek Animal Hospital, Corpus Christi
 - Corpus Christi Veterinary Medical Association Listserve
 - U.S. Centers for Disease Control and Prevention HAB Researchers
- Helped PAIS personnel develop sampling protocols to determine the spatial extent and environmental persistence of brevetoxin (see Appendix F).
- Helped develop standard operating procedures PAIS may follow in the event of another HAB episode (see Appendix G).
- Helped develop precautionary messages and educational information that can be disseminated to the public.
- Established a collaborative relationship with Florida Wildlife Conservation Commission HAB researchers that will produce a peer-reviewed article for publication, with PAIS personnel as co-authors
- Continue to provide assistance to PAIS personnel until the investigation is completed to the Superintendent's satisfaction.

Although the cause of mortality and morbidity in coyotes and dogs in and around PAIS is most likely due to brevetoxin exposure (ingestion), future cases should be evaluated for all potential causes. To ensure adequate evaluation, the DOIT recommends that PAIS continue to submit appropriate carcasses so that full necropsies and sampling can be accomplished. In addition, appropriate environmental and biological samples (e.g. sand, water, and fish) should be collected and submitted, or frozen until they can be analyzed, so that the spatial extent and persistence of brevetoxin can be determined.

Because of the recent additional coyote death and domestic dog illness, it is likely that wild and domestic canids are still at risk for brevetoxin exposure, and the DOIT would be supportive of management actions to keep dogs off the beaches at PAIS. The DOIT recognizes, however, that PAIS management personnel must carefully consider other factors, including visitor enjoyment and legal responsibilities, when making such an important decision. The DOIT stands ready to provide additional assistance to PAIS management as new information is obtained, and as the current situation evolves.

The DOIT would like to express its thanks to all of the PAIS personnel who have provided valuable input to this investigation, especially Jim Lindsay, Wade Stablein, and Cheyenne Nevada. Cheyenne's untiring work and attention to detail continue to improve our knowledge of the extent and persistence of this unique event. We would also like to thank Superintendent Joe Escoto for making this DOIT investigation possible.

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Background

Harmful algal blooms (HABs, also known as “red tides”) occurring in the Gulf of Mexico were first described in Florida in 1935¹ and, since 1986, have been observed frequently along the Texas coast.² These naturally occurring phenomena are caused by dense algal blooms, most commonly due to the dinoflagellate *Karenia brevis* which produces a potent neurotoxin (brevetoxin) which can kill large numbers of fish, birds, and marine mammals. Brevetoxin-associated toxicity in dogs and other terrestrial mammals has been suspected during previous HAB events in the Gulf of Mexico;⁴ however, this has usually not been verified by laboratory testing.

In humans, brevetoxins are associated with 2 distinct, but typically mild, clinical syndromes: 1) neurotoxic shellfish poisoning, which presents as gastroenteritis with neurologic symptoms after consumption of contaminated shellfish, and 2) exposure to aerosolized brevetoxin which may cause runny nose, watery eyes, and/or respiratory irritation.³ Both of these illnesses typically resolve within 72 hours and do not require specific treatment.

In October 2009, a possible HAB was observed off the coast of Padre Island National Seashore (PAIS) and was later confirmed to be caused by *K. brevis* based on water testing by the Texas Parks and Wildlife Department (TPWD). Respiratory irritation was reported by several employees, and a massive fish kill (estimated at tens of millions of fish) was observed starting on October 14 along the entire 60-mile length of PAIS. Affected fish species included mullet, eels, ladyfish, and red drum; no fish were collected for testing. Visual reports of HABs continued to be reported from PAIS until early November.

PAIS Surveillance

Surveillance for wildlife morbidity and mortality surveillance at PAIS is primarily passive, and is generally limited to beaches only. Vehicles are not allowed access to the grasslands, wetlands, and dunes that make up a majority of the island, except via the few roads that lead to mineral extraction maintenance sites. In addition, access to bayside beaches is difficult due to the shallow water conditions that exist. As a result of this inaccessibility, the vast majority of the island area, including the bayside beaches, cannot be regularly monitored.

Prior to the fish kill of 14 October, active surveillance for wildlife morbidity and mortality at PAIS consisted of weekly monitoring by the Sea Turtle Research Group. Once per week, the designated employee drove the entire length of the beach at PAIS, looking for sea turtles and/or their signs. This person discovered the first two coyote carcasses during her weekly patrol on 4 November, and has discovered a number of additional carcasses since then.

Immediately after the HAB-associated fish kill on 14 October, it was very difficult for PAIS personnel to drive along the beach, due to the number of fish on the beach. The fish created a physical barrier to driving and also posed a significant risk of punctured vehicle tires. On 16 October PAIS employees collected water samples at 10-mile intervals along the beach.

Collection efforts at that time were hindered by the presence of aerosolized HAB products that caused acute, moderate-severe respiratory system signs in at least one employee.

Currently, no additional systematic active surveillance is in place to monitor the beaches at PAIS. However, seashore personnel from all departments have been asked to remain vigilant to unusual wildlife illnesses or mortality, and have been asked to report any such findings to resource management personnel. The ongoing Sea Turtle Research monitoring efforts continue to be a primary source of new information. Discussions have been held with local fishing and other user groups, and they have also been asked to report unusual events to PAIS personnel. A number of reports have previously been submitted to PAIS from those user groups.

Resource management personnel have established an active surveillance program with the local veterinary community, for reporting of suspect brevetoxin cases. A number of local clinics are called on approximately a weekly basis, and many have been asked to collect and save urine samples from potentially affected dogs, so the samples can be tested for brevetoxin. In addition, PAIS personnel and Wildlife Health Program veterinarians have been added to the local veterinary listserve and discussion group, so electronic correspondence can be maintained. In addition, PAIS personnel are in contact with local public health officials on a regular basis, to monitor for unusual human cases of brevetoxin-related illness.

PAIS Sample Collections and Test Results

PAIS personnel have collected, and are continuing to collect, a variety of samples since the HAB event started in October. A protocol for sampling is presented in Appendix F. A large number of environmental and biological samples (e.g. sand, water, fish, and dog urine) were submitted to collaborators in Florida on 4 January; test results are pending.

On 16 October, immediately after the fish kill, water samples were collected, so the State of Texas could test for HAB organisms (*K. brevis* primarily). Those samples have been stored and have not yet been analyzed by the State.

To date, PAIS has been able to collect and submit for necropsy three coyote carcasses and one domestic dog carcass. The first coyote was submitted 23 November; a full necropsy was performed at the Colorado State University (CSU) Diagnostic Laboratory by a CSU veterinary pathologist and two WHP wildlife veterinarians. The first coyote was in good body condition, and there were no external signs suggestive of a cause of death. The second coyote carcass had been scavenged and most internal organs had been removed, so only brain tissue was tested. A necropsy on the third coyote will be conducted at CSU on 6 or 7 January. The dog carcass was in similar condition as the first coyote, and a necropsy was done by the CSU veterinary pathology service.

In addition to standard histological testing of tissues, a number of ancillary tests were conducted when samples were available, in order to fully investigate the cause of death (Appendix D). Ancillary tests were included for infectious diseases, a number of toxins whose effects include neurological signs, and heavy metals. Ancillary tests were conducted at the CSU Diagnostic Laboratory, the California Animal Health and Food Safety Laboratory-Davis (Dr. Poppenga), and the Florida Fish and Wildlife Research Institute (Florida Wildlife Conservation Commission; Drs. Flewelling and Landsberg). Almost all ancillary tests were negative; stomach, liver, and

kidney samples from the coyote and dog were strongly positive for brevetoxin, and a coyote liver sample also contained a very high concentration of mercury. The significance of the latter finding is unknown, but is under investigation.

Although the cause of mortality and morbidity in coyotes and dogs in and around PAIS is most likely due to brevetoxin exposure (ingestion), future cases should be evaluated for all potential causes. To ensure adequate evaluation, until further notice, the WHP recommends that PAIS continue to submit appropriate carcasses so that full necropsies and sampling can be accomplished. In addition, appropriate environmental and biological samples (e.g. sand and fish) should be collected and submitted, or frozen until they can be analyzed, so that the spatial extent and persistence of brevetoxin can be determined.

Summary of Wildlife Health Program, Office of Public Health, and Disease Outbreak Investigation Team Activities

On 17 November 2009, PAIS personnel contacted the NPS Wildlife Health Program (WHP) to report and discuss an unusual coyote mortality event. At that time PAIS was primarily seeking information regarding how to submit coyote carcasses to WHP for necropsy and additional analyses, as they began their investigation into the cause(s) of coyote death and illness. Over the next week, PAIS provided WHP personnel with updates, and on 23 November PAIS submitted a coyote that had been euthanized via gunshot on 22 November. A necropsy on that coyote was conducted on 27 November.

On 24 November, PAIS informed the WHP that a group of visitors who were camping on the beach had contacted them to let them know that two of their dogs had become ill after ingesting something found on the beach. Because this report included potential impacts to visitors, WHP personnel contacted the NPS Office of Public Health (OPH) to make them aware of the situation and to seek their input. A conference call was held among WHP and OPH personnel on 27 November; at that time the programs elected to schedule a conference call with PAIS personnel early in the week of 30 November, to address any questions PAIS might have, and to offer additional assistance with the investigation.

During the 30 November conference call, PAIS personnel provided an update on the situation and outlined some of the additional information they hoped to obtain, possibly with the assistance of the WHP and OPH. Capt. Chuck Higgins described the Disease Outbreak Investigation Team (DOIT) and suggested that perhaps the team could be of assistance to PAIS in an official capacity. The DOIT is comprised of personnel from the NPS WHP and NPS Office of Public Health (OPH), who work together using a One Health approach to investigate wildlife and human disease outbreaks. Core members of the DOIT are a medical epidemiologist and environmental health specialist from the OPH, and a wildlife veterinarian from the WHP. Additional team members may be recruited from a variety of NPS disciplines as the situation dictates. In a subsequent phone conversation with Capt. Higgins, PAIS superintendent Joe Escoto requested DOIT assistance. A charge for the DOIT was drafted and then signed by Mr. Escoto, and the DOIT made plans to conduct a field investigation at PAIS (see Appendix E for the charge document). The primary goals for the DOIT were to:

- Use field and laboratory methods to investigate the cause(s) of death, the species involved, and other epidemiologic aspects of the outbreak;

- Determine any human health effects associated with this incident;
- Coordinate communication with Texas Department of Parks and Wildlife, Texas Department of State Health Services, Texas State Veterinarians office (Region 5), local/county health departments, clinical providers, diagnostic laboratories, as well as with internal staff including PAIS personnel, Intermountain Region personnel (Pam Benjamin, lead), Office of Public Health, Biological Resource Management Division, Environmental Quality Division, and Risk Management Division;
- Provide a report of activities, results, and recommended best practices to protect human, wildlife, and domestic animal health.

On 1 December, DOIT members started arriving at North Padre Island to begin their field investigation. On 2 December K. Castle participated in a survey designed by PAIS personnel to look for evidence of unusual wildlife mortality and morbidity beyond the beaches. A total of 15 people took part in the survey (see Appendix A for a list of participants, and Appendix C for the survey protocol and a map of the survey area). The survey covered an area west of the beach/dune interface approximately 200 m wide and 42 km (25 mi) long. Despite the large area covered by the survey, the only carcass discovered was that of a fox, which consisted primarily of skin and bones, and was not recovered. No moribund animals were observed.

Additional DOIT members (J. Bryan, A. Kramer, and D. Wong) arrived on North Padre Island the evening of 2 December. In the morning of 3 December, the DOIT met with PAIS personnel to discuss the recent events and to obtain additional local contact information. In addition, team members toured the beaches and areas beyond the dunes, in order to gain a better appreciation of the geography, topology, and habitat types present at PAIS. During the tour, the groups hiked along the dunes and drove along inland maintenance roads to mineral extraction stations. At one of the stations, employees of a mineral extraction company provided information regarding a recently observed sick coyote seen along one of the maintenance roads. No carcasses were seen during the tour, however one apparently healthy coyote was observed running away from the vehicles.

Just prior to a scheduled meeting with PAIS personnel during the afternoon of 3 December, the DOIT received test results which indicated that the first coyote submitted by PAIS had very high levels of brevetoxin in its stomach, liver, and kidney (see Appendix D). Brevetoxin ingestion was therefore the likely cause of death in that animal. During the meeting, the DOIT summarized and discussed their findings and made short-term recommendations for incident management and additional surveillance and sample collection. The topic of beach closures was discussed. At that time, because there had been no additional coyote or dog illnesses or deaths reported for one week, and because PAIS warnings to visitors appeared adequate to protect dog health from the risk of brevetoxin exposure, beach closure did not seem warranted. If additional canine deaths or illnesses were reported, the decision to close beaches would need to be reconsidered. An additional topic of discussion during the meeting was to consider how the DOIT could continue to assist PAIS. Below is a summary of PAIS expectations:

- DOIT will help develop protocols for sampling in the near future to help provide information on how the park could continue to investigate the current outbreak. Specifically, DOIT would work with PAIS personnel and outside investigators to design

a sampling scheme to determine how long wildlife and pets may be at risk from brevetoxins associated with the recent HAB event.

- DOIT will work with PAIS to develop a set of standard operating procedures that could be used during future HAB events.
- DOIT will continue to coordinate communication among federal, state, and other entities involved in the investigation.
- DOIT will provide information for, and review of, press releases and visitor education documents, and will help develop precautionary messages to protect visitor and pet health.

On 4 December, DOIT members met with local veterinary and public health personnel, in order to establish contacts, provide information regarding the situation at PAIS, and to help establish active local surveillance for cases of brevetoxin exposure among companion animals. DOIT visited the VCA Oso Creek Animal Hospital in Corpus Christi, and spoke with Drs. Prewitt and Higginbotham, who agreed to help establish a response network with area veterinarians to report and communicate about future disease outbreaks, especially concerning HAB events. DOIT members also visited the Corpus Christi-Nueces County Public Health District, and discussed similar communication possibilities.

Summary of Canine Cases

Between 4 November and 31 December, at least 11 coyotes and three domestic dogs died or were euthanized at PAIS or local veterinary clinics due to illness that may have been related to the recent harmful algal bloom (HAB) event (see Appendix B). In addition, there have been at least six reported sightings of “sick” coyotes along the beaches at PAIS. There is no way to determine if those sightings represent distinct individuals, or whether those coyotes subsequently died or recovered. Five domestic dogs became ill after visiting PAIS or other nearby HAB-affected beaches; three were treated by veterinarians and recovered, and two recovered without veterinary treatment.

Details of Canine Cases

Coyote Mortality

As of 31 December, 11 coyotes have been found dead ($n = 9$) or were euthanized by NPS Law Enforcement personnel ($n = 2$; see Appendix B). The earliest coyote deaths were reported by a member of the PAIS Sea Turtle Research Team while driving the beach during sea turtle surveillance on 4 November; the most recent death was reported by a PAIS employee on 29 December. Locations of the coyotes ranged from mile marker (MM) 0 to MM 59. Three of the coyote carcasses were collected by PAIS personnel and submitted for necropsy. The first coyote, which had been euthanized by NPS LE, yielded numerous viable samples at necropsy for additional testing (see Appendix D). The second carcass submitted had been extensively scavenged, so post-mortem testing was limited to analysis of brain tissue. The third carcass will undergo a necropsy on 6 or 7 January 2010.

Coyote Morbidity

Six live coyote sightings have been reported by visitors and NPS personnel since 12 November; the most recent sighting was 20 December. Sightings ranged from the north end of “closed beach” to near MM 40. In the most recent instance, a visitor offered a coyote with hind limb weakness a bowl of water. The coyote drank from the bowl, and when the visitor returned to the site approximately 2h later, the coyote was not present.

Domestic Dog Mortality

Three dogs are known to have died or were euthanized after becoming ill subsequent to being on a HAB-affected beach in or near PAIS (Appendix B). The first was a terrier that had been admitted to a local veterinary clinic after visiting a beach on or about 11 November. The dog presented to the clinic for vomiting, bloody diarrhea, and tremors. Tremors resolved after treatment with IV fluids, however it was euthanized at the veterinary clinic after several days of additional treatment did not improve its health.

On 23 November, PAIS personnel were contacted by a group of visitors camping on the beach who had four dogs with them. The visitors reported that one of their dogs had become severely ill after ingesting something from the beach, and that two of the other dogs were ill but less severely affected. When the group of visitors was again contacted on 24 November, they told PAIS personnel that they had euthanized via gunshot the dog that had become very debilitated; the owners buried the dog on the side of a dune. The owners led park personnel to the carcass, which was subsequently submitted for necropsy. The owners of that dog left PAIS on 25 November and sought veterinary care for their other dog. That dog, a terrier mix, was hospitalized for five days. The other sick dog associated with that group of visitors, a 5 month old Labrador retriever, recovered without veterinary care; that dog had not been as severely affected as the other two sick dogs in that group.

On 25 November PAIS was contacted by the owner of a 9 month old Labrador retriever that died after visiting North Beach all day on 20 November. The dog had been on a leash the entire time and was not observed eating anything off the beach. Later, the dog began refusing to eat or drink. The animal exhibited vomiting, diarrhea, and seizures. The animal died before it could be taken to a veterinarian.

Domestic Dog Morbidity

PAIS has been made aware of five dogs that became ill while visiting affected beaches or shortly after a visit, but that survived their illness. Two of those dogs were described briefly in the preceding paragraph. Three additional cases are described below.

PAIS received an email message on their website from a citizen whose dog became ill while the owners were fishing from a dock at Yarborough Pass on 10 October. This dog became lethargic and began sneezing while standing on the dock as the owners were fishing. When taken away from the pier, placed in the owner’s truck, and exposed to “fresh” air, the dog recovered rapidly. It is noteworthy that this episode occurred before the massive fish kill on 14 October.

On 6 December a PAIS employee took her dog to the beach at Bob Hall Pier, which is just north of the Seashore boundary. During the 20 minute visit, while accompanying her owner near the dunes and pavement, the dog was observed eating a dead fish. Within 1.5 hours, the dog became acutely ill with neurological signs (weakness, tremors, and seizures) and was taken to a veterinary clinic for emergency treatment and hospitalization. The dog was discharged from the hospital 4 days later, and continued to exhibit seizure activity, generalized weakness, and ataxia before making a full recovery.

On 22 December PAIS was notified that a dog that had visited the beach near Bob Hall Pier on 18 December had been hospitalized for acute onset of vomiting, weakness in its hind legs, and lethargy. The dog had been walking on the beach with its owner and another dog, and had not been observed to have drunk or eaten anything during the walk. It had waded into the water briefly; the dog that did not become ill had not entered the water. After 20 minutes on the beach, the dog vomited twice and became lethargic. The next day, the dog was able to sit up, but could not stand, so was taken to a veterinary clinic. Test results obtained by the veterinarian at admission were normal, however the following day the dog became febrile, and bloodwork revealed mild anemia and an elevated white blood cell count. On 4 January the owner of that dog contacted PAIS personnel to say that her pet was “doing better and pretty much back to normal”.

Human Cases

Besides the initial cases of respiratory, nasal, and eye irritation reported among PAIS employees, no other HAB-associated human illnesses have been reported to the park. No clusters of human illness (including unexplained neurologic presentations) potentially associated with exposure to PAIS or to HABs have been reported to local/county health departments or to the TDSHS. The direct human health risks associated with this canine mortality event appear to be low.

PAIS Management Responses

24 November

PAIS Superintendent Joe Escoto recommended that park visitors not bring their dogs to the beach, in light of the multiple coyote deaths and reports that visitor dogs had become ill. Notices were placed on the PAIS public website, at the entry station, and at the visitor center. In addition, PAIS personnel informed visitors with whom they made contact.

3 December

The topic of beach closures was discussed at a meeting of DOIT members and PAIS personnel during the DOIT field investigation. At that time there had been no additional coyote or dog illnesses or deaths reported for one week. In addition, the likely cause of illnesses and deaths had just been determined (brevetoxin ingestion) and PAIS warnings appeared adequate to protect dog health from that risk, so beach closure was not warranted. Additional illnesses or deaths would necessitate reconsideration of that decision, and may lead to beaches being closed to pets.

9 December

After becoming aware of additional cases of illness in dogs that had visited HAB-affected beaches in or near the seashore, PAIS instituted a ban on dogs within the park. Notices were placed as above, and visitors arriving at the entry station were told they could not bring their

dogs into the park. Visitors who ignored the ban or who were already within the seashore when the ban went into effect were contacted by PAIS law enforcement or other personnel. Citations were not issued, however contact information was obtained for each visitor, and the visitors were strongly urged to remove their dogs from the beach to protect the health of their pet.

29 December

PAIS rescinded the ban keeping dogs from beaches. In announcing the decision to lift the ban, PAIS strongly cautioned visitors with dogs that there is still a substantial risk for severe illness and potentially death if dogs are taken to the beach. The announcement recommended that visitors with dogs take precautions, which include keeping dogs on a leash six feet in length or less, and not allowing dogs to eat any dead fish or other marine life found on the beach.

Investigation Results and Continuing Efforts

Through the collaborative efforts of PAIS personnel, the DOIT, and state personnel (primarily from California, Florida, and Texas), the following results were obtained and actions were taken.

Key Results:

- Coyotes and domestic dogs continued to be affected long after the HAB-related fish kill of 14 October; the most recent coyote carcass was found on 29 December, and a dog apparently became ill on 18 December.
- All of the animals observed prior to death exhibited neurological signs, including tremors, severe weakness or paralysis, and seizures. Additional signs often included anorexia, vomiting and drooling.
- Two coyote carcasses and one domestic dog carcass were submitted for necropsy and ancillary tests; a third coyote carcass is en route to the WHP for necropsy as of 4 January.
- Coyote and dog samples contained very high concentrations of brevetoxin, which was likely the cause of death.
- The most likely route of brevetoxin exposure is via ingestion of dead fish, water, or sea foam; other potential routes include ingestion of sand/sediment, trash, or other beach items, however testing of these items has not been conducted.
- Ancillary tests for infectious disease (including rabies and distemper), other toxins, and heavy metals were negative, with the exception of one coyote liver sample, which contained a high mercury concentration.
- Large-scale die-offs of other terrestrial vertebrates were not reported.
- Analyses are pending for additional environmental and biological samples collected by PAIS personnel during and after the HAB event, including samples collected on 29 December. Those samples will provide information regarding the environmental persistence of brevetoxin.

Key DOIT Actions:

- Conducted a field investigation at PAIS to:
 - Gain a better appreciation of the geography, topology, and habitat types present at PAIS that might help explain the observed patterns of morbidity and mortality.
 - Meet with local veterinary and public health officials to exchange information and enhance collaborative efforts

- Helped PAIS establish or strengthen communications and collaborations with a number of local, state and other entities, including:
 - Texas HAB Response Program
 - Texas State Veterinarian, Region 5
 - Cameron County, TX Department of Health and Human Services
 - Texas A&M University HAB Researchers
 - Florida Wildlife Conservation Commission HAB Researchers
 - VCA Oso Creek Animal Hospital, Corpus Christi
 - U.S. Centers for Disease Control and Prevention HAB Researchers
- Helped PAIS personnel develop sampling protocols to determine the spatial extent and environmental persistence of brevetoxin (see Appendix E).
- Helped develop standard operating procedures PAIS may follow in the event of another HAB episode (see Appendix F).
- Helped develop precautionary messages and educational information that can be disseminated to the public.
- Established a collaborative relationship with Florida Wildlife Conservation Commission HAB researchers that will produce a peer-reviewed article for publication, with PAIS personnel as co-authors
- Continue to provide assistance to PAIS personnel until the investigation is completed to the Superintendent's satisfaction.

References

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APPENDIX A

List of Contacts and Participants

<u>Name</u>	<u>Affiliation</u>	<u>State</u>
Poppenga, Dr. Robert	California Animal Health and Food Safety Laboratory System	CA
Reich, Mr. Andy	Aquatic Toxins Coordinator, Florida Dept of Health	FL
Bolton, Birgit	CDC HABISS, National Center for Environmental Health	FL
Backer, Dr. Lorrie	CDC HABISS, National Center for Environmental Health, Team Leader	FL
Goff, Dr. Kendra	Florida Department of Health, Toxicologist	FL
Stanek, Dr. Danielle	Florida Department of Health, Medical Epidemiologist	FL
Dickey, Dr. Robert	FDA Dolphin Island Lab	FL
Flewelling, Dr. Leanne	Florida Fish and Wildlife Commission-Marine Toxin Expert	FL
Landsberg, Dr. Jan	Florida Fish and Wildlife Commission-Marine Toxin Expert	FL
Fleming, Dr. Lora	Professor, Univ. of Miami; Director, Center for Oceans and Health	FL
Byrd, Meredith	Texas Parks and Wildlife, HAB Response Coordinator	TX
Nunez, Alex	Texas Parks and Wildlife, HAB Response	TX
Salinas, Yvette	Cameron County, Texas; Health Administrator for DHHS	TX
Simmons, Linda	Corpus Christi-Nueces County, Texas; Public Health District	TX
Zimbra, Dr. Paul	Center for Coastal Studies, Texas A&M University, Corpus Christi	TX
Guererro, Dimitra	PAIS-Administration	TX
Aldrich, Chelsea	PAIS-Interpretation	TX
Rodriguez, Juan	PAIS-Interpretation	TX
Connolly, Dominique	PAIS-Law Enforcement	TX
Madera, Grisel	PAIS-Law Enforcement	TX
Cowan, Craig	PAIS-Maintenance	TX
Talip, Roger	PAIS-Maintenance	TX
Lindsay, James	PAIS-Chief of Resources	TX
Nevada, Cheyenne	PAIS-Resources	TX
Stablein, Wade	PAIS-Resources	TX
Swanson, Katie	PAIS-Resources	TX
Larkin, Hugh	PAIS-V.I.P.	TX
Larkin, Sandy	PAIS-V.I.P.	TX
Stedronsky, Judy	PAIS-V.I.P.	TX
French, Johnny	PAIS-Volunteer	TX
Sandifer, Billy	Concessioner-PAIS	TX
Allred, Dr. Carie	Staff veterinarian, VCA Oso Creek Animal Hospital	TX
Higgenbotham, Dr. Laurie	Staff veterinarian, VCA Oso Creek Animal Hospital	TX
Prewitt, Dr. Pam	Staff veterinarian, VCA Oso Creek Animal Hospital	TX
Tennant, Dr. Michael	TX Dept. State Health Services, Seafood and Aquatic Life Group	TX
Prozenzano, Dr. Danielle	Texas Sea Grant	TX
Reisinger, Dr. Tony	Texas Sea Grant	TX
Young, Dr. John	Texas Parks and Wildlife Department, Wildlife Biologist	TX

Leonarduzzi, Dr. James
Trainer, Dr. Vera

Texas State Veterinarian's Office, Region 5
Marine Biotoxin Group (NOAA), Program Manager

TX
WA

APPENDIX B

Coyote and Dog Cases

Coyote mortality and morbidity; the outcome for all sick coyotes is unknown.

Date	Condition Found/Outcome	Location
11/4/2009	Dead	32 Mile Marker
11/4/2009	Dead	50MM
11/12/2009	Dead	9MM
11/13/2009	Dead	19.6MM
11/19/2009	Dead	~40MM
11/23/2009	Dead	16MM
11/27/2009	Dead	25MM
11/29/2009	Dead	43MM
12/29/2009	Dead	44MM
1/10/2010	Dead	Campgrounds
11/21/2009	Alive-Euthanized	0MM
11/22/2009	Alive-Euthanized	59MM
11/17/2009	Sick	Not Reported
12/6/2009	Sick	~30MM
12/20/2009	Sick	N. End of Closed Beach
Unknown	Sick	42MM
Unknown	Sick	Not Reported
Unknown	Sick	S. of 20MM (~40's)

Domestic dog mortality and morbidity.

Date	Condition Found/Outcome	Animal	Location
11/11/2009	Alive-Euthanized	Dog	Not Reported
11/20/2009	Died	Labrador	N. End of Closed Beach
11/22/2009	Alive-Euthanized	Labrador	20MM
10/10/2009	Sick-Recovered	Dog	Yarborough Pass Pier
11/22/2009	Sick-Recovered	Labrador	20MM
11/22/2009	Sick-Recovered	Terrier Mix	20MM
12/6/2009	Sick-Recovered	German Shepherd	Bob Hall Pier
12/18/2009	Sick-Recovered	Schnauzer	Bob Hall Pier

APPENDIX C

PAIS Dune Survey Protocol and Map

Canid Illness 2009 – Dune Survey

December 2, 2009

Padre Island National Seashore, Texas

Objective

To locate mammalian and avian species in the dunes that may be associated with unknown illness that is causing coyotes and domestic dogs to be found sick or dead in the park. Semi-fresh animal carcasses will be collected for analysis. Animals that are too far decomposed will be buried to prevent double documentation.

Equipment

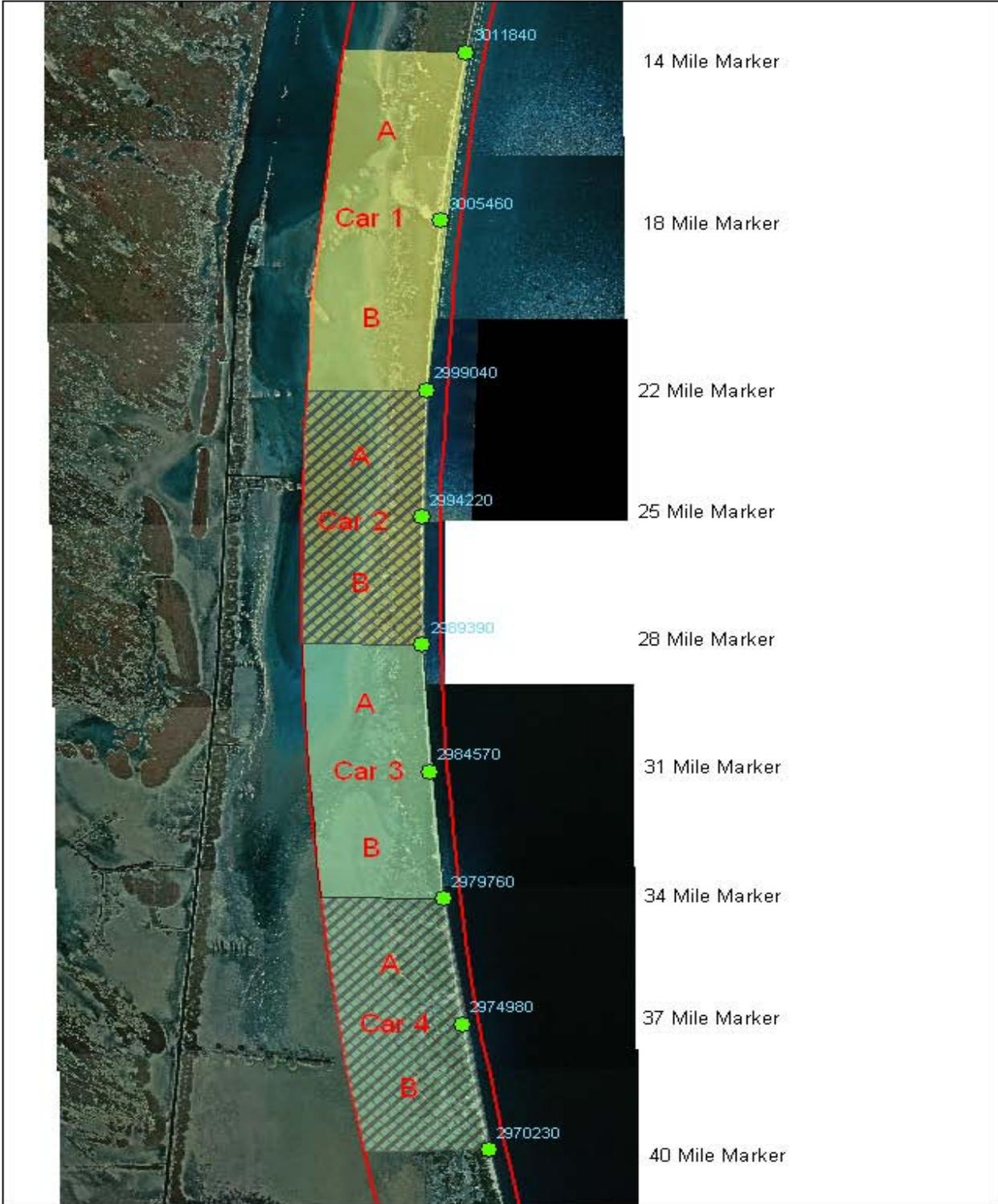
Binoculars, Bug Repellent, Cameras, Gloves, Goggles, GPS's, Hand Sanitizer, Masks, Pin Flags, Plastic Bags, Radios, Shovels, Sunscreen

Method

- Three or four mile southerly transects (dependent on starting position) within the dunes will be walked by a team made up of two people, starting off from specific locations along the Gulf beach.
- Two teams will be associated to one vehicle. (Team A and Team B)
- Team A will be dropped off at a starting point to begin their survey, where Team B will continue down island to begin survey from Team A's survey end point.
- When Team A begins their survey (except northern most car), they will mark their starting point by placing a stake with flagging attached. This will provide reference for a complete survey.
- When Team A completes their survey, they will pick up vehicle to rendezvous with Team B at the end of their survey. Keys need to be left in vehicle's gas compartment by Team B for Team A.
- Surveyor 1 will begin 50 meters (~60 paces) to the west from top of first dune, where Surveyor 2 will begin 100 meters (~120 paces) west from Surveyor 1. This will allow for a 200 meter swath to be surveyed with 50 meter to each side of each surveyor.
- Surveyor 1 and Surveyor 2 will walk evenly in a southerly direction.
- Any animal carcass that is identified will be recorded by GPS and photo documentation. Animal carcass will be pinned flagged or bagged by park personnel and brought to edge of dunes to be collected at later time. Other items of management concern such as archaeological or natural resource finds should also be recorded and flagged. Items flagged can be picked up, if appropriate, by most southerly truck returning at end of day.
- Animal carcasses that are too far gone for analysis (skin and bones) should also be recorded by GPS and photo documentation.

Safety

- Only trained park personnel wearing appropriate PPE should handle sick or dead animals. A FWS permit is required for transport of animals and should only be done by those on park's permit.
- STAY IN VISUAL CONTACT WITH OTHER SURVEYOR ON TEAM.
- Dress in layers.
- Please use provided sunscreen and bug repellent.
- Bring a lunch, snack, and drink plenty of fluids.
- The dune topography can be difficult to walk in. Please take breaks as needed to prevent fatigue. Injuries are most likely to occur when someone is tired.



APPENDIX D

Test Results

Test	Labrador Retriever	Coyote #1	Coyote #2
Rabies	Negative	Negative	Negative
Distemper	Negative	Negative	Negative
Toxoplasma (histology)	Negative	Negative	No samples
Heartworm	Negative	Positive ⁴	No samples
Botulinum	? ¹	Negative	No samples
ACh Inhibition ²	?	Normal	?
Strychnine	Negative (stomach)	Negative (stomach)	No samples
Cyanide	Negative	Negative	No samples
Bromethalin rodenticide	Negative	Negative	No samples
Carbamate pesticide	Negative	Negative	No samples
Organophosphate pesticide	Negative	Negative	No samples
Arsenic	?	Non-toxic level	No samples
Lead	?	Non-toxic level	No samples
Mercury	0.13 ppm (Liver)	Positive 16.6 ppm (Liver)	No samples
Metaldehyde	?	?	No samples
Zn Phosphide	Negative	Negative	No samples
Brevetoxin Stomach ³	Positive 330 ng/g	Positive 128 ng/g	No samples
Brevetoxin Liver ³	Positive 545 ng/g	Positive 216 ng/g	No samples
Brevetoxin Kidney ³	Positive 143 ng/g	Positive 170 ng/g	No samples

Explanations:

1. ? in a cell means that the test result is pending, results were equivocal, or insufficient sample was available for testing
2. Ach Inhibition = Acetylcholinesterase inhibition, which is a test run on brain tissue to determine if certain pesticides have disrupted nervous system function.
3. For comparison, concentrations of brevetoxin in marine mammals previously tested were:
 - Dolphins: Liver = 51 ng/g, Kidney = 26 ng/g
 - Manatees: Liver = 120 ng/g, Kidney = 30 ng/g
 - Stomach contents of those species (usually full of food) are typically much higher (hundreds of thousands of ng/g)
4. The first coyote's heart contained numerous adult heartworms, but not enough to have been the cause of death.

APPENDIX E

DOIT Charge



United States Department of the Interior
NATIONAL PARK SERVICE
Biological Resource Management Division

1201 Oakridge Drive, Suite 200

Fort Collins, CO 80525

IN REPLY REFER TO:

N1615(2340)

1 December 2009

MEMORANDUM

To: Joe Escoto, Superintendent, Padre Island National Seashore

From: CAPT Charles Higgins and Dr. Margaret Wild, DOIT Supervisors

Subject: Activation of NPS Disease Outbreak Investigation Team

As joint supervisors of the National Park Service Disease Outbreak Investigation Team (DOIT), we have approved your request to activate the Team. The Team will address the ongoing outbreak of coyote and domestic dog deaths that have occurred in the park since the first week of November 2009. Core team members are wildlife veterinarian Dr. Kevin Castle (team leader), medical epidemiologist CDR David Wong, and environmental health officer LCDR Adam Kramer. Additional team members are wildlife veterinarians Jenny Powers and John Bryan.

For this assignment, the specific charge to the DOIT is to:

- Use field and laboratory methods to investigate the cause(s) of death, the species involved, and other epidemiologic aspects of the outbreak;
- Determine any human health effects associated with this incident;
- Coordinate communication with Texas Department of Parks and Wildlife, Texas Department of State Health Services, Texas State Veterinarians office (Region 5), local/county health departments, clinical providers, diagnostic laboratories, as well as with internal staff including PAIS personnel, Intermountain Region personnel (Pam Benjamin, lead), Office of Public Health, Biological Resource Management Division, Environmental Quality Division, and Risk Management Division;
- Provide a report of activities, results, and recommended best practices to protect human, wildlife, and domestic animal health.

All WASO personnel salary and travel expenses, and disease diagnostic costs incurred as part of this response will be funded by the Office of Public Health and Biological Resource Management Division. Other costs, e.g., management actions, will be agreed upon in advance by the park, region, and DOIT.

APPENDIX F

Suggested short-term sampling protocol

Canine Illness 2009 – Sampling Plan (Brevetoxin). This is a modification of a protocol originally written by PAIS Natural Resource Management personnel. The actual number of sites and samples collected per site may differ from this based upon availability, logistics, and cost of testing.

Objective

To locate fish and eel species on the beach that may be associated with the illness that is causing coyotes and domestic dogs to be found sick or dead in the park. Decaying fish and eel will be collected for analyses. In addition, fresh dead fish, water samples, and sand/sediment samples will be collected, in order to provide a comparison to decaying fish and to samples previously analyzed.

Questions to be addressed:

- Can we make a reasonable connection between toxin presence in fish and water, and toxin found in the coyote and dog samples?
 - Using samples previously collected by PAIS and the state of Texas. These include water, sediment/sand, vertebrates and invertebrates.
 - Using samples collected now, two months after the event.
- Can we determine if toxin is still present and therefore continues to pose a threat to terrestrial animals?
 - Using decayed fish samples.
 - Using fresh fish and water samples.

Equipment

Gloves, Goggles, Mask, GPS's, Plastic bags, Whirl-pac bags, Specimen cups, Sharpies, Shovels, Radios, Hand Sanitizer, Sunscreen, Bug Repellent, Cooler with ice packs.

Method

- Decaying fish will be collected from three sites on the beach. Collections can continue on a weekly basis, however we will base additional lab submissions on results of the first sampling period.
 - The sites will be chosen based upon: high visitor and dog use; proximity to coyote and dog mortality and illness; concentration of dead fish during the red tide event.
- At each site:
 - the surveyor will search for and collect 6-8 decaying fish and eels on the surface and also below the surface of the beach, where fish from the initial die-off are most likely to be found. Ideally, an equal number of fish and eels will be collected at each site.
- Up to three small, fresh fish/eels will be collected per site.

- 250 ml of water will be collected from the surf zone at each site, and a similar volume of sand will be collected. Fish carcasses will be **bagged individually** and labeled; sand and water samples will be placed into an appropriate container (e.g. whirl pac, specimen cup, centrifuge tube). All samples will be immediately placed on ice packs in the field.
- A GPS point will be recorded at each site.
- Samples will be placed into the specimen freezer upon return to PAIS headquarters, and will need to remain frozen until and during shipping.

APPENDIX G

Recommendations For Future Harmful Algal Bloom (HAB) Events at PAIS

If a HAB event occurs in or near PAIS, especially if associated with a massive fish kill, it is probably safe to assume that pets and wildlife are at high risk for exposure, and that people may also be affected. During red tide events, known risks for human disease include: 1) consuming contaminated shellfish which can lead to gastrointestinal and neurologic symptoms and 2) exposure to aerosolized red tide toxin(s) which may cause runny nose, watery eyes, and/or respiratory symptoms. Both of these illnesses typically resolve within 72 hours and do not require specific treatment. If the illnesses are severe or persistent, medical help should be obtained.

I. Continue SOP development to enhance surveillance during next HAB event, and to protect human and animal health:

- Request that all users (visitors, mineral company employees, all PAIS employees) report any unusual events and make it easy for them to do so.
- Consider additional day(s) where someone drives the length of the beaches. Perhaps Monday would be a good day to add, since that would allow adequate time for any samples to be submitted to a cooperating lab that same week.
- Enhance coordination with Texas HAB personnel (Meredith Byrd and Paul Zimba especially). Collaborate on sample collection and submission.
- Continue coordination with the local veterinarians and public health officials.
- Produce informational brochures for future events

II. Provide information for visitors with pets (primarily dogs, however cats could potentially be at risk if they are allowed beach access):

- Key Facts to include in an announcement and/or a brochure:
 - At least __ coyotes and __ dogs have died subsequent to the recent “red tide” event that affected Padre Island National Seashore.
 - Test results definitively show that brevetoxin exposure killed (or has caused illness in __); it is very likely that the additional ____ deaths and illnesses were also due to brevetoxin.
 - Brevetoxin poisoning may occur from eating or licking dead/decaying fish or other items on the beach, or by exposure to water, foam, or sand/sediment.
 - Toxin exposure and clinical signs can occur after very limited time on the beach (20 minutes in one case), and in pets under close observation.
- Please keep your dog on a leash at all times.
- Do not let your dog dig into the sand or pick up/lick any item from the beach, including sticks, shells, carcasses, or trash.
- Do not allow your dog to drink from the surf or from pools of water on the beach.
- A basket muzzle may keep your dog from picking up items from the beach, however most basket muzzles are designed to allow a dog to drink or lick, which could lead to exposure. Other muzzle types are not recommended.
- If you suspect that your dog has picked up or licked any item on the beach, rinse its mouth with copious amounts of fresh water.

- If you believe that your dog has swallowed or licked an item, rinse its mouth as above, keep it off the beach, and watch closely for the following signs (which usually start within 12-24 hours, sometime much sooner):
 - Excessive drooling
 - Vomiting
 - Lethargy or reluctance to move
 - Decreased appetite
 - Weakness in any limb or an inability to hold the head up normally
 - Head or body tremors, seizures, or other abnormal neurological signs
 - Respiratory difficulty
 - Any other behaviors or physical signs that you feel are abnormal for your dog

- If any of those signs appear, or if you are at all concerned, please contact a veterinarian immediately. Keep in mind that dogs showing the above signs may be ill from causes other than brevetoxin exposure, and some of those causes can be equally serious.

- There is no specific “antidote” for brevetoxin poisoning, and there is no rapid test to detect the toxin, so veterinary care is generally supportive and may include:
 - Induction of vomiting (if appropriate; if certain sharp items are ingested, vomiting is NOT recommended)
 - Administration of a gastrointestinal toxin-binding agent
 - Hospitalization with intravenous fluid therapy
 - Intravenous or oral gastrointestinal protection medication
 - Anti-seizure medication and/or sedation
 - Testing for other causes of illness

- Each case is unique, and only a veterinarian can determine the appropriate course of testing and treatment for each patient. Veterinary therapy does not guarantee a successful outcome, however in most cases it greatly increases the chances of survival.