In cooperation with the U.S. Fish and Wildlife Service

Bats of Ouray National Wildlife Refuge, Utah

By Laura E. Ellison

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Bats of Ouray National Wildlife Refuge, Utah

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Introduction

Ouray National Wildlife Refuge (NWR) is located in the northeastern corner of Utah along the Green River and is part of the Upper Colorado River System and the Colorado Plateau. Ouray NWR is in central Uintah County, 2 miles northeast of Ouray, and 10 miles southeast of Randlett. The Refuge covers 11,987 acres, includes 12 miles of the Green River, and was originally established in 1960 to serve as a refuge for breeding and migrating waterfowl. Management strategies today (2011) focus on managing water to mimic the natural flood plains that existed before dams were erected along the river. Portions of protective levees throughout the Refuge were removed to allow more frequent flooding. There are five bottom lands within the river floodplain: Johnson Bottom, Leota Bottom, Wyasket Lake, Sheppard Bottom, and Wood's Bottom. These bottom lands are all fed by the river as it winds through an otherwise desert-like landscape. With more than 4,000 acres of wetland and riparian habitat, the Refuge is home to a diverse group of birds, mammals, fish, plants, and amphibians and reptiles. Prior to this study, the assumption was that Ouray NWR would provide excellent habitat for bats, but no previous bat studies had been conducted, and it was unknown what species of bats occurred on the Refuge.

The Colorado Plateau is home to 19 species of bats, 18 of which have been documented in Utah (Hasenyager, 1980; Oliver, 2000). Of the 18 species found in Utah, a few do not range into northern parts of the state and would not be expected to be found on the Ouray NWR [for example, western red bat (*Lasiurus blossevilii*) and Allen's big-eared bat (*Idionycteris phyllotis*)]. Regional maps indicate the other 16 species that occur in Utah, could all potentially occur on the Refuge (Hasenyager, 1980; Oliver, 2000). Although the number of species of bats in the western United States and Utah is well known, there have been relatively few surveys of the bat fauna within specific land management areas, especially in the state of Utah (Bogan and others, 2006; Mollhagen and Bogan, 1997; Oliver, 2000). Details on the natural history, species composition, feeding ecology, roosting habitat, and other aspects of bat ecology are also typically lacking for many areas in Utah. There are several reasons for this lack of knowledge. Bats are notoriously difficult to survey due to their nocturnality, secretive daytime habits, and mobility across the landscape. The means by which bats are captured have numerous biases that make judgments of "relative abundance" difficult to determine (Kunz and others, 2009). The most efficient way to capture bats is to place mist nets in areas where bats are likely to fly near the ground to drink or forage (Kunz and others, 1996). However, using mist nets set up over water can be biased by the morphology and flight characteristics of each species (Larson and others, 2007). Some species are highly maneuverable with low aspect ratios and low wing loading and not only can avoid mist nets, but are more likely to use small isolated pools of water for drinking. Less maneuverable species are more easily captured, and are more likely to drink at larger bodies of water with more open approaches. Capturing bats as they drink or feed over water can also vary in success with the amount of water present in the landscape.

Many species of bats in western North America form maternity colonies of varying size in the summer. These roosts are in structures where ambient temperatures are warm, such as in crevices in trees and rock exposed to the sun, and the females cluster and use each other's body heat to further maintain warm temperatures and enhance rapid development of young. Typically, each female gives birth to a single young in early summer (late June, for example) and the juveniles grow rapidly in these warm maternity sites. When the juveniles are about 4 weeks old they are nearly adult sized, weaned, and make regular nightly foraging flights. It is becoming widely recognized that adult males and females can occupy separate regions in the summer, particularly in areas of the western United States that show significant zonation in elevation (for example, Cryan and others, 2000; Neubaum and others, 2006). Females tend to favor warmer, lower elevation sites for reproduction in summer whereas males occur more often at cooler, higher elevations. This differential distribution can be reflected in skewed adult sex ratios, with more males captured at higher elevations in the summer. Sex ratios of bats are usually 1:1 at birth and on an annual, distribution-wide basis (Kunz and Lumsden, 2003).

The overall goal for this project was to conduct a baseline inventory of bat species occurring at Ouray NWR. The 3 specific objectives to accomplish this goal were to: (1) identify water sources occurring at Ouray NWR where bats could be captured using mist nets and assess species occurrence; (2) capture and identify bats at these water sites and release unharmed; and, (3) collect echolocation activity of bats to augment species occurrence information.

Methods

I met the first objective of this study by conducting an initial scouting trip to Ouray NWR in May 2010 to ground truth Refuge maps and identify where bodies of water were located. I then chose 3 10-day field trips in June, July, and August 2010 based on lunar phase; the middle of each trip coincided with the new moon because it is suspected that bat capture rates are higher during darker phases of the moon. During these field trips, I used 2 different methods to inventory the bat species at Ouray NWR. The first method was to survey the bat fauna by capturing, identifying, and noting the reproductive condition of individuals, and then releasing them. This method is most efficient when done by placing mist nets in areas where bats are likely to fly near the ground to drink or forage (Kunz and others, 1996). Because much of the landscape of Ouray NWR was open water, both from wetland habitat and the Green River, it was difficult to find areas where bats would concentrate during foraging or drinking. It was feasibly impossible to set up mist nets across these large bodies of water. Therefore, I concentrated the mist netting surveys along potential flyways, roads, habitat edges, and along the margins of the ponds at the Ouray National Fish Hatchery (located within Ouray NWR). The second method I used to supplement mist netting surveys was acoustic monitoring with ultrasonic bat detectors (Anabat II; Titley Electronics, NSW, Australia). I recorded echolocation calls and searched for distinctive acoustic properties of additional species not captured in nets. Acoustic surveys to determine bat activity provide a way to increase "captures" of bats and potentially augment an inventory because the sample space is not limited to 6-m-high nets (or lower) used during this study. However, these types of surveys provide only a relative index of bat activity, and they are limited in their accuracy in identifying all species in a community (Hayes, 1997, 2000; Fenton and others, 1987).

Mist Netting Surveys

Mist netting surveys occurred the nights of 8-15 June, 7-13 July, and 3-10 August 2010. I surveyed 11 sites with mist nets (fig. 1). During the June field trip, I used up to 6 nets per night of 9 m, 12 m, and 18 m in length. These nets were set on 3-m-high poles. It was difficult to capture bats with such low nets and so much water surface area available on the refuge (I only captured one individual during the June survey). Therefore, in July and August 2010, I used higher, “stacked” nets. These stacked nets were 6-m high and used 2, 12-m-long nets on a pulley system based on the system designed by Gardner and others (1989). Two of these stacked nets were used per night during the July and August 2010 field trips.

Nets were tended from dusk until midnight, depending on the weather. For each bat captured, I determined the sex and reproductive condition following the criteria in Racey (1988). Pregnancy was assessed by palpation (a technique most reliable at advanced stages), lactation by prominence of nipples and teats (verified by expression of a milk droplet when possible), and post lactation. Bats were categorized as adult or volant juvenile (young-of-the-year) based on ossification of the phalangeal epiphyses (Anthony, 1988) as viewed against a light source. I also measured body mass (grams) and forearm length (mm). In addition to assessing age and reproductive condition, I also assessed the wings of each bat to determine a wing damage index (WDI) (Reichard and Kunz, 2009). Wing damage is a clinical sign of white-nose syndrome (WNS) in hibernating bats, a disease causing unprecedented declines in several species of North American bats since the winters 2006 and 07 (Cryan and others, 2010). WNS can cause damage to wings and tail membranes in the form of lesions, flakiness or dehydrated skin, discolored spots/scarring, multiple holes, or tears to the membranes. Although WNS has not been detected in bats in Utah, it is spreading westward from the northeastern United States and could potentially affect bats in Utah in the future, so it is important to establish a reference baseline by examining individuals for evidence of lesions and/or excessive damage to their wings.

Field personnel who handled bats wore leather gloves, had pre-exposure rabies prophylaxis, and followed capture and handling procedures approved by the Institutional Animal Care and Use Committee of the U.S. Geological Survey, Fort Collins Science Center. In addition, I used the disinfection protocols for WNS suggested by the Western Bat Working Group (*http://www.wbwg.org/conservation/whitenosesyndrome/WNSPreventionProtocol061509.pdf*) and the U.S. Fish and Wildlife Service (*http://www.fws.gov/northeast/whitenose/FINALContainmentandDecontaminationProceduresforCavers June2009.pdf*). Any equipment that came in contact with a bat was decontaminated. Bats were typically released within 15 minutes or less of capture.

I followed regional publications for species names (Durrant, 1952; Hasenyager, 1980; Oliver, 2000). There were a few exceptions: I used canyon bat (*Parastrellus hesperus*) for the previously named western pipistrelle (*Pipistrellus hesperus*) (Hoofer and others, 2006) and *Corynorhinus townsendii* for the Townsend’s big-eared bat (Tumlison and Douglas, 1992; Bogdanowicz and others, 1998).

Anabat Acoustic Surveys

I set up four permanent monitoring stations for collecting acoustic data in June 2010 and I added two more stations in July and August 2010 (fig. 1). The general locations were chosen nonrandomly to maximize the area sampled at the refuge and specific locations were chosen based on proximity to water, habitat edges, and potential flyways. We recorded acoustic activity of bats from sunset to sunrise on six nights at each station in June (Stations 1-4), July (Stations 1-6), and August 2010 (Stations 1-6). We used the Anabat II bat detectors with programmable zero-crossing analysis interface modules (Anabat CF Storage ZCAIM; Titley Electronics, NSW, Australia). Detectors were placed in weatherproof boxes oriented in random directions and angled 45 degrees to a reflective polycarbonate-plastic surface (fig. 2). Detectors were precalibrated to minimize variation in zone of reception among units. I downloaded echolocation call data from detectors every other day and cleared the storage ZCAIMs for redeployment. I used Analook for Windows software, version 3.7w

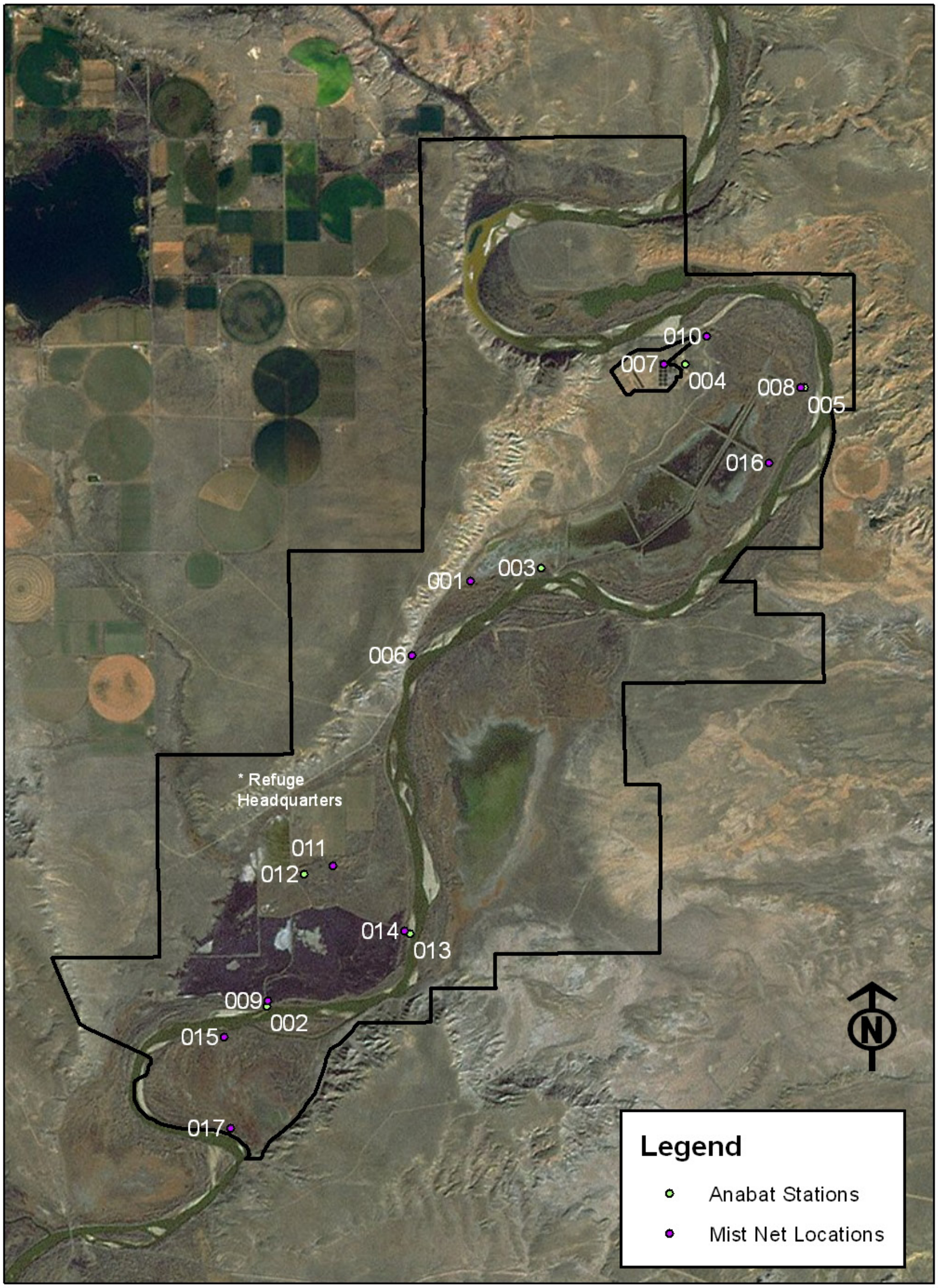

Figure 1. Map of Ouray National Wildlife Refuge, Utah, with Mist Netting Locations and Anabat Station locations. The numbers by each point refer to the global positioning system waypoints described in detail in table 1.

Figure 2. Anabat ultrasonic bat detectors were fitted inside metal cases and affixed to steel posts. Detector microphones were oriented downward to avoid damage from weather. Bat calls were deflected into the microphone from an acrylic glass place mounted on a steel bracket near the bottom of the case. These detectors were programmed to automatically turn on and off near sunset and sunrise.

(*http://users.lmi.net/corben/anabat.htm*), to analyze call recordings, and I categorized them by species, based on qualitative and quantitative features documented in libraries of species-specific echolocation calls (C. Corben and M. O'Farrell, O'Farrell Biological Consulting, unpub. data, 2007; Ellison and others, 2005; Everette and others, 2001; O'Farrell, 1997; O'Farrell and others, 1999). I did not attempt to distinguish between calls from potential species occurring on the refuge that have similar calls [for example, silver-haired bats (*Lasionycteris noctivagans*) and Brazilian free-tailed bats (*Tadarida brasiliensis*)]. When I could not identify a bat call sequence to species, I identified it as one of four groups based on echolocation frequency: (1) Myotis 40 kHz group; (2) a Myotis 50 kHz group; (3) a low frequency group; and, (4) Unidentified. I defined a "bat pass" as a sequence of ≥ 2 call pulses produced by a single bat from the moment it was detected until it left the range of detection (Thomas, 1988). Detection events of <2 call pulses were not used to quantify bat activity. Bat passes were tallied by location (Anabat Station), date, time of night, and species. Simple summary statistics were made to describe bat activity by location, date, time of night, and species using the "count labels" tool in Analook and with Excel spreadsheets.

Results

Mist Netting Surveys

We netted 11 locations at Ouray NWR during June, July, and August 2010 for a total of 21 nights (table 1; fig. 1). We captured 36 individuals of 9 different species (table 2). The most productive netting site was L1 SE Corner, which was located in Leota Bottom at the southeastern corner of L1 pond. This location was at the intersection of three roads, one of which led directly to the Green River, and was most likely an important flyway concentrating bats as they flew between Leota Bottom and the Green River. On each night this location was netted, I captured at least one bat, and on August 3, 2010, I captured 15 individuals of 5 species. The 2 most commonly captured species were the pallid bat (*Antrozous pallidus*; 12 individuals; 33 percent of total captures) and the big brown bat (*Eptesicus fuscus*; 12 individuals; 33 percent of total captures). I captured four long-legged myotis (*Myotis volans*),

Table 1. Site names, location information, and dates surveyed for mist netting and Anabat monitoring stations at Ouray National Wildlife Refuge, Utah, during the summer 2010. (Waypoint numbers refer to labels on figure 1).

Waypoint	Site name	Site type	X/Y coordinates	Latitude/Longitude	Elevation (m)	Dates surveyed
001	L10 Entrance	Mist net	0617564/ 4445982	40.15597042/ -109.61960340	1424	8 June
002	Station 1	Anabat		40.11002610/ -109.64835031	1422	10-15 June 8-13 July 6-9 August
003	Station 2	Anabat		40.15744027/ -109.60956842	1424	10-15 June 8-13 July 4-9 August
004	Station 3	Anabat		40.17941837/ -109.58916737	1426	10-15 June 8-13 July 4-9 August
005	Station 4	Anabat		40.17688930/ -109.57226207	1423	10-15 June 8-13 July 4-9 August
006	River Bluff Road	Mist net	0616876/ 4445083	40.14797056/ -109.62783962	1428	9 June 9 July 5 August
007	Fish Hatchery	Mist net	0619861/ 4448623	40.17943187/ -109.59214076	1429	10 June 10 July 8 August

Waypoint	Site name	Site type	X/Y coordinates	Latitude/Longitude	Elevation (m)	Dates surveyed
008	L1 SE Corner	Mist net	0621515/ 4448376	40.17696784/ -109.57277019	1424	11 June 7 July 3 August
009	Auto Tour River Access	Mist net	0615205/ 4440901	40.11053564/ -109.64819323	1422	13 June 8 July 6 August
010	NW L2 Green River	Mist net	0620372/ 4448971	40.18249596/ -109.58608082	1425	14 June 4 August
011	Nature Trail Flyway	Mist net	0615959/ 4442544	40.12523037/ -109.63905964	1458	15 June
012	Station 5	Anabat		40.12423972/ -109.64312486	1463	8-13 July 4-9 August
013	Station 6	Anabat		40.11782723/ -109.62813576	1427	8-13 July 4-9 August
014	Fishing Pier	Mist net	0616836/ 4441775	40.11818245/ -109.62890907	1418	11 July
015	Wood's Bottom Y	Mist net	0614681/ 4440457	40.10660654/ -109.65442191	1421	12 July
016	L5/L3 Road	Mist net	0621148/ 4447462	40.16879473/ -109.57724889	1437	13 July
017	Wood's Back	Mist net	0614778/ 4439373	40.09682779/ -109.65348221	1408	10 August

Table 2. All bats captured using mist nets by species, location, and date at 11 locations at Ouray National Wildlife Refuge, Utah, during the summer 2010. Sex (F for female and M for male), age (A for adult and J for juvenile), reproductive status (Repro; L for lactating, NR for nonreproductive, and PL for post lactating), time of capture, forearm (FA), and mass are also provided.

Common name (Scientific name)	Site name	Date	Sex	Age	Repro	Time (24-hour)	FA (mm)	Mass (g)
California myotis (*Myotis californicus*)	L5/L3 Road	13 July	F	A	L	22:29	35.3	5.0
	L1 SE Corner	3 Aug	F	A	NR	22:20	32.7	5.0
Long-eared myotis (*M. evotis*)	L1 SE Corner	11 June	F	A	NR	21:56	42.0	7.0
	L1 SE Corner	3 Aug	M	A	NR	21:07	37.8	7.5
Little brown bat (*M. lucifugus*)	Auto Tour River Access	6 Aug	F	A	PL	23:00	38.6	7.0
Long-legged myotis (*M. volans*)	Fish Hatchery	10 July	F	A	NR	22:09	37.5	8.0
	Fish Hatchery	10 July	F	A	L	23:59	38.9	10.0
	Fish Hatchery	8 Aug	F	A	PL	23:15	39.2	10.5
	Fish Hatchery	8 Aug	F	J	NR	23:15	38.0	7.5
Yuma myotis (*M. yumanensis*)	L5/L3 Road	13 July	F	A	L	22:29	38.7	8.5
Pallid bat (*Antrozous pallidus*)	L1 SE Corner	7 July	F	A	L	21:45	57.1	20.5
	L1 SE Corner	7 July	F	A	NR	22:16	56.0	19.0
	L1 SE Corner	3 Aug	F	J	NR	21:30	55.9	17.0
	L1 SE Corner	3 Aug	F	A	PL	21:30	58.1	15.5
	L1 SE Corner	3 Aug	F	A	NR	21:30	58.0	20.5
	L1 SE Corner	3 Aug	F	A	PL	21:48	56.1	21.0
	L1 SE Corner	3 Aug	F	A	NR	21:48	56.1	20.5
	L1 SE Corner	3 Aug	M	J	NR	21:48	56.3	16.0

	L1 SE Corner	3 Aug	M	A	NR	21:48	59.5	23.0
	L1 SE Corner	3 Aug	F	A	NR	21:48	58.8	19.0
	L1 SE Corner	3 Aug	F	A	PL	22:10	61.4	24.0
	L1 SE Corner	3 Aug	M	A	NR	23.07	56.9	17.0
Big brown bat (*Eptesicus fuscus*)	Auto Tour River Access	8 July	F	A	L	21:22	47.5	17.5
	Auto Tour River Access	8 July	F	A	L	21:22	46.8	16.0
	Auto Tour River Access	8 July	F	A	L	21:22	48.0	17.0
	Auto Tour River Access	8 July	F	A	L	21:22	46.8	16.0
	River Bluff Road	9 July	F	A	NR	22:03	50.3	18.0
	Wood's Bottom Y	12 July	F	A	PL	21:35	49.2	19.0
	Wood's Bottom Y	12 July	F	A	L	21:52	50.2	16.5
	Wood's Bottom Y	12 July	F	A	PL	21:52	46.0	22.5
	L1 SE Corner	3 Aug	F	A	PL	21:07	47.8	15.5
	L1 SE Corner	3 Aug	M	A	NR	23:48	46.8	14.0
	River Bluff Road	5 Aug	F	J	NR	21:55	47.6	17.5
	Auto Tour River Access	6 Aug	F	J	NR	21:15	47.9	14.0
Townsend's big-eared bat (*Corynorhinus townsendii*)	Auto Tour River Access	6 Aug	F	A	PL	22:30	46.4	9.0
Canyon bat (*Parastrellus hesperus*)	L1 SE Corner	3 Aug	F	A	PL	22:10	34.1	3.5

all at the Ouray National Fish Hatchery. Two California myotis (*M. californicus*) and two long-eared myotis (*M. evotis*) were captured. Finally, one each of the following species were captured: little brown bat (*M. lucifugus*), Yuma myotis (*M. yumanensis*), Townsend's big-eared bat, and canyon bat. The majority of bats captured were adult females (30; 83.3 percent). I captured only four male adults: one big brown bat, two pallid bats, and one long-eared myotis. In August, I captured five volant juveniles: one long-legged female, one female and one male pallid bat, and two female big brown bats.

I found evidence for reproduction in females of eight species of bats at Ouray NWR and more than half of all females captured showed evidence of reproductive activity (19; 63.3 percent). No females that were visibly pregnant were captured (table 2). Most females that showed evidence of reproduction in July were lactating (9; 81.8 percent). Two big brown bats were captured in July that were post lactating. In August, all bats captured showing evidence of reproduction were post lactating. No male bats captured showed evidence of reproductive activity. Four female big brown bats were captured on 8 July 2010 at 21:22 (9:22 p.m). These bats were all lactating and most likely came from a nearby roosting site, probably not from off the Refuge. These 4 females could have come from a maternity colony roosting in a cottonwood tree near the mist net location.

Anabat Acoustic Surveys

The Anabat acoustic surveys took place 10-15 June, 8-13 July, and 4-9 August, 2010 at Stations 1 through 4 (table 1; fig. 1). Stations 5 and 6 collected data on 8-13 July and 4-9 August. A total of 22,006 Anabat files were collected to storage ZCAIMs from all 6 stations of which 17,791 (80.8 percent) were classified as a bat pass and identified to species or species grouping. Less than a third of these bat passes (4,986; 28.0 percent) were identified to species and 72.0 percent (12,805 passes) were classified in a species grouping.

I identified 12 species from echolocation calls, 4 of which were not captured in mist nets (table 3). The four additional species detected acoustically were the western small-footed myotis (*Myotis ciliolabrum*), the fringed myotis (*M. thysanodes*), the hoary bat (*Lasiurus cinereus*), and the big free-tailed bat (*Nyctinomops macrotis*). Most Anabat Stations picked up at least one pass of every species identified with a few exceptions. The fringed myotis was not identified at Stations 2 and 6. The Yuma myotis was not identified at Station 6. Finally, the hoary bat was not identified at Stations 2 and 5. The largest number of bat passes identified to a specific species (4,986 total passes) were from the canyon bat (31.7 percent) followed by the big free-tailed bat (25.1 percent), the pallid bat (13.2 percent), the big brown bat (8.9 percent), and the western small-footed myotis (6.0 percent). More than a third (35.4 percent) of the total bat passes were classified in the Low Frequency group, 19.7 percent were classified as Myotis 40 kHz, and 6.9 percent Myotis 50 kHz. Ten percent of all bat passes were classified as the Unidentified group (these were passes that were definitely made by a bat, but the sequence was completely unidentifiable) (table 3). I provide examples of time-frequency displays for the four species identified acoustically, but not captured inhand in Appendix 1.

Total bat activity varied by station with the highest number of passes collected at Station 4 (fig. 3). This station collected more than double the number of calls collected at Stations 1 and 2, and nearly six times the number collected at Stations 3. Station 4 was located at the southeastern corner of Leota Bottom, the same location where the majority of the bats were captured in mist nets. The average number of bat passes per night (averaged across nights within a month) and by station varied dramatically (fig. 4). The highest average activity was recorded during the June 2010 survey at Station 4 (862.3 $\pm$ 500.8 SD bat passes). This high average activity level and wide standard deviation was due to the fact that Station 4 collected more than 1,600 bat passes on June 10, more than 1,200 on June 11, and more than 1,400 on June 12 (see Appendix 2). For the remaining 3 nights of June, less than 400 bat passes were collected.

Bat activity varied from hour to hour through the night and across months (fig. 5). In June 2010, the number of bat passes followed somewhat of a bell curve with lower activity early in the night and early in the morning with higher levels of activity from 11 p.m. to 1 a.m. In July, activity was high from 9-10 p.m. and again from 1-2 a.m., but with the lowest activity in the early morning (5-6 a.m.). In August, nightly activity indicated more of a bimodal pattern with higher activity early in the evening (9-10 p.m.) and again early in the morning (5-6 p.m.). Summaries of bat activity by date and Anabat Station are provided in Appendix 2 and summaries of activity by hourly increments through the night for each station are provided in Appendix 3.

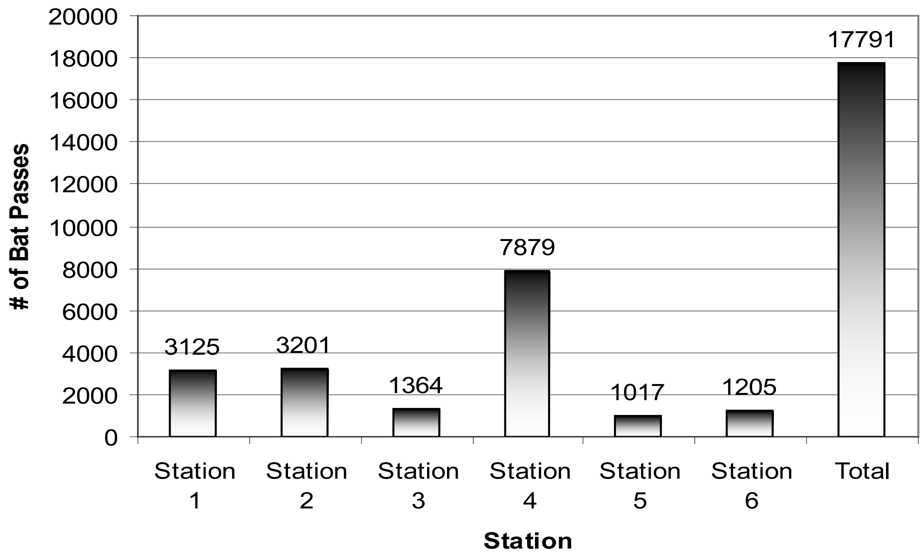

Figure 3. Total number of bat passes collected by Anabat Station at Ouray National Wildlife Refuge, Utah, during the summer 2010. Note that Stations 5 and 6 only collected acoustic data during July and August.

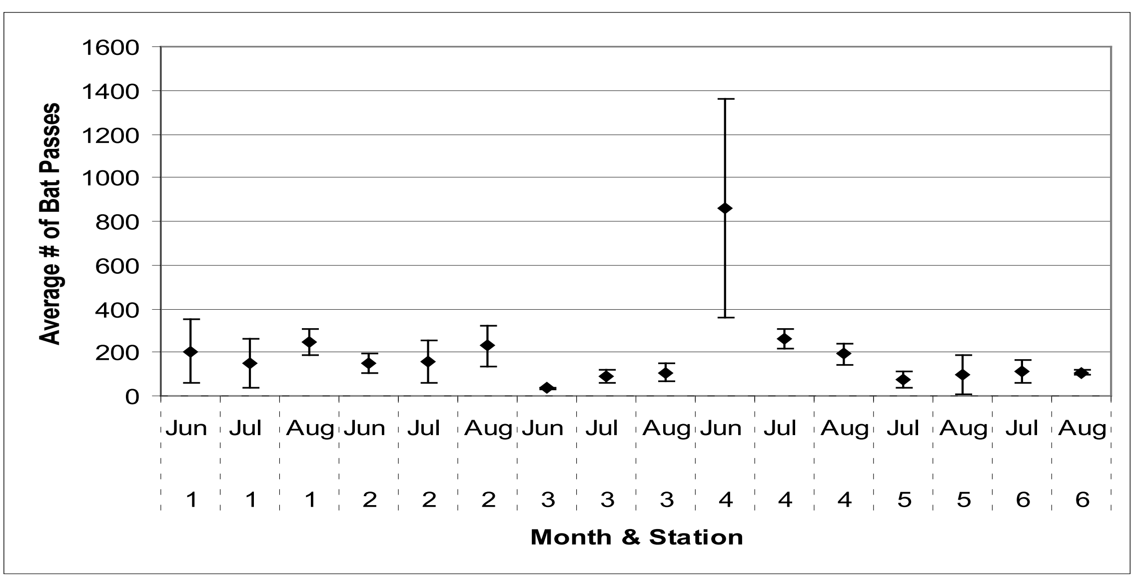

Figure 4. Average number of bat passes per month and Anabat Station at Ouray National Wildlife Refuge, Utah, during the summer 2010. The error bars displayed for each point estimate are the standard deviations.

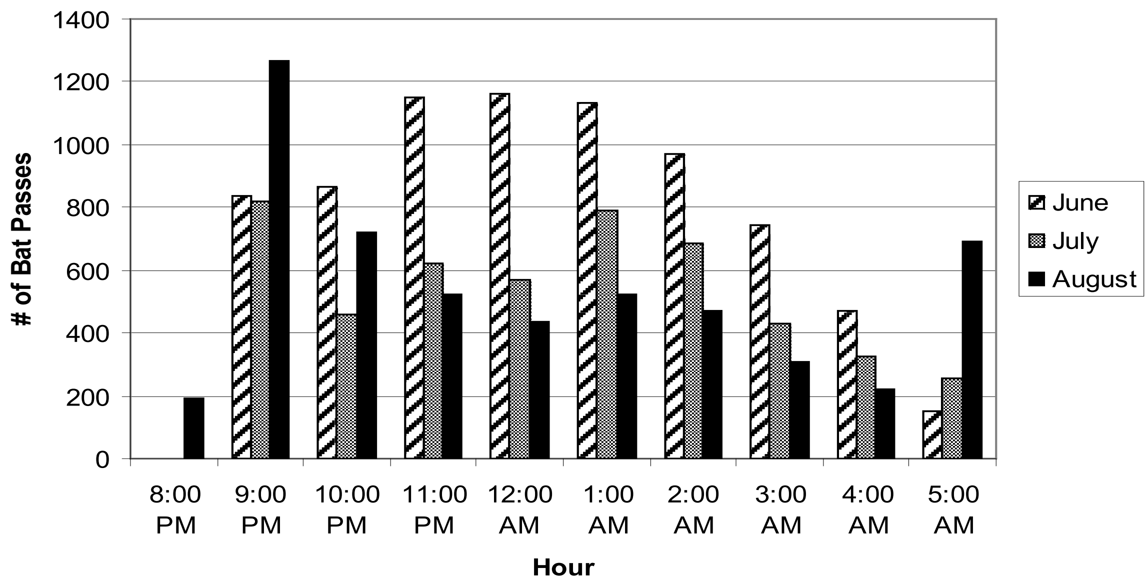

Figure 5. Total number of bat passes in hourly increments through the night and by month using data from all Anabat Stations combined at Ouray National Wildlife Refuge, Utah, during the summer 2010.

Table 3. Number of bat calls identified to species by month and Anabat Station at Ouray National Wildlife Refure, Utah, during the summer 2010.

Common name (Scientific name)[1]	Month	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Total by month	Grand total
California myotis (*Myotis californicus*)	**June**	10	4	4	29	N/A	N/A	47	92
	July	5	21	4	2	0	1	33	
	August	4	0	7	0	1	0	12	
Western small-footed myotis (*M. ciliolabrum*)	**June**	28	49	2	98	N/A	N/A	170	302
	July	15	30	3	15	8	2	73	
	August	16	3	4	15	12	2	52	
Long-eared myotis (*M. evotis*)	**June**	19	2	0	71	N/A	N/A	92	134
	July	1	3	4	4	5	0	17	
	August	6	0	4	7	4	4	25	
Little brown bat (*M. lucifugus*)	**June**	21	3	1	9	N/A	N/A	34	87
	July	5	27	2	3	1	0	38	
	August	8	1	0	2	3	1	15	
Fringed myotis (*M. thysanodes*)	**June**	1	0	2	12	N/A	N/A	15	25
	July	0	0	1	4	0	0	5	
	August	1	0	2	1	1	0	5	
Long-legged myotis (*M. volans*)	**June**	32	18	2	70	N/A	N/A	122	194
	July	3	16	6	4	4	0	33	
	August	19	3	2	3	10	2	39	

Yuma myotis (*M. yumanensis*)	**June**	12	8	10	97	N/A	N/A	127	
	July	1	39	2	4	1	0	47	193
	August	7	0	6	4	2	0	17	
Pallid bat (*Antrozous pallidus*)	**June**	14	55	7	224	N/A	N/A	300	
	July	4	10	6	117	3	4	144	657
	August	77	19	3	84	11	19	213	
Big brown bat (*Eptesicus fuscus*)	**June**	83	6	9	78	N/A	N/A	176	
	July	53	4	35	5	0	12	109	442
	August	40	10	12	20	1	74	157	
Hoary bat (*Lasiurus cinereus*)	**June**	0	0	0	3	N/A	N/A	3	
	July	2	0	3	2	0	5	12	28
	August	3	0	6	2	0	2	13	
Canyon bat (*Parastrellus hesperus*)	**June**	25	26	47	282	N/A	N/A	380	
	July	27	121	83	317	55	36	639	1579
	August	35	71	96	225	43	90	560	
Big free-tailed bat (*Nyctinomops macrotis*)	**June**	0	1	0	0	N/A	N/A	1	
	July	179	51	73	427	56	411	1197	1253
	August	7	5	1	1	8	33	55	
Myotis 40 kHz	**June**	362	251	20	1251	N/A	N/A	1884	
	July	171	390	37	98	183	19	898	3505
	August	170	35	24	157	289	48	723	

	June	123	42	16	543	N/A	N/A	724	
Myotis 50 kHz	**July**	123	110	20	58	14	5	333	1235
	August	60	9	18	36	38	20	181	
	June	413	426	38	2307	N/A	N/A	3184	
Low frequency	**July**	289	87	192	488	44	63	1163	6290
	August	520	70	388	550	84	322	1934	
	June	90	10	12	100	N/A	N/A	212	
Unidentified	**July**	28	19	76	13	71	15	222	1775
	August	4	1146	74	37	65	15	1341	
Total		3125	3201	1364	7879	1017	1205		17791

Discussion

Ouray NWR has a diverse bat fauna. I documented nine species by inhand captures and an additional four species based on recordings of unique vocalizations. These findings document the occurrence at Ouray NWR of 13 of the 18 species of bats known to occur from Utah (Hasenyager, 1980; Oliver, 2000). The other 5 of the 18 species of Utah bats not documented during this study are the silver-haired bat (*Lasionycteris noctivagans*), the Brazilian free-tailed bat (*Tadarida brasiliensis*), the western red bat (*Lasiurus blossevilii*), the spotted bat (*Euderma maculatum*), and Allen's big-eared bat (*Idionycteris phyllotis*). A silver-haired bat was captured at Ouray NWR in 2009 by the USFWS (Drew Crane, oral commun., 2010). With the addition of this single individual, the total number of bat species documented to occur at Ouray NWR is 14. Three of the species I documented as occurring at Ouray NWR are identified by the Utah Division of Wildlife Resources as Utah Species of Concern in the Utah Sensitive Species List: the fringed myotis, the Townsend's big-eared bat, and the big free-tailed bat (Oliver and others, 2008; Utah Division of Wildlife Resources, 2005).

The Brazilian free-tailed bat is suspected to occur at the refuge and this species was likely recorded during the echolocation surveys. However, the Brazilian free-tailed bat's echolocation calls are difficult to distinguish from both the big brown bat and the silver-haired bat, and I did not feel confident definitively documenting the presence of this species on the Refuge without a capture inhand. Records of the spotted bat are lacking from large parts of Utah (Oliver, 2000). However, this species has a wide range, it is known from all states bordering Utah, and its presence was found to be locally common in Dinosaur National Monument, Colorado, approximately 46 miles from Ouray NWR (Navo and others, 1992; Storz, 1995). The echolocation calls of spotted bats are audible to the human ear (Fenton and others, 1987). However, no field personnel heard the audible calls of spotted bats while mist netting during this study. Also, no spotted bat calls were recorded during echolocation surveys, but the Anabat microphones are not sensitive to the low-frequency calls of this species. The western red bat and Allen's big-eared bat are only known from the southern-most parts of Utah and were not anticipated to occur on the Refuge (Hasenyager, 1980; Oliver, 2000).

The majority of the bats I captured were females. In mountainous regions during the summer months (June, July, August), male bats of most species tend to be found at higher elevations and cooler temperatures whereas females tend to be found at lower elevations more favorable to reproduction. Lower elevations provide warmer roosts for female bats to rear young, whereas higher elevations can allow deeper daily torpor for males and nonreproductive females (see review in Weller and others, 2009). At least one female of each species captured showed evidence of reproduction except for the long-eared myotis. I captured one male and one female of long-eared myotis, both adults and neither of which showed evidence of reproduction. Although the long-eared myotis is common throughout Utah and has been captured in a wide variety of habitats, little is known about its roosting habitat in the state, and maternity roosts have not been documented in the state (Oliver, 2000). No pregnant bats were captured; however, only one individual bat (female) was captured in June 2010. Typically, bats in western North America are pregnant in May and June (Cockrum, 1955). Based on the capture data, female bats at Ouray NWR are most likely pregnant and give birth in the month of June, begin lactating through late July, and are post lactating in August.

Bat activity is generally higher along riparian corridors when compared to more upland habitats (Bell, 1980; Ellison and others, 2005; Rogers and others, 2006), and I found bat activity to be relatively high at Ouray NWR as indicated by the total number of bat passes collected (17,791). Rogers and others (2006) examined patterns of habitat use in a community of bats along the Provo River in Heber Valley, Utah. They established 10 acoustic detector survey points and recorded calls for 23 nights collecting

2,629 (6.7 times less overall activity than Ouray NWR). Bogan and others (2006) also used acoustic surveys at Canyonlands National Park in southern Utah and during 17 survey nights collected 3,751 bat passes (4.7 times less than Ouray). The Anabat Stations at Ouray NWR were deployed in nonrandom locations to maximize the amount of bat activity recorded and potentially pick up bat calls from species not captured with mist nets. The stations were typically situated near habitat edges, open bodies of water, and potential flyways. Differences in bat activity and species richness among these sites or studies can therefore only be attributed to their unique locations, and the differences cannot be extrapolated to habitat type or other landscape features. Of the six Anabat stations, the highest amount of activity was at Station 4 during the June 2010 sampling and based on the first three nights of sampling (10-12 June) where total number of bat passes collected was at least three times more than any other night of sampling at that location. Station 4 is located at the most productive mist-netting location (L1 SE Corner, table 2) with the already mentioned flyway feature probably concentrating bats into a narrow area. The lowest activity recorded was at Station 3 at the Fish Hatchery, also during the June sampling period. Station 3 was the most open location with potentially less insect abundance and no flyways for concentrating bat activity compared to the other locations. Station 3 was also located farthest from the Green River and riparian habitat. Bat activity has been found to be highly variable among sampling nights (Ellison and others, 2005; Krusic and others, 1996; Hayes, 1997; Seidman and Zabel, 2001) with one, two, or multiple peaks of nightly bat activity documented (Hayes, 1997). Factors influencing bat activity on a particular night are complex and may include current weather, previous weather, distribution of insects, and intra- and interspecific interactions among bats (Hayes, 2000).

Bat activity occurred throughout the night at all stations at Ouray NWR. Anabat recordings were collected during each hourly increment from 9 p.m. until 6 a.m. at every station and earlier recordings were made before 9 p.m. at some stations later in the summer (July and August). The pattern of activity over the course of the night differed somewhat by month. During the time when female bats were most likely pregnant (June), activity followed somewhat of a bell curve with an increase in activity from 11 p.m. to 1 a.m. During July, when females were most likely to be lactating, activity was generally lower overall and showed no consistent pattern. In August, when females were likely to be post lactating and the juveniles were out foraging, activity followed a slightly bimodal pattern with high bat activity from 9-11 p.m. and a second small peak in activity at 5 a.m. A bimodal pattern of activity with peaks at dusk and before dawn is typical of bats in many areas (Cockrum and Cross, 1964; Jones, 1965; Kuenzi and Morrison, 2003; O'Farrell and Bradley, 1970; Ekert, 1978), with activity during the post-sunset period generally being higher than that of the predawn period (Kunz and Brock, 1975; Walsh and Mayle, 1991; Hayes, 1997).

The bat fauna at Ouray NWR contains species that are continental migrants (for example, hoary and silver-haired bats), species with affinities for more arid southwestern ecosystems (for example, canyon bats, pallid bats, and Yuma myotis; Barbour and Davis, 1969), species with more montane affinities and distributions that tend to extend further northward (for example, long-eared myotis, long-legged myotis, and fringed myotis; Barbour and Davis, 1969), and species found throughout much of North America (for example, big brown bats, Townsend's big-eared bats, and western small-footed myotis; Barbour and Davis, 1969). This diverse fauna is most likely due to the availability of more than 4,000 acres of wetland and riparian areas on the Refuge providing excellent foraging and roosting habitat for bats.

Where do the bats roost on the Refuge? This question could not be answered with this current project because it would have required radiotelemetry and tracking bats back to their daytime roosts. The 4 female big brown bats that were captured in July 2010 soon after dusk were all lactating and most likely came from a nearby maternity roost on the Refuge, possibly in a cottonwood. Big brown bats roost in hollow trees, storm sewers, rock crevices, under loose bark, and in a variety of human-made structures (Barbour and Davis, 1969). A potential future research project for bats at Ouray NWR could involve radiotelemetry to track bats back to their daytime roosts.

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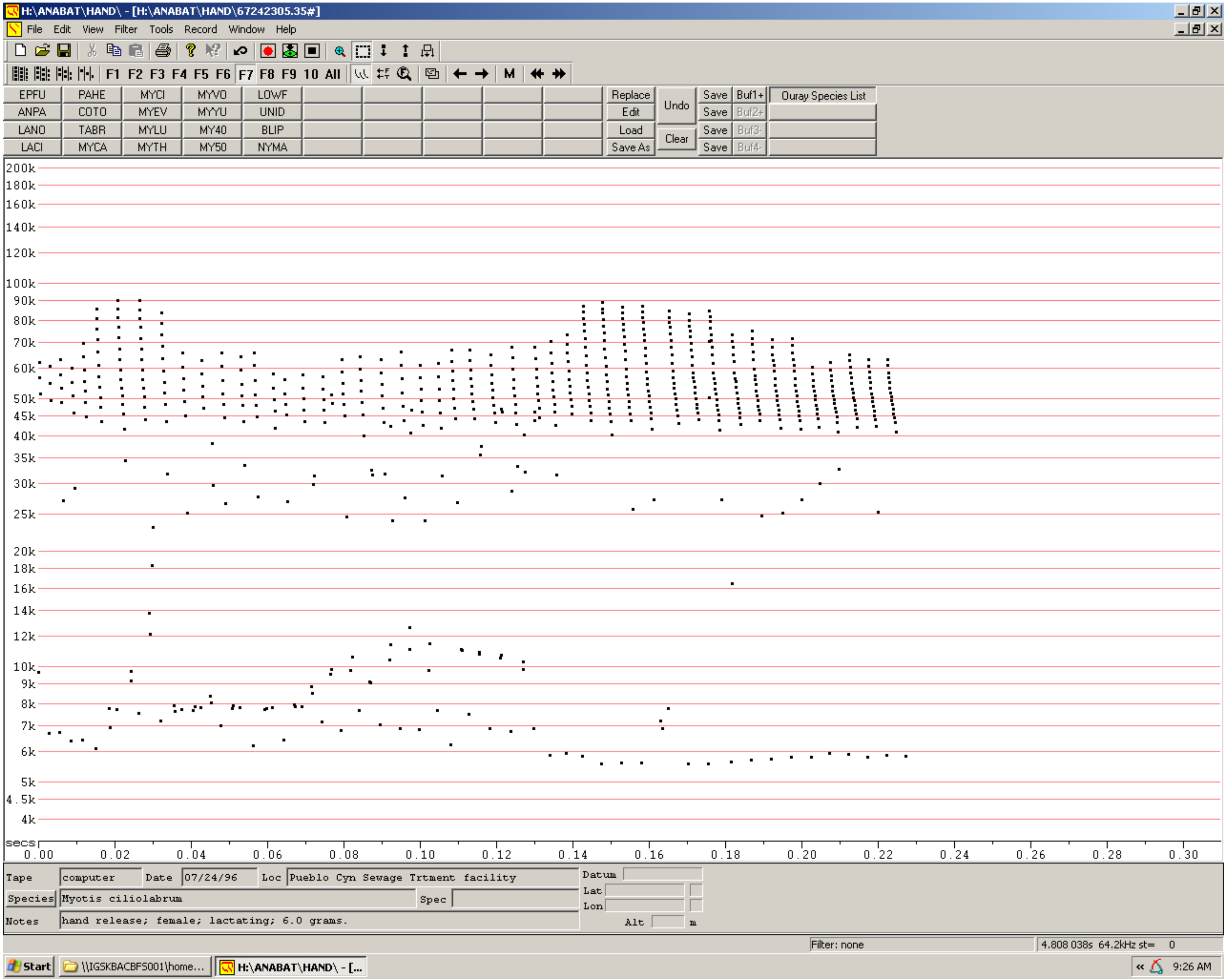
Appendixes

Appendix 1. A selection of time-frequency displays of the 4 species identified from Anabat recordings not captured in mist nets at Ouray National Wildlife Refuge, Utah, during the summer 2010. Detailed information about each time-frequency display is located at the bottom of each image. The first 2 time-frequency displays are examples of known reference calls for these species.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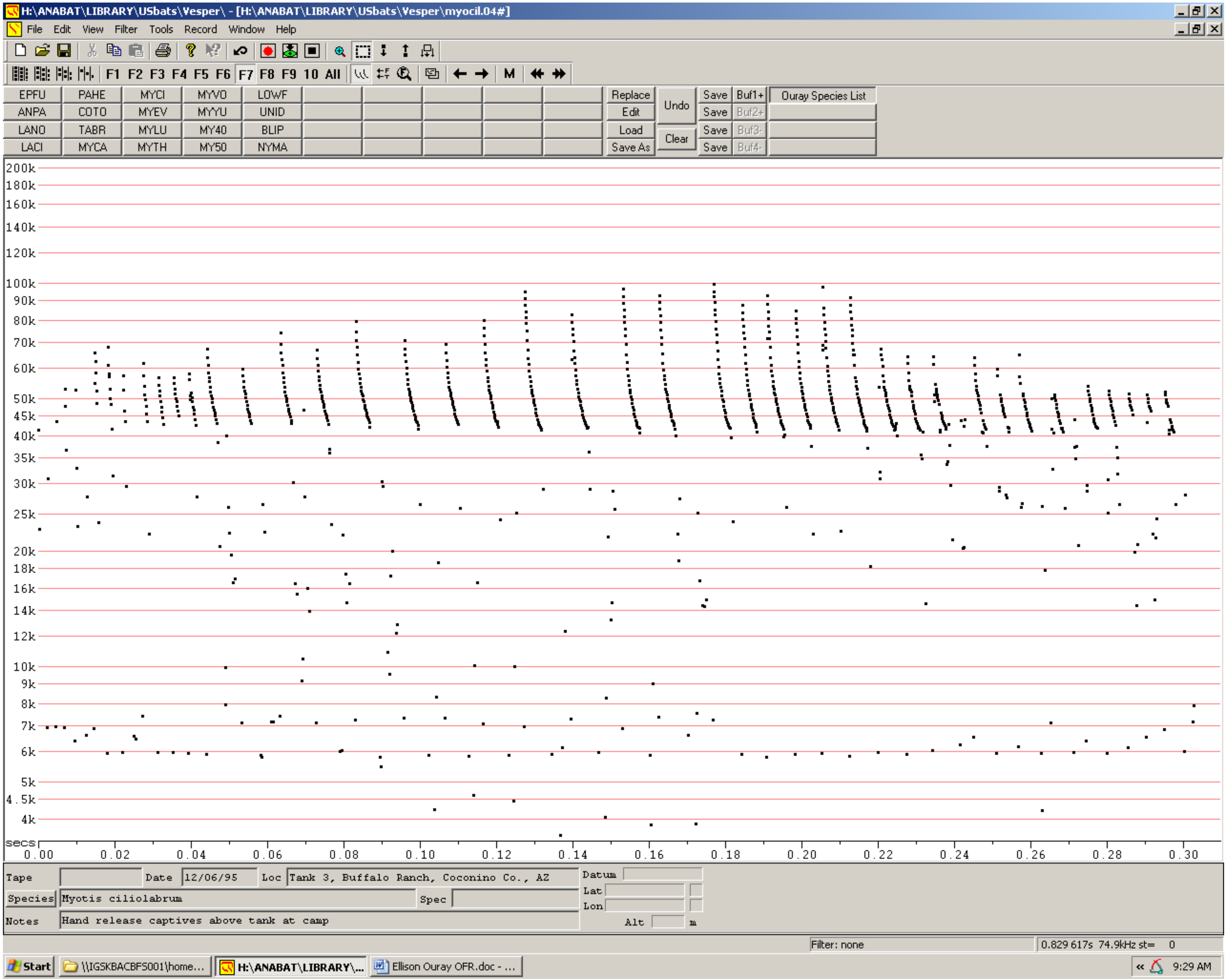
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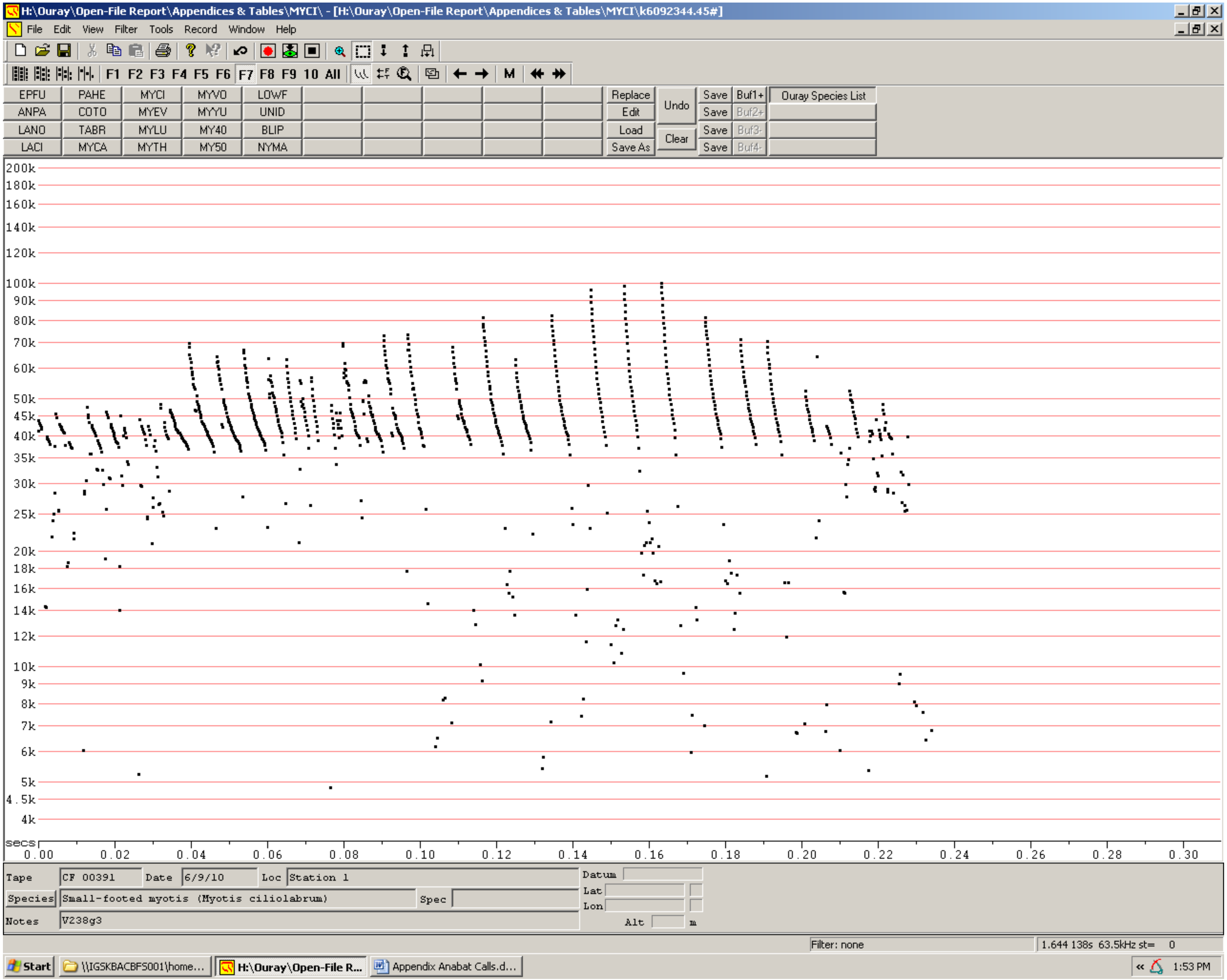
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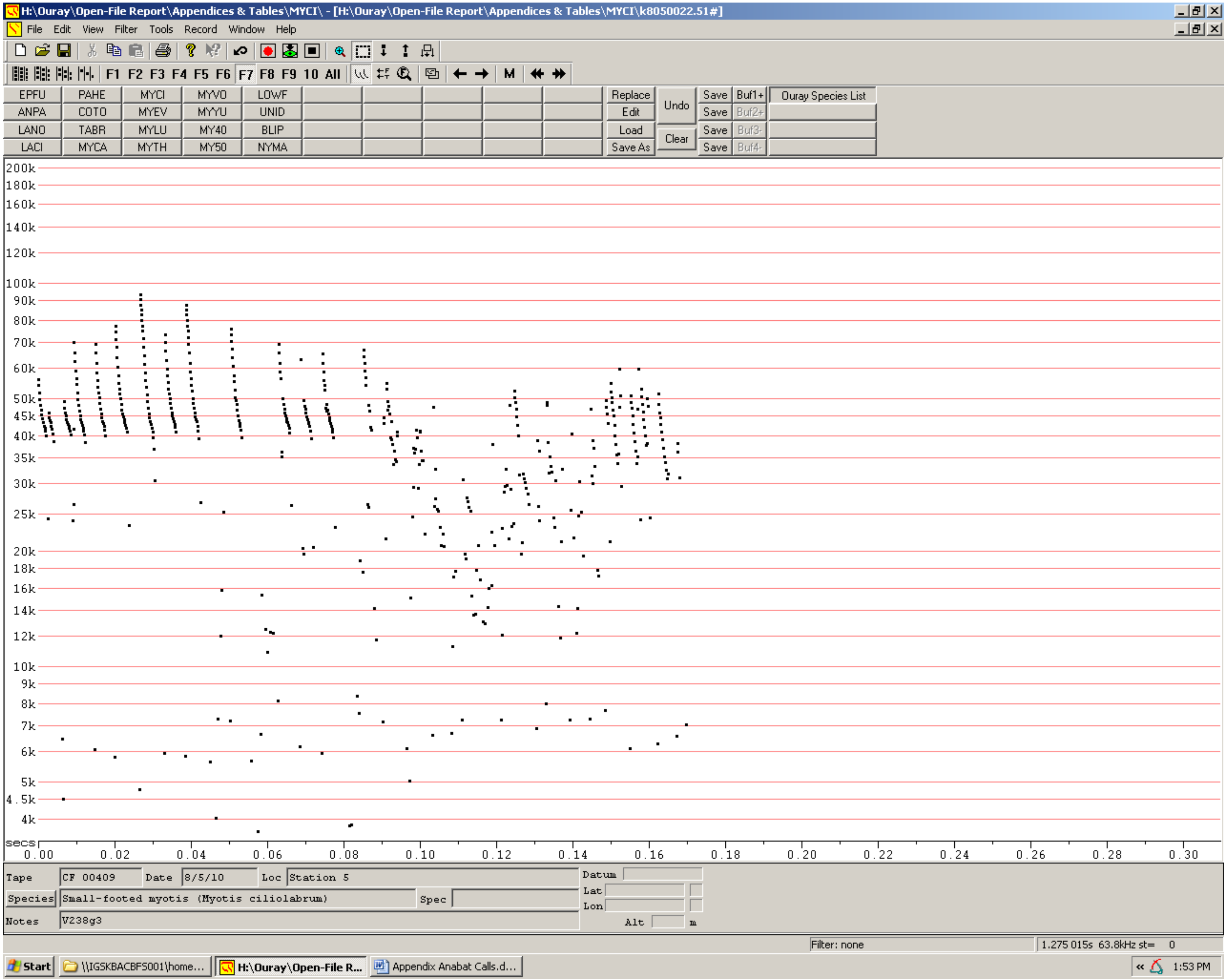
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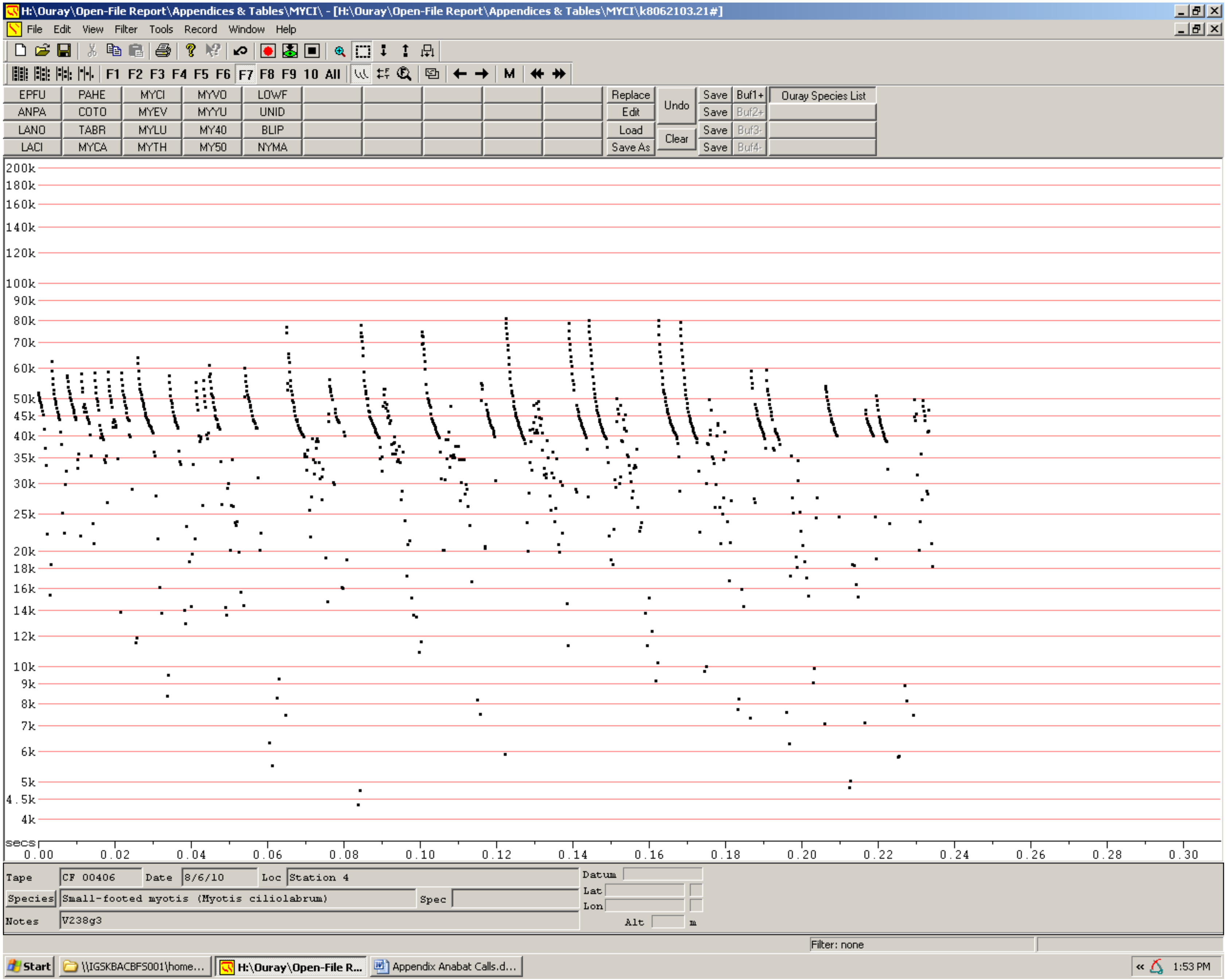
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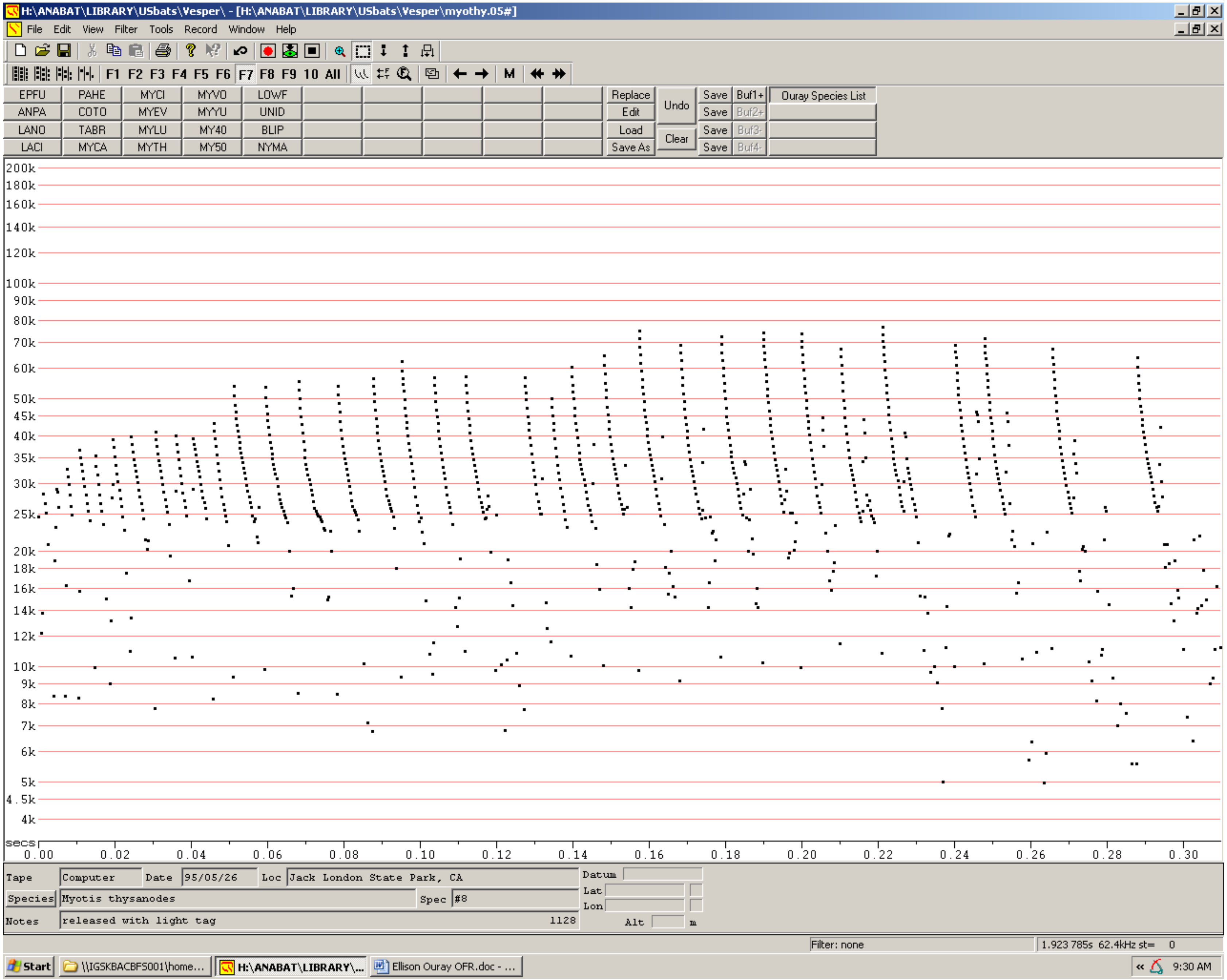
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Ouray Species List
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45k
40k
35k
30k
25k
20k
18k
16k
14k
12k
10k
9k
8k
7k
6k
5k
4.5k
4k
secs
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30
Tape Computer Date 95/05/26 Loc Jack London State Park, CA
Datum
Lat
Lon
Species Myotis thysanodes Spec #8
Notes released with light tag 1128
Alt m
Filter: none
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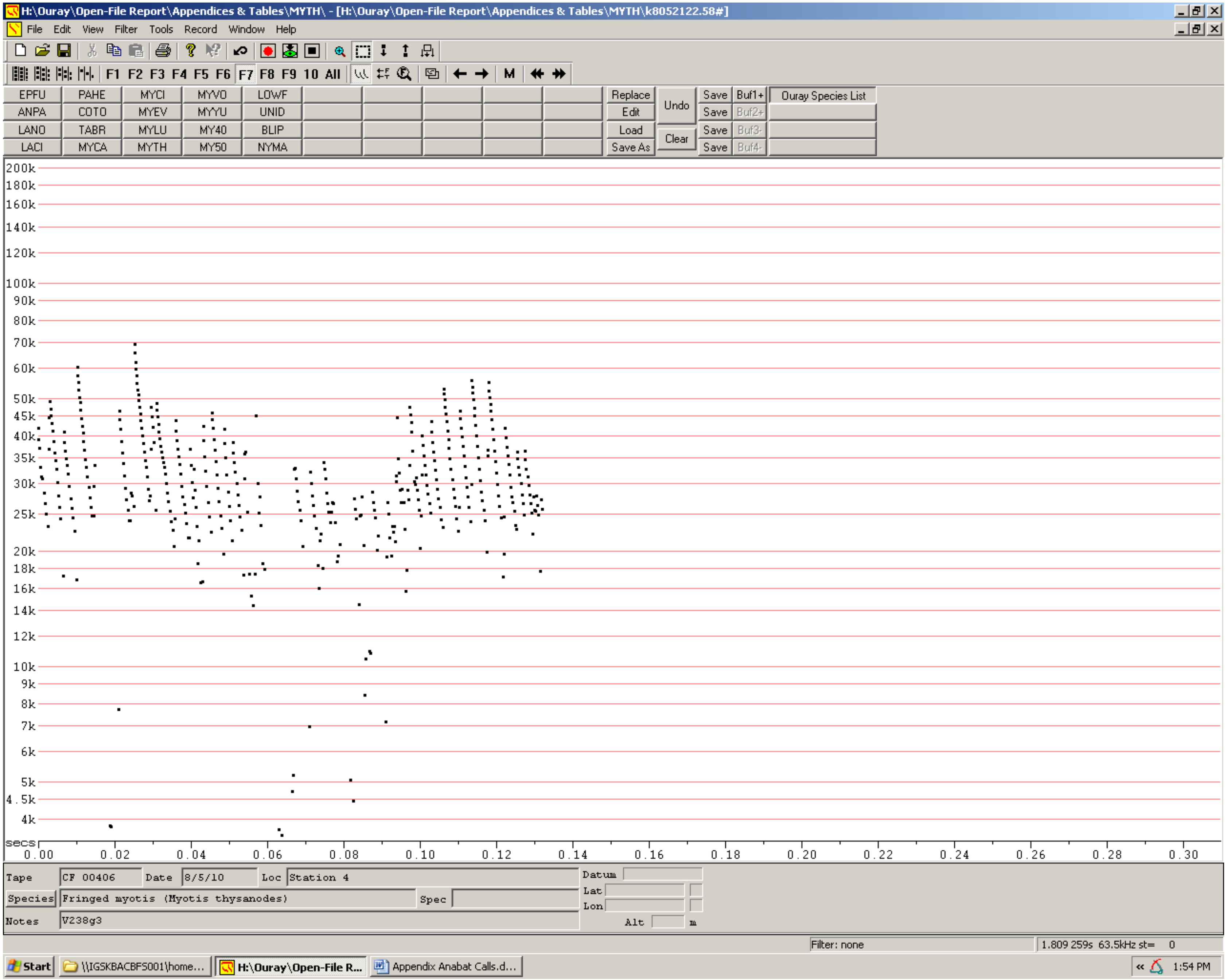
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secs
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30
Tape CF 00406 Date 8/5/10 Loc Station 4
Species Fringed myotis (Myotis thysanodes) Spec
Notes V238g3
Datum
Lat
Lon
Alt m
Filter: none
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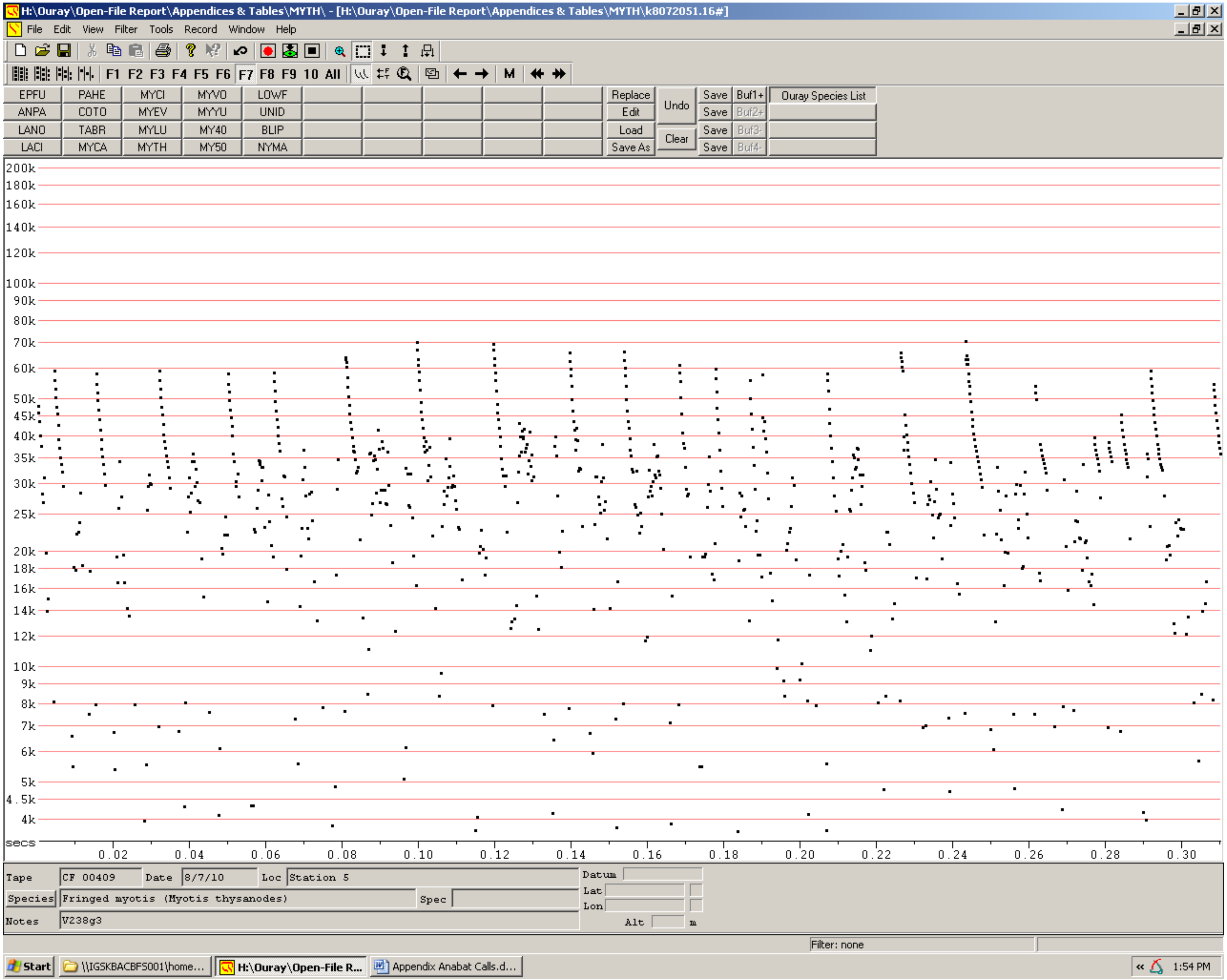
1:54 PM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Tape CF 00409 Date 8/7/10 Loc Station 5
Species Fringed myotis (Myotis thysanodes) Spec
Notes V238g3
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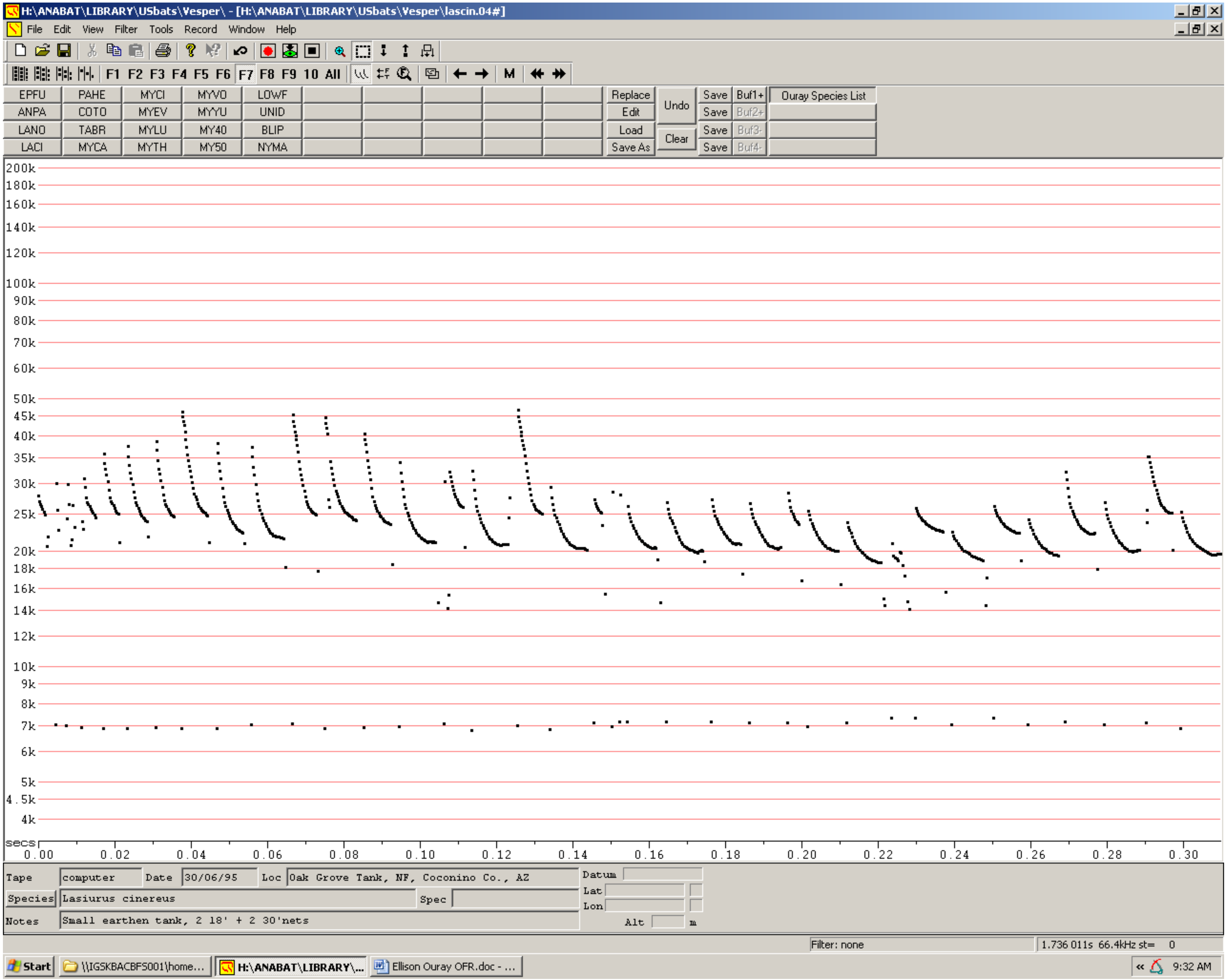
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LACI MYCA MYTH MY50 NYMA
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secs 0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30
Tape computer Date 30/06/95 Loc Oak Grove Tank, NF, Coconino Co., AZ
Species Lasiurus cinereus Spec
Notes Small earthen tank, 2 18' + 2 30'nets
Datum Lat Lon Alt m
Filter: none 1.736 011s 66.4kHz st= 0
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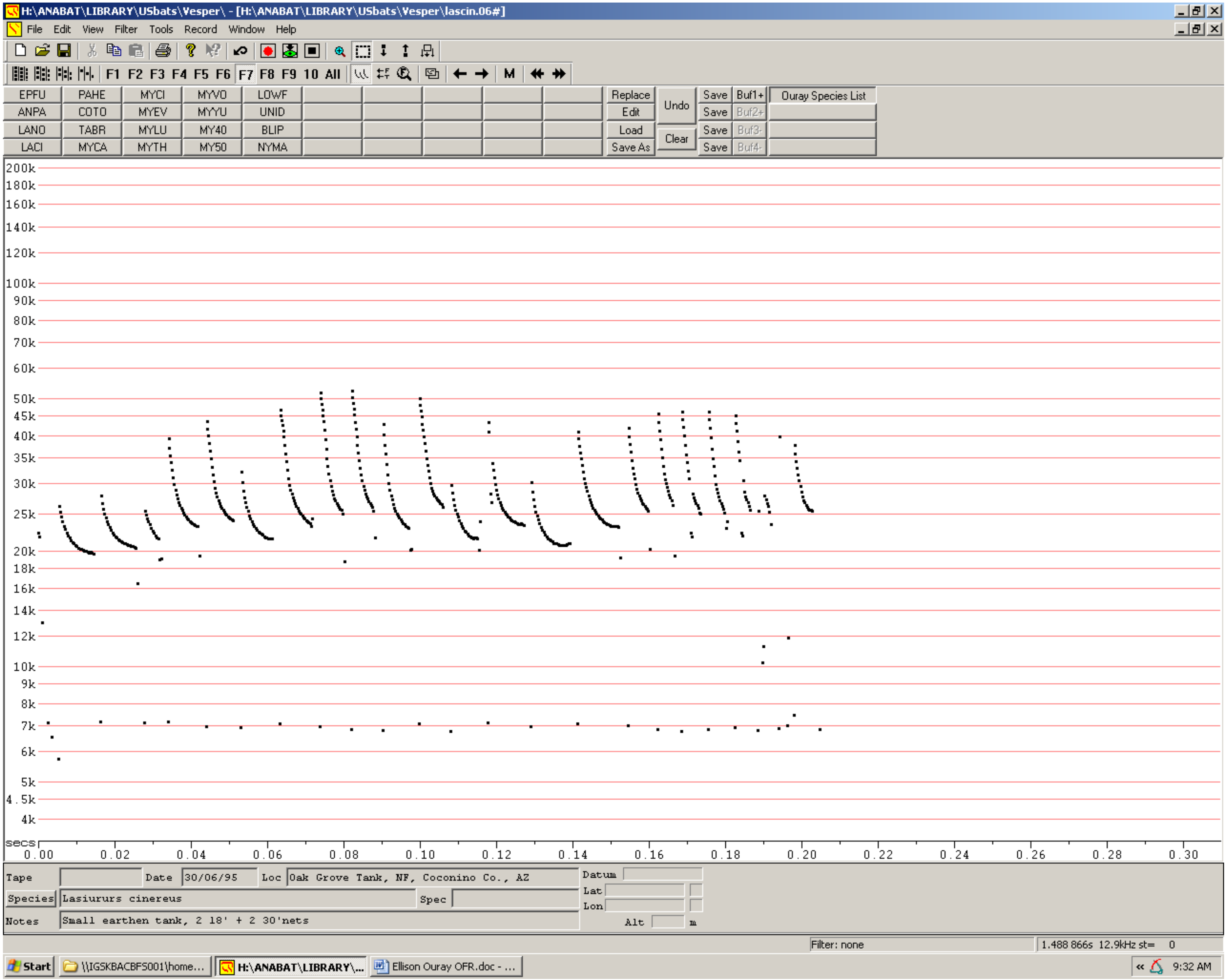
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LACI MYCA MYTH MY50 NYMA
Replace Edit Load Save As Undo Clear
Save Buf1+ Ouray Species List
Tape Date 30/06/95 Loc Oak Grove Tank, NF, Coconino Co., AZ
Species Lasiururs cinereus
Notes Small earthen tank, 2 18' + 2 30'nets
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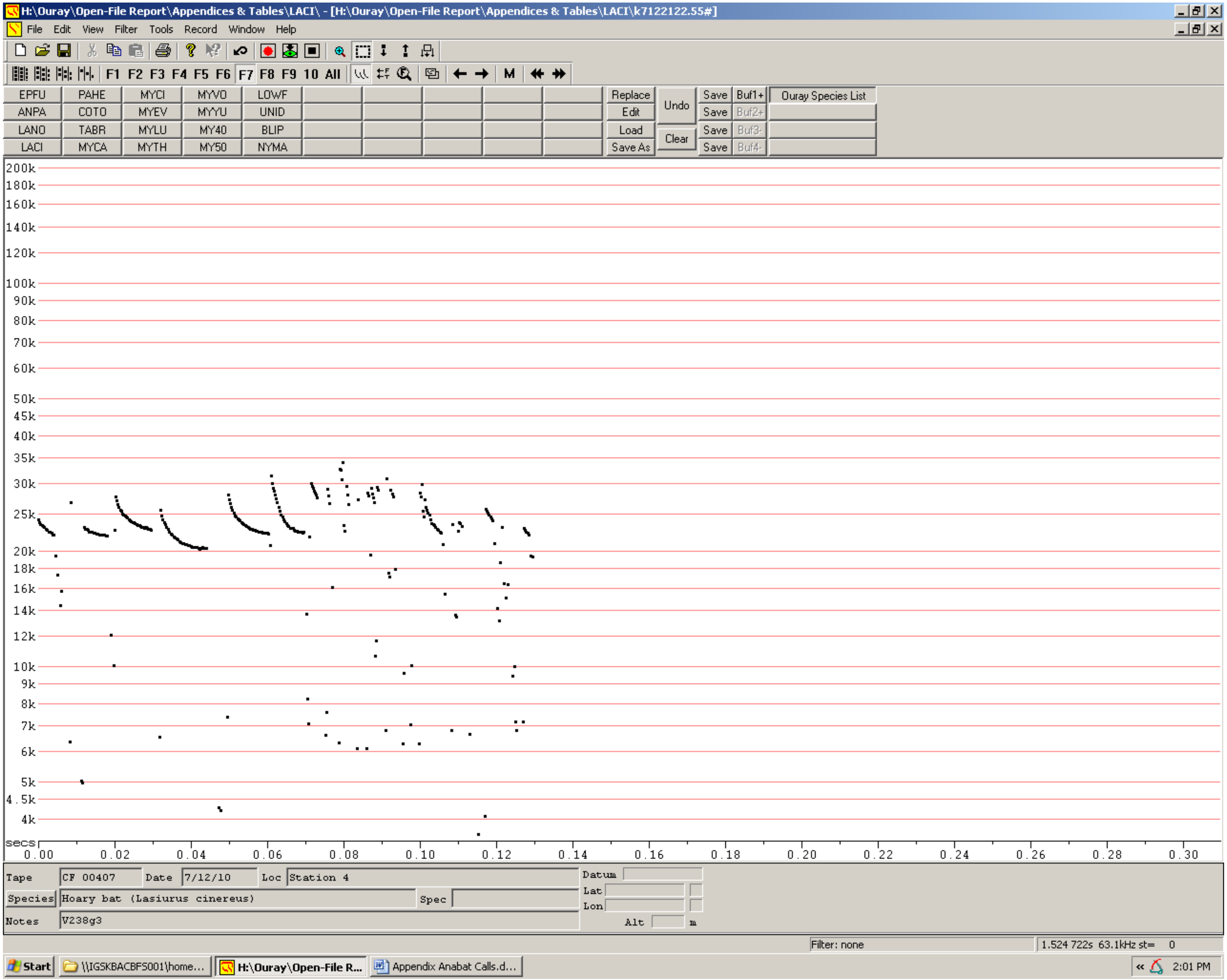
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Replace Edit Load Save As Undo Clear
Save Buf1+ Save Buf2+ Save Buf3- Save Buf4-
Ouray Species List
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Species Hoary bat (Lasiurus cinereus)
Notes V238g3
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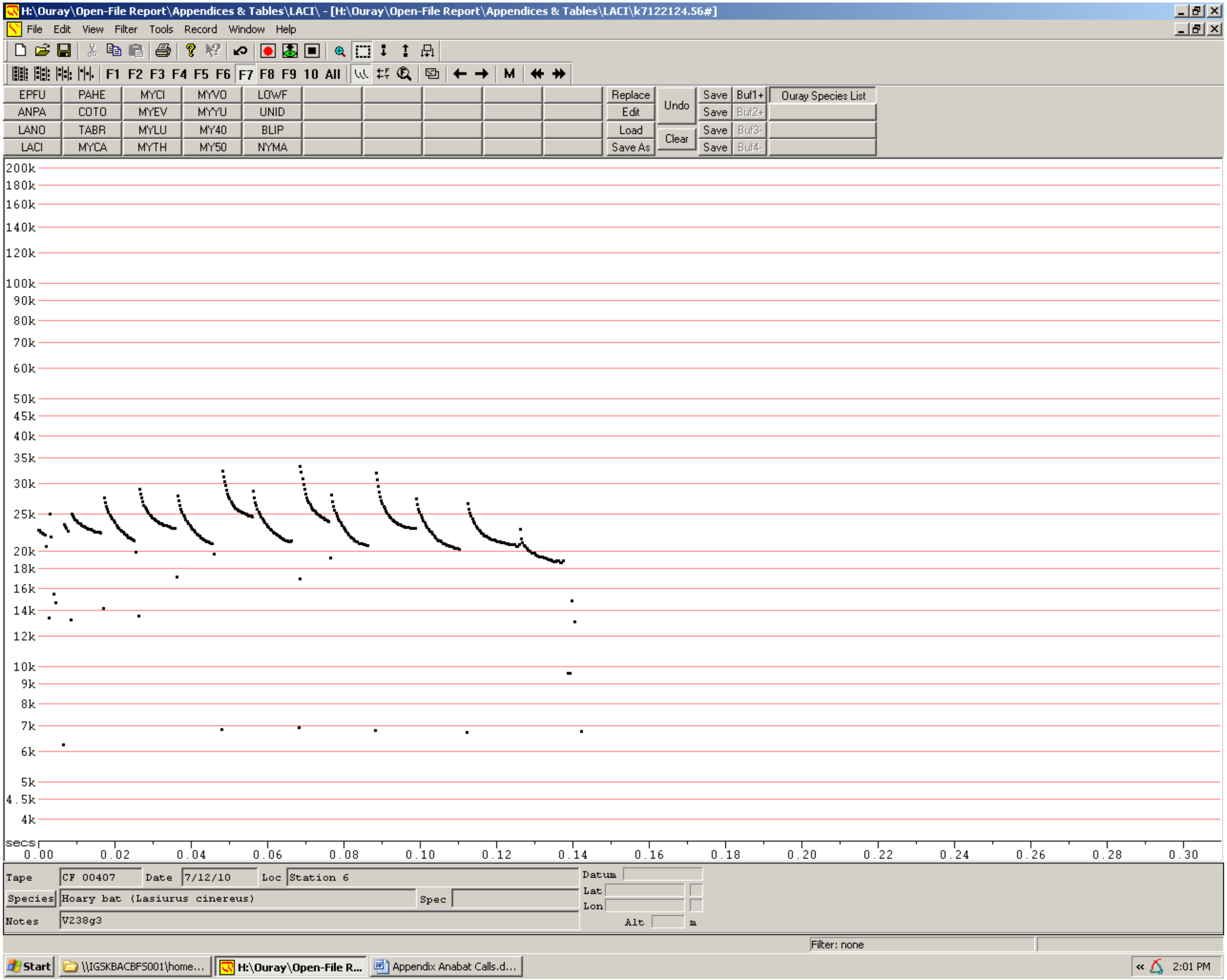
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Tape CF 00407 Date 7/12/10 Loc Station 6
Species Hoary bat (Lasiurus cinereus) Spec
Notes V238g3
Datum Lat Lon Alt m
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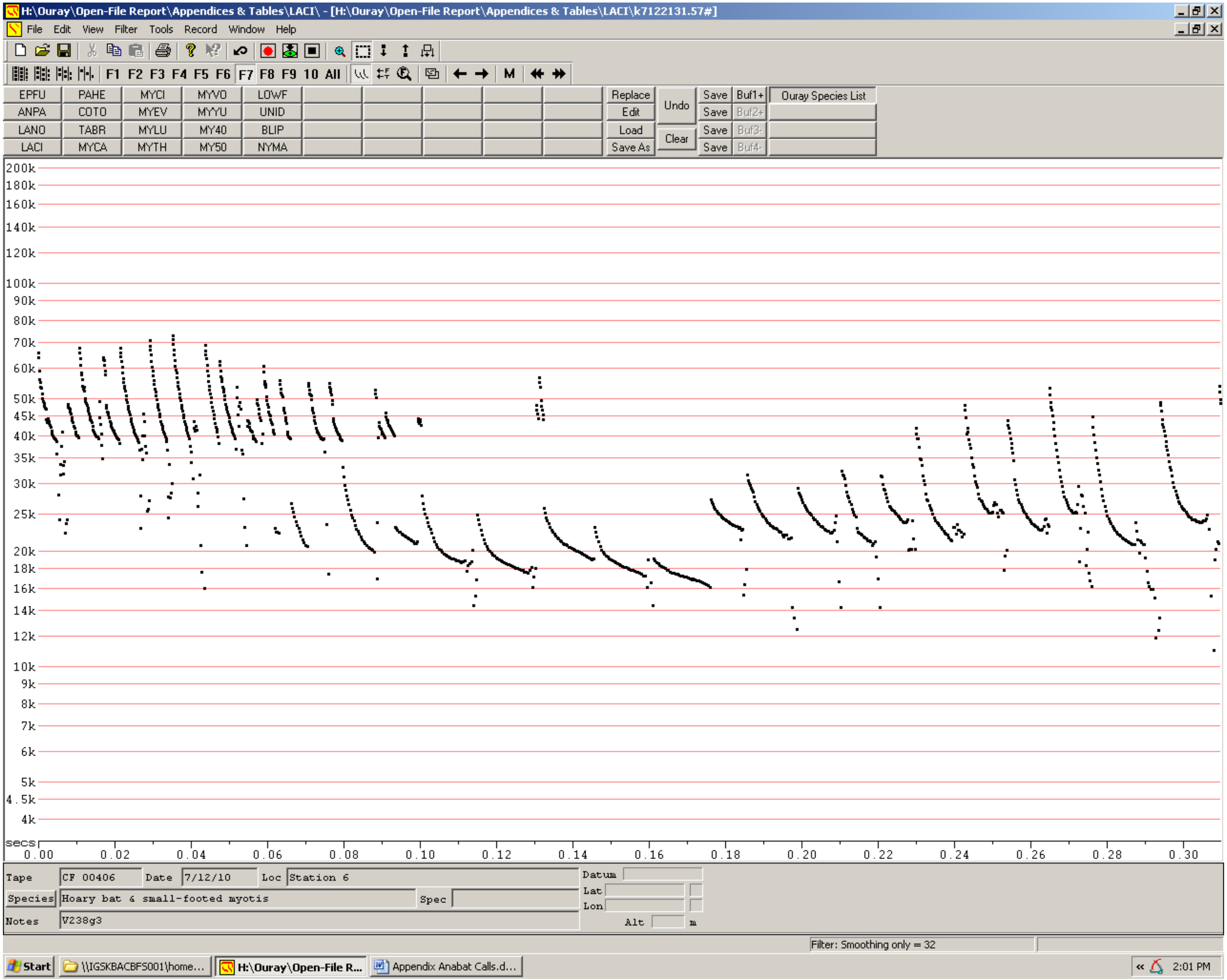
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Tape CF 00406
Date 7/12/10
Loc Station 6
Datum
Species Hoary bat & small-footed myotis
Spec
Lat
Lon
Notes V238g3
Alt m
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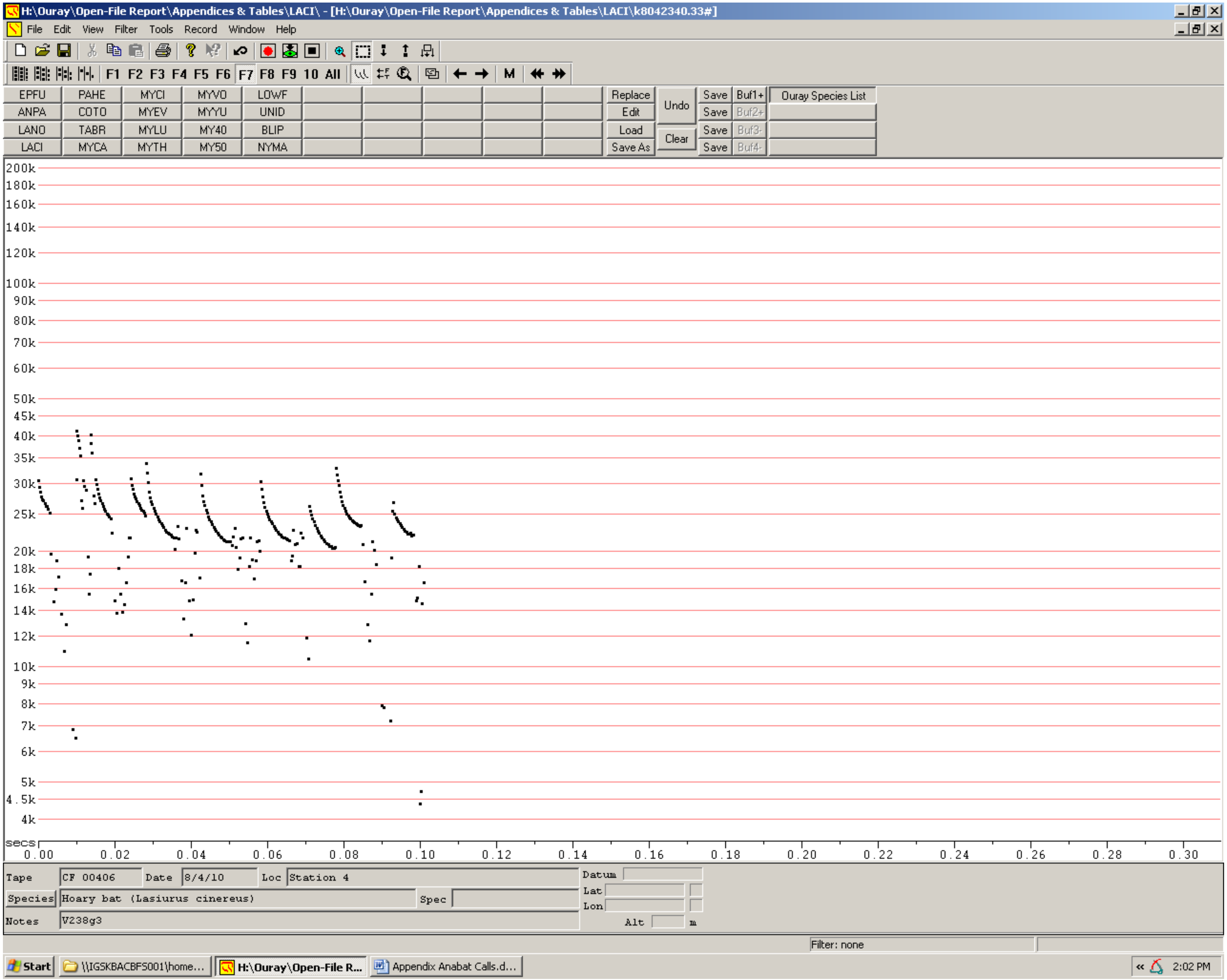
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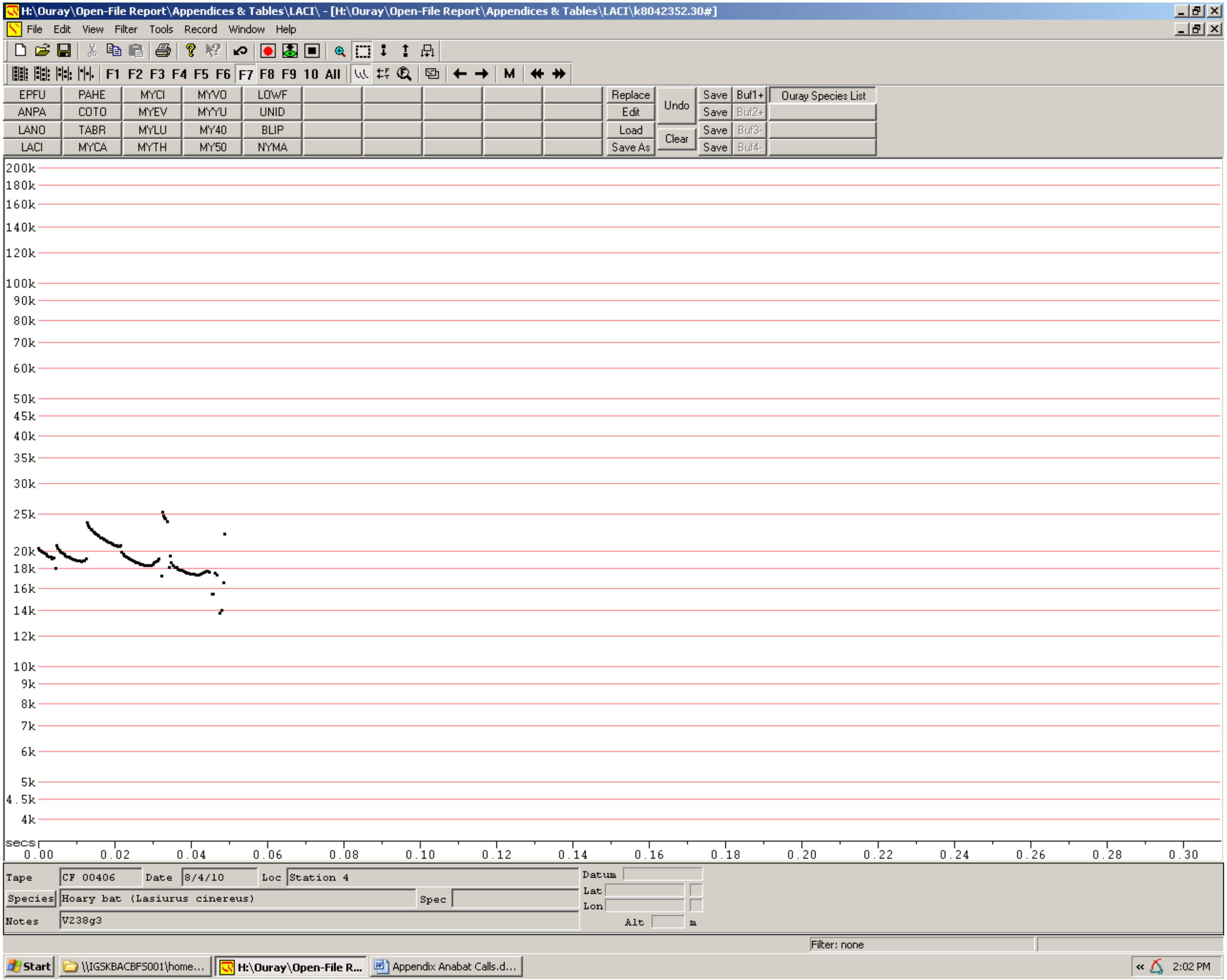
Species Hoary bat (Lasiurus cinereus)
Notes V238g3
Filter: none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secs
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30
Tape CF 00406 Date 8/4/10 Loc Station 4
Species Hoary bat (Lasiurus cinereus) Spec
Notes V238g3
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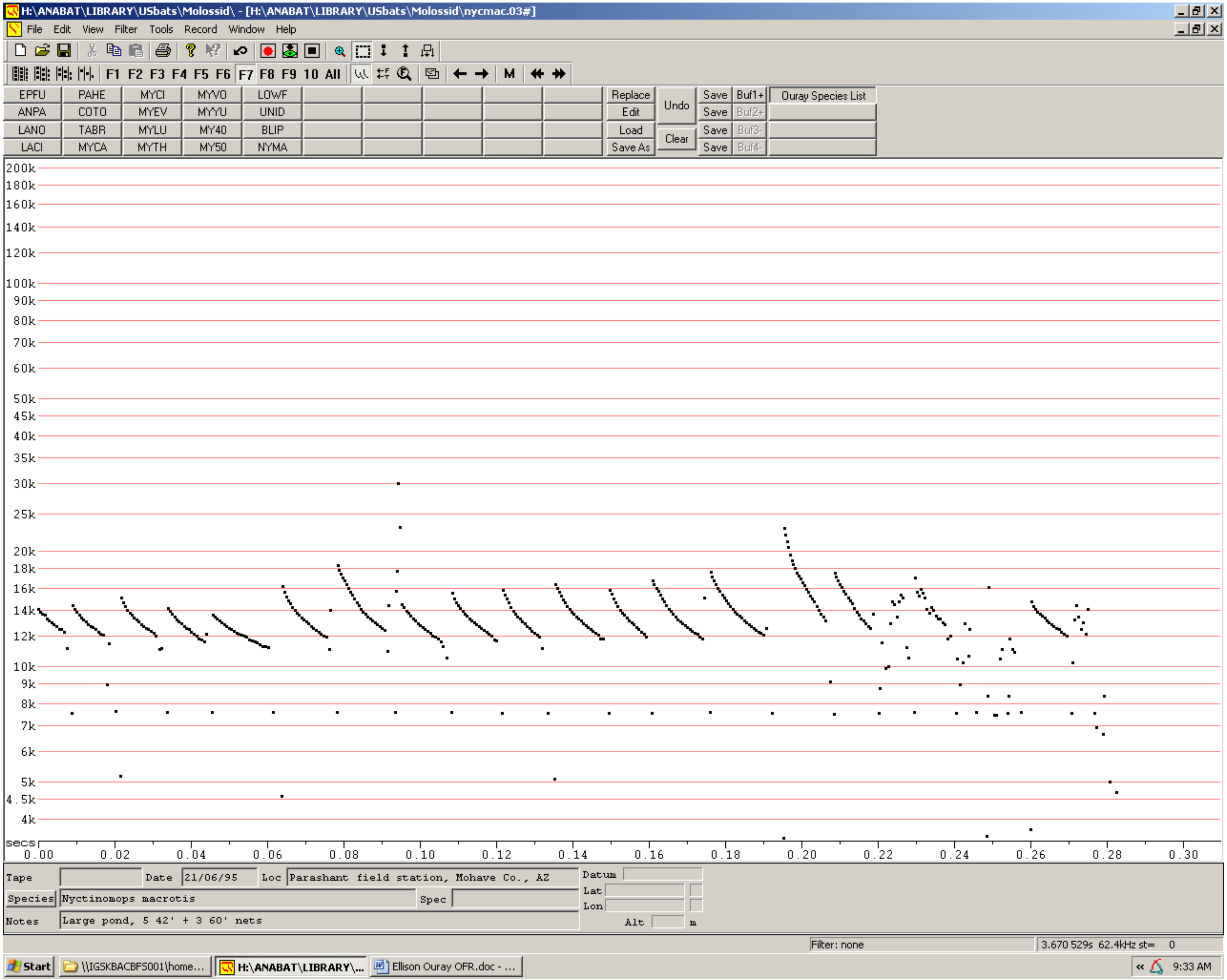
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secs 0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30
Tape Date 21/06/95 Loc Parashant field station, Mohave Co., AZ
Species Nyctinomops macrotis Spec
Notes Large pond, 5 42' + 3 60' nets
Datum Lat Lon Alt m
Filter: none 3.670 529s 62.4kHz st= 0
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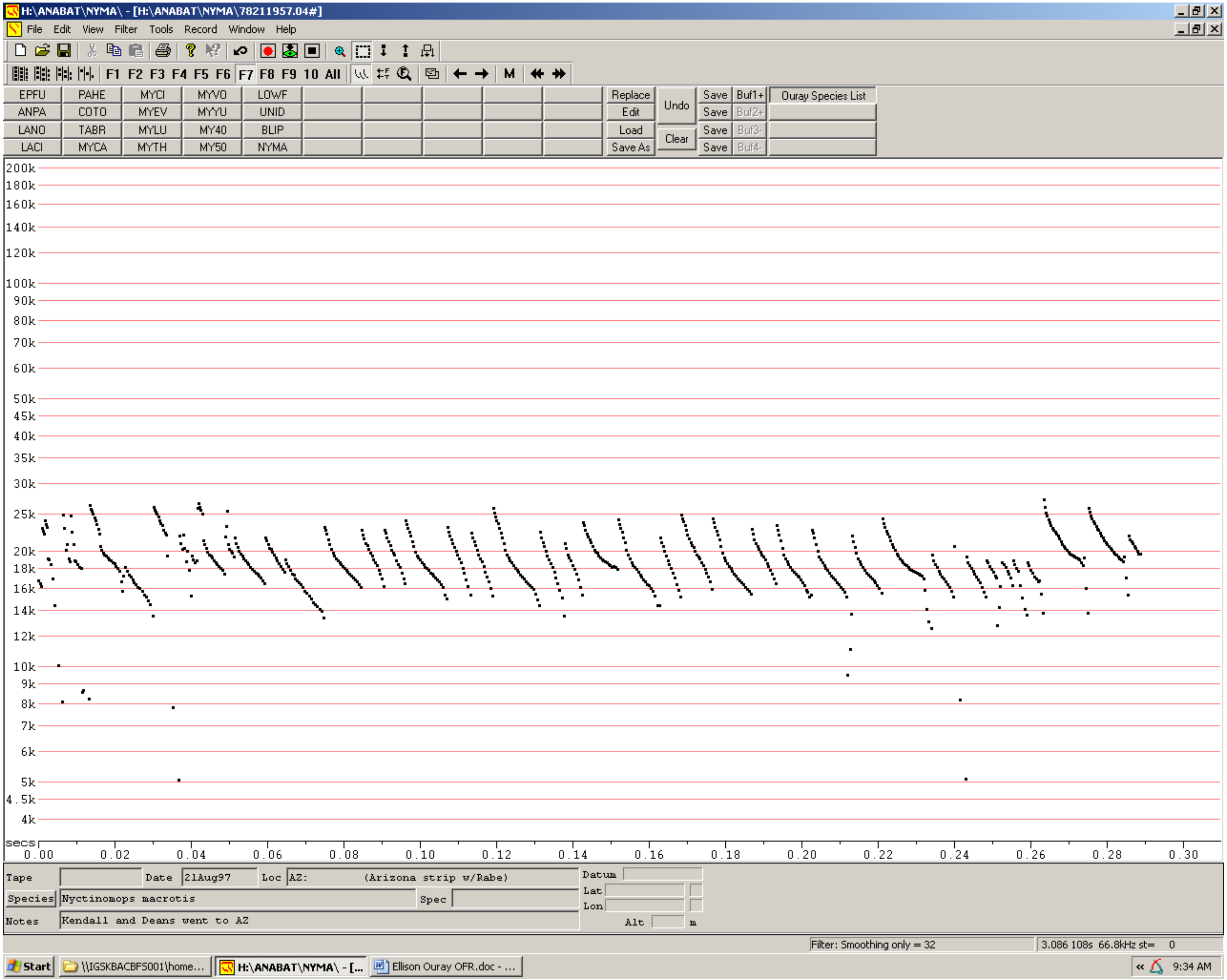
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4k
secs
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30
Tape
Date 21Aug97
Loc AZ: (Arizona strip w/Rabe)
Datum
Species Nyctinomops macrotis
Spec
Lat
Lon
Notes Kendall and Deans went to AZ
Alt m
Filter: Smoothing only = 32
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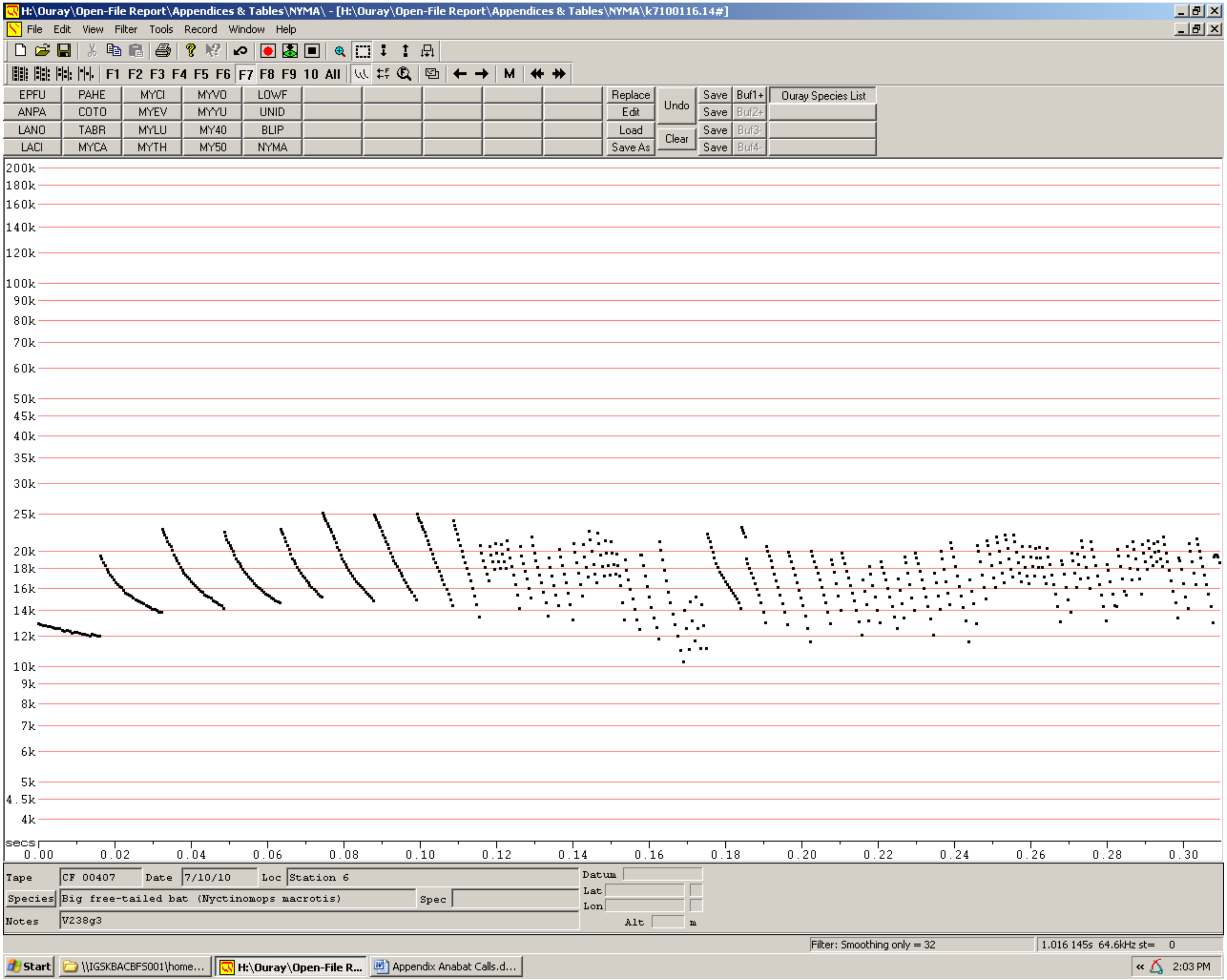
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Replace Edit Load Save As Undo Clear
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Ouray Species List
Tape CF 00407 Date 7/10/10 Loc Station 6
Species Big free-tailed bat (Nyctinomops macrotis) Spec
Notes V238g3
Datum Lat Lon Alt m
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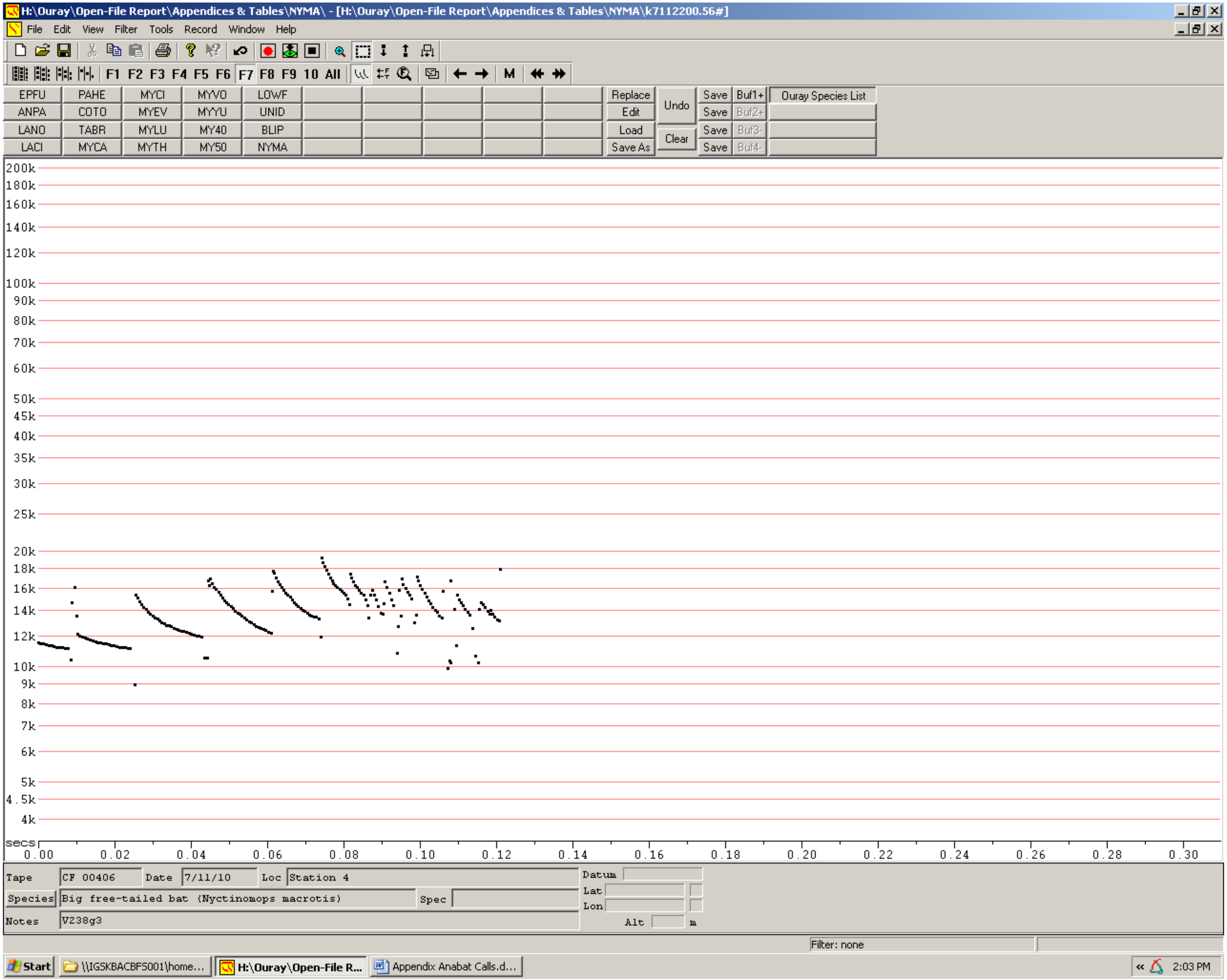
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Tape CF 00406 Date 7/11/10 Loc Station 4
Species Big free-tailed bat (Nyctinomops macrotis) Spec
Notes V238g3
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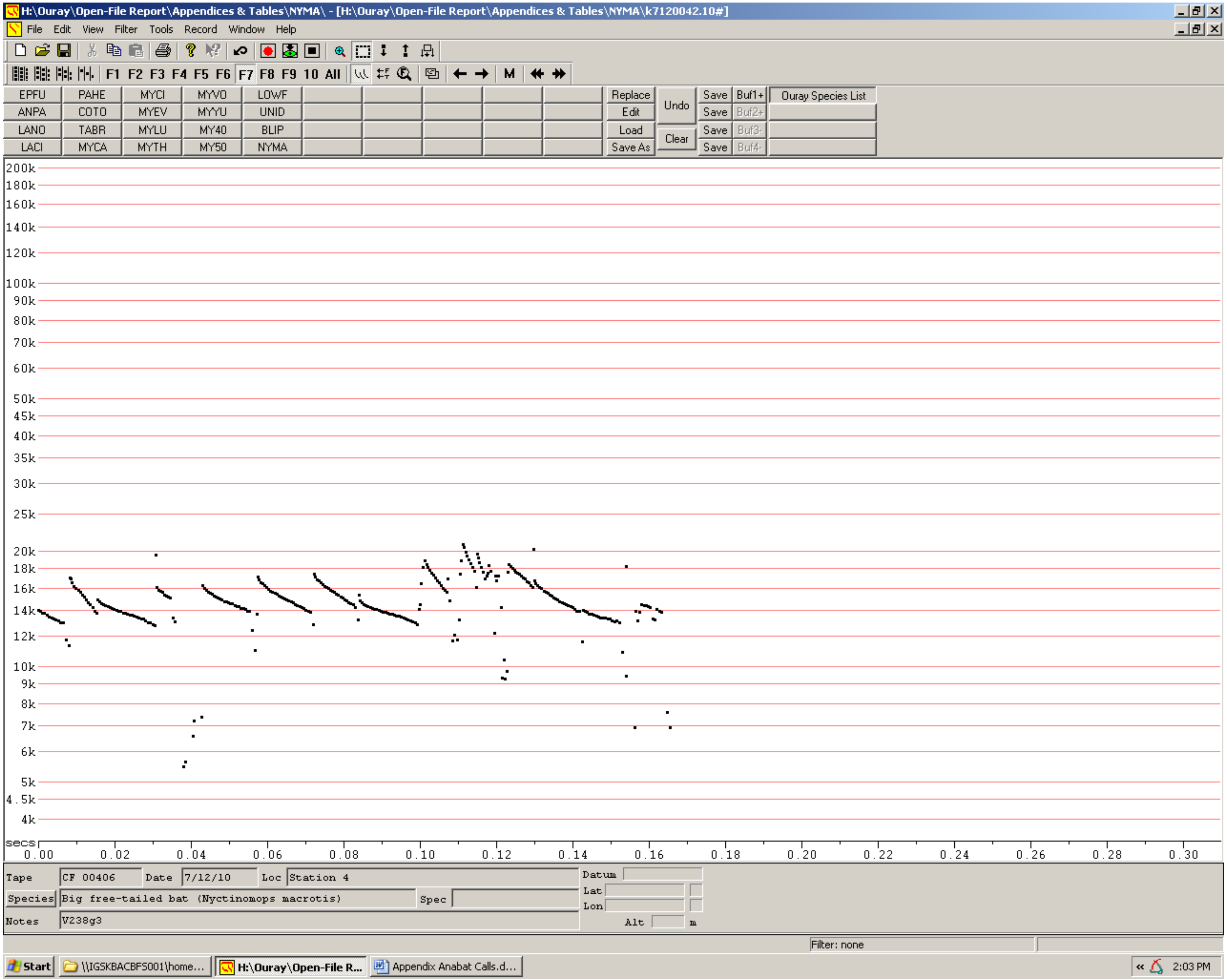
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Tape CF 00406
Date 7/12/10
Loc Station 4
Species Big free-tailed bat (Nyctinomops macrotis)
Spec
Notes V238g3
Datum
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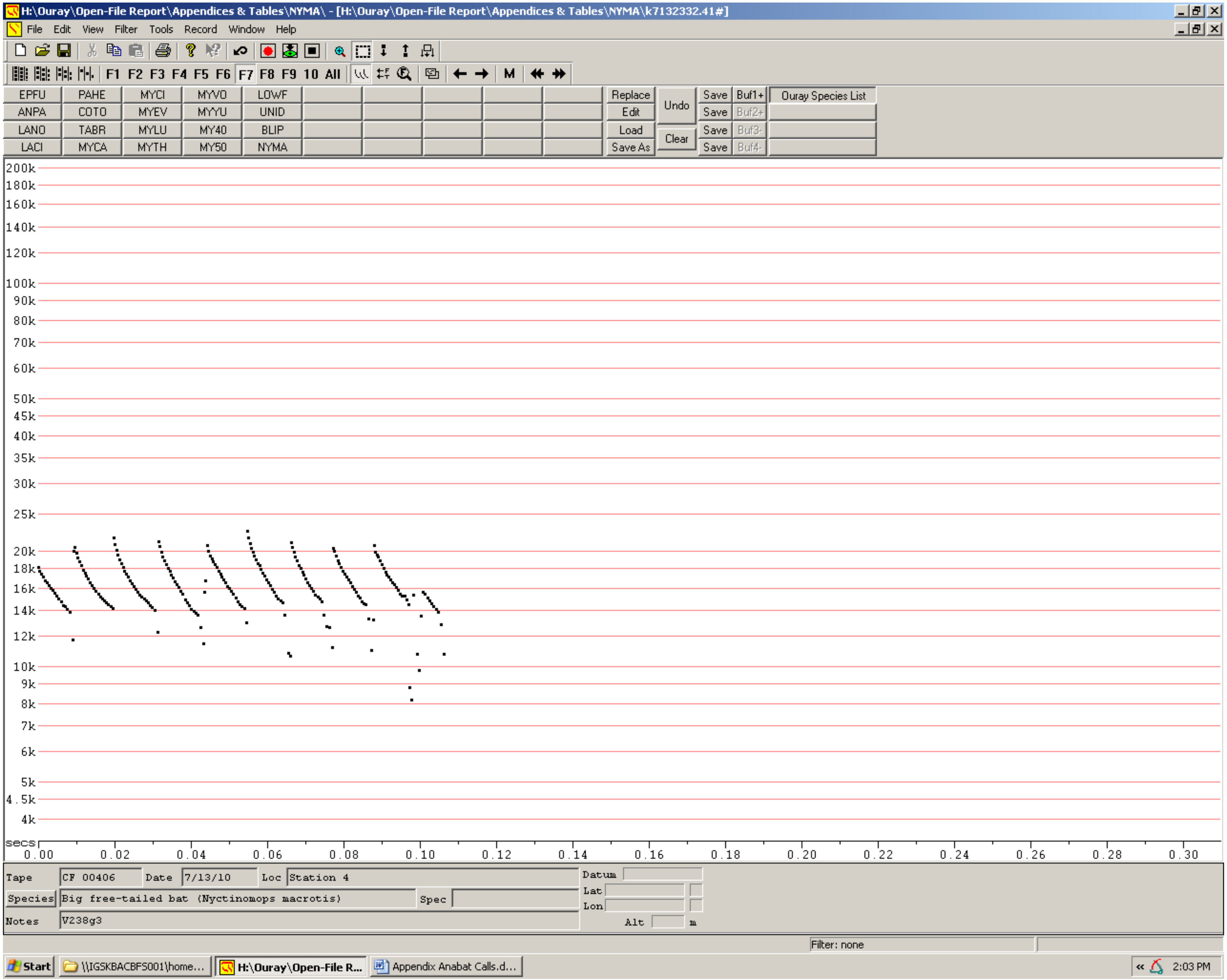
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Tape CF 00406 Date 7/13/10 Loc Station 4
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Notes V238g3
Datum Lat Lon Alt m
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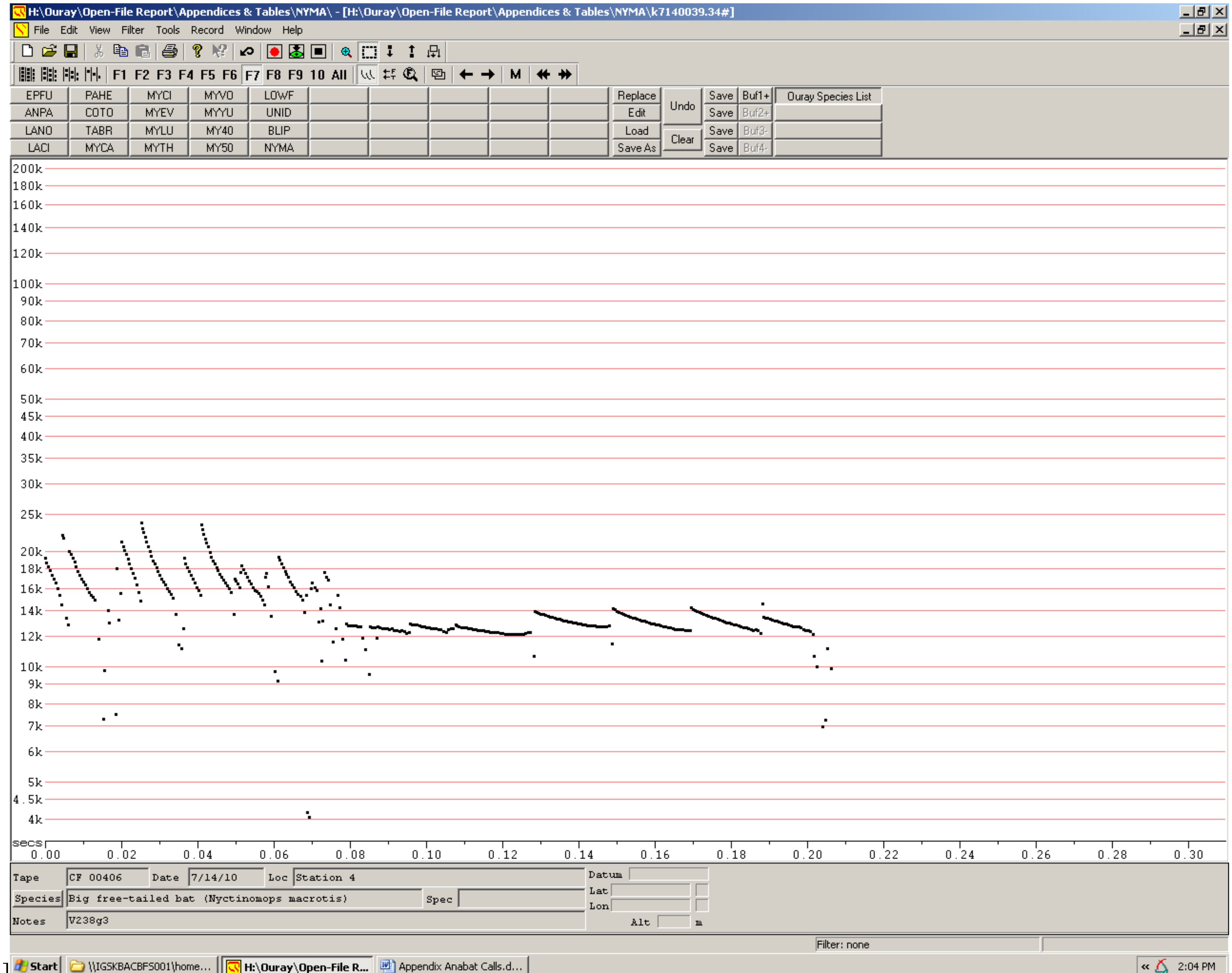
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LACI MYCA MYTH MY50 NYMA
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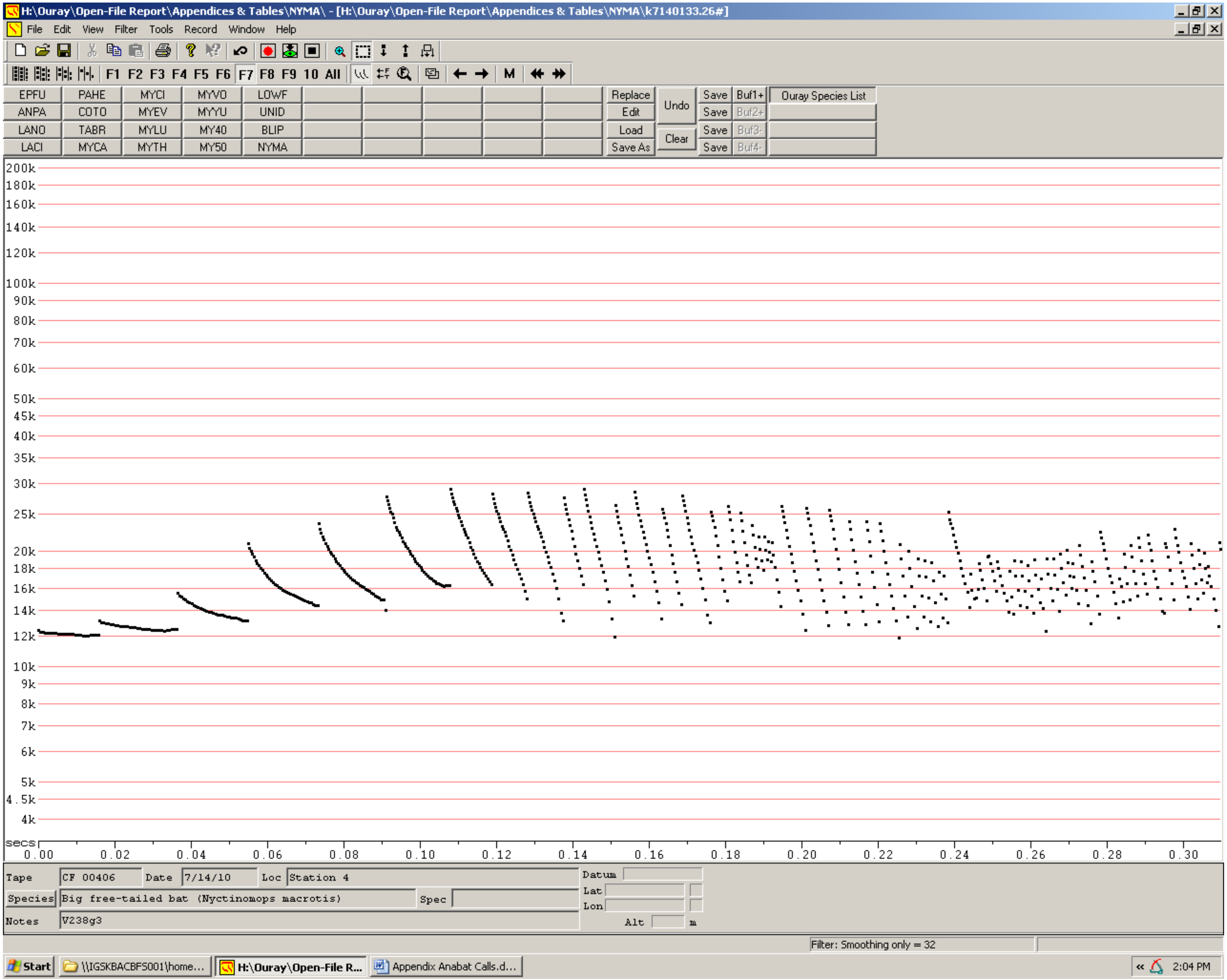
Date 7/14/10
Loc Station 4
Species Big free-tailed bat (Nyctinomops macrotis)
Notes V238g3
Filter: none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Tape CF 00406 Date 7/14/10 Loc Station 4
Species Big free-tailed bat (Nyctinomops macrotis) Spec
Notes V238g3
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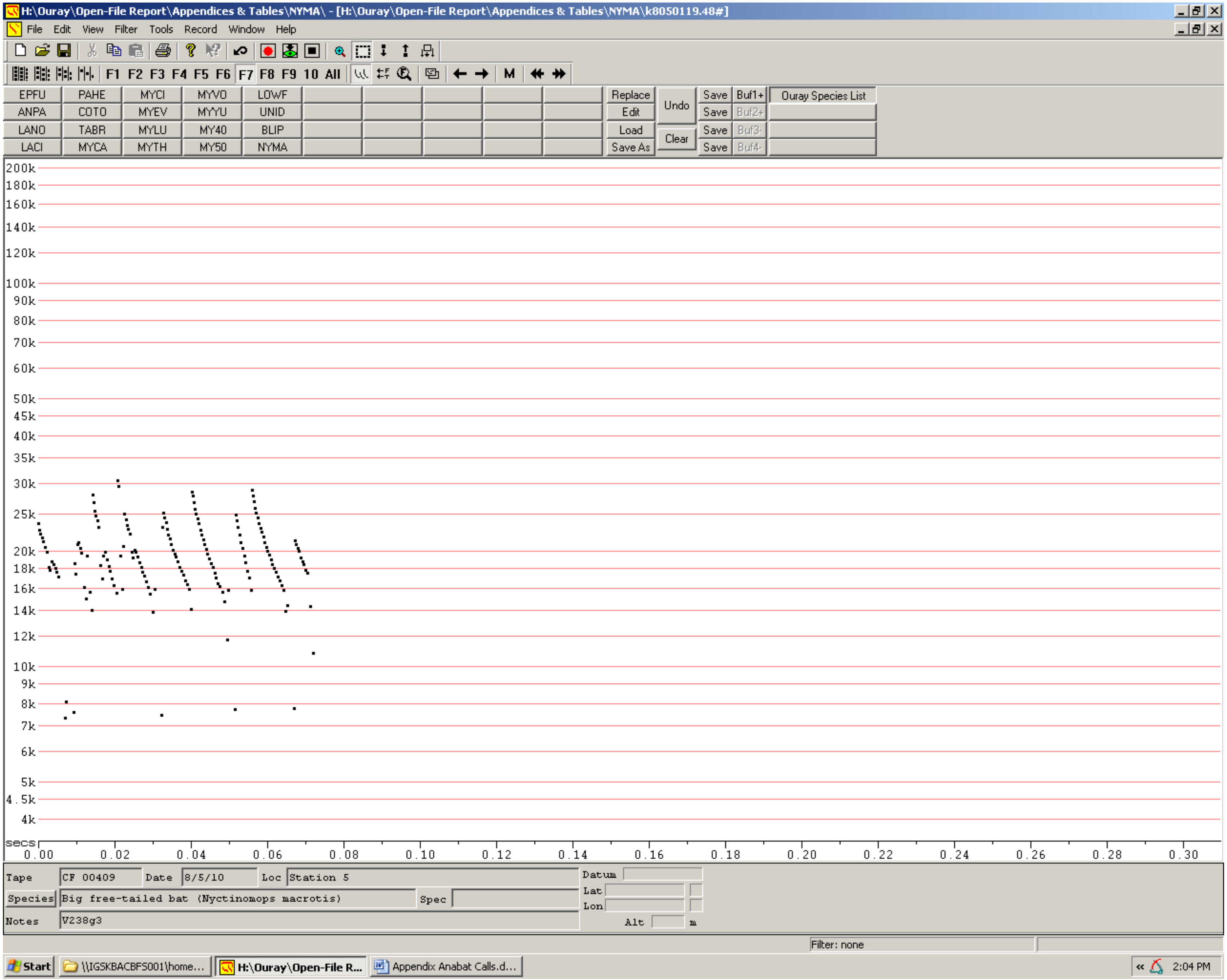
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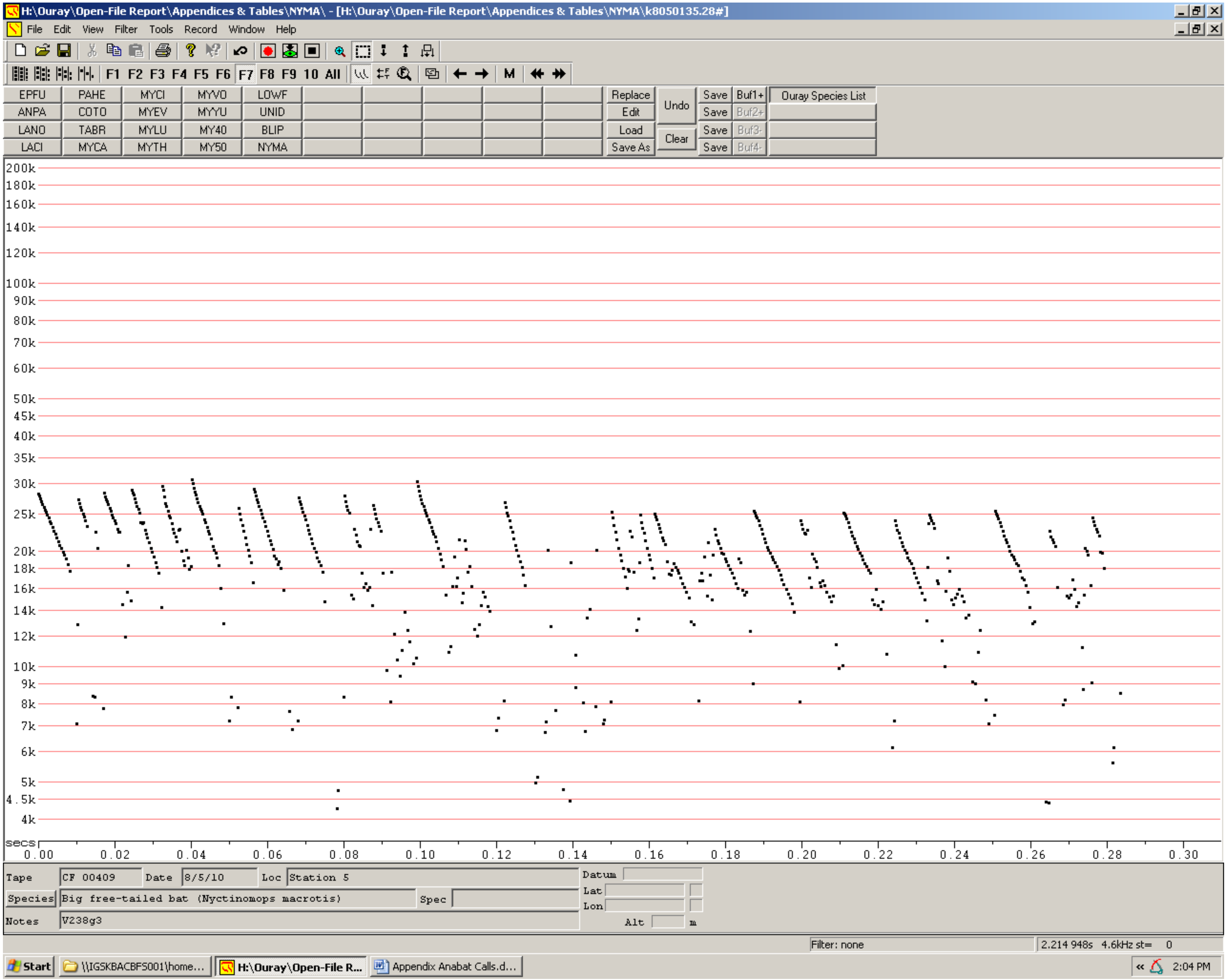
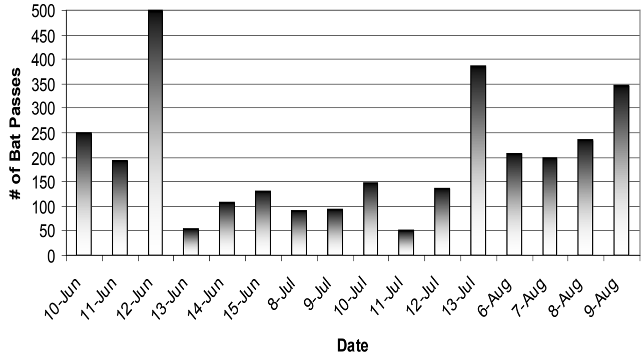
secs 0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30
Tape CF 00409 Date 8/5/10 Loc Station 5
Species Big free-tailed bat (Nyctinomops macrotis) Spec
Notes V238g3
Datum Lat Lon Alt m
Filter: none
Start \\IGSKBACBFS001\home... H:\Ouray\Open-File R... Appendix Anabat Calls.d...
2:04 PM



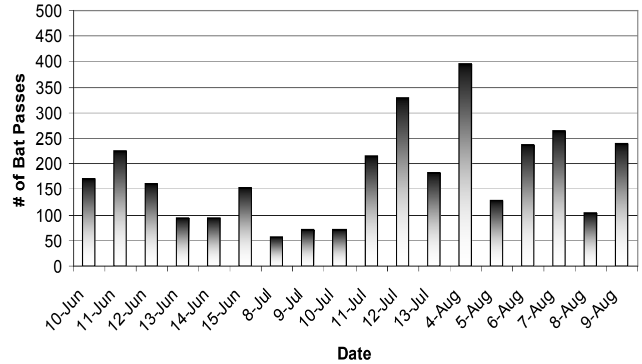
H:\Ouray\Open-File Report\Appendices & Tables\NYMA\ - [H:\Ouray\Open-File Report\Appendices & Tables\NYMA\k8050135.28#]
File Edit View Filter Tools Record Window Help
EPFU PAHE MYCI MYVO LOWF
ANPA COTO MYEV MYYU UNID
LANO TABR MYLU MY40 BLIP
LACI MYCA MYTH MY50 NYMA
Replace Edit Load Save As Undo Clear
Ouray Species List
200k 180k 160k 140k 120k 100k 90k 80k 70k 60k 50k 45k 40k 35k 30k 25k 20k 18k 16k 14k 12k 10k 9k 8k 7k 6k 5k 4.5k 4k
secs 0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30
Tape CF 00409 Date 8/5/10 Loc Station 5
Species Big free-tailed bat (Nyctinomops macrotis)
Notes V238g3
Filter: none
2.214 948s 4.6kHz st= 0

Appendix 2. Total number of bat passes collected by date and Anabat Station at Ouray National Wildlife Refuge, Utah, during the summer 2010. Note that the y-axis scale for all graphs is the same except for Station 4.

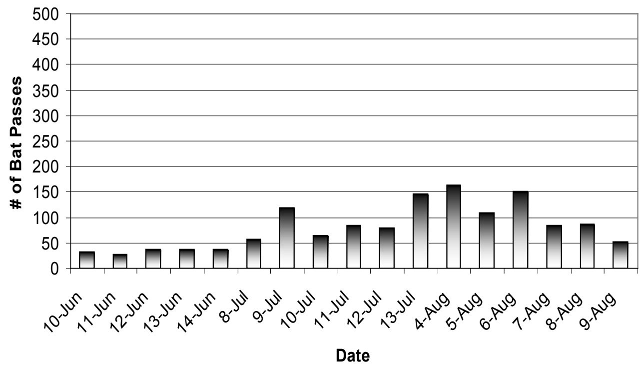
Station 1



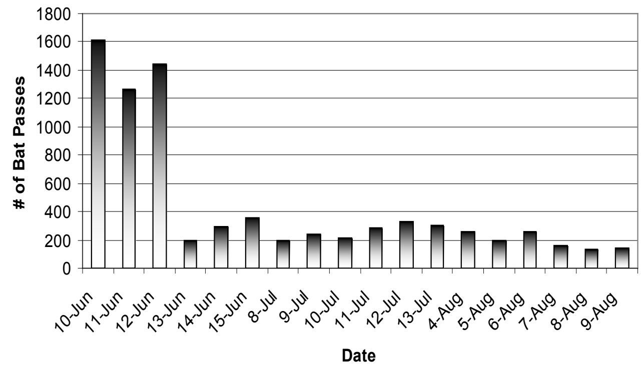
Station 2



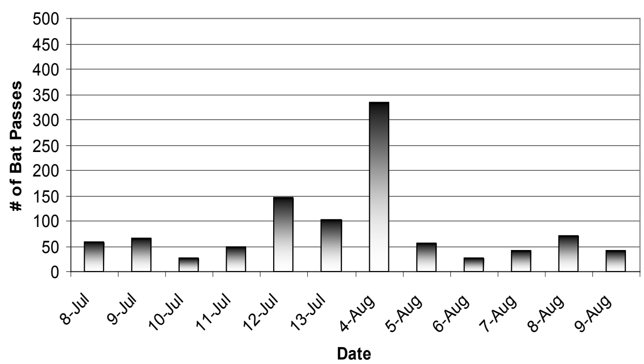
Station 3



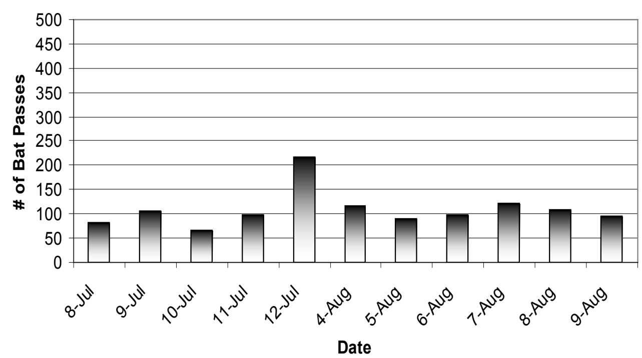
Station 4



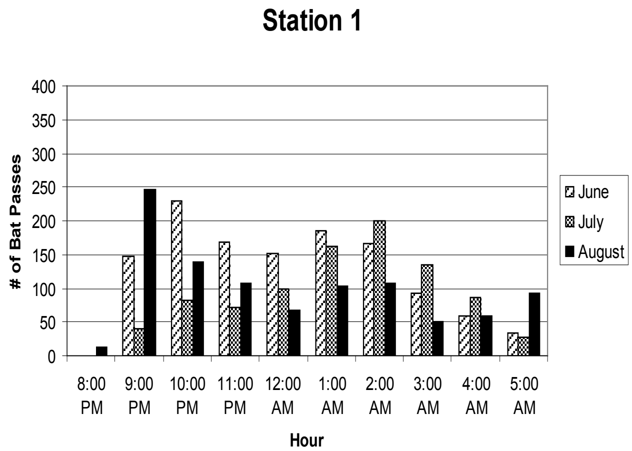
Station 5

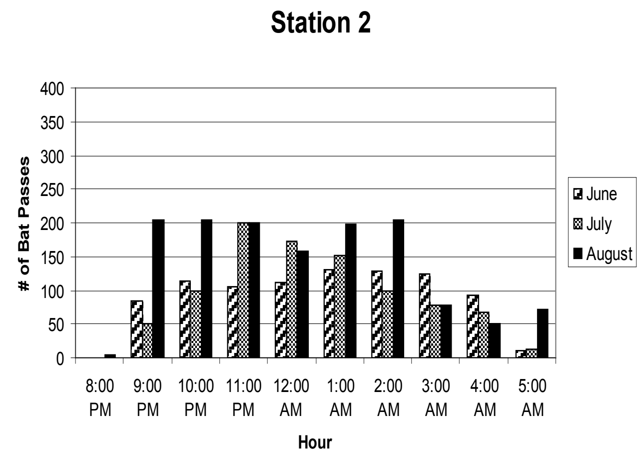


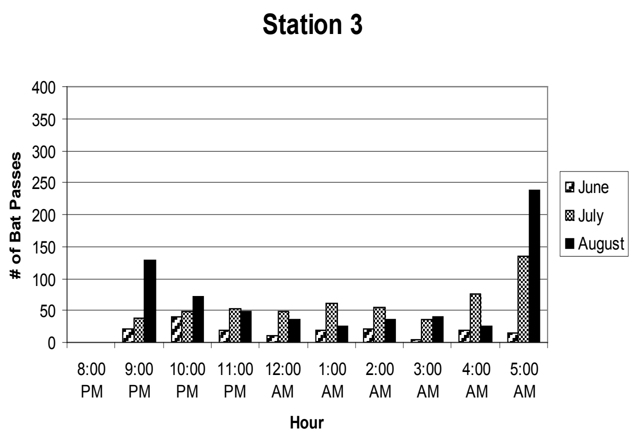
Station 6

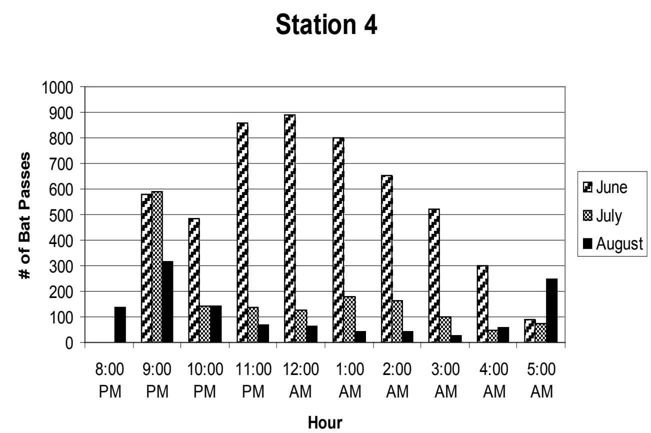


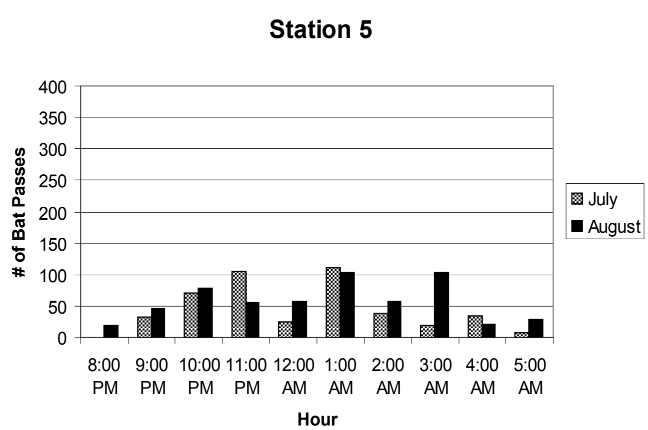
Appendix 3. Total number of bat passes collected in hourly increments by month and Anabat Station at Ouray National Wildlife Refuge, Utah, during the summer 2010. Note that the scale on the y-axis for all graphs is the same except for Station 4.

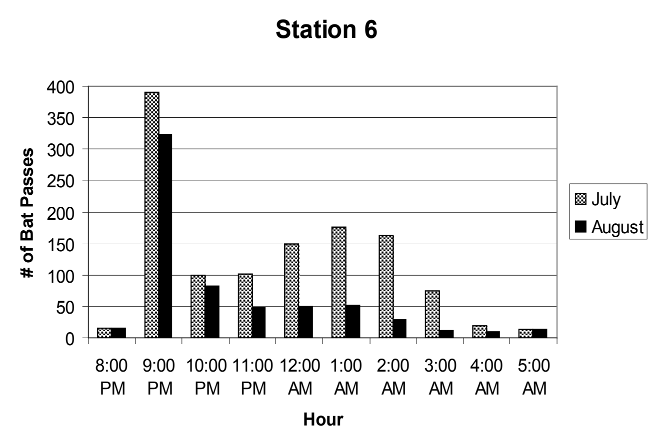

Station 1
# of Bat Passes
Hour
June
July
August
8:00 PM
9:00 PM
10:00 PM
11:00 PM
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM


Station 2
# of Bat Passes
Hour
June
July
August


Station 3
# of Bat Passes
Hour
June
July
August


Station 4
# of Bat Passes
Hour
June
July
August


Station 5
# of Bat Passes
Hour
July
August


Station 6
# of Bat Passes
Hour
July
August

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