

**Hibernation, Seasonal Activity, Movement Patterns,
and Foraging Behavior of
Adult Lake Erie Water Snakes
(*Nerodia sipedon insularum*)**

**Annual Report
to the
Ohio Division of Wildlife
and the
U.S. Fish and Wildlife Service**

27 February, 2003

Richard B. King

**Department of Biological Sciences
Northern Illinois University
DeKalb, IL 60115**

INTRODUCTION

A grant agreement was reached between the U.S. Fish and Wildlife Service and Northern Illinois University (Grant Agreement No. 301810G038) to undertake a radio-telemetry study of adult water snakes on the four largest Ohio islands in western Lake Erie. Dr. Richard B. King (Associate Professor, Department of Biological Sciences, Northern Illinois University) is principle investigator (PI) on this project. Doug Wynn (teacher, Westerville North High School, Westerville, Ohio) and Kristin Stanford (graduate student, Department of Biological Sciences, Northern Illinois University) are collaborators. The letter of authorization from Michael J. Budzik (Chief, Ohio Division of Wildlife) to the PI dated 8 May, 2000 stipulates that quarterly reports be provided to the Ohio Division of Wildlife in October, April, and July and that an annual report be provided in January of each year. This document represents the third annual report on this project. Additional information on this project can be found in previous reports (King, 2000; 2001a, 2001b, 2001c, 2002a, 2002b, 2002c).

In the sections that follow, movement patterns during the summer active season and characteristics of hibernation sites are summarized. The results are in general agreement with those reported in King (2002a) but are based on larger sample sizes and should be used in preference to those provided in previous reports.

LAKE ERIE WATER SNAKES MOVEMENTS AND HIBERNATION SITES

A total of 63 adult Lake Erie water snakes were chosen for surgical implantation of radio transmitters (Table 1). Temperature sensitive radio transmitters designed for use in snakes were purchased from Holohil, Inc. and ranged in size from 5.2 – 13.8 g. Expected battery life varied from 12 – 36 months. Surgery was conducted under aseptic conditions using either isoflurane (in 2000) or halothane (in 2000, 2001, and 2002) anesthetic following methods modified from Reinert and Cundall (1982). Instruments and transmitters were sterilized using cold sterilization liquid. Anesthesia was induced by placing up to 0.5 ml anesthetic in a cotton swab within a small bottle which was then inserted into the end of a clear plastic tube. The snake was allowed to crawl into the tube and monitored until fully anesthetized (a variety of tube diameters were used to accommodate snakes of different sizes). Once the snake was anesthetized, a small lateral incision was made 2-3 scale rows above the ventral scales about 1/3 anterior to the vent. A blunt probe was used to separate tissues, providing an opening to the body cavity from below the ribs through which the transmitter was inserted. A small incision was then made through the skin anterior to the surgical site and a long probe was inserted beneath the skin posterior from this second incision to the surgical site. The antenna wire of the transmitter was then inserted into an 'eye' in this probe and the probe was then pulled to the anterior, drawing the antenna under the skin. In 2001 and 2002, transmitters were loosely sutured to a rib to prevent posterior movement of the transmitter. Both incisions were sutured and sealed with veterinary adhesive. Snakes were monitored continuously until they recovered from anesthesia and were then placed in clean cages for recovery. Cages were equipped with shelters and clean water and were positioned over a heat tape to provide snakes with a thermal gradient during recovery. Snakes were given subcutaneous injections of Baytril antibiotic immediately following surgery and daily until released.

The 63 animals selected for surgery included 26 males ranging in size from 118 – 347 g and 37 females ranging in size from 306 – 954 g (Table 1). The fates of these animals is summarized as follows (additional information can be found in Table 1 and 2):

- 63 snakes selected for surgery
 - * 2 died prior to release (male 219 failed to recover from anesthesia, male E56 died several days after surgery)
 - * 1 was never located following release (female 156), perhaps due to transmitter failure
- 60 snakes released at site of capture and monitored regularly to obtain location data
 - * 13 are currently at known hibernation sites (female 168, 173, 467, 629, 712, 83E, A54, D76, E66; male 477, 50C, 708, A77)
 - * 29 are known to have died
 - 22 died of apparently natural causes (female 111, 129, 157, 159, 16A, 193, 215, 255, 404, 552, 628, 67D, 80A, B1E, B69, D64, F7D; male 047, 165, 186, 213, 216)
 - 4 died during the first summer after release; possibly due to complications associated with surgery (female 137, 651; male 124, 51A)
 - 3 died due to human activities (male 301 disappeared when its hibernation site was disturbed, female E71 died when a brush pile into which it had retreated was burned, female F0F was apparently killed by a mower shortly after spring emergence)
 - * 18 are of unknown status
 - 11 have not been located due to transmitter battery failures (female 507, male 184, 221, 26C, 209, 35C, 551, 730, B15, D1C, D60)
 - 1 has not been located since June 2003 because landowners have not allowed access (female B35)
 - 6 have not been located for unknown reasons (female 128, 139, 218 22E; male 196, 123)

Movements during the Summer Active Season. – Data on movement patterns during the summer active season were obtained from 56 individual Lake Erie water snakes (34 females, 22 males). Data were obtained from five snakes during three summers and from 21 snakes during two summers. Locations used by individual snakes were recorded 5 – 18 times per active season (5 – 37 times across all active seasons). Each time a snake was located, GPS coordinates were recorded using a handheld Garmin *etrex* GPS receiver. GPS locations were plotted onto Digital Orthophoto Quarter Quadrangles (DOQQ) using ArcView GIS software. Amount of shoreline utilized during the summer active season was determined by using ArcView to estimate the maximum extent of shoreline between the any two locations used by a snake during the active season (“Extent” in Table 1, also see Fig. 1). For snakes monitored during multiple summers, the maximum extent among all active season locations (regardless of year) was determined.

The distance each snake was from shore was estimated or measured using a tape measure or distance-measuring wheel each time a snake was located. Analysis focused on the maximum distance each snake was ever observed from shore during this time period (“Max. Dist. To Shore” in Table 1, also see Fig. 1). For snakes monitored during multiple summers, the maximum distance in any summer was used for analysis

Maximum extent of shoreline used and maximum distance to shore both exhibited right-skewed distributions (Fig. 2 & 3). Both variables were normalized for analysis by computing

natural logarithms. Neither variable differed significantly between males and females. Therefore, the sexes were pooled to generate a population-wide description of active season movements.

Snakes consistently used the same areas during successive summers. Maximum extent of shoreline used ranged from 30 – 1360 m among individuals and averaged 252 m (back transformed from natural logarithms). The estimated upper limit of the extent of shoreline used by specific fractions of the population were: 50% of the population used 252 m or less, 75% used 437 m or less, 90% used 714 m or less, 95% used 960 m or less, and 99% used 1674 m or less (Fig. 2). Given that snakes were not monitored continuously and that some individuals were monitored for only a portion of the active season, these distances may underestimate the true extent of shoreline used during the active season.

Maximum distance to shore ranged from 1 – 50 m among individuals and averaged 8 m (back transformed from natural logarithms). The estimated upper limit of the maximum distance from shore for specific fractions of the population were: 50% of the population ranged up to 8 m, 75% ranged up to 13 m, 90% ranged up to 21 m, 95% ranged up to 27 m, and 99% ranged up to 47 m (Fig. 3).

Hibernation Sites. – Data on hibernation sites were obtained for 49 individual Lake Erie water snakes (27 females, 22 males). Hibernation sites were located for two snakes in each of three years, for 10 snakes in each of two years, and for 36 snakes in a single year each. With one exception, snakes for which hibernation sites were located in successive years consistently used the same hibernation location (within 10 m and often less). For these snakes, information on hibernation sites was pooled across years. In contrast, female E66 used hibernation sites separated by about 220 m in 2001 and 2002 (Table 2). These two hibernation sites were treated separately in the analyses below – thus, these analyses are based on 50 hibernation sites.

Of the 50 hibernation sites, 30 were located directly inland from shoreline areas used during the summer active season (Table 2). The other 20 hibernation sites were located inland from shoreline areas outside of the extent of shoreline used during the summer active season (Table 2, also see Fig. 1). To reach these hibernation sites, snakes apparently moved between 35 and 1410 m along the shore (estimated using ArcView) prior to selecting a hibernation site (Table 2).

The distance between hibernation sites and shore (Dist. to Shore in Table 2) was measured using a tape measure or distance-measuring wheel. Distance to shore exhibited a right-skewed distribution (Figure 4) and was normalized by computing natural logarithms. Distance to shore did not differ significantly between males and so the sexes were pooled to generate a population-wide description of this variable.

Distance to shore ranged from 1 – 580 m among individuals and averaged 27 m (back transformed from natural logarithms). The estimated upper limit for distance to shore for specific fractions of the population were: 50% of the population hibernated within 27 m of shore, 75% hibernated within 69 m of shore, 90% hibernated within 161 m of shore, 95% hibernated within 267 m of shore, and 99% hibernated within 700 m of shore (Fig. 4). The elevation above lake level of the ground surface over hibernating snakes was estimated to range from 1 – 10 m (Table 2).

Characteristics of hibernation sites were variable (Table 2). Most had soil and rock substrates and appeared to consist of natural openings or fissures. Access holes to some hibernation sites were apparent and may have been the result of burrowing by small mammals, shoreline erosion, or tree falls. In addition, some hibernation sites were found in or near human-

made structures: #B35 and #123 both hibernated in or near the remains of stone building foundations, #221 hibernated near a drainage tile, #309 hibernated near a sewer line, #477, #E71, #A77, #B69, and #D1C hibernated in or near concrete shoreline protection, patio, or wall, #111 hibernated in the rock foundation of a cottage, #A77 hibernated inside an old wine cellar (Table 4). Vegetation around hibernation sites was also variable and included mature forest, woody scrub, and grass/herbaceous vegetation (sometimes including mown lawns).

Usually only a single telemetered snake was observed to hibernate at a given location although other untelemetered animals were sometimes observed nearby. Exceptions include female #168 and #173 which hibernated within a few meters of each other on Long Point (Kelley's Island) in 2000 and in 2001, male #047 and male #730 which hibernated within about 10 m of each other on the State Park property on Middle Bass Island, and male #551 and female #E66 which hibernated within about 10 m of each other also on the State Park property on Middle Bass Island.

Entry into and Emergence from Hibernation. – Estimated dates of entry into hibernation were generated as follows. The latest date in the fall that each snake was observed within its summer active area and the earliest date that each snake was observed near its hibernation site were recorded. The mid-point between these dates was then used as an estimate of the date of entry into hibernation. Similarly, the latest date in the spring that each snake was observed near its hibernation site and the earliest date that each snake was observed within its summer active area were recorded. The mid-point between these dates was then used as an estimate of the date of emergence from hibernation.

Dates of entry into hibernation were estimated for a total 59 hibernation events in fall 2000, fall 2001, and fall 2002. Dates of emergence from hibernation were estimated for a total of 28 hibernation events in spring 2001 and spring 2002 (the smaller sample size for emergence reflects the fact that some snakes died in hibernation, others will emerge in spring 2003). Dates of entry into and emergence from hibernation did not differ significantly between sexes or among years (although sample sizes are small). Dates of entry into hibernation ranged from 12 September to 17 October (Fig. 5). Dates of emergence from hibernation ranged from 27 April to 31 May (Fig. 5). Comparison of these dates with mean daily minimum and maximum air temperatures (Put-in-Bay, Ohio; 1971 – 2001;

<http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html>) suggests that entry into hibernation starts when the mean minimum daily temperature drops to about 60° F (Fig. 5). Entry into hibernation is largely complete by the time mean maximum daily temperature no longer rises above 60° F (Fig. 5). Emergence from hibernation starts when mean maximum daily temperature first exceeds 55° F and is largely complete by the time mean minimum daily temperature exceeds 57° F (Fig. 5).

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Table 1. Characteristics of Lake Erie water snakes implanted with radio transmitters in July 2000, June 2001, and June 2002 and summary of active season movements. Variables are defined as follows:

“Mass” = snake mass at the time of surgery

“Trans. Mass” = radio transmitter mass

“Freq.” = transmitter frequency

“Release Date” = date of release following surgery (surgical implantation of radio transmitters took place several days prior to this)

“Start” = the first date of active season monitoring following release or emergence from hibernation

“End” = the last date of active season monitoring

“# of Loc.” = the number of times a snake was located during the active season

“Extent” = the linear extent of shoreline between locations during the active season (see Fig. 1)

“Mean Dist. To Shore” and “Max. Dist. To Shore” = the mean and maximum distance inland that a snake was located during the active season, receptively

For snakes monitored for more than one active season, rows labeled “all” in the “Year” column provide information on “# of Loc.,” “Extent,” “Mean Dist. To Shore,” and “Max. Dist. To Shore” for all active seasons combined.

ID	Island	Site	Sex	Mass (g)	Trans. Mass (g)	Freq.	Release Date	Year	Active Season					
									Start	End	# of Loc.	Extent (m)	Mean Dist. To Shore (m)	Max. Dist. To Shore (m)
047	Middle Bass	MBSP	m	191	8.9	150.760	22-Jun-01	2001	12-Jul-01	11-Sep-01	8	365	1.1	1.5
								2002	23-May-02	27-Aug-02	13	235	0.8	1.0
								all			21	420	0.9	1.5
111	North Bass	South Shore	f	461	11.2	150.069	21-Jun-01	2001	11-Jul-01	13-Oct-01	11	240	3.9	7.6
								2002	1-May-02	27-Aug-02	14	250	2.4	4.0
								all			25	250	3.1	7.6
123	Kelleys	KISP-ramp	m	289	11.2	150.422	20-Jul-00	2000	9-Aug-00	18-Sep-00	9	100	3.3	13.7
								2001	9-May-01	18-Jun-01	7	65	5.3	9.1
								all			16	155	4.2	13.7
124	Kelleys	KISP-ramp	m	161	11.2	150.301	20-Jul-00	2000	24-Jul-00	10-Oct-00				
128	Kelleys	KISP-ramp	f	819	13.8	150.501	20-Jul-00	2000	24-Jul-00	21-Sep-00	15	85	4.3	10.0
129	Kelleys	KISP-ramp	f	954	13.8	150.662	19-Jul-00	2000	24-Jul-00	21-Sep-00	17	150	4.7	10.0
								2001	9-May-01	9-Oct-01	16	165	3.8	9.1
								all			33	180	4.2	10.0
137	Kelleys	KISP-beach	f	513	13.8	150.637	20-Jul-00	2000	24-Jul-00	9-Aug-00	7	65		20.0

139	Middle Bass	Haunks	f	418	11.2	150.121	22-Jun-01	2001	12-Jul-01	11-Sep-01	7	180	3.2	6.1
156	Kelleys	Minshall	f	544	13.8	150.522	21-Jul-00	2000						
157	Kelleys	Minshall	f	652	13.8	150.601	20-Jul-00	2000	24-Jul-00	16-Sep-00	11	375	5.4	9.1
								2001	10-May-01	15-Aug-01	11	590	2.8	4.6
								2002	4-Jun-02	6-Sep-02	8	545	2.7	5.0
								all			30	725	3.4	9.1
159	Kelleys	KISP-beach	f	778	13.8	150.560	20-Jul-00	2000	24-Jul-00	8-Sep-00	12	110	17.1	22.9
165	Kelleys	Long Point	m	275	11.2	150.321	21-Jul-00	2000	24-Jul-00	25-Sep-00	14	1360	6.9	20.0
168	Kelleys	Long Point	f	651	13.8	150.540	22-Jul-00	2000	24-Jul-00	22-Sep-00	17	960	6.2	20.0
								2001	13-May-01	25-Sep-01	16	790	2.8	9.1
								2002	2-Jun-03	27-Jun-02	3		2.2	2.5
								all			36	1185	4.0	20.0
16A	Kelleys	Minshall	f	553	13.8	150.637	18-Jun-01	2001	9-Jul-01	9-Oct-01	9	180	6.6	9.1
173	Kelleys	Long Point	f	408	13.8	150.619	21-Jul-00	2000	24-Jul-00	18-Sep-00	13	100	10.1	20.0
								2001	22-May-01	24-Sep-01	14	1060	8.6	20.0
								2002	2-Jun-02	24-Sep-02	9	225	3.9	6.0
								all			36	1085	7.6	20.0
184	Kelleys	Minshall	m	221	11.2	150.442	21-Jul-00	2000	24-Jul-00	14-Oct-00	17	100	3.5	12.2
								2001	10-May-01	3-Sep-01	14	90	12.7	50.0
									17-May-02	22-Jun-02	4	110	14.3	25.0
								all			35	140	9.1	50.0
186	Kelleys	Minshall	m	234	11.2	150.341	21-Jul-00	2000	24-Jul-00	19-Sep-00	14	665	3.3	7.6
193	Kelleys	Bait Shop	f	577	13.8	150.577	28-Jul-00	2000	29-Jul-00	24-Sep-00	16	160	1.9	4.6
196	Kelleys	Bait Shop	m	158	11.2	150.379	28-Jul-00	2000	29-Jul-00	24-Sep-00	13	50	0.8	1.2
								2001	9-May-01	9-Jul-01	9	360	0.2	0.9
								all			22	360	0.6	1.2
213	Kelleys	KISP-north	m	268	11.2	150.401	28-Jul-00	2000	20-Jul-00	22-Aug-00	8	160	6.7	30.0
								2001	13-May-01	16-May-01	2		15.2	15.2
								all			10	160	8.8	30.0
215	Kelleys	Trailer Park	f	829	13.8	150.678	28-Jul-00	2000	29-Jul-00	18-Sep-00	11	100	3.9	13.7
								2001	9-May-01	24-Sep-01	16	155	2.7	15.2
								all			27	155	3.3	15.2
216	Kelleys	Long Point	m	203	11.2	150.459	28-Jul-00	2000	30-Jul-00	25-Sep-00	12	435	7.5	15.0
								2001	10-May-01	20-Aug-01	13	550	8.0	15.2
								all			25	580	7.8	15.2
218	Kelleys	KISP-north	f	607	11.2	150.360	27-Jul-00	2000	30-Jul-00	16-Sep-00	12	30	2.2	3.0
								2001	22-May-01	19-Jul-01	7	230	6.7	18.3
								all			19	230	4.1	18.3
219	Kelleys	Trailer Park	m	198				2000						

221	Kelleys	Trailer Park	m	347	11.2	150.482	28-Jul-00	2000	29-Jul-00	25-Sep-00	15	75	3.3	7.6
								2001	9-May-01	3-Sep-01	15	145	2.3	4.6
								2002	2-Jun-02	12-Aug-02	7	755	2.0	2.0
								all			37	755	2.8	7.6
22E	North Bass	South Shore	f	565	11.2	150.179	21-Jun-01	2001	11-Jul-01	18-Sep-01	9	260	6.3	9.1
255	Middle Bass	Sonny's	f	653	11.2	150.105	22-Jun-01	2001	12-Jul-01	11-Sep-01	8	490	2.1	3.0
								2002	1-May-02	31-Jul-02	10	125	1.7	7.0
								all			18	490	1.8	7.0
26C	North Bass	South Shore	m	150	5.2	150.238	21-Jun-01	2001	11-Jul-01	11-Sep-01	8	195	3.4	9.1
								2002	1-May-02	17-Aug-02	9	440	3.2	5.0
								all			17	440	3.3	9.1
301	Kelleys	SE Shore	m	252	11.2	150.401	18-Jun-01	2001	9-Jul-01	24-Sep-01	6	725	6.0	9.1
309	Middle Bass	Sonny's	m	131	5.2	150.189	22-Jun-01	2001	12-Jul-01	11-Sep-01	8	70	2.1	4.6
35C	South Bass	East Point	m	118	5.2	150.208	19-Jun-01	2001	21-Jun-01	17-Sep-01	11	720	1.6	4.6
404	Kelleys	Bait Shop	f	471	11.2	150.321	18-Jun-01	2001	9-Jul-01		5			
467	Middle Bass	MBSP	f	345	11.2	150.087	8-Jun-02	2002	24-Jun-02		15	275	0.8	2.0
477	Middle Bass	Sonny's	m	237	8.9	150.778	22-Jun-01	2001	12-Jul-01	11-Sep-01	8	100	1.5	3.0
								2002	23-May-02	27-Sep-02	16	500	1.2	3.0
								all			24	500	1.3	3.0
507	South Bass	East Point	f	384	11.2	150.148	19-Jun-01	2001	21-Jun-01	17-Sep-01	11	100	5.1	9.1
								2002	10-Jun-02	6-Sep-02	12	145	5.0	15.0
								all			23	250	5.0	15.0
50C	South Bass	East Shore	m	248	8.9	150.799	8-Jun-02	2002	18-Jun-02	19-Sep-02	13	210	2.5	6.0
51A	South Bass	State Park	m	210	8.9	150.822	19-Jun-01	2001						
551	Middle Bass	MBSP	m	137	5.2	150.229	22-Jun-01	2001	12-Jul-01	11-Sep-01	8	120	0.6	0.9
552	South Bass	East Shore	f	623	11.2	150.007	22-Jun-01	2001	11-Jul-01	18-Aug-01	7		4.1	9.1
628	South Bass	SBSP	f	397	11.2	150.097	19-Jun-01	2001	21-Jun-01	17-Sep-01	11	490	3.7	6.1
629	South Bass	East Shore	f	306	11.2	150.097	8-Jun-02	2002	10-Jun-02	19-Sep-02	14	315	1.9	5.0
651	Kelleys	Long Point	f	507	13.8	150.560	18-Jun-01	2001						
67D	Kelleys	SE Shore	f	564	11.2	150.158	18-Jun-01	2001	9-Jul-01	20-Aug-01	6	260	6.1	10.7
708	Kelleys	Minshall	m	246	11.2	150.301	18-Jun-01	2001	9-Jul-01	25-Sep-01	8	340	5.1	12.2
								2002	27-Apr-02	1-Oct-02	14	480	4.8	10.0
								all			22	480	4.9	12.2
712	Middle Bass	MBSP	f	591	11.2	150.042	8-Jun-02	2002	10-Jun-02	23-Sep-02	13	105	1.6	6.0
730	Middle Bass	MBSP	m	164	5.2	150.201	22-Jun-01	2001	12-Jul-01	11-Sep-01	8	485	1.8	12.2
80A	North Bass	South Shore	f	485	11.2	150.081	21-Jun-01	2001	11-Jul-01	11-Sep-01	8	190	3.1	4.6
83E	Gib.	Gib.	f	606	11.2	150.142	22-Jun-01	2001	12-Jul-01	18-Sep-01	8	335	1.8	4.6
								2002	21-May-02	3-Oct-02	15	360	3.0	5.0
								all			23	360	2.7	5.0

A54	Middle Bass	Sonny's	f	330	8.9	150.840	22-Jun-01	2001	12-Jul-01	11-Sep-01	8	120	0.6	1.5
								2002	1-May-02	1-Oct-02	18	120	0.8	2.0
								all			26	120	0.7	2.0
A77	South Bass	East Point	m	214	8.9	150.697	19-Jun-01	2001	21-Jun-01	6-Sep-01	9	85	2.4	6.1
								2002	28-Jun-02	19-Sep-02	11	85	2.3	10.0
								all			20	85	2.3	10.0
B15	South Bass	SBSP	m	169	5.2	150.217	19-Jun-01	2001	21-Jun-01	6-Sep-01	8	105	2.1	3.0
B1E	Kelleys	SE Shore	f	478	11.2	150.030	18-Jun-01	2001	9-Jul-01	24-Sep-01	8	140	1.1	7.6
B35	Kelleys	Long Point	f	519	11.2	150.061	18-Jun-01	2001	23-Jun-01	25-Sep-01	2		9.1	9.1
								2002	2-Jun-02	27-Jun-02	3		3.7	6.0
								all			5		5.9	9.1
B69	South Bass	East Shore	f	322	8.9	150.718	22-Jun-01	2001	11-Jul-01	12-Oct-01	11	290	5.2	7.6
								2002	29-Apr-02	31-May-02	5	120	4.8	6.0
								all			16	290	5.0	7.6
D1C	South Bass	East Shore	m	192	5.2	150.262	22-Jun-01	2001	11-Jul-01	12-Oct-01	10	85	4.7	9.1
								2002	29-Apr-02	23-Jul-02	12	340	3.3	6.0
								all			22	340	3.9	9.1
D60	Gib.	Gib.	m	170	5.2	150.281	22-Jun-01	2001	12-Jul-01	5-Sep-01	6	30	1.3	3.0
D64	South Bass	SBSP	f	360	11.2	150.167	19-Jun-01	2001	21-Jun-01	12-Oct-01	12	100	5.0	6.1
								2002	10-Jun-02	28-Jun-02	4	100	2.4	4.0
								all			16	100	4.3	6.1
D76	South Bass	Peach Point	f	580	13.8	150.560	8-Jun-02	2002	10-Jun-02	19-Sep-02	14	490	2.3	5.0
E56	Kelleys	KISP-ramp	m	196				2001						
E66	Middle Bass	MBSP	f	328	8.9	150.740	22-Jun-01	2001	12-Jul-01	11-Sep-01	7	85	4.1	12.2
								2002	23-May-02	5-Sep-02	14	250	2.0	6.0
								all			21	250	2.8	12.2
E71	Middle Bass	Sonny's	f	351	11.2	150.131	22-Jun-01	2001	12-Jul-01	7-Sep-01	8	80	3.0	4.6
								2002	1-May-02	19-Jul-02	8	65	2.8	6.0
								all			16	90	2.9	6.0
F0F	North Bass	South Shore	f	550	11.2	150.087	21-Jun-01	2001	11-Jul-01	18-Sep-01	9	350	1.4	4.6
F7D	South Bass	East Point	f	431	11.2	150.042	19-Jun-01	2001	21-Jun-01	12-Oct-01	12	260	6.5	12.2
								2002	30-Apr-02	2-May-02	2		10.0	10.0
								all			14	260	7.0	12.2

Table 2. Hibernation site characteristics and current status of Lake Erie water snakes implanted with radio transmitters. Variables are defined as follows:

“Entered” = the range of dates between which a snake moved from its area of summer activity to its hibernation site

“Dates of Above Ground Activity” = dates when a snake was observed above ground (e.g., basking) while at or near its hibernation site

“Emerged” = the range of dates between which a snake moved from its hibernation site to its area of summer activity

“Dist. To Shore” = the shortest straight-line distance between a hibernation site and the Lake Erie shore (see Fig. 1)

“Elev.” = the estimated elevation above lake level of the ground surface at a hibernation site

“Within Active Area?” indicates whether a given hibernation site was directly inland from that snake’s area of summer activity. If ‘No,’ the shoreline distance from the area of summer activity to the nearest shoreline point to the hibernation site is given (see Fig. 1).

ID	Year	Hibernation					Description of Hibernation Site	Current Status	
		Dates of Above Ground Activity	Entered	Emerged	Dist. to Shore (m)	Elev. (m)			Within Active Area? (dist.)
047	2001	11-Sep-01 - 22-Oct-01		30-Apr-02 - 23-May-02	20	2	Yes	Underground next to large willow; grass, weeds, reed canary grass; grass and soil substrate; 20 m to marina shore (390 m to lake shore)	
	2002								Dead, October 2002
111	2001	13-Oct-01 - 22-Oct-01		prior to 1-May-02	47	3	Yes	In rock cottage foundation; periwinkle, hackberry; rock and tree root substrate	
	2002								Dead, fresh carcass found 75 m W of active area, 5 September 2002 (predation)
123	2000	18-Sep-00 - 21-Sep-00	13-Apr-01	17-Apr-01 - 9-May-01	20	5	Yes	Among rocks of an old foundation on a forested slope inland from the State Park boat ramp.	
	2001								Not found after 18 June 2001
124	2000								Dead; removed from study 10 October 2000 due to poor health, subsequently died
128	2000								Not found after 21 Sept. 2000

129	2000	21-Sep-00 - 25-Sep-00	12-Apr-01, 13-Apr-01	18-Apr-01 - 9-May-01	190		Yes	Within rock rubble at the base of wall of abandoned quarry adjacent to glacial grooves.	Removed from study 9 October 2001 due to poor health, subsequently died
	2001								
137	2000								Dead; missing after 9 Aug 2000, skeletal remains & transmitter recovered 14 October 2000
139	2001								Not found after 11 September 2001
156	2000								Never located following release
157	2000	16-Sep-00 - 13-Oct-00		18-Apr-01 - 10-May-01	580	10	Yes	Under grass covered rocks among cedar trees 10 m from ridge of rock paralleling old road in abandoned quarry area.	
	2001	15-Aug-01 - 25-Sep-01		17-May-02 - 4-Jun-02	580		Yes	Same as 2000 hibernation site	
	2002								Dead, transmitter recovered 24 September 2002
159	2000								Dead; in poor health prior to hibernation, carcass & transmitter recovered 11 April 2001
165	2000	25-Sep-00 - 11-Oct-00	12-Apr-00, 18-Apr-00		35	4	Yes	Underground in grassy area NE of metal barn, interspersed with hackberry trees ca 10 cm in diameter.	Died after spring emergence; carcass & transmitter recovered 10 May 2001

168	2000	22-Sep-00 - 25-Sep-00	10-May-01	10-May-01 - 13-May-01	24	3	Yes	Beneath shallow depression (ca 1 m in diameter and 20 cm deep) amid mature hackberry trees, poison ivy, garlic mustard; soil, rock, and treeroot substrate. Multiple small 'entrance holes' 3 – 10 cm diameter. Same location as female #173.	
	2001	25-Sep-01 - 9-Oct-01		17-May-02 - 2-Jun-02	40	2	Yes	Same as 2000 hibernation site	
	2002	prior to 24- Sep-02	1-Oct-02		39		Yes	Same as 2000 and 2001 hibernation site	Hibernation, October 2002 (no access June – September 2002)
16A	2001	9-Oct-01 - 20-Oct-01			21	2	Yes	In pile of rocks next to large maple near wood pile; poison ivy, grape; soil and rock substrate	Dead; failed to emerge from hibernation in 2002
173	2000	18-Sep-00 - 20-Sep-00		16-May-01 - 22-May-02	24	3	No (335)	Beneath shallow depression (ca 1 m in diameter and 20 cm deep) amid mature hackberry trees, poison ivy, garlic mustard; soil, rock, and treeroot substrate. Multiple small 'entrance holes' 3 – 10 cm diameter. Same location as female #168.	
	2001	24-Sep-01 - 9-Oct-01		17-May-02 - 2-Jun-02	40	2	Yes	Within about 5 m of 2000 hibernation site	
	2002	24-Sep-02 - 1-Oct-02			32		No (285)	Same as 2001 hibernation site	Hibernation, October 2002
184	2000	14-Oct-00 - 18-Oct-00	12-Apr-01	18-Apr-01 - 10-May-01	15	1	Yes	Under large rocks near steps to lake immediately in front of Fran Minshall's house. Next to concrete breakwall; grass and concrete substrate	
	2001	3-Sep-01 - 25-Sep-01	16-Apr-02	27-Apr-02 - 17-May-02	8	2	Yes	Same as 2000 hibernation site	Not located since 22 June 2002, battery failure
186	2000	19-Sep-00 - 21-Sep-00			10	1	Yes	Beneath soil, rocks, and tree roots adjacent to shore.	Dead; failed to emerge from hibernation in 2001
193	2000	24-Sep-00 - 10-Oct-00							Dead; failed to emerge from hibernation in 2001

196	2000	24-Sep-00 - 10-Oct-00		17-Apr-01 - 9-May-01	20	2	Yes	Beneath rocks and boards behind Craft's Lakeview Cottage.	
	2001								Not found after 9 July 2001
213	2000	15-Sep-00 - 18-Sep-00	18-Sep-00, 20-Sep-00, 11-Oct-00, 13-Oct-00	10-May-01 - 13-May-01	40	6	No (460)	Just west of Minshall/State Park property line in rock bank separating lakeshore from abandoned quarry.	
	2001								Died after spring emergence, carcass & transmitter recovered 20 May 2001
215	2000	25-Sep-00 - 10-Oct-00	10-Oct-00, 19-Oct-00	17-Apr-01 - 9-May-01	6	3	No (475)	Under lawn at base of large cottonwood adjacent to shore.	
	2001	24-Sep-01 - 9-Oct-01	9-Oct-01, 20-Oct-01		9	2	No (530)	Underground near cottonwood tree, 10 - 15 m from 2000 hibernation site; grass; rock substrate	Dead; failed to emerge from hibernation in 2002
216	2000	25-Sep-00 - 12-Oct-00		18-Apr-01 - 10-May-01	100	3	Yes	Under leaf-litter covered ground among dense shrubs (dogwood?) and a few hackberry trees. A 3 cm diameter 'entrance hole' is present.	
	2001								Dead; remained in same position since 20 August 2001
218	2000	16-Sep-00 - 19-Sep-00	19-Sep-00, 10-Oct-00, 13-Oct-00, 9-May-01	18-May-01 - 22-May-01	50		No (350)	Under rock slope adjacent to summertime position of metal ladder leading to beach near State Park maintenance building ('Stone Barn') and VIP campsite.	
	2001								Not found after 19 July 2001
219	2000								Died prior to release
221	2000	25-Sep-00 - 10-Oct-00		17-Apr-01 - 9-May-01	12	3	No (1410)	Beneath logs, soil, and rocks adjacent to shore.	
	2001	3-Sep-01 - 24-Sep-01	16-Apr-02	17-May-02 - 2-Jun-02	19	6	No (1410)	Heavily vegetated patch near drainage tile emerging from under road; milkweed, raspberry, grape, dogwood; soil, grass, and rock substrate. About 30 m from 2000 hibernation site	
	2002								Not found since 12 August 2002, battery failure
22E	2001								Not found since 18 September 2001

255	2001	11-Sep-01 - 11-Oct-01		prior to 1- May-02	6	1	Yes	Near large boulders on shoreline; grape, willow; rock substrate	Presumed dead after 31 July 2002 (has not moved since 14 August 2002)
	2002								
26C	2001	11-Sep-01 - 18-Sep-01	18-Sep-01	prior to 1- May-02	141	1	Yes	Rocky depression next mowed path; grass, goldenrod, shrubs, raspberry; soil and rock substrate	Not found since 12 July 2002, battery failure
	2002								
301	2001	24-Sep-01 - 19-Oct-01			18	1	Yes	Brushpile on shore, dead cedar and other plant material; soil and rock substrate	Dead? Hibernation site disrupted between 19 October & 14 November 2001
309	2001	11-Sep-01 - 15-Oct-01			45	2	No (135)	Grassy area near sewer hole; grass, dogwood; soil and grass substrate	Not found since November 2001, battery failure
35C	2001	17-Sep-01 - 12-Oct-01			17	1	No (300)	Compost/dead vegetation pile next to rocky shoreline; elm; rock and soil substrate	Not located since 21 May 2002, battery failure
404	2001								Dead; remained in same location since 15 Aug. 2001
467	2002	11-Oct-02 - 22-Oct-02			20		Yes	Base of willows 20 m inland from marina; 390 m to lake shore	Hibernation, November 2002
477	2001	11-Sep-01 - 15-Oct-01		1-May-02 - 23-May-02	1	1	Yes	In concrete patio/dock; vegetation lacking; concrete substrate	
	2002	27-Sep-02 - 1-Oct-02			1		Yes	Within 5 m of 2001 hibernation site	Hibernation, October 2002
507	2001	17-Sep-01 - 12-Oct-01		11-Apr-02 - 29-Apr-02	280	2	No (160)	Rocky depression in wooded area; short bushes; rock and soil substrate	brought in for medical care, 29- Apr-02; released, 21-May-02 Not found since 6 September 2002, battery failure
	2002								
50C	2002	19-Sep-02 - 26-Sep-02			11		Yes	Beneath lawn and ornamental ground cover plants	Hibernation, November 2002 (battery failed since?)
51A	2001								Dead; has not moved since release
551	2001	11-Sep-01 - 22-Oct-01			180	2	No (155)	Large rockpile in wooded area next to marina; dogwood, mulberry, grape; rock substrate; 120 m from marina	Not located since November 2001, battery failure
552	2001								Dead; remained in same location since 18 August 2001

628	2001	17-Sep-01 - 12-Oct-01			12	4	Yes	8-10 inch diameter hole next to sloping trail to shore; grass; small shrubs; rock and soil substrate	Dead; carcass & transmitter recovered 20 December 2001
629	2002	19-Sep-02 - 26-Sep-02	1-Oct-02		6		Yes	In concrete crib/shoreline protection	Hibernation, November 2002 (weak signal)
651	2001								Dead; carcass & transmitter recovered 6 August 2001
67D	2001	after 20- Aug-01			40		No (320)	Apparently in drainage tiles under lawn	Died prior to or soon after spring emergence, did not move after 17 May 2002
708	2001	25-Sep-01 - 9-Oct-01	16-Apr-02	16-Apr-02 - 27-Apr-02	21	2	Yes	In pile of rocks next to large maple near wood pile; poison ivy, grape; soil and rock substrate	
	2002								Hibernation? Not found after 8 October 2002 (battery failure?)
712	2002	23-Sep-02 - 8-Oct-02			3		No (55)	Within shoreline protection structure (rock, concrete, timbers) adjacent to Middle Bass Ferry Company dock	Hibernation, October 2002 (thin and lethargic 27 Sept 02; brought in and fed; released 1 Oct 02)
730	2001	11-Sep-01 - 22-Oct-01			395	2	No (35)	Underground 10 ft from large willow; grass and soil substrate; 24 m from marina	Not located since November 2001, battery failure
80A	2001	11-Sep-01 - 18-Sep-01			6	1	Yes	Near large boulder and rock shoreline protection; ash, shrubs, grape, Virginia creeper; rock and tree root substrate	Dead; did not emerge from hibernation in 2002
83E	2001	18-Sep-01 - 12-Oct-01	24-Oct-01, 15-Apr-02	1-May-02 - 21-May-02	11	3	Yes	Rocky cliff-side ledge; small bushes, hackberry; rock and soil substrate	
	2002	3-Oct-02 - 7-Oct-02					Yes	Same as 2001 hibernation site	Hibernation, October 2002
A54	2001	11-Sep-01 - 15-Oct-01		prior to 1- May-02	30	2	No (170)	In dead wood and tree roots near large willow; dogwood, grass; soil and tree root substrate	
	2002	1-Oct-02 - 8-Oct-02			26		No (170)	Same as 2001 hibernation site	Hibernation, October 2002
A77	2001	6-Sep-01 - 23-Oct-01	10-Jun-02	20-Jun-02 - 28-Jun-02	220	2	No (300)	Inside old wine cellar next to vineyard near log piles; grape, cedar; rock and concrete substrate	
	2002	19-Sep-02 - 7-Oct-02			220		No (300)	Same as 2001 hibernation site	Hibernation, October 2002

B15	2001	6-Sep-01 - 23-Oct-01	30-Apr-02		162	5	Yes	Rocky area in woods next to golf course near septic station; bushes, ash, hackberry; rock and soil substrate	Not located since 31 May 2002, battery failure (locations in June are probably interference from 150.167)
B1E	2001	24-Sep-01 - 9-Oct-02			15	2	No (445)	Rocky birm with large boulders and smaller rocks; vines, dogwood, willow; rock substrate	Died after spring emergence, did not move after 17 May 2002?
B35	2001	25-Sep-01 - 9-Oct-01	16-Apr-02	17-May-02 - 2-Jun-02	40	2	Yes	NW corner of old stone foundation; lilac, hackberry, periwinkle; rock substrate	monitored wrong frequency June - August
	2002								Unknown, no access since 27 June 2002
B69	2001	12-Oct-01 - 17-Oct-01	15-Apr-02	15-Apr-02 - 29-Apr-02	12	2	Yes	Hollowed out concrete/timber crib dock with concrete cap; vegetation lacking; concrete and timber substrate	
	2002								Died after spring emergence, carcass & transmitter recovered 10 June 2002
D1C	2001	12-Oct-01 - 17-Oct-01		15-Apr-02 - 29-Apr-02	15	2	Yes	Under concrete wall or nearby; horticultural plants, trees; soil and concrete substrate	
	2002								Not found since 23 July 2002, battery failure
D60	2001	5-Sep-01 - 11-Sep-01		after 1-May- 02	6	5	No (195)	Rocky cliff-side ledge; hackberry, white ash; rock and soil substrate	Not located since 1 May 2002, battery failure
D64	2001	12-Oct-01 - 17-Oct-01		21-May-02 - 10-Jun-02	9	2	Yes	Rocky cliff ledge with openings; mulberry; rock and tree root substrate	
	2002								Dead, October 2002, transmitter recovered (may have died as early as July 2002)
D76	2002	19-Sep-02 - 26-Sep-02			9		Yes	Rocky bank adjacent to Terwilligers Pond, 65 m from lake shore	Hibernation, October 2002
E56	2001								Died prior to release
E66	2001	11-Sep-01 - 22-Oct-01		30-Apr-02 - 23-May-02	180	2	No (135)	Low area in woods near rockpiles and crayfish burrows; dogwood' grasses; rock and soil substrate; 120 m from marina	
	2002	5-Sep-02 - 20-Sep-02			4		No (710)	Inland from old Lonz boathouse, about 220 m from 2001 hibernation site	Hibernation, October 2002

E71	2001	11-Sep-01 - 15-Oct-01		prior to 1- May-02	7	2	Yes	Under concrete shoreline protection; grass; concrete substrate	Dead due to burning of brush pile between 19 July & 31 July 2002, transmitter recovered 20 August 2002
	2002								
F0F	2001	18-Sep-01 - 10-Oct-01		1-May-02 - 22-May-02	105	1	No (185)	Rocky hole next to raspberry patch, dead vegetation and wood; mulberry, black walnut; soil and rock substrate	Died after spring emergence (killed by mower?), carcass & transmitter recovered 22 May 2002
F7D	2001	12-Oct-01 - 23-Oct-01	30-Apr-02, 2-May-02	prior to 30- Apr-02	280		No (135)	Wooded area near refuse pile	Died after spring emergence, carcass & transmitter recovered 21 May 2002
	2002								

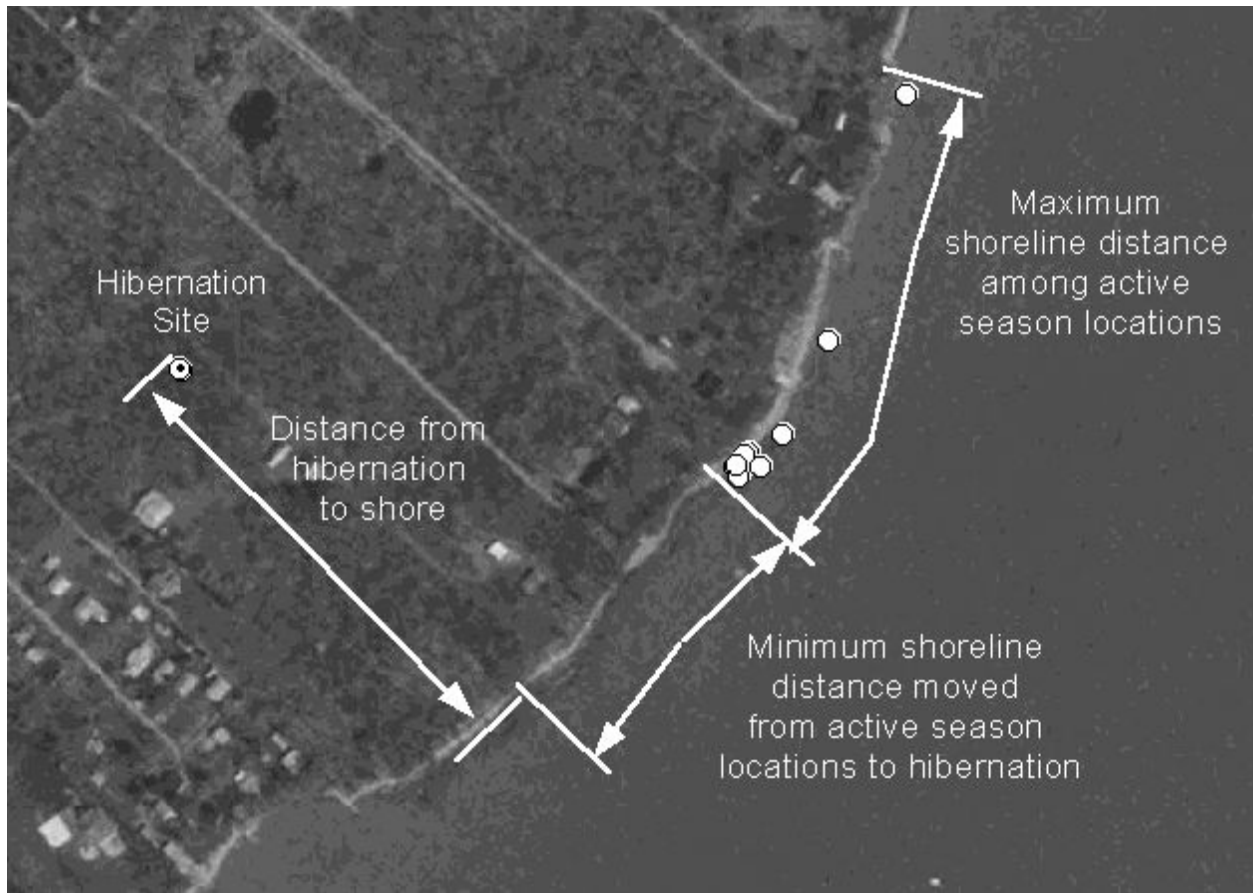


Figure 1. Movements of a representative Lake Erie water snake (female F7D), illustrating 'Maximum shoreline distance among active season locations', 'Minimum shoreline distance moved from active season locations to hibernation', and 'Distance from hibernation to shore'. Open circles are locations at which this snake was found between 19 June 2001 and 12 October 2001 (active season locations) and were recorded using a handheld GPS receiver. The 'bullseye' represents the hibernation site where this snake has remained since 23 October 2001. Maximum shoreline distance among active sites for this snake was 260 m. Sometime between 12 October and 23 October 2001, this snake moved about 135 m along the shore beyond where it spent the active season (= 'Minimum shoreline distance moved from active season locations to hibernation') and 280 m inland (= 'Distance from hibernation to shore') to hibernate.

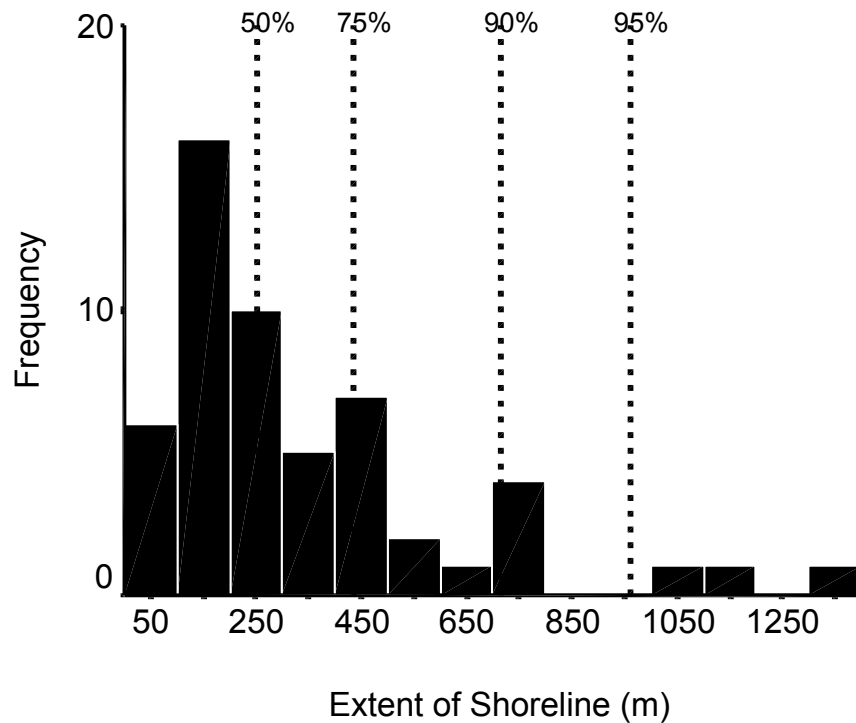


Figure 2. Extent of shoreline used during summer active seasons by 54 adult Lake Erie water snakes monitored using radio telemetry. Shoreline use ranged from 30 – 1360 m among individuals and averaged 252 m (back transformed from natural logarithms). Dashed lines show the estimated upper limit of the extent of shoreline used by specific fractions of the population: 50% of the population used 252 m or less, 75% used 437 m or less, 90% used 714 m or less, 95% used 960 m or less, and 99% (not shown) used 1674 m or less.

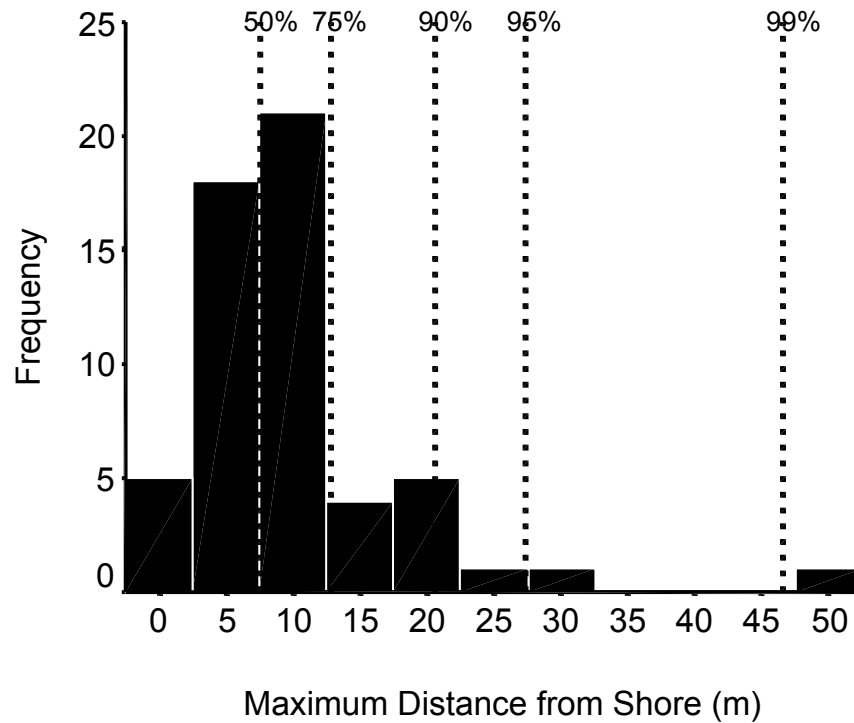


Figure 3. Maximum distance from shore moved during the summer active seasons by 50 adult Lake Erie water snakes monitored using radio telemetry. Maximum distance ranged from 1 – 50 m among individuals and averaged 8 m (back transformed from natural logarithms). Dashed lines show the estimated upper limit of the maximum distance from shore for specific fractions of the population: 50% of the population ranged up to 8 m, 75% ranged up to 13 m, 90% ranged up to 21 m, 95% ranged up to 27 m, and 99% ranged up to 47 m.

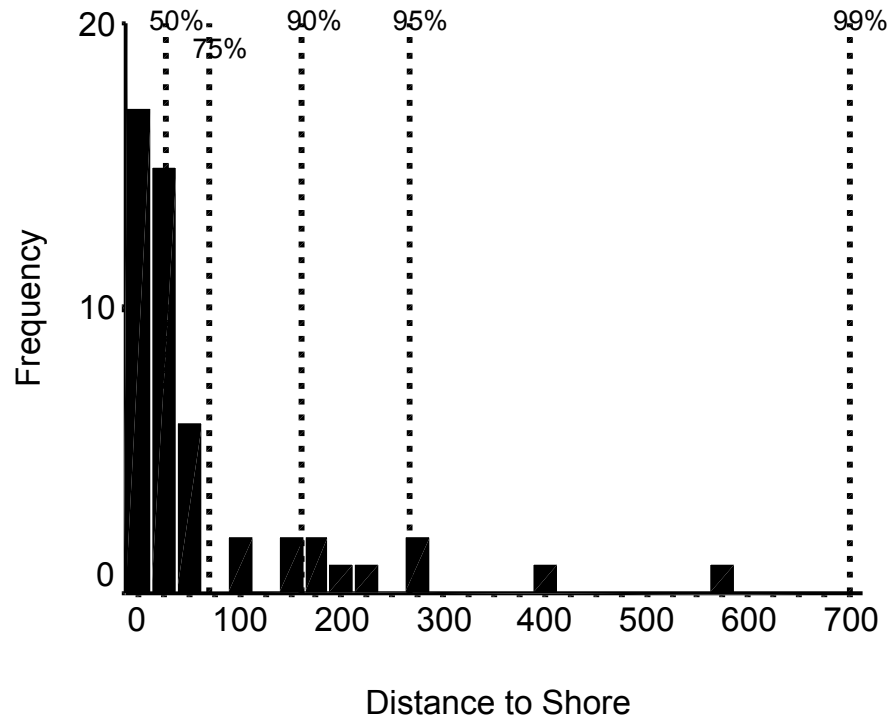


Figure 4. Distance from hibernation site to shore for 51 hibernation sites used by 50 adult Lake Erie water snakes monitored using radio telemetry. Distance ranged from 1 – 580 m and averaged 27 m (back transformed from natural logarithms). Dashed lines show the estimated upper limit of the maximum distance from shore for specific fractions of the population: 50% of the population hibernated within 27 m of shore, 75% hibernated within 69 m of shore, 90% hibernated within 161 m of shore, 95% hibernated within 267 m of shore, and 99% hibernated within 700 m of shore.

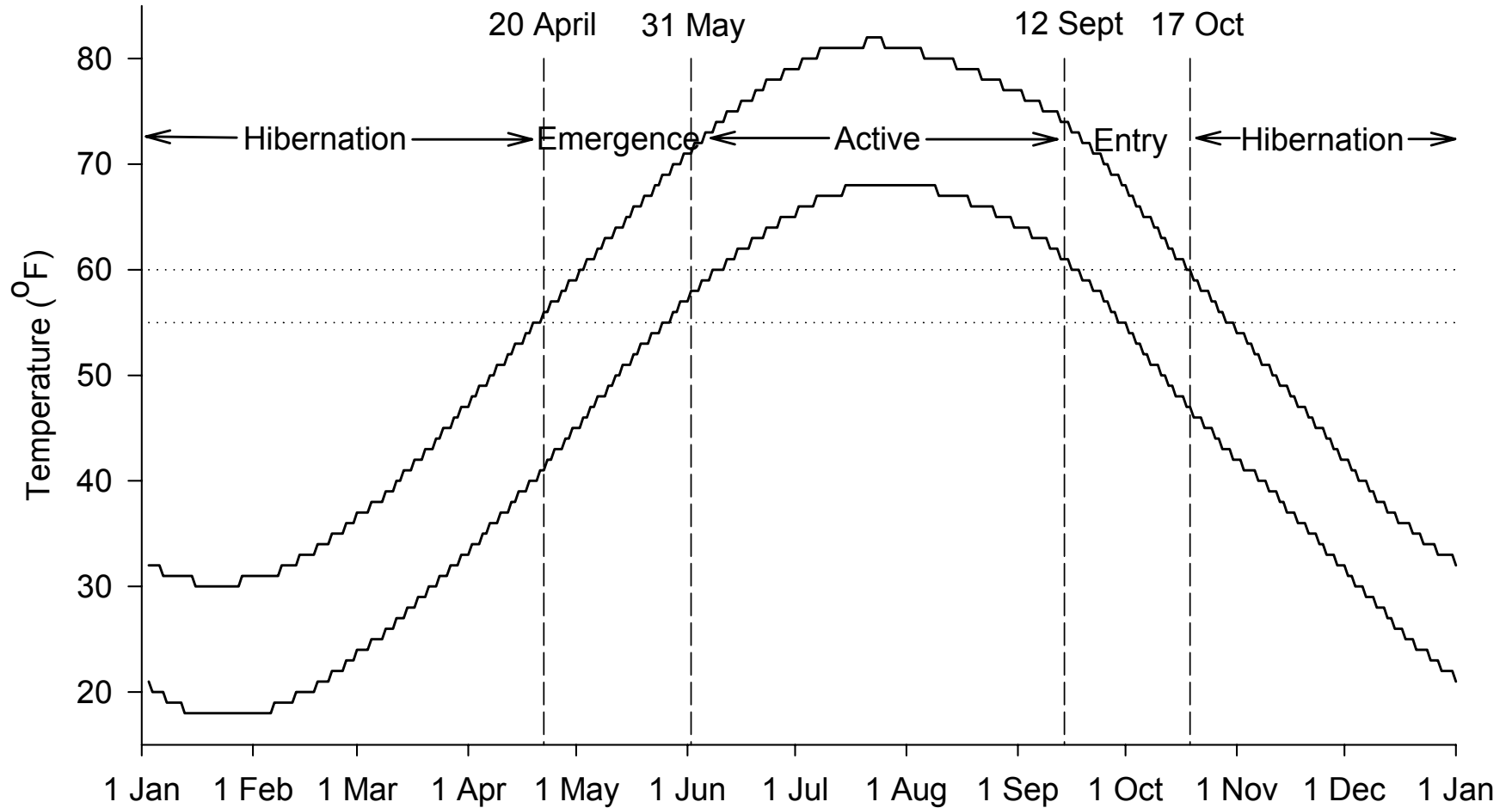


Figure 5. Estimated dates of hibernation, emergence from hibernation, summer activity, and entry into hibernation by adult Lake Erie water snakes. Also shown is the mean daily minimum temperature (lower solid line) and mean daily maximum temperature (upper solid line) for Put-in-Bay, Ohio 1971 – 2000 (from <http://www.ncdc.noaa.gov/oa/climate/normal/usnormals.html>). Vertical dashed lines delimit approximate dates of emergence from and entry into hibernation. Horizontal dotted lines correspond to 55° and 60° F.