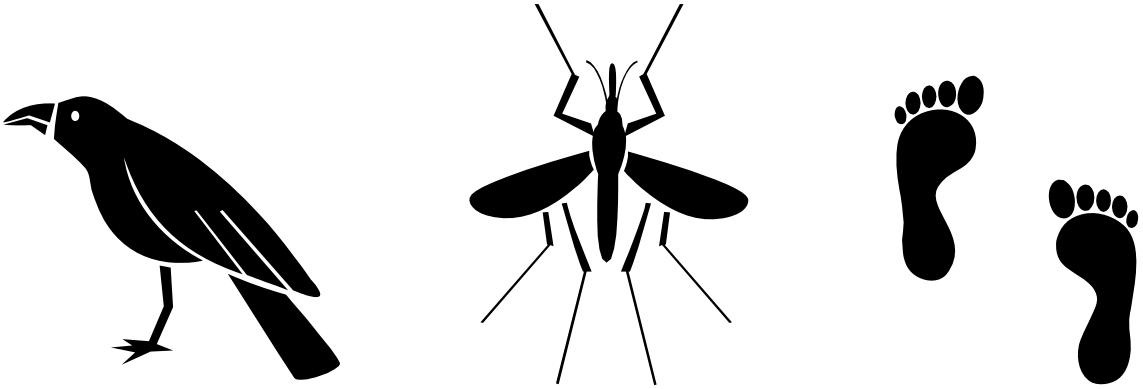
West Nile Virus Activity in British Columbia: 2010 Surveillance Program Results



Epidemiology Services
British Columbia Centre for Disease Control
www.bccdc.ca/westnile

Executive Summary

Only one human case of West Nile Virus (WNV) infection (non-neurological syndrome) was reported in 2010; the infection was most likely acquired in the central Okanagan. Five corvids – 4 crows and one magpie also tested positive, and all were from the central Okanagan. This indicates establishment of WNV in both the south and central Okanagan Valley. No positive mosquito pools and no horses were reported positive in BC in 2010. As in 2009, WNV activity was low in the rest of Canada with only 4 human cases reported from three other provinces (Table 1).

While activity was greater in 2010 compared to 2009 in the Unites States, there were relatively few human cases of WNV (Table 1) with focal clusters primarily in two states. Washington State had much lower activity in 2010 than in 2009, its peak year for WNV activity to date (Figure 1).

Table 1: Human WNV Infections in North America, 2004-2010

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Canada	20	239	127	2,353	36	8	5
United States	2,344	2,949	4,052	3,404	1,301	515	972

Sources: (PHAC, as of October 23, 2010 and CDC, as of December 7, 2010)

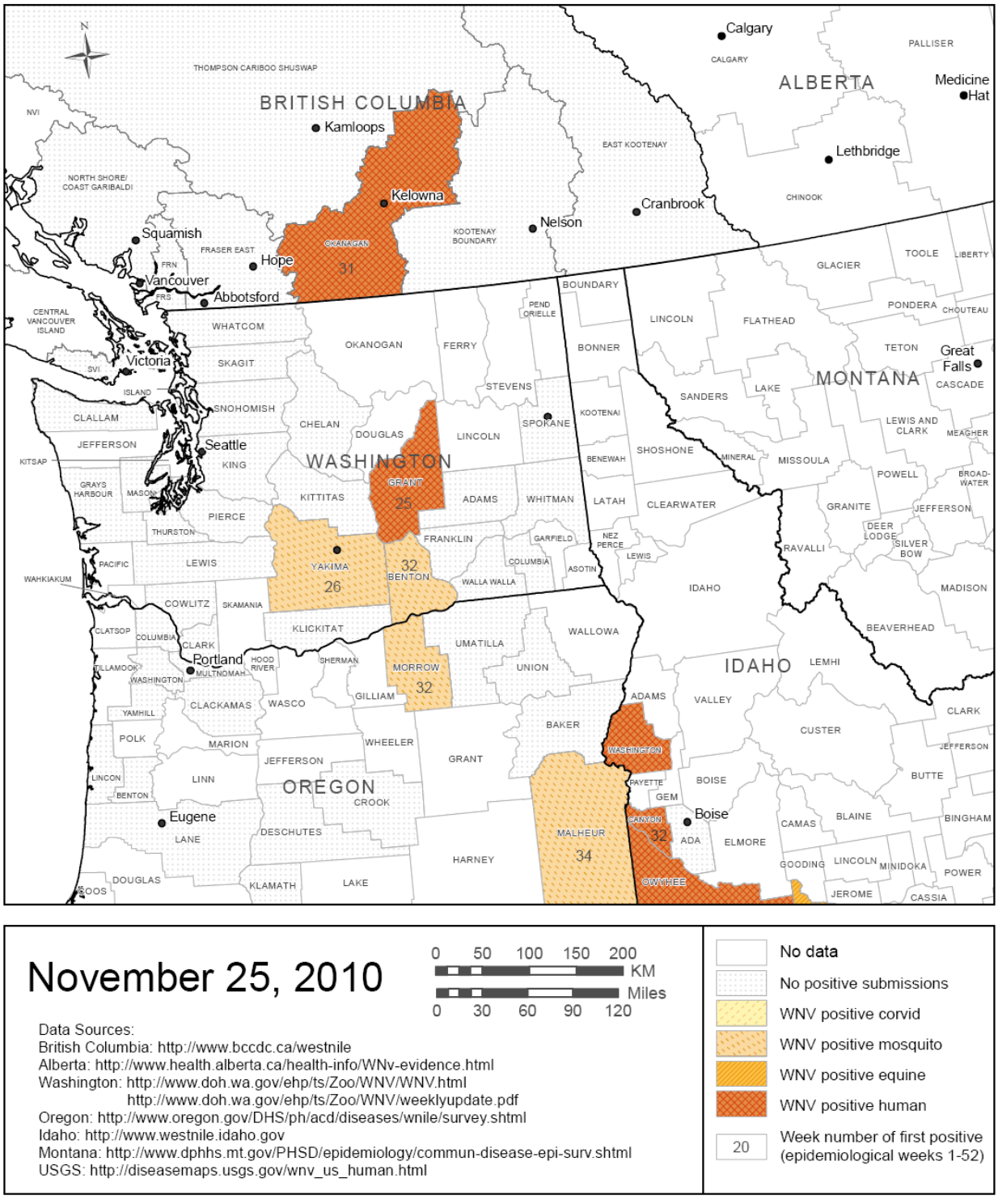
Corvid and mosquito surveillance in 2010 was focused on the higher risk areas of the province including Richmond, Fraser Health Authority (FHA), particularly the Fraser Valley and Interior Health Authority (IHA), particularly the south and central Okanagan (Figure 4).

Two hundred and thirty-three corvids were collected for testing in 2010, an increase over the 2009 total of 144. Increases in submissions were from the central Okanagan, Thompson region and the Fraser Valley-Lower Mainland area. The number of dead birds reported online (355) was down from the number reported in 2009 (398).

Overall the number of mosquitoes trapped was up from last year, likely reflecting the mild winter and wet spring conditions. The average number of *Culex pipiens* trapped (23.7/trap-night) was very similar to 2009 (21.1/trap-night), but the average number of Cx*. tarsalis* was fewer in 2010 (4.9/trap-night) vs. 2009 (11.8/trap-night).

In addition to surveillance activities, in 2010 the BC Centre for Disease Control (BCCDC) provided WNV prevention brochures to stakeholders such as parks and tourist centres, responded to media inquiries, posted updates to our website and issued two news releases. The BCCDC also participated in a joint media briefing with IHA when the first human case was detected in August.

Figure 1: WNV Activity in the Pacific Northwest, 2010



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Surveillance Planning Sessions

On November 23, 2009 a surveillance planning session was held with WNV coordinators and medical health officers (MHOs) at BCCDC. The health authorities (HAs) and BCCDC discussed their priorities for mosquito and corvid surveillance, and mosquito control for the 2010 season at that time. In April 2010, BCCDC hosted their annual BC Vector-Borne Disease Committee Meeting (formerly the Provincial WNV Meeting), which included attendees from the HAs, municipalities, colleagues in animal health, and other stakeholders. Past surveillance results were evaluated and plans for the upcoming 2010 season were reviewed.

Surveillance Activities

Active WNV surveillance is carried out on both corvids and mosquitoes. Passive surveillance is focused on humans, horses and potentially other species that could be infected and reported. The objectives of WNV surveillance are two-fold:

1. To monitor WNV activity in various species in BC to:
    a. Predict increased risk to human health
    b. Inform public health decisions
    c. Guide communication strategies
    d. Monitor the effectiveness of control measures

2. To optimize mosquito control decision-making by identifying:
    a. The geographic and temporal distribution of potential vector species in BC
    b. Mosquito development sites

Human surveillance involves the BCCDC Epidemiology Services, Provincial Health Services Authority (PHSA) Public Health Reference Laboratories (PHL), Canadian Blood Services (CBS), BC Transplant Society and the physicians of BC. Physician requests for WNV testing received by BCCDC labs are tracked. Data sharing protocols with CBS are in place to ensure prompt deferral of blood collected from suspected WNV-infected persons and to allow BCCDC to monitor asymptomatic infections identified through screening of the blood supply. From May to November, all solid organs and tissues intended for transplant are screened prior to transplant. In the low risk period (December through April) only organs from donors with a travel risk are screened.

In accordance with established practice, information on any probable human cases was communicated to the requesting physician as well as to the appropriate HA to enable administration of a case questionnaire to collect information on symptoms, travel history and likely mode of transmission. Cases are classified as either West Nile Non-Neurological Syndrome (WN-Non-NS) or West Nile Neurological Syndrome (WNNS) according to both self-reported symptoms and clinical information collected from the

patient's physician. Cases are further categorized as probable or confirmed depending on the laboratory test performed. Case definitions can be found at http://www.phac-aspc.gc.ca/wnv-vwn.

The human testing algorithm entails screening acute serum samples for Flavivirus EIA – IgM and IgG. Convalescent sera are requested and tested in parallel with the acute sample for both IgM and IgG. Hemagglutinin Inhibition testing is performed on positive IgM and/or IgG samples, as required. WNV IgG avidity is also done as required. Probable positive cases are referred to the National Microbiology Laboratory (Winnipeg) for confirmatory plaque-reduction neutralization testing (PRNT).

BCCDC works with the Animal Health Centre (AHC), Animal Health Branch, BC Ministry of Agriculture (MoA) in the reporting of animal cases of WNV. Work is ongoing to improve monitoring and reporting of animal infections between animal health and public health. Additionally, a recommendation has gone forward to make WNV in animals reportable to public health under the new Public Health Act Communicable Disease Regulation being drafted.

As per established protocols, corvid surveillance was achieved in 2010 through two mechanisms:

- Dead corvids were submitted to the AHC in Abbotsford during the 2010 surveillance season for WNV testing using a commercially available dipstick test (VecTest®) for initial screening and PCR as required for confirmation. Tissue samples from positive specimens were then sent to the PHSA PHL for confirmation.
- In addition to birds tested, an online form was available again in 2010 on the BCCDC website (www.bccdc.ca/westnile) for the public to report sightings of dead corvids. The intent is that dead corvids sighted by the public and reported through the online form are separate from those picked up for testing. The locations of birds tested and reported online were used to create corvid density maps for regions of the province with sufficient data (maps.bccdc.org).

Mosquito surveillance focuses annually on identification and distribution of adult vector mosquitoes and PCR testing of female *Culex* mosquitoes. Mosquito surveillance activities were started June 1st, 2010 with surveillance focused on the two higher risk RHAs in BC. IHA reduced the number of trap locations in the Kootenays and added more in the Okanagan. FHA maintained most of their trap site locations, changing some sites to better evaluate the mosquito population species makeup. These decisions were based upon a risk assessment of the respective areas. Some traps were operated in more than one location on 2 different days of the week. Traps were run overnight and the catches sent in coolers to BCCDC for identification and WNV testing.

The PHSA PHL separated mosquito submissions into sex and taxonomic groupings: 1) *Aedes,* 2) *Anopheles,* 3) *Coquillettidia,* 4) *Culiseta* and 5) *Culex*. Mosquitoes were sorted on a chill table (to prevent denaturation of any viral RNA) and identified to genus, and in the case of *Culex*, to species. If a trap failed to capture any mosquitoes, the

information (i.e. trap malfunctioned, no mosquitoes trapped or trap was not run) was faxed to the lab and recorded. Beginning in 2006, only female *Culex* mosquitoes were tested for the virus in groups of up to 50 mosquitoes per pool, by PCR. The remaining mosquitoes were identified but not tested. When traps contained more than 500 mosquitoes, the entire sample was sorted to selectively pick out all the female *Culex* mosquitoes for PCR testing. Five hundred mosquitoes from large volume traps were initially identified and reported; the remainder (i.e. non-*Culex* species) was saved for identification at the end of the season. A fraction of the remainder (½, ¼, ⅛, etc.) was identified and the total number for each genus in the trap extrapolated.

Surveillance for WNV in horses is passive. That is, there is no active program to look for infection or test the sero-prevalence of WNV antibodies in horses. Instead, serologic specimens from horses suspected of being infected with the virus are collected by the attending veterinarians and submitted for WNV testing. Specimens are tested using the IgM enzyme-linked immunosorbent assay (ELISA, also called enzyme immunoassay, or EIA), and rarely, serum neutralization tests. WNV is often fatal in horses. Specimens from horses that die or are euthanized after exhibiting neurological symptoms, and are submitted for diagnostic necropsy to the AHC may be tested for WNV by immunohistochemistry.

Ongoing, prospective, cumulative temperature degree-day maps were used to help forecast higher risk areas for WNV. Degree day assessments can assist in predicting the number of generations of mosquitoes expected in a given area and the speed of virus replication.

Mosquito, bird, geographic and temperature data were integrated using an interactive online mapping tool (maps.bccdc.org). This was developed to assist stakeholders with geo-spatial risk assessment to help target appropriate mosquito control activities. Larval data, collected by independent mosquito control contractors are included in this mapping tool for use by MHOs when making mosquito control decisions.

Those involved in WNV surveillance activities include BCCDC Epidemiology Services, PHSA PHL; CBS, MoA and HA staff; federal, provincial, municipal and regional government staff; mosquito control contractors; academic centres; wildlife biologists and communications personnel. All were invited to participate in regular teleconferences to discuss emerging surveillance issues. Surveillance results from BC, across Canada and the United States were summarized in a routine surveillance report distributed to BC stakeholders, including members of the surveillance group, infectious disease physicians, medical microbiologists and those involved in the provision of blood products and transfusion services.

Surveillance Results

Results at a Glance

Table 2: Summary of BC Surveillance Statistics, 2010

	Human samples[1]	Corvids Submitted[1]	Corvids Sighted[1]	Mosquito Pools[2]	Horse
# Tested	325	233	355	2,092	
# Positive	1	5		0	0

1. Surveillance started on June 1st.
2. A pool may contain up to 50 mosquitoes that are tested at one time.

Surveillance of WNV in Humans

Epidemiology of Human Infections

In 2010, 325 human specimens were tested by PHSA PHL, with only one confirmed human infection. The case reported non-neurological symptoms and was in the central Okanagan region during their exposure period in the middle of August.

Five human infections were reported in Canada in 2010 (2 in Saskatchewan, 1 in Alberta, 1 in Ontario, 1 in BC). One human case that acquired their infection in state was reported from Washington State in 2010; this is in contrast to the 38 cases reported in 2009. However, 126 positive mosquito pools and two positive birds were reported in 2010. A total of 972 human WNV infections were reported in the US in 2010 (as of December 7). Significant outbreaks of neuroinvasive infections were reported in Maricopa County, Arizona and Long Island, New York.

Protecting the Blood Supply from WNV – Testing at CBS

CBS performs year-round WNV nucleic acid testing on every donation. Although routine screening is performed in mini-pools (MP) of six specimens, more sensitive, single unit (SU) testing is selectively done for blood donations collected from regions of higher WNV risk (Busch et al. 2005). CBS uses two criteria for implementing SU testing: either a positive donor test result or an incidence of public health-reported symptomatic WNV in a health region over a two week period exceeding either 1:1000 in rural areas or 1:2500 in urban settings. SU testing is then implemented for a minimum of one week for all donor clinics in proximity to an affected region. WNV testing reverts to routine MP screening if neither criterion is met over the ensuing one week period.

In BC, CBS, BCCDC and BC Ministry of Health Services (MoHS) continued their close co-operation in WNV planning, preparation and surveillance. A comprehensive WNV Action Plan is updated each year; the 2010 edition is available at www.pbco.ca.

Between June 1 and October 9, the BCCDC provided daily reports of WNV test requests received by the centre to the CBS BC and Yukon Centre. This enables rapid identification of donors who may have recently given potentially WNV infectious blood, so that a product recall can be carried out as quickly as possible and when necessary, to defer donors for a 56 day period to prevent them from donating while potentially infectious. CBS was advised of 641 WNV test requests received by BCCDC; 46 of 641 (7.2%) were determined to originate from 33 registered CBS blood donors.

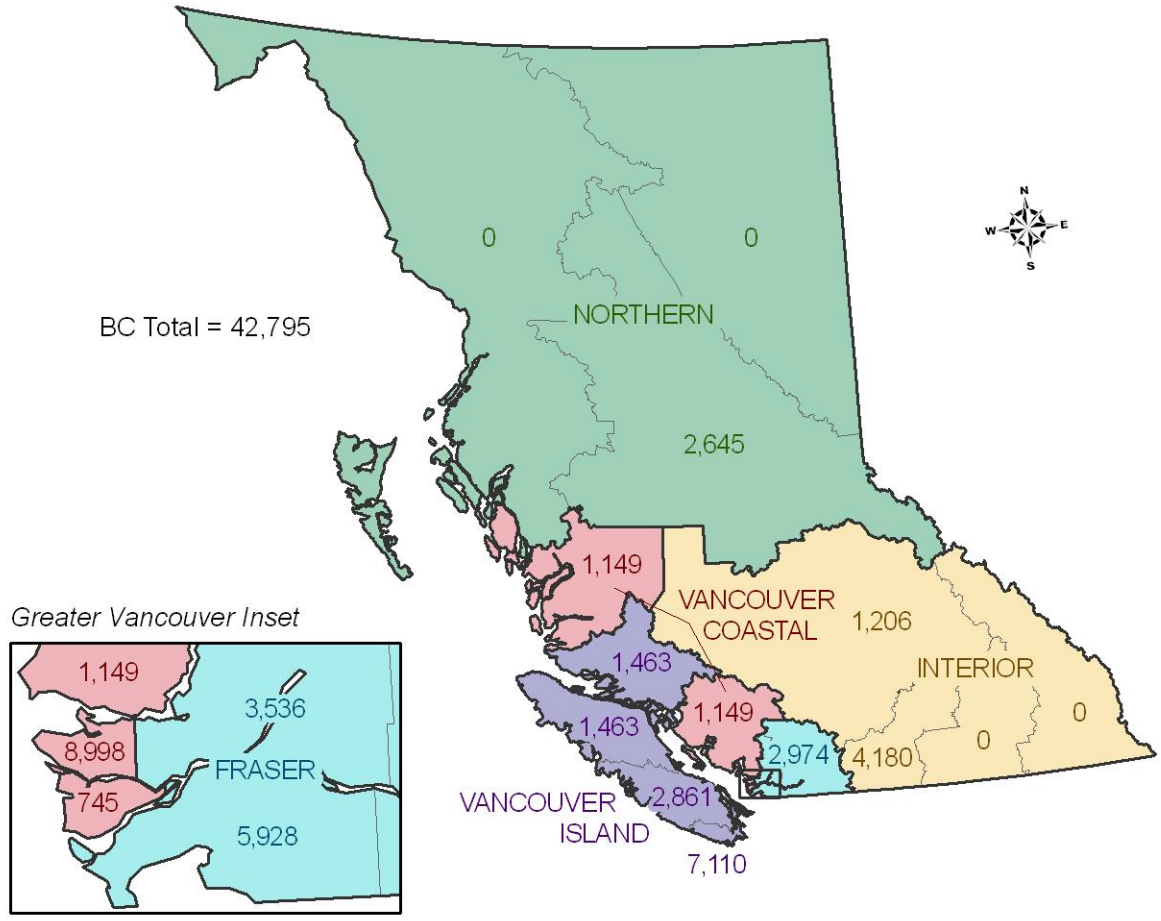
Two of these donors had donated a whole blood unit within 56 days of WNV testing at BCCDC and a recall of in-date products was done. From these two donations, one red cell component was discarded, one plasma component, sent for fractionation, was destroyed, while both platelet components and one red cell component were not in-date and so were not recalled; one plasma component had been transfused by the time of

recall. No transfusion transmitted infection was reported from any transfused component from either of these donations.

Blood Donor WNV Screening

CBS, BC and Yukon Centre provided BCCDC with aggregate, regional blood donor WNV testing updates for BC collections throughout the WNV season. This reporting provides geographically comprehensive and timely ongoing human WNV surveillance data to public health. Between May 31 and October 10, 2010, there were 42,795 collections of blood in BC (Figure 2). There were no positive WNV screening test results from any blood donation in British Columbia in 2010.

Figure 2: Number of blood donor collections by HSDA, May 31-Oct 10, 2010

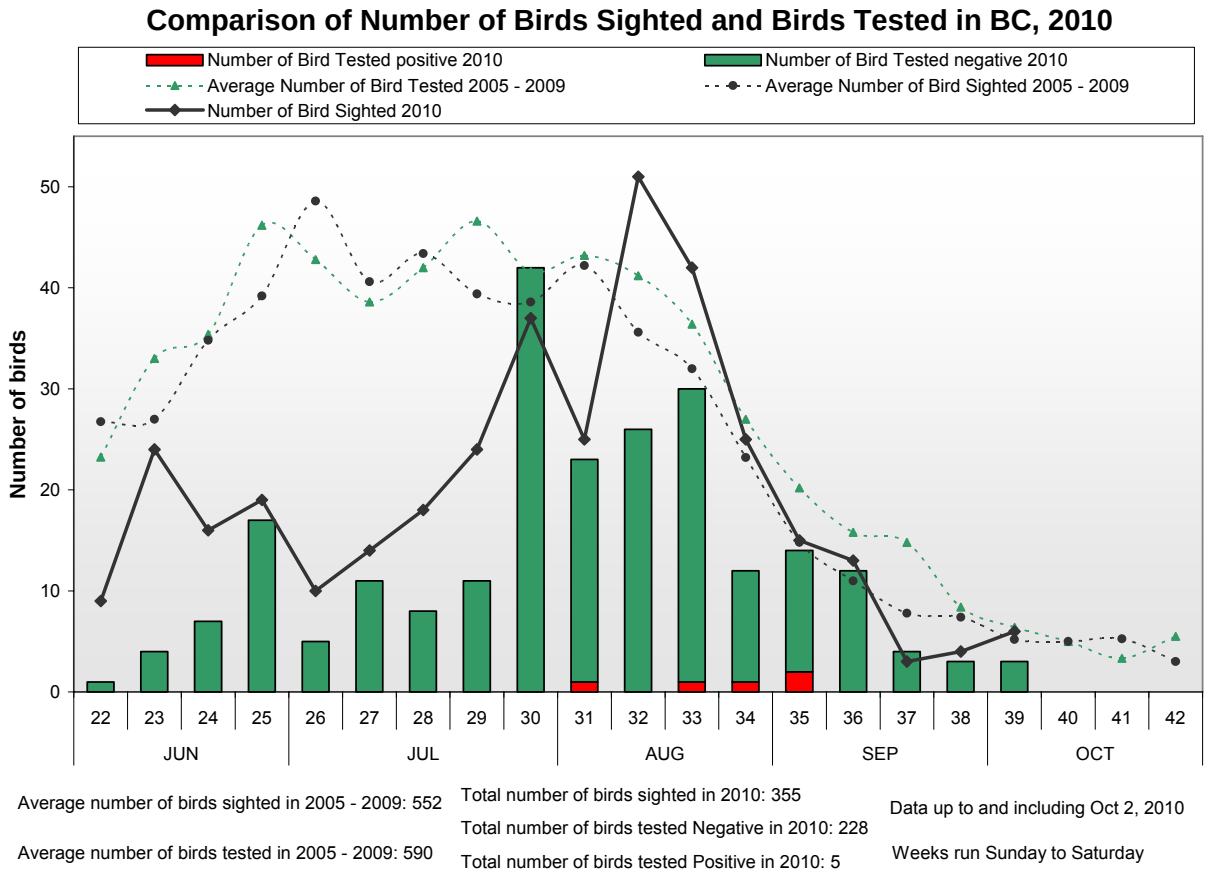


In Canada, neither CBS nor Héma-Québec identified any WNV positive donors during 2010. No cases of suspected transfusion-transmitted WNV have been reported in Canada during in the past 7 years.

Surveillance of WNV in Corvids

During the 2010 surveillance season, 5 positive corvids were reported. This is the first time WNV has been reported in corvids in BC. All 5 were reported from the Central Okanagan LHA. The first positive corvid was collected in the first week of August. All other positive corvids were collected throughout August. A total of 233 corvids were collected and tested in 2010. This is a slight increase in the number of corvids tested compared to 2009, likely due to increased media attention and changes to corvid surveillance once the positives had been reported. The number of corvids tested in 2010 remains significantly below the average number tested between 2005 and 2009. This decrease compared to historical seasons may be due to changes in public interest and in surveillance program participation (testing was only done on birds collected in FHA, IHA and Richmond). The peak in the number of corvids tested occurred in the last week in July but was related to a non-WNV related bird die-off in the Fraser Valley (Figure 3).

Figure 3: Comparison of Birds Sighted and Tested, 2005-2010



A total of 355 dead birds was sighted and reported online to BCCDC. This number is below the historical average of 552 reported between 2005 and 2009. The number of

birds sighted peaked in weeks 32 and 33 which were the weeks immediately following the reports of the first positive bird.

The spatial distribution of dead corvid submissions was generally limited to the areas that participate in corvid collection (Richmond, FHA and IHA). The majority of birds were collected in the Metro Vancouver, the Fraser Valley, Okanagan valley, and Kamloops (Figure 4). Although there were submissions from 23 LHA's, all of the positive corvid samples were from one LHA (Central Okanagan). As observed in 2009, there were no corvids submitted for testing from the south Okanagan this year. Additional charts of weekly corvids submitted for testing and sighted in 2010 by HSDA can be viewed at www.bccdc.ca/westnile.

In addition to the birds submitted through the WNV surveillance program there were 2 related clusters of crow die-offs reported in Aldergrove and North Langley at the end of July. Collaboration between FHA, the Canada Wildlife Service, the Ministry of Environment and AHC expedited the on-site investigation, collection & delivery of samples, the screening for WNV and the diagnostic work-up. The cause of death was determined to be acute reoviral enteritis unrelated to WNV.

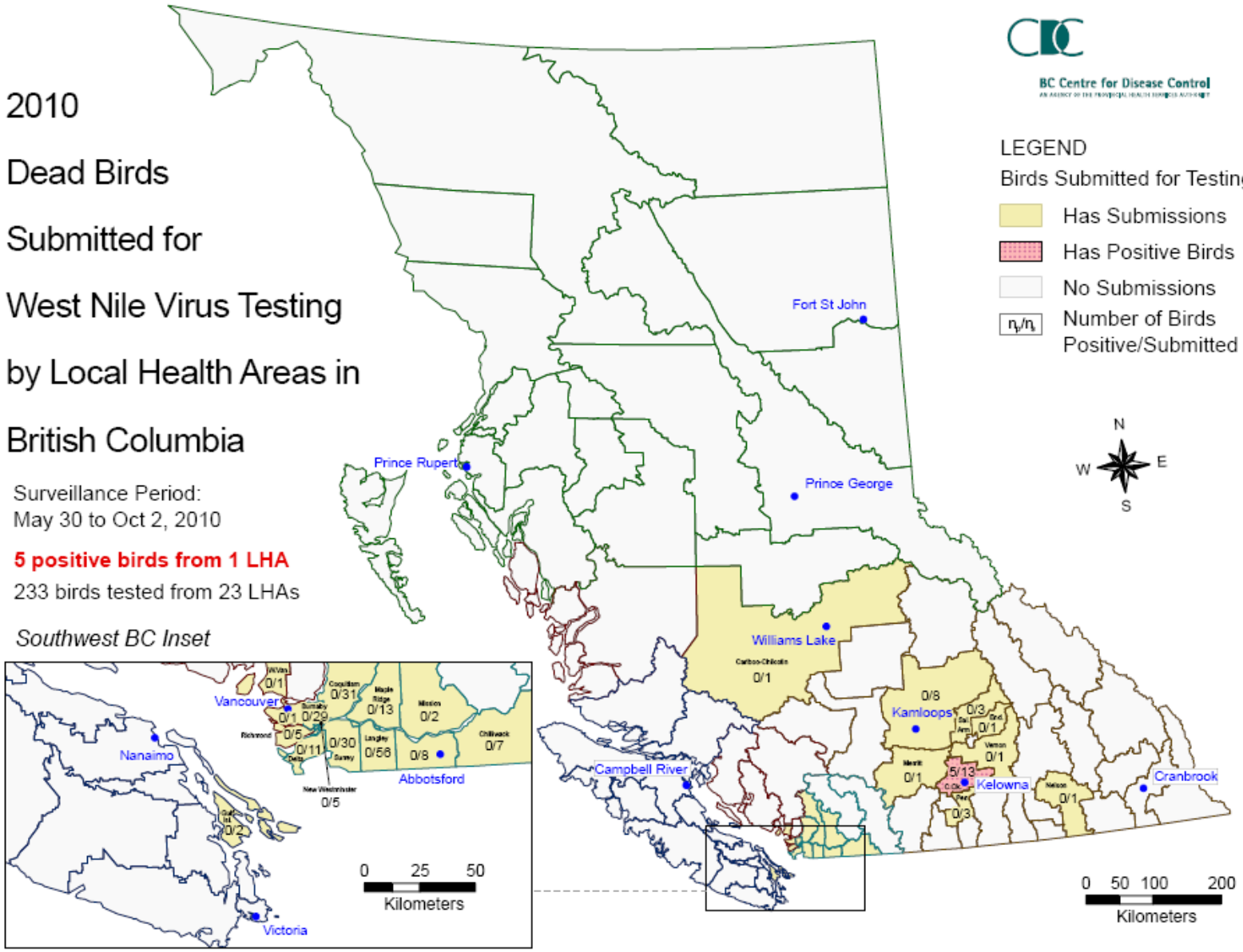
Corvid Testing Issues

The BC Animal Health Centre provides diagnostic surveillance testing for WNV in dead corvids collected and submitted by the local HAs.

Avian WNV screening relies on a commercial rapid immunochromatographic antigen detection assay called the VecTest® which declares 79% test sensitivity for oral swabs in corvids. The VecTest® has been used extensively in WNV bird surveillance programs since 2001. To strengthen the BC bird surveillance program, all submitted corvids were screened for WNV using the VecTest® and every 20th bird had brain tissue tested for WNV using PCR. Also, VecTest® positive birds were tested by the PCR method for confirmation. Multiple tissues from WNV positive birds were also forwarded to BCCDC for duplicate, confirmatory testing.

The second and third positive Central Okanagan birds (Aug 20, Aug 27) were detected by PCR but had initially tested negative by the VecTest®. The on-hand supply of VecTests® had run out on Aug 18th so, with the assurance of the supplier, the AHC began using recently expired test kits while awaiting a new shipment of fresh kits. Meanwhile, all birds that were screened with an expired VecTest® were followed by PCR on oral swabs. When the new kits arrived both of the PCR positive/VecTest® negative birds were retested using an unexpired kit but they remained negative by the new VecTest®. One explanation is that the birds may not have died directly from WNV but had been killed while incubating the infection and therefore were below the detection threshold of the VecTest®. The VecTest® sensitivity can also vary between the corvid species with lower sensitivity in magpies. As a precautionary measure for future VecTest®–dependent WNV bird surveillance, supplemental PCR testing should be enhanced to bridge the gap in test sensitivity.

Figure 4: Geographic Distribution of Corvid Test Results, 2010



Surveillance of WNV in Mosquitoes

Many regions use the collection of mosquitoes and testing for infection as part of arbovirus surveillance and as the cornerstone of their WNV program. Random sampling in potentially active areas may give an early warning of the arrival of the virus before other animals become sick, but sampling in known endemically infected areas can offer vector population estimates and some insight into risk for the upcoming season. In addition to information about the spread of the virus, an active mosquito surveillance program can identify which species are present, which can then lead to assessment about the type of habitat producing that species.

In 2010, there was a total of 1,421 submissions from miniature CDC mosquito light traps, baited with dry ice (to produce $CO_{2)}$, resulting in 2,092 pools tested. A total of 203,753 mosquitoes was collected from these trap locations. There were lower numbers of nuisance species of *Aedes* all across the province this year. The provincial average of *Culex* per trap night was 27.5 (all *Culex* species, including males). This was lower than last year's average *Culex* count (Table 3).

Trap Coverage

Mosquito traps are used across North America for arbovirus surveillance, yet there is no standardized methodology to determine number and placement of traps. This dilemma probably stems from the fact there are many different vector species and each will behave in a different manner according to available habitat. The two primary vector species that drive WNV activity in Canada are *Cx. pipiens* and *Cx. tarsalis*, and trap site selection is based primarily on the known geographic distribution of these vectors.

The WNV Program has been monitoring mosquitoes in BC since 2003. Testing has been focused on female *Culex* species only, since 2006, and it was *Culex* species in traps from the south Okanagan that were first identified as positive. This section of the report reviews mosquito surveillance in 2010 and compares it with 2009.

Figure 5 depicts the locations of adult mosquito traps in 2010. Since adult mosquito surveillance began in 2003, the geographic coverage of traps has changed and the strategic placement of traps in mosquito rich environments has improved, reducing the number of low yield traps and providing better capture of high risk species like *Cx. pipiens* and *Cx. tarsalis* (Table 3). A more focused surveillance effort was undertaken again this year, and sampling was reduced to the southern border of the province. A few traps began running in May but the full complement did not start until June, so even though there were more traps this year the actual number of submissions was less (Table 3). A later start to surveillance is done to focus more on the period when WNV is active in North America rather than the broader season when mosquitoes are active.

Figure 5: Geographic Distribution of Mosquito Traps in BC, 2010

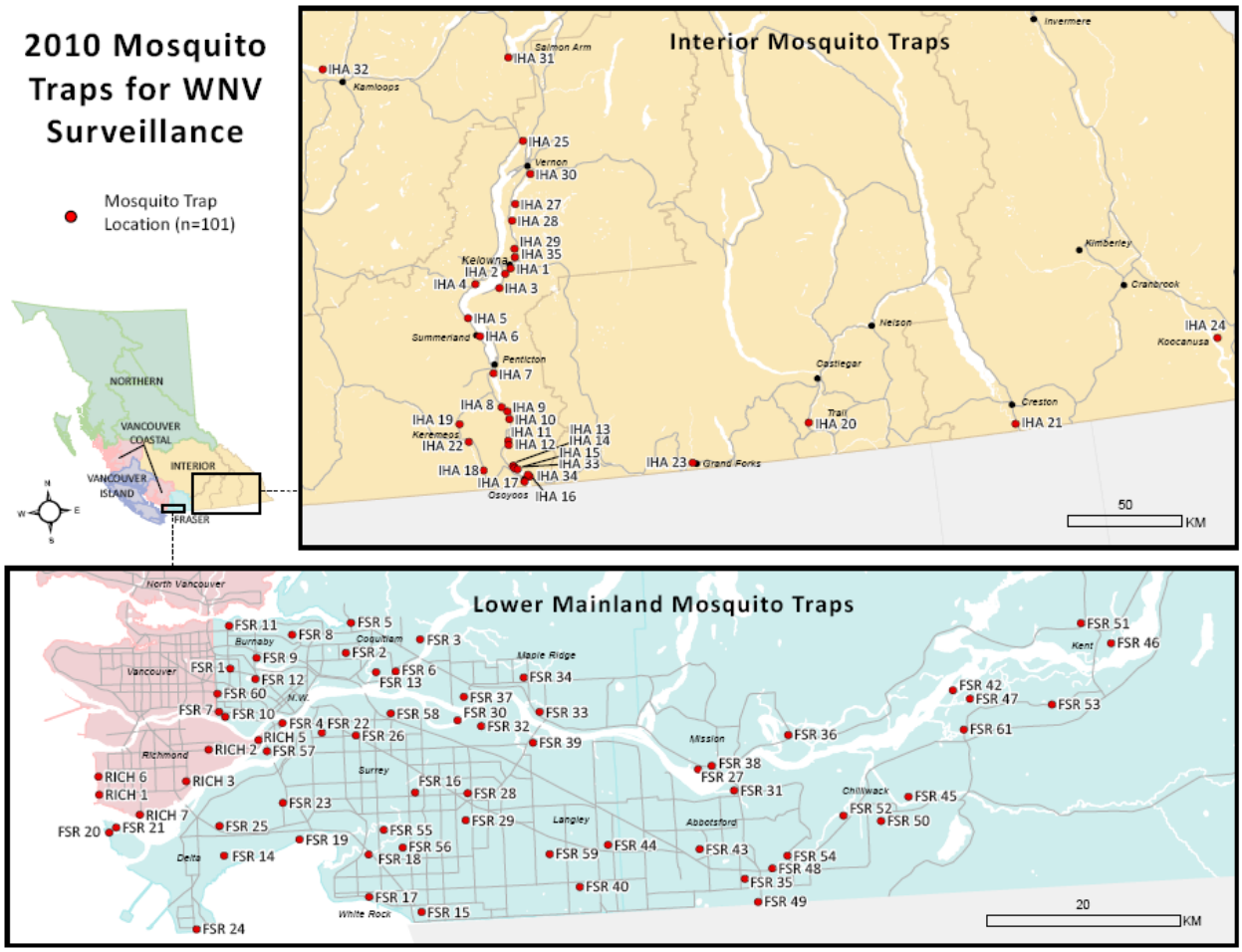


Table 3: Changes in Mosquito Trap Operations, 2005-2010

Parameter	2005	2006	2007	2008	2009	2010
# Permanent locations	189	148	155	98	91	101
# Mosquitoes	198,228	394,047	242,215	202,460	182,063	203,753
# Pools tested	6,631	2,329*	2,568*	1,873*	2,482*	2,092*
Submissions	2,778	2,287	2,365	1,471	1,536	1,421
Ave # *Cx. tarsalis*^	1.9	4.8	3.5	1.4	11.8	4.9
Ave # *Cx. pipiens*^	5.1	8.6	14.3	10.5	21.1	23.7

** Only Culex species tested for WNV.*
^ Including male and female mosquitoes during the season. It is calculated by: Total number of Culex ÷ Total number of trap submissions = # per trap-night.

Geographic Distribution of Species

The most competent vectors of WNV are only occasionally found in NHA and this has guided surveillance to focus on the southern part of the province. The most northerly WNV report in Canada is from Meadow Lake, Saskatchewan (approximately N54° 08').

Figure 6 illustrates the distribution and abundance of mosquito species groups collected in 2010. The most northerly traps were near Salmon Arm (N50° 42') and Kamloops (N50° 43") in the Thompson Cariboo Shuswap area of IHA. A trap in Agassiz (N49° 14') was the farthest north for FHA (Figure 5).

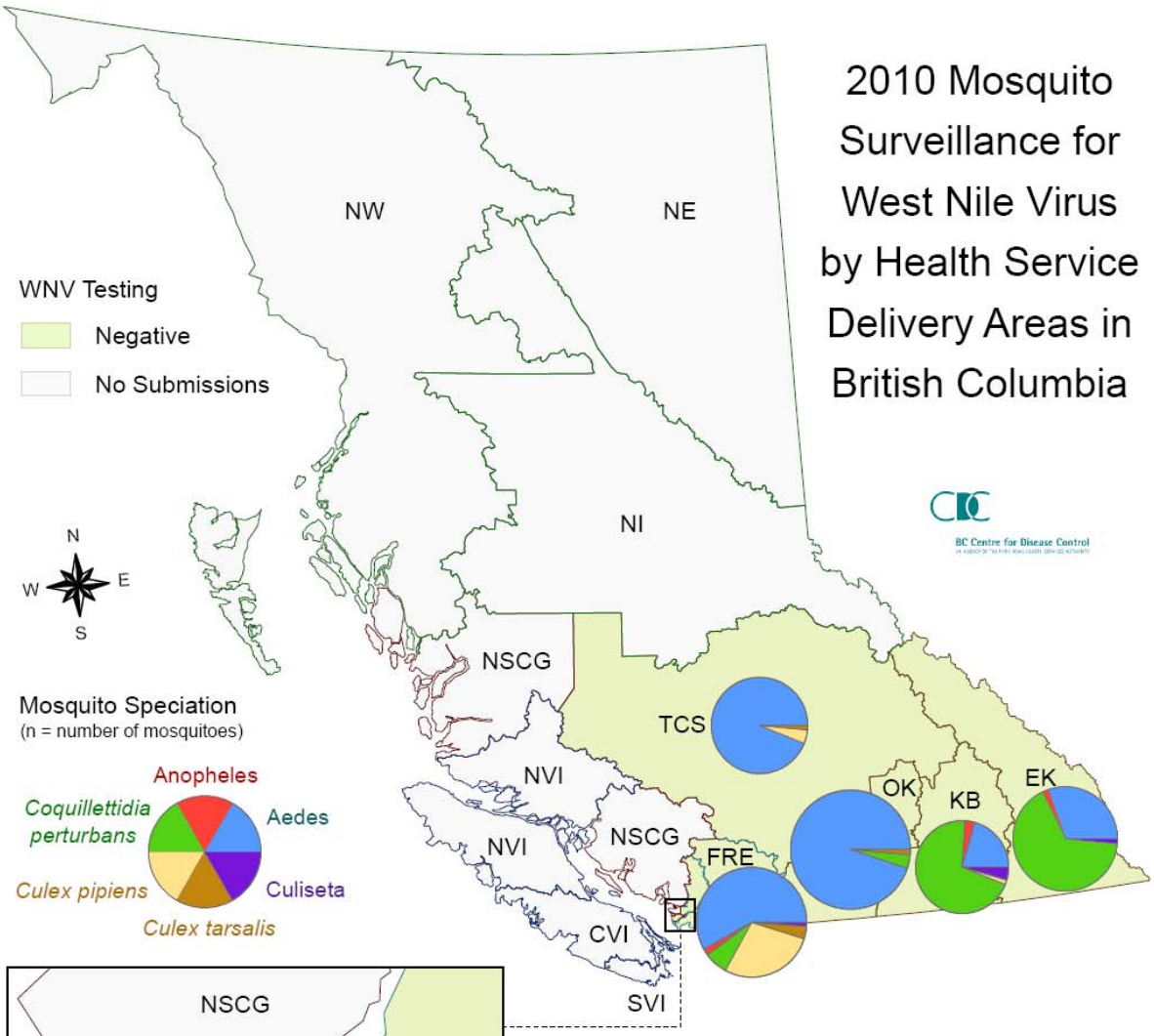
The Effect of Rainfall and Snowpack on Mosquito Abundance

Environmental factors can be used to assist in predicting mosquito populations, and can be used to predict the potential for arboviral diseases. In BC, snow accumulation and melting of the snowpack affects the hydrology along the mountainous corridors as spring unfolds. Reisen et al (2008) recently proposed a model for conditions in California that are similar to BC. By the beginning of May, the subsequent melt of accumulated snow is a clue to the potential for standing water for early mosquito development. In contrast, for 2010 the Fraser River level at the Mission gauge (Figure 8) remained at normal levels from May to the end of August, with a peak at about 3.95 meters on June 29, so there was no threat of flooding this year (Environment Canada, 2010). Normal water levels in the lower Fraser and active control programs kept the floodwater species of the *Aedes* group to minimal levels.

The accumulated precipitation is illustrated in Figure 7 for May 1, 2009 and 2010. Much like 2009, the moisture accumulation was low in the southern portion of the province early in May. However, a series of cold low pressure systems pushed through BC during May, bringing a mix of frontal and convective rain to most of the province, with heavy and widespread rain in some areas. Most of the southern Interior, including the Thompson, Nicola, Okanagan, Kootenay and southern portions of the Columbia saw higher than average precipitation. Observed May rainfall was: Lytton – 291% of normal; Kamloops – 224%; Kelowna – 135%; Penticton – 203%; Princeton – 163% - Vernon – 98%; Castlegar – 118%; Cranbrook – 112%; Creston – 97% (MoE 2010).

The excessive rain in late spring presumably resulted in more mosquitoes emerging from surface waters as reflected in the total number collected (Table 3) compared to last year for this region.

Figure 6: Geographic Distribution of Mosquito Species in BC, 2010



SUMMARY OF 2010 SURVEILLANCE

Cumulative Submsisions June 1 - October 2, 2010

HSDA	*Aedes*	*Anoph.*	*Coqui.*	*Cx.pipi.*	*Cx.tars.*	*Culis*	Total
EK	2991	159	6534	25	17	140	**9866**
KB	365	61	1232	28	17	80	**1783**
OK	111541	421	4343	802	1590	404	**119101**
TCS	2761	20	2	133	43	12	**2971**
FRE	14414	433	1738	6912	926	284	**24707**
FRN	715	54	884	4935	623	1420	**8631**
FRS	5157	113	4749	19639	3462	1753	**34873**
RICH	338	1	44	1151	259	23	**1816**

Total number of mosquitoes caught = 203,753

No mosquitoes tested positive

Figure 7: Ministry of Environment Basin Snow Water Index Maps 2009 to 2010 (MoE 2010)

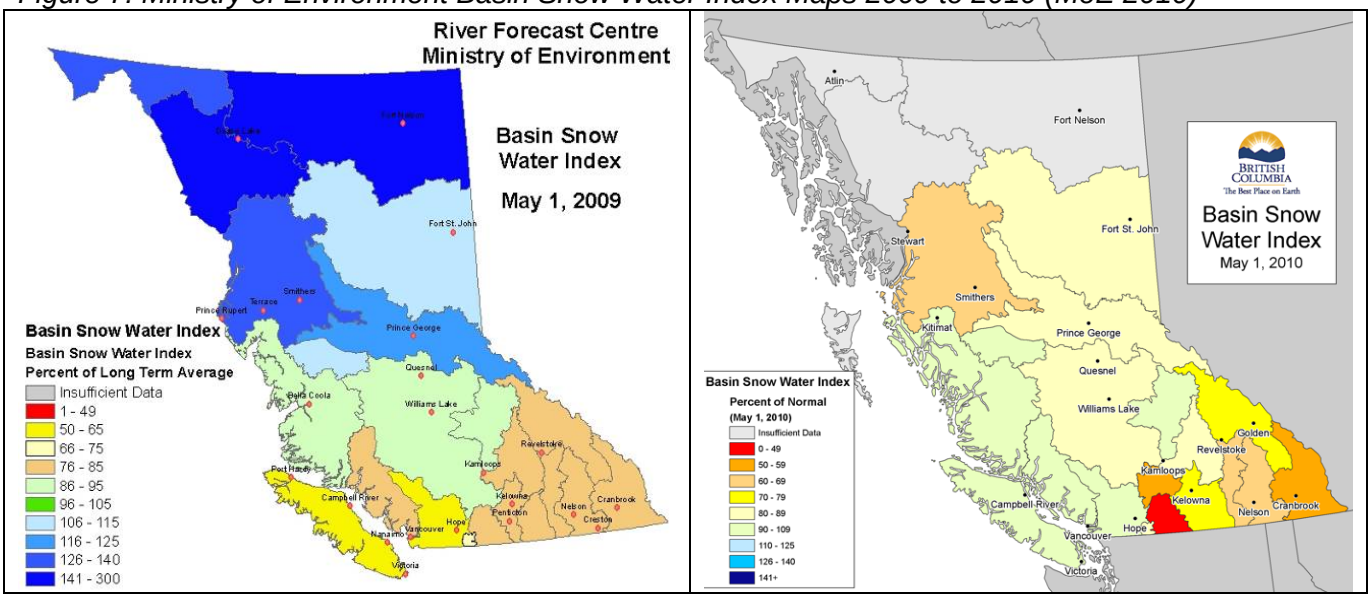
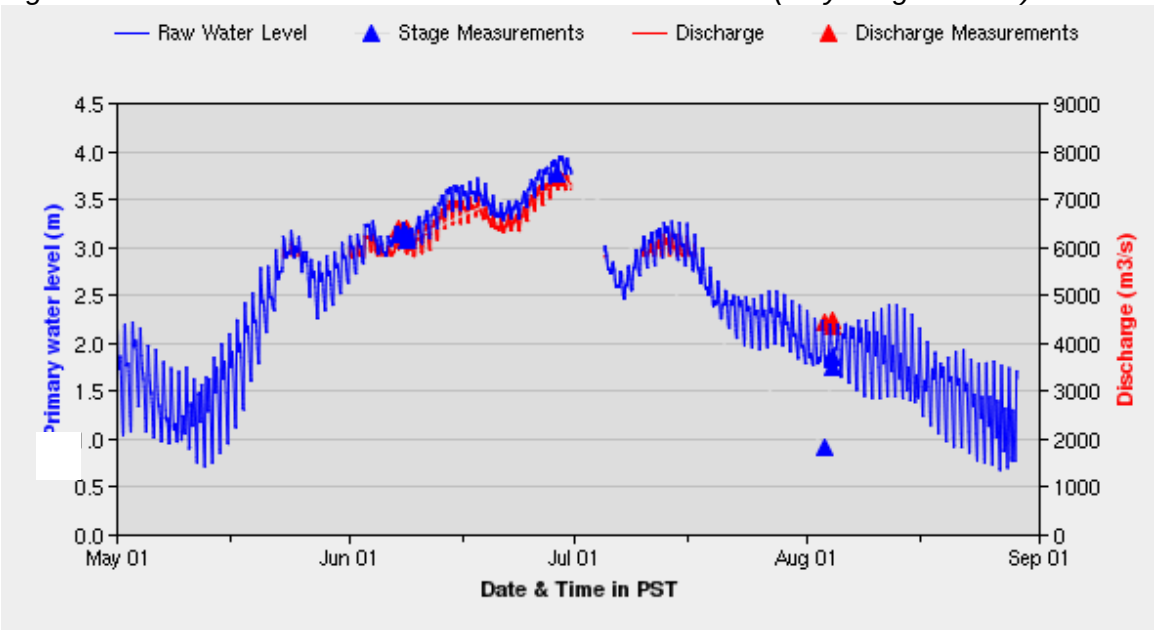


Figure 8: Fraser River Water Level as Recorded at Mission (May- August 2010)



(Environment Canada, 2010)

Climate Data – Growing Degree Days Calculations

Temperature plays a key part in WNV biology, ecology and epidemiology. WNV amplification and rate of mosquito development occurs more rapidly with warmer temperatures, resulting in development of multiple generations of *Culex* mosquitoes and a larger number of infectious mosquitoes during the season. Warmer temperatures also increase mosquito biting activity, thereby increasing the risk of transmission to humans.

A base 14.3°C growing degree days model was developed for *Cx. tarsalis* mosquito forecasting for 2010. The concept of growing degree days involves the amount of accumulated heat required for mosquitoes to complete their growth and development. Growing degree days were monitored on a weekly basis for select BC communities from various parts of the province.

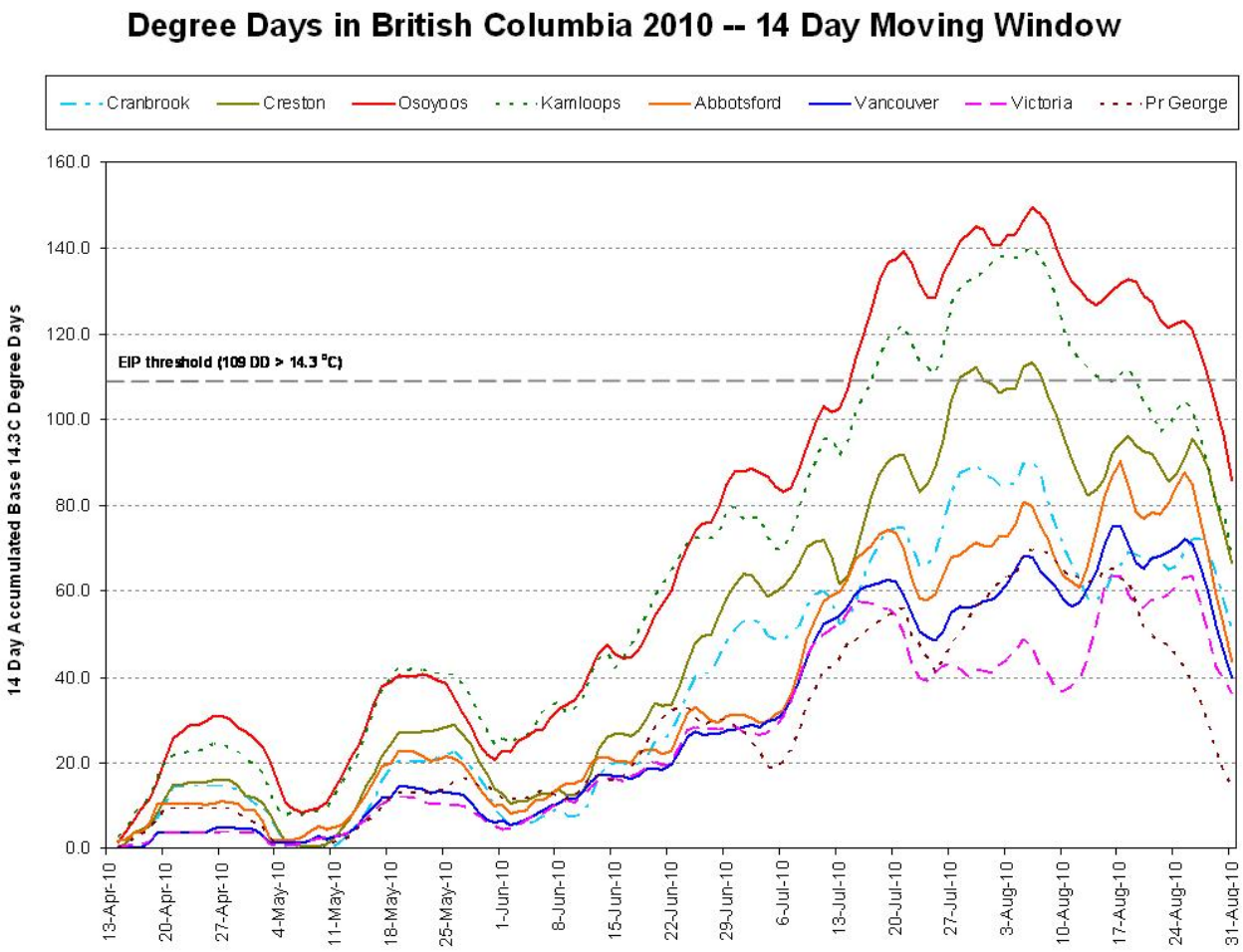
During 2010, all communities experienced fewer accumulated degree days than compared to 2009 which was among the hottest summers on BC record, and the first year of WNV activity in BC (Table 4). In particular, late spring and early summer temperatures in 2010 were relatively cool and it was not until the middle of June when temperatures finally increased in BC (Figure 9). Despite the cooler temperatures observed in 2010, WNV activity was still detected in the central Okanagan region, thereby suggesting that WNV is now endemic in the hot interior regions of BC.

Table 4: Accumulated Base 14.3°C Growing Degree Days for Select Communities up to August 31st

August 31st	2010	2009	2008	2007	2006	2005	2004	2003
Cranbrook	399	478	475	561	542	410	479	598
Creston	515	661	552	757	700	581	668	770
Osoyoos	761	919	811	859	851	850	993	962
Kamloops	688	860	729	738	821	738	879	820
Abbotsford	392	518	387	417	470	481	586	485
Vancouver	322	422	312	344	366	386	485	408
Victoria	277	365	282	311	346	357	425	375
Prince George	285	343	265	273	237	275	361	283

Note: Degree day calculations beyond August 31st are not meaningful for WNV risk prediction as newly emerged Culex will likely enter diapause (a state where they do not seek a blood meal) by this time, and therefore the effect of temperature on mosquito development and viral replication after this time does not contribute to WNV risk.

Figure 9: 14 Day Moving Window of Base 14.3°C Growing Degree Days for Select Communities up to August 31st, 2010



Note: The extrinsic incubation period (EIP) threshold of 109 base 14.3°C degree days reflects the point at which a female mosquito imbibing an infectious bloodmeal is able to transmit WNV.

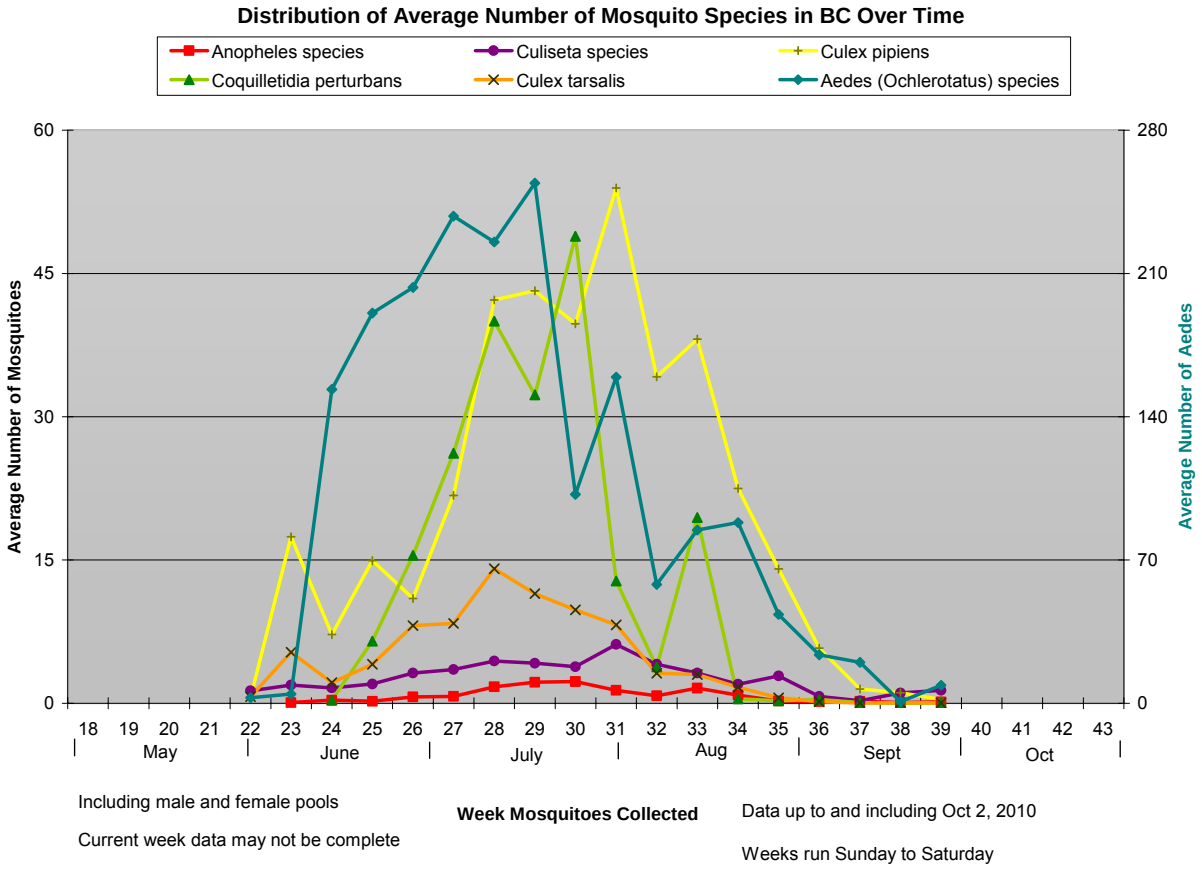
The change to using 14.3°C as the new baseline temperature for the degree days model from the previous base of 16°C reflects recent research indicating the minimum temperature at which WNV amplifies within *Cx. tarsalis* (Reisen et al. 2006). Furthermore, Bailey et al. (1965) observed *Cx. tarsalis* to start flying at ~13°C and biting at ~15°C. Our previously used base temperature of 16°C was based on McLintock's work in 1948, but in light of the findings from the studies mentioned above, 14.3°C was chosen as the new baseline temperature because it is a better estimate of potential WNV risk. Accordingly, the degree days calculations for 2003-2009 were re-calculated using the 14.3°C base (Table 4), and Saskatchewan Health will also be using the baseline temperature of 14.3°C from here onwards.

Temporal Distribution of Mosquitoes

Over the last 5 years, trap deployment ranged from as early as the beginning of May to as late as the end of October. This window of surveillance serves 2 basic functions: to give a record of populations as they progress through the season and to give an advanced estimate of risk of WNV infection based on the number of infected vector specimens during the most active time of the year. Surveillance has now confirmed that WNV will appear when vector species are most active.

In 2010, FHA began surveillance at the beginning of June, incrementally adding traps until they were fully deployed in July. IHA started deployment of the majority of their traps at the beginning of July, but some traps were started in the middle of June. VCHA did surveillance in Richmond and they began in the middle of June. All 3 HAs ended their surveillance by the beginning of October. This surveillance window is when WNV infection is most prevalent in other jurisdictions. Figure 10 illustrates the changes of species groups in BC over time for all traps.

Figure 10: Average Number of Mosquito Species Trapped per Week, 2010



Aedes was the most common genus collected in 2010 surveillance for BC, as has been the case in every year of this program. *Coquillettidia perturbans* is usually the 2nd most common species collected, but in 2010 had a similar abundance as *Cx. pipiens* due to the large numbers in the Fraser South (FRS) Health Service Delivery Area (HSDA). *Cx.*

pipiens exploits the many storm water catch basins, and this may be the reason it is so commonly collected in this substantially urban region. *Cx. tarsalis* was the next most numerous mosquito species, followed by *Culiseta* and *Anopheles*, with *Cx. territans* being the least common. This species is often collected in surveillance of larvae but does not seem to be attracted to the CO_2-baited light traps.

Most *Aedes* overwinter as eggs and their numbers will depend on moisture accumulation and snowmelt. This year, *Aedes* numbers peaked about 2 weeks after the Fraser River crested in the Lower Mainland. *Coquillettidia perturbans* overwinter as larvae, and the adult population typically peaks around the 2nd to 3rd week of July in BC. This trend has been repeated ever since surveillance began in 2003. Most other mosquito species in BC overwinter as adults and their success in our northern latitude depends on spring and summer temperatures.

Timing of WNV Emergence: Canada, BC and the Pacific Northwest

The first positive results for WNV in other regions of close proximity, or similar latitude where WNV is endemic has been considered a useful indicator for when the virus might appear in BC.

Table 5: First Recorded Dates of Positive Mosquitoes in Canada (Source: PHAC, 2010)

Prov	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
BC									6-Aug	
AB			23-Jul	10-Aug	7-Aug	18-Jul	15-Jul			
SK			12-Aug	13-Aug	28-Jul	17-Jul	20-Jun	8-Aug	25-Jul	31-Jul
MN		15-Aug	25-Jul	28-Jul	15-Jul	4-Jun	5-Jun	25-Jul	16-Aug	17-Jul
ON	22-Oct	16-Jul	23-Jul	3-Aug	26-Jul	5-Jul	15-Jul	4-Jul	23-Aug	31-Jul
QC		16-Aug	29-Jul	19-Aug	3-Aug	10-Aug				

Table 6: Earliest Positive Surveillance Findings in Washington (Washington DOH, 2010)

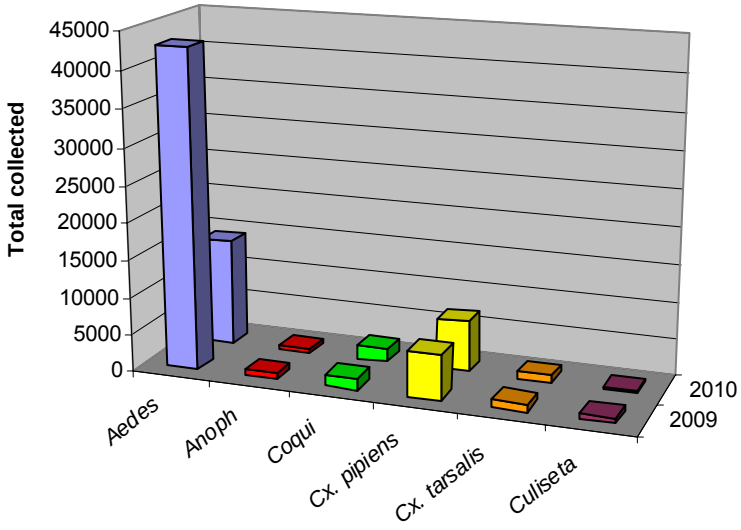
Year	First Positive in Washington
2010	Week 24 (Jun 13-19), mosquitoes
2009	Week 22 (May 31-Jun 3), mosquitoes
2008	Wk 29 (Jul 16), mosquitoes
2007	Wk 33 (Aug 12-18), horse
2006	Wk 29 (July 16-22), human
2005	Wk 34 (Aug 21-27), mosquito
2004	None
2003	None
2002	October, bird

Alberta and Quebec did not conduct mosquito surveillance in 2010, but positive mosquitoes were found in Manitoba in mid-July, and in Saskatchewan and Ontario by the end of July (Table 5). In the US, Washington had positive mosquito pools by mid-June (Table 6).

Relative Abundance of Mosquito Species Compared with Previous Years

Fraser Health Authority

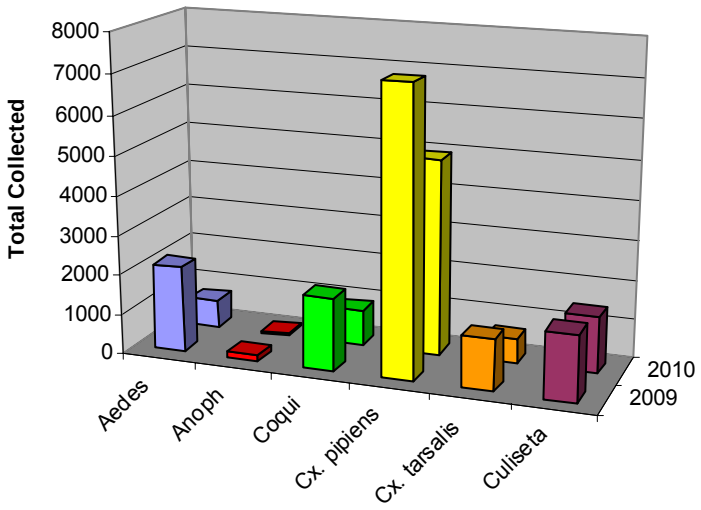
Figure 11: Species Abundance from 2009-2010 in Representative Light Traps, Fraser East HSDA



In this region there is a mix of urban and rural habitat for mosquitoes. The Fraser River is the prominent feature that affects mosquito biology, where multiple islands can flood creating large mosquito development sites. As previously noted under "The Effect of Rainfall and Snowpack on Mosquito Abundance", the Lower Fraser was below flood levels and *Aedes* populations were considerably lower this year (Figure 8). Unlike last year, *Cx. pipiens* was the most common species group when the entire region is considered (Figure 6 - FRE, FRN, FRS and RICH).

In the eastern end of the Lower Mainland, *Aedes* numbers were much lower than last year. *Culiseta* numbers were lower, only about 1/3 as abundant as in 2009. No *Cx. territans* were identified this year in Fraser East (FRE).

Figure 12: Species Abundance from 2009-2010 in Representative Light Traps, Fraser North HSDA

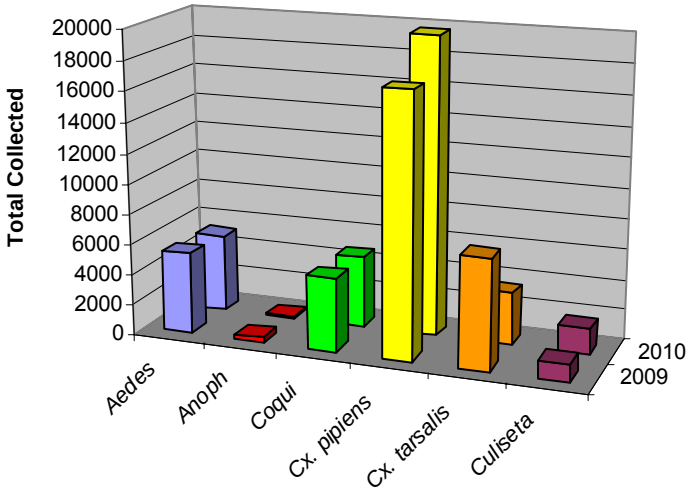


In Fraser North (FRN) *Cx. pipiens* was the most common mosquito and its numbers were slightly less than last year. *Culiseta* was about the same as in 2009 but all other groups were about ½ as abundant.

In the last few years the number of *Cx. pipiens* has dramatically increased and now is the most common mosquito collected in the surveillance program in FRS. This is the primary vector for

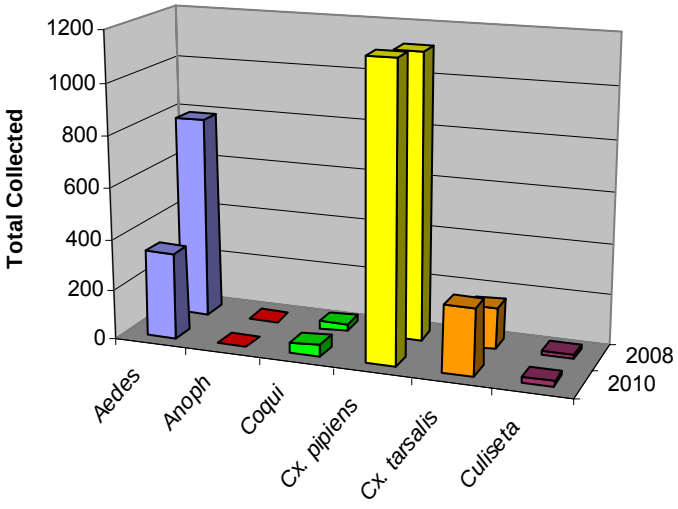
WNV in the eastern parts of Canada. Last year *Cx. tarsalis* was the second most common species collected in FRS but their numbers were less than ½ of those recorded last year. This change in abundance from year to year may play a role if the virus spreads to this region. *Aedes*, *Anopheles* and *Coquillittidia* abundance was similar to last year and there was a slight increase in *Culiseta*. Three of the 5 specimens of *Cx. territans* identified were collected in this region.

Figure 13: Species Abundance from 2009-2010 in Representative Light Traps, Fraser South HSDA



Vancouver Coastal Health Authority

Figure 14: Species Abundance from 2009-2010 in Representative Light Traps, Richmond HSDA



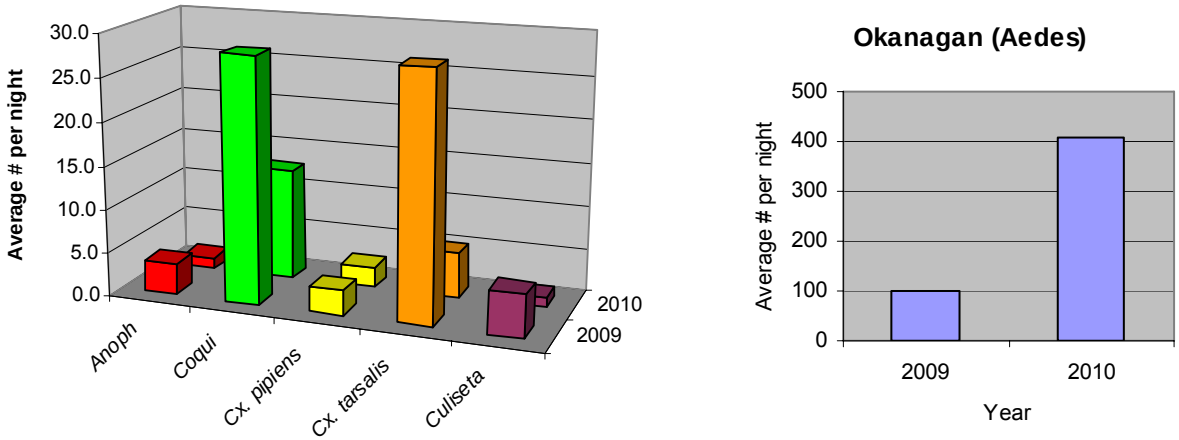
Mosquitoes were not collected in Richmond in 2009 but they were in 2008. Most species groups were in about the same proportions this year, except *Aedes*, which was lower than compared to 2008. *Cx. pipiens* remains the most common species collected from this region.

Interior Health Authority

The number of traps run in the southern Okanagan was increased in 2009. Additional traps were added farther up the valley into the central Okanagan region in 2010. For this reason the numbers are recorded as average catch per night rather than total catch in Figure 15. *Aedes* was the most common mosquito genus caught in 2010, likely owing to the heavy rainfall in May which potentially provided additional development sites for this species. In 2009 there were much higher numbers of *Cx. tarsalis* than in 2010; the cool temperatures for our province in 2010 may have set back their

development. In the Kootenay Boundary and East Kootenay there were 4 traps and they collected only 34 specimens over the entire season.

Figure 15: Species Abundance from 2009-2010 in Representative Light Traps, Okanagan HSDA (Aedes is shown in a separate graph).



Summary

West Nile Virus was present in the Okanagan in 2010 but not detected by mosquito surveillance. In the central Okanagan, where the positive birds were collected, only 42 specimens of *Cx. tarsalis* were trapped. In Kelowna, 297 *Cx. pipiens* were collected, but none of those were infected with the virus. Targeting analysis of these species remains the focus of surveillance in this region of the province.

In the Fraser River and Lower Mainland *Cx. pipiens* remains the most common known vector for this virus. In FRS in 2009, *Cx. tarsalis* was more common in surveillance than species of other groups. We can reasonably speculate that the cool spring temperatures kept this species from being as prevalent in 2010 as it was in 2009. Using a combination of temperature and virus surveillance, through mosquitoes, birds and horses, we are developing an understanding of WNV risk in this region.

Additional charts of weekly mosquito catch by HSDA in 2010 can be viewed at www.bccdc.ca/westnile.

Surveillance of WNV in Horses

Surveillance for WNV in horses was enhanced in 2010 when the Animal Health Centre started offering serologic testing for horses in BC with compatible clinical symptoms in addition to diagnostic testing at necropsy. Outreach to equine practitioners about WNV testing was done, and submissions reflected awareness, however no laboratory confirmed cases were reported.

Geographic Information Systems – Applications to WNV

Geographic information systems (GIS) mapping and analysis has been an integral tool for WNV surveillance and planning in BC. Data from a variety of sources (health-related events, field sampling, municipal infrastructure, environmental, etc.) and technologies (global positioning systems, remote sensing, databases, etc.) can be integrated in a GIS for visualization and analysis. In addition to the weekly summary maps posted on the WNV website, BCCDC has developed:

- an interactive web-based GIS mapping system for public health officials and members of the public to view WNV surveillance data in spatial format,
- a growing degree day model to forecast *Cx. tarsalis* mosquito development during the surveillance season,
- density maps of dead corvid sightings and submissions for WNV testing to detect hotspots of corvid die-offs,
- an assessment on the feasibility of adult mosquito control in select BC communities, and
- forecasted WNV risk models based on mosquito, temperature, geographic and environmental factors to inform WNV preparedness, surveillance and response.

Please refer to www.bccdc.ca/westnile and maps.bccdc.ca for all WNV mapping related content.

Communications

Communication Objectives

- Inform British Columbians and visitors to the province of the potential risk associated with WNV and to provide awareness regarding using personal protective measures. Awareness is created through the distribution of resource materials (including brochures), news releases, fact sheets, information bulletins and the BCCDC website.
- Inform stakeholders about specific strategies and responses by providing an up-to-date WNV resource plan and key messages.
- Provide up-to-date information on human WNV surveillance in BC through weekly surveillance reports.
- Respond to issues/inquiries via provincial spokespersons (PHO, BCCDC, regional MHOs), HealthLink BC, and other correspondence as required.

Strategies

- Provincial coordination of communications/public information through regular BC WNV communication group teleconference meetings
- Series of press releases and informational support material distributed throughout summer months with targeted timelines and key messages
- BCCDC Web site – updated with timely and consistent materials for public and professional use
- Regular conference calls between MHOs, BCCDC and other related professionals
- Cooperation with other provinces/territories and Health Canada in coordinating public information and education

Target Audiences:

- Home and property owners in both rural and urban areas
- People aged 50 years and older
- Physicians
- Public health nurses/HealthLink BC
- Provincial ministries, regional districts and municipalities
- General public who spend, or whose children spend a significant amount of time outdoors on a regular basis

2010 Communications Review

The public awareness campaign emphasized personal protection and the campaign consisted of several components, such as:

- Stakeholders across the province (e.g., parks, hospitals, tourist centers, veterinary offices, etc.) received brochures.
- News releases and information bulletins were done on an as needed basis.
- Inquiries were directed through BCCDC via provincial spokespersons.

- Up-to-date information/resources including weekly reports were posted via the BCCDC website at www.bccdc.ca/westnile

- News releases issued in 2010 included:
  - Crow First positive test for WNV in 2010
  - Be vigilant and take precautions to avoid WNV

- Media Activity
  - BCCDC received 32 media calls focused on WNV in 2010

Web trends

In 2010 we tracked the number of visits to the BCCDC.ca WNV pages (on www.bccdc.ca/wnv). This allowed us to identify times of higher traffic to the website and increased public interest. There were a few interesting peaks in web traffic observed after the positive corvid release was issued on August 12th and after media attention on the first positive human was identified on September 13th (Figure 16). The peak of traffic occurred between Aug 21st and 30th, when the WNV surveillance page was viewed 481 times (excluding PHSA users).

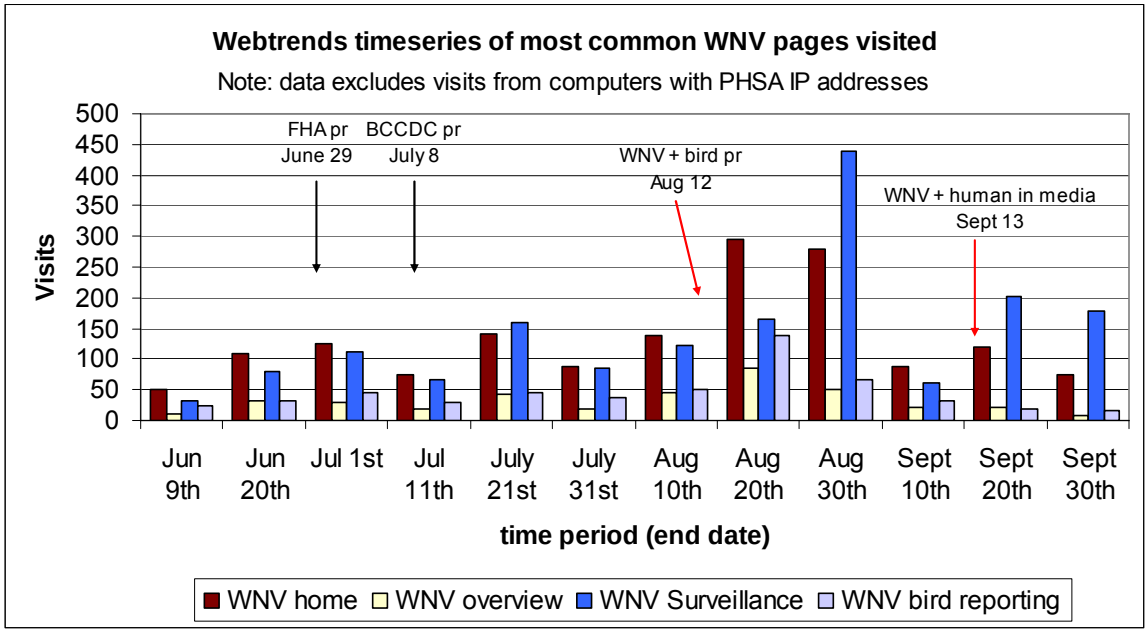


Figure 16: Webtrends from www.bccdc.ca WNV pages in 2010

2011 Communication Strategy

- The 2011 WNV campaign resources remain similar to those used during 2010. The activities for 2011 include:
  - Series of press releases and informational support material distributed throughout summer months with targeted timelines and key messages:

    - A news release in June encouraging British Columbians to prepare for the WNV season
    - A news release in August focused on personal protection.
- Provincial coordination of communications/public information through regular BC WNV communication group teleconference meetings
- BCCDC Web site – updated with timely and consistent materials for public and professional use
- Regular conference calls between MHOs, BCCDC and other related professionals
- Cooperation with other provinces/territories in coordinating public information and education

Media Inquiries

Media inquiries are handled by BCCDC (604-707-2412) and Health Authority Communications offices.

Provincial Spokespersons

Regional MHOs are the primary spokespersons for their jurisdictions, with PHO and BCCDC supporting these efforts.

Discussion: WNV in BC in 2010: What does it tell us about the future?

WNV was detected in BC for the first time in 2009 with human cases, positive mosquito pools, and positive horses identified in the southern Okanagan valley. This novel activity followed 6 years of surveillance during which no positive indicators were detected in BC despite WNV activity in neighbouring provinces and states. Here we identify two general scenarios (Figure 17) describing potential causes of the delayed occurrence of WNV in BC.

Scenario A posits that the virus was first introduced and established in 2009, moving up from Washington State, which experienced its largest outbreak in 2009. In this scenario, it is predicted that viral introduction and successful establishment were the limiting factors; now that the virus has a foothold in the province, we would expect continued cases of illness in both humans and horses. Furthermore, previous research has identified a characteristic three-year cycle in which low levels of activity are followed by significant increases in human cases in the subsequent year, with the third year showing a return to low case counts (Reisen and Brault, 2007). We may therefore have expected a greater level of human illness in 2010.

Scenario B hypothesizes that it was not novel introduction that led to the novel WNV activity in 2009, but instead a "perfect storm" of unique environmental conditions that facilitated amplification. In this scenario, a return to normal temperature in 2010 would be followed by a disappearance of the WNV activity.

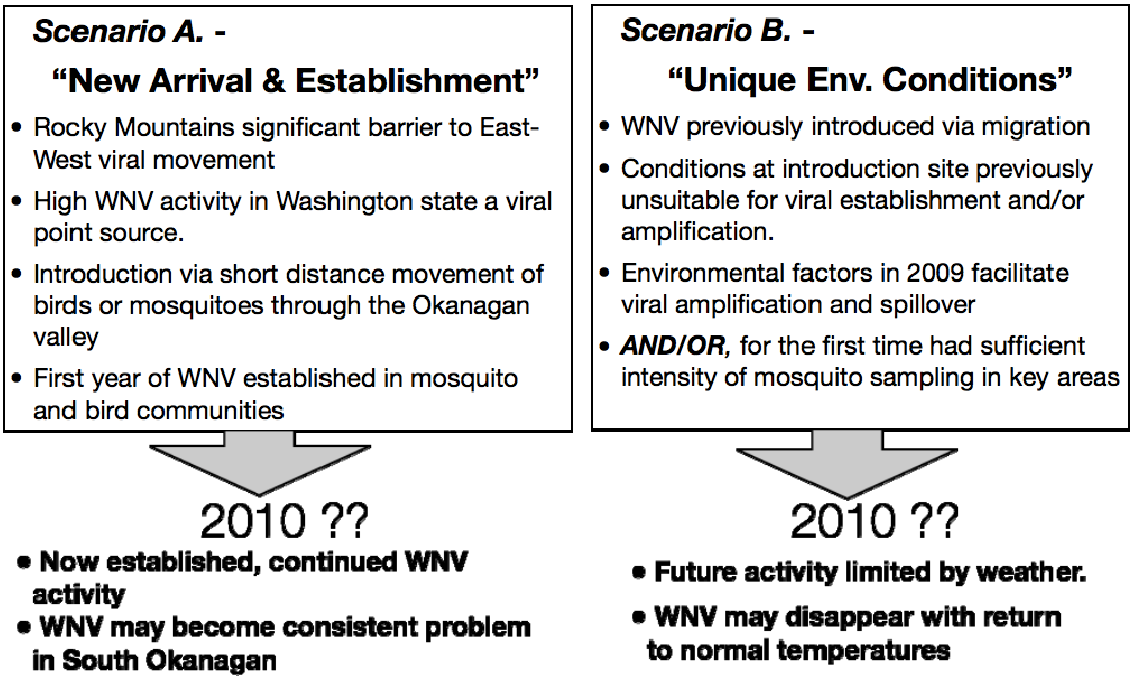


Figure 17. Two possible scenarios relating to the novel observed WNV activity in BC in 2009.

So what level of WNV activity did we observe in 2010, and what does it reveal about the future of the disease in BC? WNV was detected only in the central Okanagan Valley in 2010, north of the focal point in the 2009 outbreak. WNV remained rare, with only 1 human case and no positive mosquito pools detected. However, 5 WNV positive dead corvids were detected in the central Okanagan, the first ever in BC. An examination of daily maximum temperatures in Kelowna in 2010 (Figure 18) show no obvious above-average temperatures as was observed in the south Okanagan in 2009 (Figure 19), indicating that normal temperatures in these regions are likely sufficient for WNV amplification. We also saw a general decrease in the provincial averages of the key WNV vector in Interior BC, *Cx. tarsalis*, compared to 2009, while *Cx. pipiens* populations remained relatively high (Figure 20). *Cx. tarsalis* is considered a bridge vector of WNV in BC, meaning they feed on both birds and mammals, in comparison to *Cx. pipiens*, which is primarily a bird feeder (Belton, 2007). It may be that in 2010, BC had sufficient levels of *Cx. pipiens* to facilitate WNV amplification in avian populations, but that the low levels of *Cx. tarsalis* minimized transmission to human and horse populations.

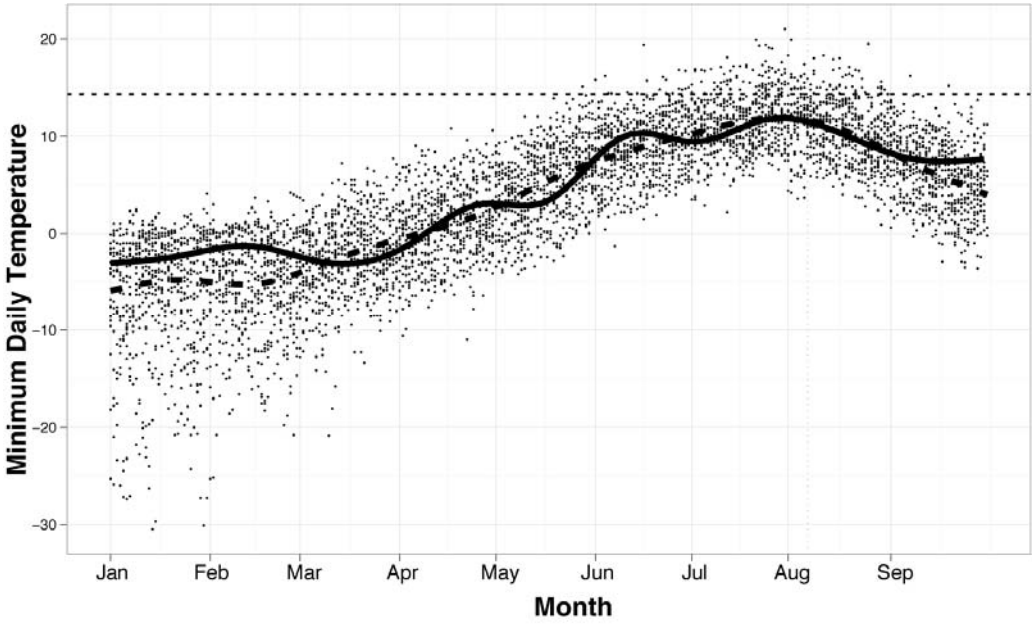


Figure 18. Daily minimum temperatures in Kelowna in 2010. The solid line represents the daily minimum temperature in 2010, and the dotted line represents the 10-year average (1999-2008).

In summary, 2010 showed that WNV activity did not increase as would be expected under the 3 year cycle identified by Reisen and Brault (2007). Nor did it disappear with a return to average temperatures. Hence, what we may be observing is a mixture of the two hypothesized scenarios. Conditions in 2009 likely represented a “perfect storm” of environmental and ecological conditions (elevated temperatures, high levels of activity in neighbouring states, and high *Cx. tarsalis* abundance) that allowed WNV to gain a foothold in BC’s avian population. If so, WNV has likely now become firmly established in our province. The low levels of WNV activity observed in BC in 2009 and 2010 are similar to that observed in Washington State prior to 2009, during which time only sporadic human cases were observed (max=3). Given the similarities between the

environmental and ecological conditions of BC and Washington, we can expect similar sporadic, low WNV activity in the future, primarily focused in the Okanagan Valley where temperatures are high. It is unlikely that WNV levels in BC will ever reach those seen in Saskatchewan and Manitoba, however, it does appear that WNV is here to stay and public health policy should proceed as such.

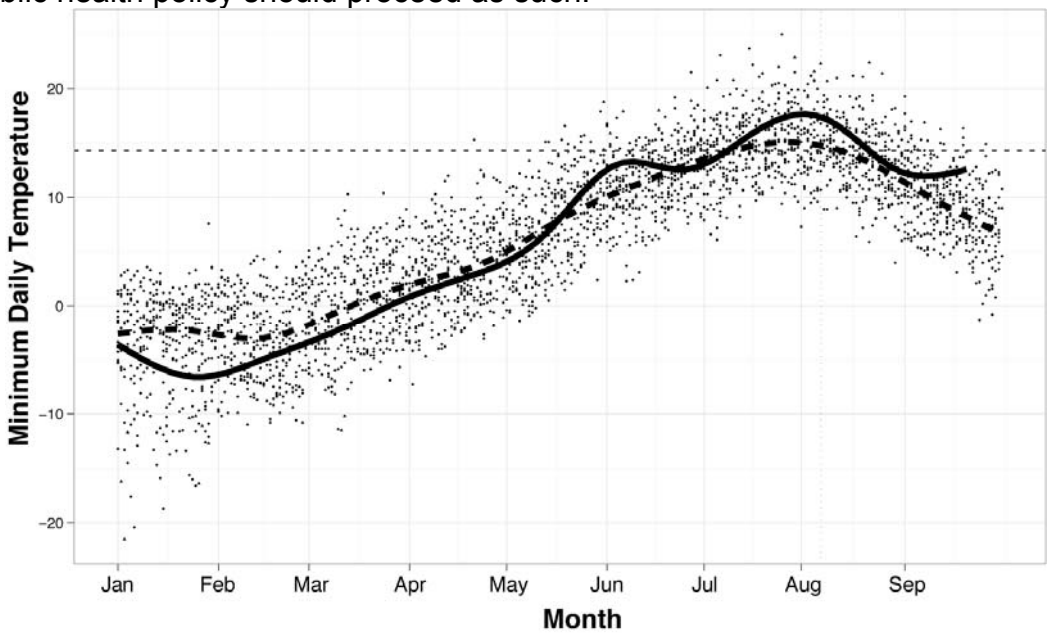


Figure 19. Daily minimum temperatures in Osoyoos in 2009. The solid line represents the daily minimum temperature in 2009, and the dotted line represents the 10-year average (1999-2008).

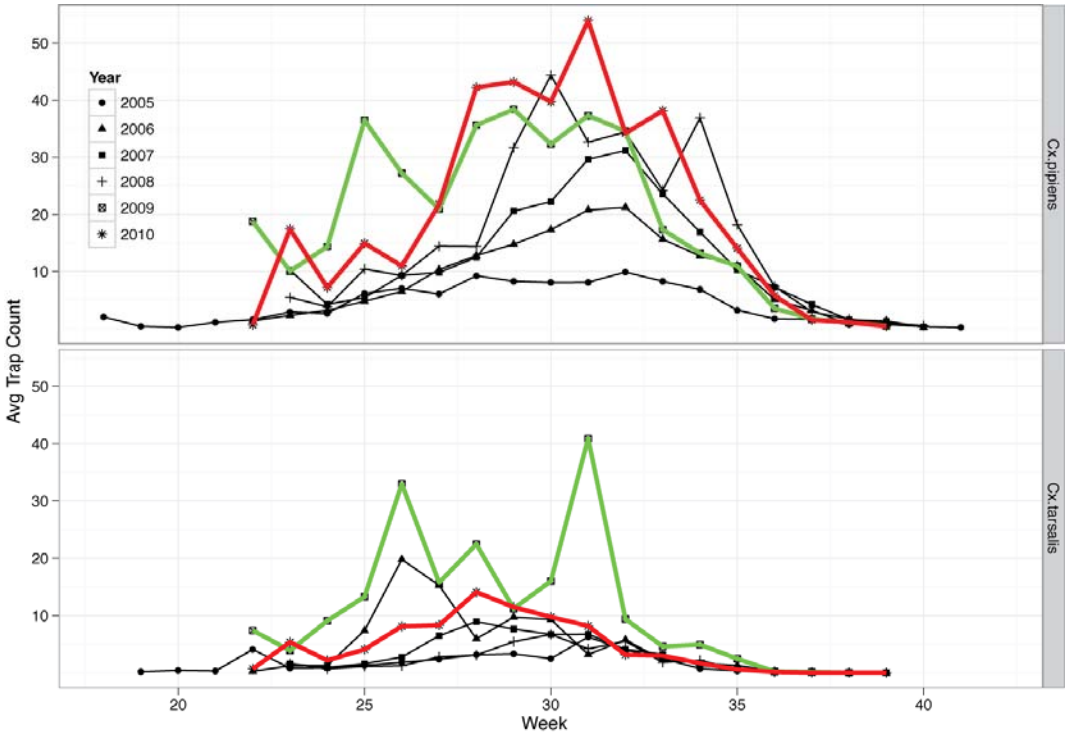


Figure 20. Average nightly catch for Cx. pipiens (top) and Cx. tarsalis (bottom). The green line represents values from 2009, while the red line represents values from 2010.

BCCDC Research

Articles:

West Nile Virus Range Expansion into British Columbia

David Roth, Bonnie Henry, Sunny Mak, Mieke Fraser, Marsha Taylor, Min Li, Ken Cooper, Allen Furnell, Quantine Wong, Muhammad Morshed, and Members of the British Columbia West Nile Virus Surveillance Team

In 2009, an expansion of West Nile Virus (WNV) into the Canadian province of British Columbia was detected. Two locally acquired cases of infection in humans and 3 cases of infection in horses were detected by ELISA and plaque-reduction neutralization tests. Ten positive mosquito pools were detected by reverse transcription–PCR. Most WNV activity in British Columbia in 2009 occurred in the hot and dry southern Okanagan Valley. Virus establishment and amplification in this region was likely facilitated by above average nightly temperatures and a rapid accumulation of degree-days in late summer. Estimated exposure dates for humans and initial detection of WNV-positive mosquitoes occurred concurrently with a late summer increase in *Cx. tarsalis* mosquitoes (which spread western equine encephalitis) in the southern Okanagan Valley. The conditions present during this range expansion suggest that temperature and *Cx. tarsalis* mosquito abundance may be limiting factors for WNV transmission in this portion of the Pacific Northwest.

West Nile Virus Finally Debuts in British Columbia 10 Years After Its Introduction to North America

Muhammad Morshed, Patrick Tang, Martin Petric, Mel Krajden, David Roth, Bonnie Henry, Judith Isaac-Renton, and the BCCDC West Nile Virus Team

Since its first detection in New York (1999), West Nile Virus (WNV) has spread across the United States and Canada with the first activity reported in Canada in 2001. By 2004, WNV had been detected in every province of Canada and the contiguous regions of the United States with the exception of British Columbia (BC), this despite being detected in Alberta in 2003 and Washington as early as 2002. In August 2009, two human cases were serologically found to have WNV infection. They reported mosquito bites and had only traveled in the south and central Okanagan areas of BC before their presentation. On the basis of clinical, laboratory and epidemiological data, these two human cases have been confirmed as the first locally acquired WNV cases in BC. Various factors may have contributed to the 10-year delay in the spread of WNV to BC, including regional weather conditions and unique topography.

Conference Presentations:

- David Roth. The Late Arrival: A West Nile Virus Range Expansion into British Columbia. British Columbia Centre for Disease Control 3rd Annual Research Symposium, Vancouver Canada, Nov 16-17, 2010. 15 min oral presentation.

- David Roth, Bonnie Henry, Phil Curry; Avian biodiversity as a determinant of West Nile Virus incidence in Saskatchewan, Canada (2003-2007). EcoHealth Conference, London UK, Aug 18-21, 2010: 15 min oral presentation.

- David Roth, Ron Hall Dr. Bonnie Henry, Dr. Muhammad Morshed. Collaborative surveillance with First Nations Community leads to initial detection of West Nile Virus in British Columbia. EcoHealth Conference, London UK, Aug 18-21, 2010: Poster presentation". • 2010 International Conference on Emerging Infectious Diseases, Atlanta Georgia, July 11-14, 2010:

- David Roth, Bonnie Henry, Sunny Mak, Mieke Fraser, Marsha Taylor, Min Li, Ken Cooper, Allen Furnell, Quantine Wong, Muhammad Morshed. The Late Arrival : Environmental & Ecological Drivers of a West Nile Virus Range Expansion into British Columbia. National Non-Enteric Zoonoses Workshop, Public Health Agency of Canada, Ottawa Ontario, February 25-26th,2010.

Future Surveillance and Intervention Activities

BCCDC staff met with the 4 southern HAs and the Ministry of Health Services on November 29, 2010 to discuss future surveillance plans and mosquito control. Over the past 8 years, BCCDC and the HAs have developed and refined surveillance techniques, and learned much from our collaborative experiences and the experiences of other jurisdictions in Canada and the US.

The research that BCCDC had conducted on the effectiveness of larviciding and adulticiding in controlling adult mosquito numbers and WNV infection rates was shared with the HAs at the November 29 meeting.

Surveillance activities and results for 2010 were reviewed.

The value of corvid and mosquito surveillance was discussed, and input was received from the HAs on the degree of surveillance they could provide. There was also discussion about the value of pre-emptive larviciding by communities.

At the meeting it was generally agreed that:

- Adulticiding should be removed as an annual planning focus;
- Although there is limited evidence of effectiveness in the literature of larviciding as a means to control adult mosquito vectors and prevent WNV infection, pre-emptive larviciding is of value in targeted areas of BC;
- Partnerships with local governments around WNV prevention is valuable and should continue;
- Dead corvid online reporting should be supported;
- Corvid collection for testing should be supported in the Fraser Valley, where it has not been shown that WNV is established; and
- Mosquito trapping could continue in the same jurisdictions that carried it out in 2010, but with some modification of trap locations and an increased intensity in higher risk areas.

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Acknowledgements:
As with previous years, both field and laboratory workers have to be congratulated on making the mosquito surveillance system operate efficiently. Often there are seasonal staff that need to be trained in the submission routine and processing of samples. We would like to acknowledge their efforts at making this system work so well. Furthermore, we would like to acknowledge the work of AHC in carrying out prompt testing of corvid specimens and for their aid in the tracking of equine positives. We also acknowledge the efforts of CBS in testing blood donations, and for their participation in this program. We would like to thank all our partners for their efforts, without whom a comprehensive epidemiological approach to WNV would be impossible.