Temperature and Depth Profiles of Namaycush (Lake Trout) in Lake Superior

by

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ABSTRACT

This project collected information on the depth and temperatures used by lake trout in Lake Superior through the use of archival tags. Fifteen (15) of 124 lake trout implanted with depth and temperature archival tags were recaptured. Information was recovered from 14 tags. For these 14 lake trout, the number of days between date of release and recapture ranged from 40 to 706 days and averaged 372 days, temperature recordings ranged from 31.6°F to 63.0°F and averaged 40.4°F, while depth recordings ranged from the water's surface to 548 feet and averaged 93 feet.

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INTRODUCTION

The objective of this study was to collect more precise and more continuous information on the depth and temperature used by lake trout (*Salvelinus namaycush namaycush*) in Lake Superior through the application of archival tags (Lotek 2001). The use of archival tags to obtain more accurate and complete data for temperatures and depths occupied by lake trout over a longer period of time, offers another tool to fishery managers and researchers for understanding behavior and refining models.

Previous information on depths and temperatures used by lake trout was derived largely from agency assessment surveys and harvest reports. These data for specific locations and dates of fishing when viewed across seasons and years, provided insight into lake trout behavior. For example, depth data indicated that, in general, siscowet (*Salvelinus namaycush siscowet*) occupied waters greater than 240 feet while lake trout occupied waters less than 240 feet. Also, these depth data indicated that hatchery and native lake trout behaved differently, as evidenced by dissimilar fishing selectivity patterns (Linton 2002) and differing spawning success rates (Hansen et al. 1995).

Temperature data are important when developing lake trout models. For example, the Pauly equation (Pauly 1980) is used to determine the initial natural mortality parameter in lake trout stock assessment models for Michigan waters of Lake Superior. When calibrating this equation, which relates natural mortality to growth parameters and water temperature, the mean annual temperature encountered by lake trout is assumed to be 41°F (Bence 2002 and 2003). In contrast, insufficient thermal habitat use data for lake trout led Johnson et. al (2001) to abandon their bioenergetics model for Lake Superior.

METHODS

Lake Trout Collection and Tagging

Lake trout were collected for tagging in fall 2001 and 2002 during spawning assessment surveys of lake trout stocks at Buffalo Reef and Presque Isle Reef and during harvest monitoring at Traverse Point (Figure 1, Table 1). Fish were transported to shore in an aerated water filled horse tank where they were held for tagging. Prior to tagging fish were anaesthetized then transferred to an operating table with a water recirculating system for archival tag insertion and suturing (Bergstedt et al. 2003). In addition to the archival tag, fish received a floy tag imprinted with the wording "$100 Reward for Fish + Internal Tag, GLIFWC POB 9 Odanah WI". Biological information collected included length, weight, sex, and lamprey scaring. Fish were then held for recovery in an aerated holding tank for approximately 12 hours. All lake trout that appeared healthy and capable of surviving were released at either Big Traverse Bay or Marquette Bay one day after capture (Figure 1). Seven percent of the lake trout (9 fish) died within the initial 12 hours as a result of tagging. Archival tags from these fish were removed and placed in other fish.

Methods for recapture of tagged lake trout included agency assessment fishing, commercial fishing, and sport fishing. Location of harvest, date, and depth were collected upon recapture. When possible, biological data were collected from recaptured fish. Temperature and depth information were downloaded from archival tags into a database.

Description of Archival Tag Data

The archival tags used in this study (Lotek 2001) record atmospheric pressure in pounds per square inch (psi) and temperature in degrees Celsius (°C). Atmospheric pressure was converted to depth using the conversion 1 psi = 0.703 meters. The tags record psi and temperature using "Time-Extension Recording(TM)" which starts recording with a sampling interval of 1/256 hour or about every 14 seconds. When memory is full the tag compresses the data, doubles the sampling interval, and then continues recording. Recording continues in this manner until the optimal "maximum sampling interval" is reached. Because of the manner in which data are recorded, the resulting data for each fish has three sets of time intervals of readings. The time interval for the first and third sets are the same, and these readings were available every 30 minutes for eight of the 14 fish. However, for fish that spent a longer time at large, readings for the first and third sets were available every 60 minutes (1 fish); for fish that spent a shorter time at large readings were every 3.75 minutes (5 fish). For all fish, readings for the second time interval were taken at half the intervals of the first and third sets, so that these readings were available every 15 minutes for most fish, and ranged from every 30 minutes for fish at large a long time, to every 1.88 minutes for fish at large a short time.

Analysis of Archival Tag Data

Archival tag data were converted to depth in feet and temperature in degrees Fahrenheit for each of 14 individual fish. Afterward, data were analyzed to determine if differences existed between the temperature and depth profiles of hatchery fish and native fish by season. Seasons were defined as winter (December through March), spring (April through June), summer (July through September), and fall (October and November), and depth categories were defined as 0-120 feet, 120-240 feet, 240-360 feet, 360-480 feet, and 480-600 feet (Ebener 2001).

Because of the nature of the differing time intervals used to record the data as described above, the use of simple counts of readings at different depth or temperature categories may provide misleading results if a change in the behavior of a fish happened to coincide with a change in the frequency of the available readings. Therefore, estimated percentages of times at different depth or temperature categories were determined by finding the percentages of times at the different depth or temperature categories for each fish for each set of frequencies of readings and season. These were then expanded to the estimated amount of time spent in each depth or temperature category. These estimates were summed over seasons and divided by the total amount of time for which readings were available. This resulted in estimates of percentages of times spent in the different depth and temperature categories that were not affected by changes in time interval at which data were recorded for each tag.

A mixed model analysis was conducted using SAS software to determine whether there were statistically significant differences in the depths observed for hatchery and native fish. The source of the fish, whether from a hatchery or native, was treated as a fixed effect, and the recaptured fish were treated as random samples from the population. This implied that results of the analysis were applicable to the entire population of fish rather than being restricted to the sampled fish.

Since the depth readings were taken at times that were relatively close together, the assumption of independence from one reading to the next was violated. Therefore, the mixed model analysis was conducted on a dataset composed of the mean depth reading for each fish for each day in order to make the assumption of independence of observations more realistic. A simple components of variance model was used for each season, which assumed that all observations from the same fish had the same covariance, and observations from different fish were uncorrelated (Neter et al., 1996).

RESULTS

Lake Trout Collection and Tagging

A total of 124 lake trout captured from Buffalo Reef (56 fish) and Traverse Point (23 fish) in Management Unit MI-4, and from Presque Isle Reef (45 fish) in MI-5 were implanted with depth/temperature archival tags (Table 1). These fish were released at Big Traverse Bay in 2001 (55 fish) and 2002 (24 fish) and at Marquette Harbor in 2001 (45 fish) (Figure 1).

Tagged lake trout averaged 26.9 inches and 6.3 pounds (Tables 1 and 2). Of the fish tagged 68% (77 fish) were of native origin and 32% (47 fish) of hatchery origin (Table 3). Seventy-eight percent (78%) (97 fish) were male, 12% (15 fish) female, and 10% (12 fish) unknown sex (Table 4). Lamprey marking rates for the 124 lake trout released were 2 wounds and 54 scars/100 fish.

Recapture Information

Fifteen (15) lake trout implanted with depth/temperature archival tags were recaptured and information was recovered from 14 tags (Figure 2, Table 5). Length obtained from 12 recaptured lake trout averaged 26.7 inches and weight from 11 recaptured lake trout averaged 5.8 pounds (Table 5). Of the 15 recaptured fish seven (47%) were of native origin and eight (53%) were of hatchery origin (Table 5). There were twelve male, one female, and two unknown sex lake trout recaptured (Table 5). Recaptured lake trout grew an average of 0.1 inch and lost an average of 0.3 pounds. Lamprey marking rates were not recorded for the 15 recaptured lake trout. For the 14 tags from which information was recovered, days at large averaged 372 (range: 40 to 706 days), temperature averaged 40.4°F (range: 31.6°F to 63.0°F), and depth averaged 93.1 feet (range: water's surface to 548.1 feet) (Table 6).

Archival Tag Data

Average daily temperature and depth data for individual lake trout are presented in Figures 3-16, which summarize the continuous data records of time, temperature, and depth (atmospheric pressure). From these data the percentage of time spent at various depths and temperatures during different seasons was determined for each fish (Tables 7 and 8). On average fish spent between 72% and 83% of the time in waters between 0 and 120 feet by season and between 17% and 28% of the time in waters between 120 and 240 feet by season. One percent or less of the time in any season was spent in waters greater than 240 feet. Overall, at least one fish spent some time in all depth categories during each season except 480+ feet in the summer season.

Lake trout temperature followed the seasonal pattern of water temperature changes within the lake. At times of the year when the lake was not thermally stratified lake trout temperature varied little. When the lake was thermally stratified and more water temperatures were available, lake trout temperature was more variable.

Results of the components of variance model for each season showed statistically significant differences between hatchery and native fish in winter, spring, and summer at the $\alpha = 0.05$ level, with native fish inhabiting greater depths than hatchery fish (Table 9). The difference in depths for the fall season was not statistically significant. Most hatchery fish spent between 75%-100% of the time in water 0 to 120 feet (Figures 3-8 and Table 7). The exception was hatchery fish number 275 (Figure 9) which spent only 47%-73% of the time by season in water 0 to 120 feet, with 27% to 53% of its time spent in water 120 to 240 feet. Very little time, 1% or less, was spent in water greater than 240 feet in any season by hatchery fish. For native fish, five spent 50%-100% of the time in water 0 to 120 feet (Figures 10-14 and Table 7), while two native fish, numbers 701 and 729, spent 32% to 98% of the time in water 120 to 240 feet (Figures 15 and 16). With the exception of fish number 729 which spent between 2% and 17% of its time by season in water 240 to 360 feet, 2% or less time was spent in water greater than 240 feet in any season by native fish.

Discussion

The archival tag data collected during this study indicated that lake trout live inshore and spend the majority of their time in waters less than 240 feet deep. The extent to which depth distribution overlaps with siscowet is unknown in the absence of similar continuous depth distribution data on siscowet. However, these data do indicate that on average very little time (<1%) is spent in waters greater than 240 feet, which is considered siscowet habitat.

There were significant differences in the depth distribution of native and hatchery fish in all seasons except fall. These significant differences coupled with the fact that the majority of fishing is in waters less than 120 feet may explain why catchability of hatchery lake trout is higher than native lake trout (Bence and Weeks 1995, WSTTC 1995). The difference in catchability for hatchery and native lake trout is one factor which has led to the use of different stock assessment models for each. The similarity in the fall depth distribution patterns between hatchery and native fish is associated with the movement of fish onto relatively shallow reefs (<50 feet) to spawn.

Finally, the average seasonal temperature at which recaptured lake trout in this study occurred was 40.4° F. This is similar to the average annual temperature of 41°F assumed in calibrating the Pauly equation used to set the initial natural mortality rate for stock assessment models in Michigan management units of Lake Superior.

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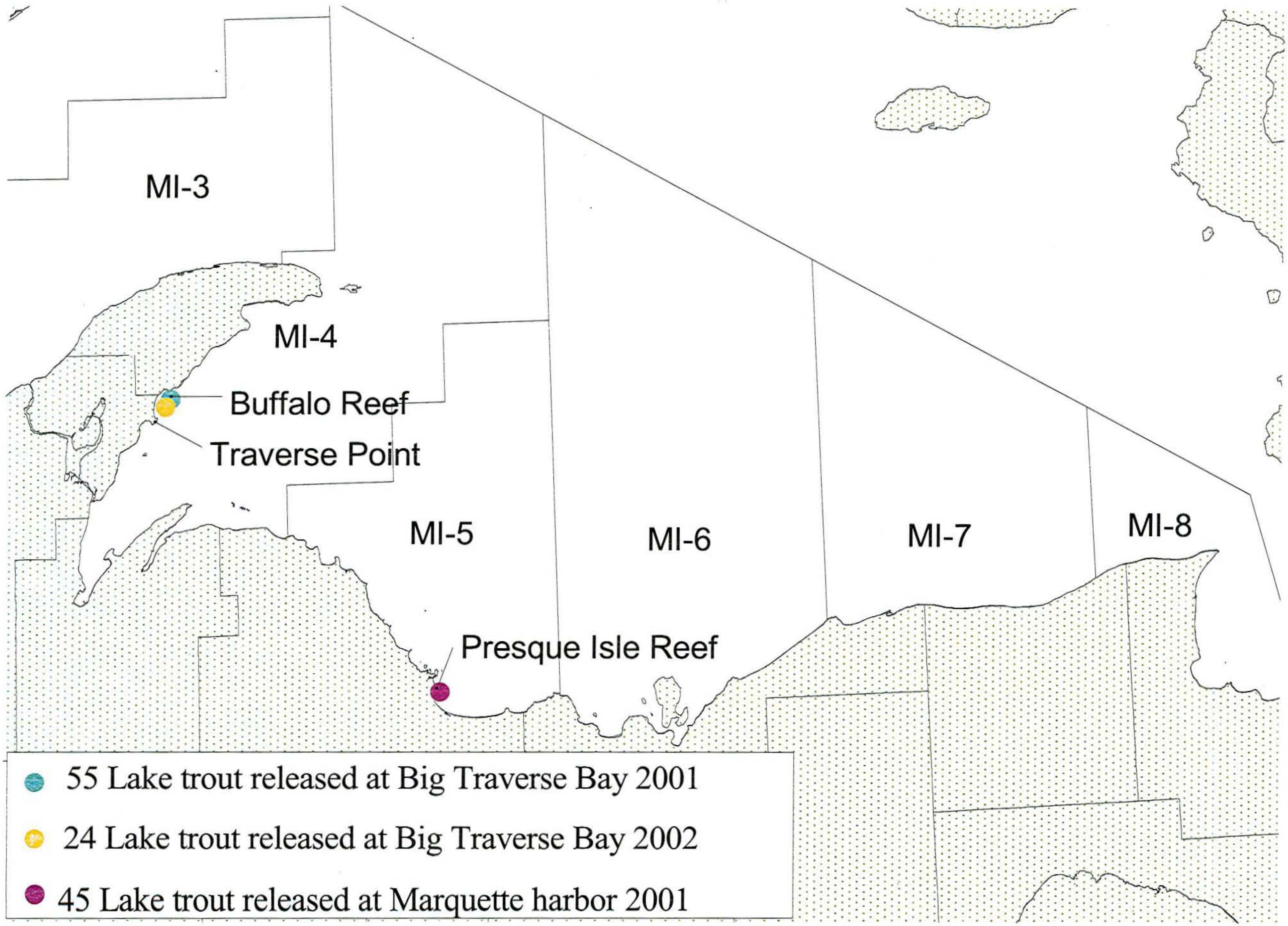

Figure 1. Location of sampling and release for 124 lake trout implanted with internal depth/temperature archival tags in Lake Superior.

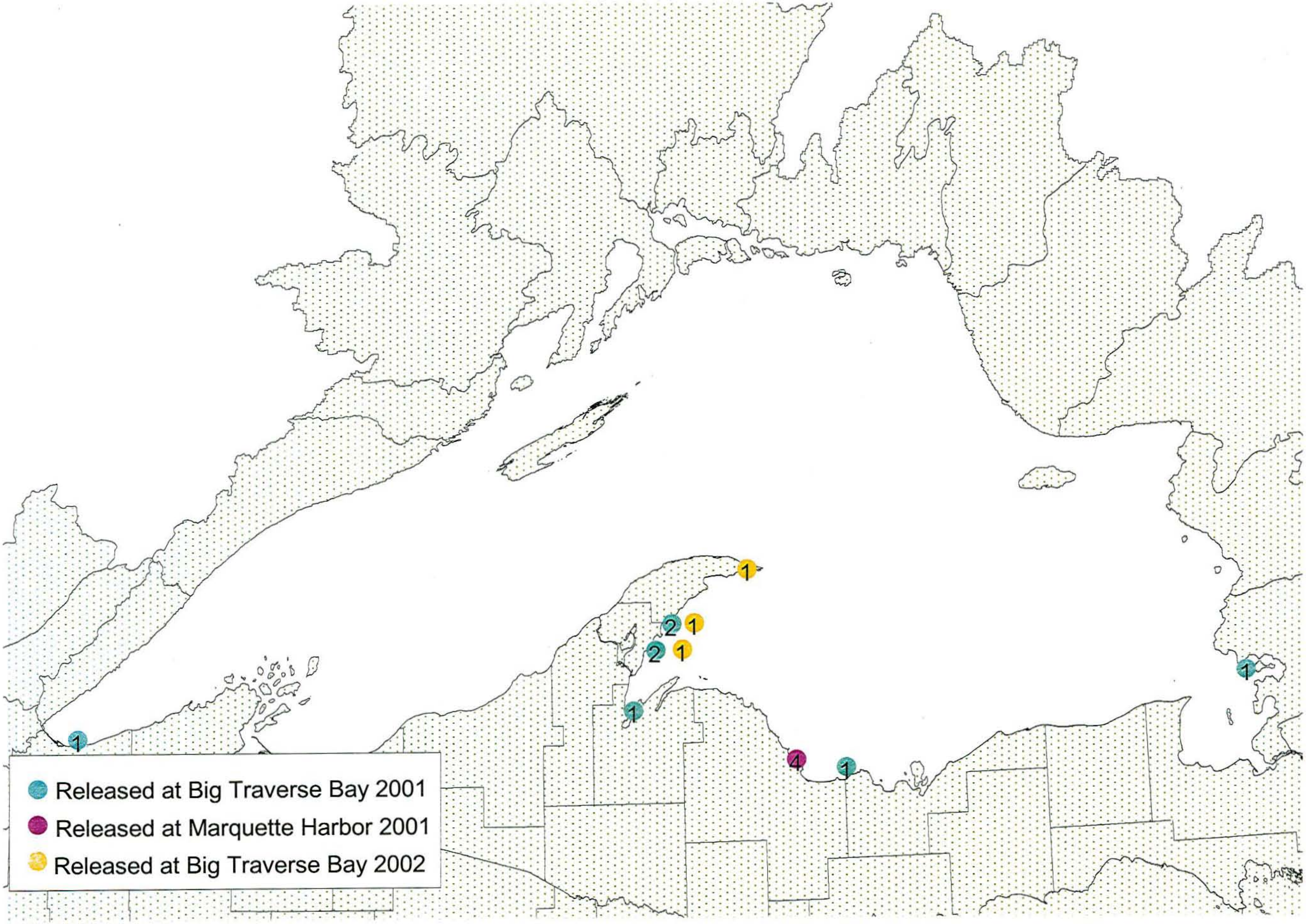

Figure 2. Location of recapture for 15 of 124 lake trout implanted with internal depth/temperature archival tags in Lake Superior.

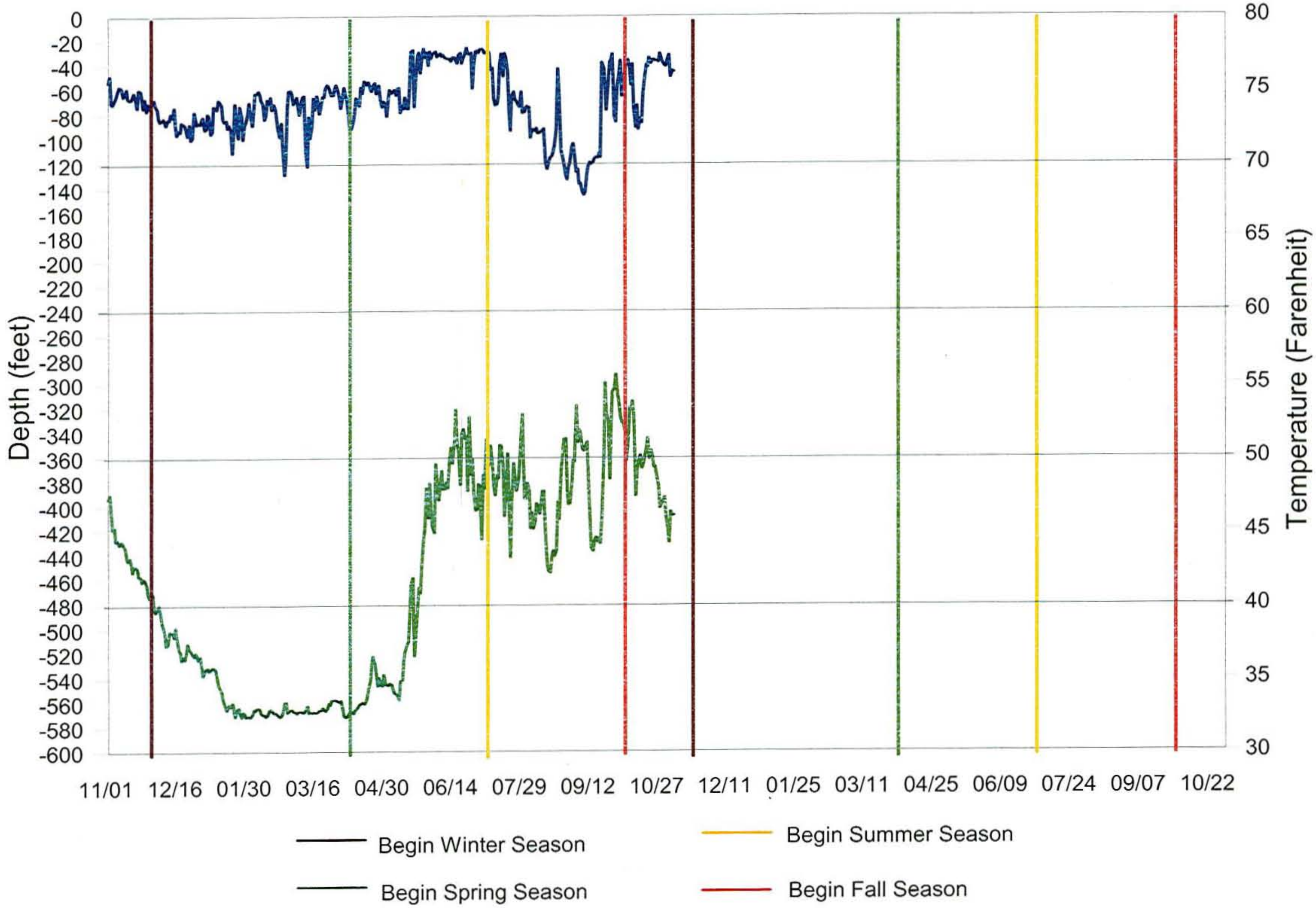

Figure 3. Depth (blue line) and temperature (green line) by season for lake trout with tag number 037.

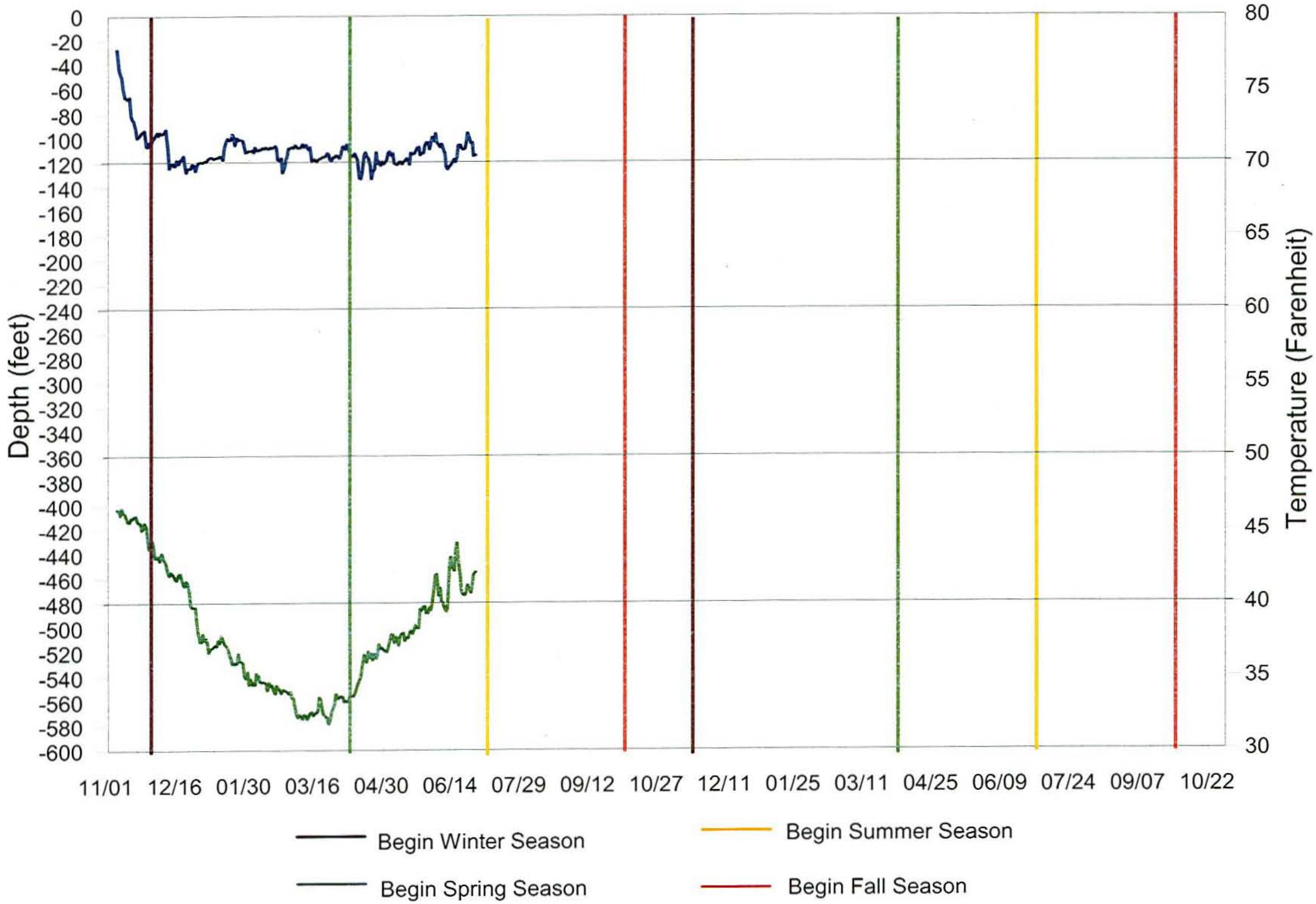

Figure 4. Depth (blue line) and temperature (green line) by season for lake trout with tag number 242.

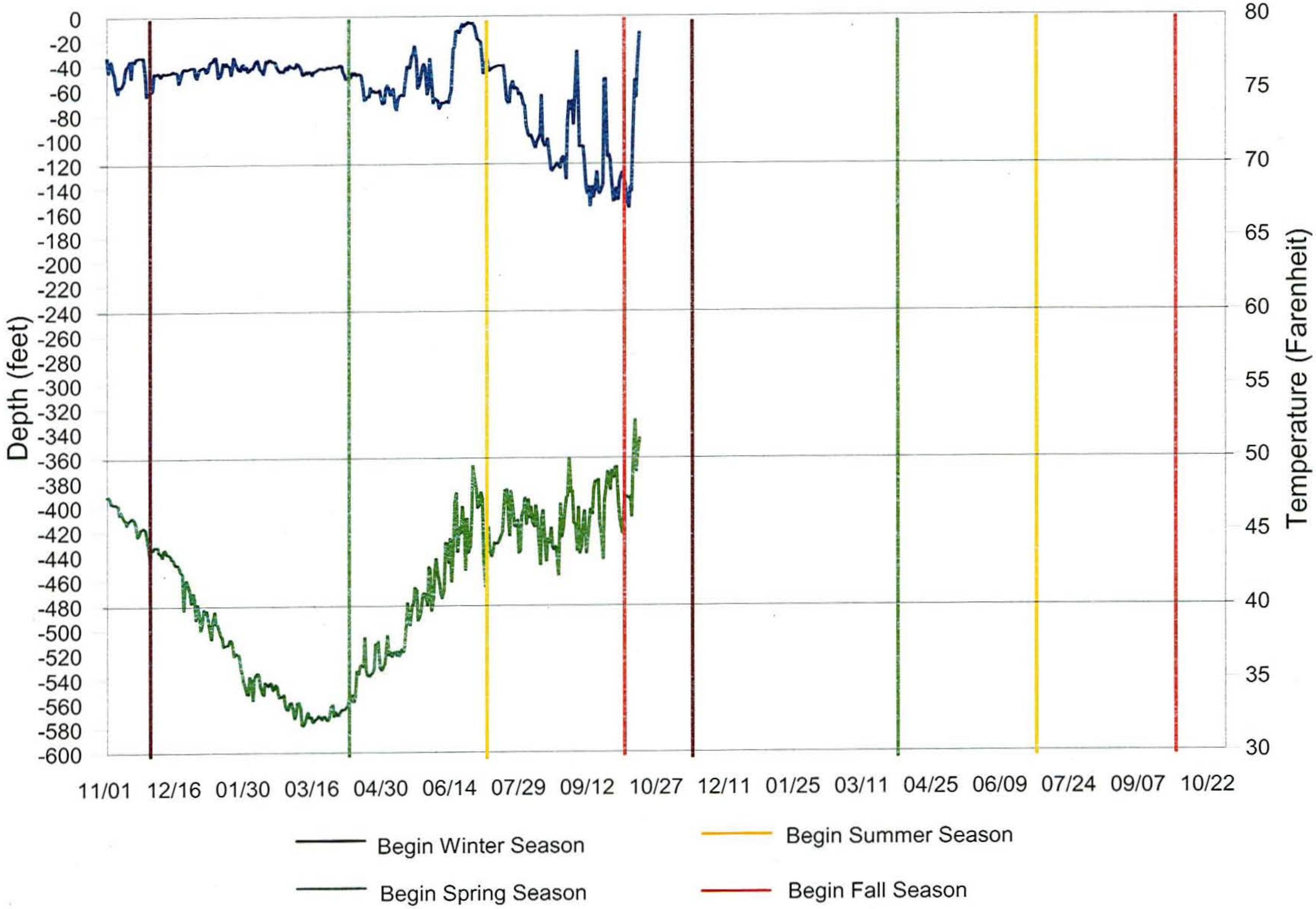

Figure 5. Depth (blue line) and temperature (green line) by season for lake trout with tag number 248.

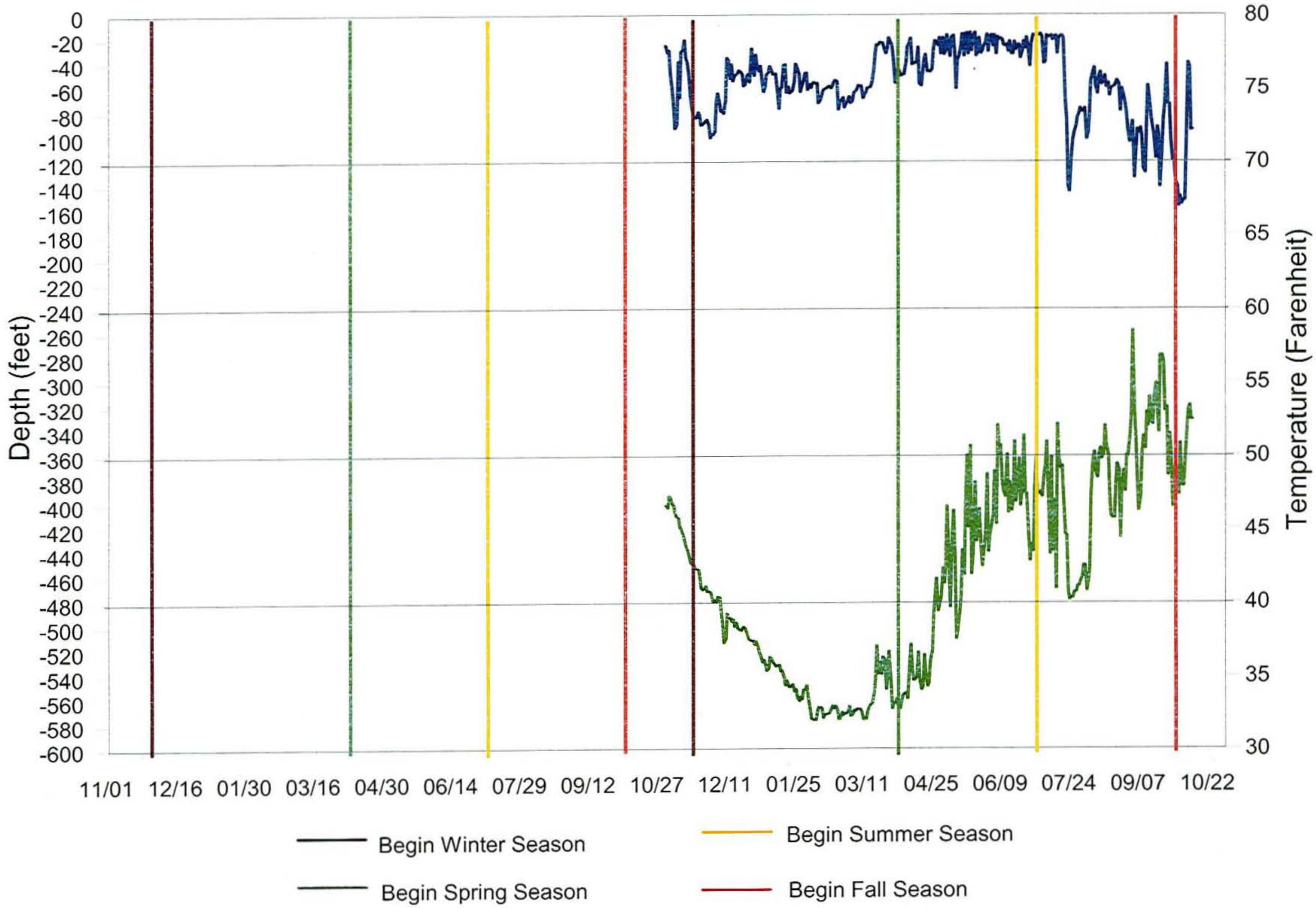

Figure 6. Depth (blue line) and temperature (green line) by season for lake trout with tag number 321.

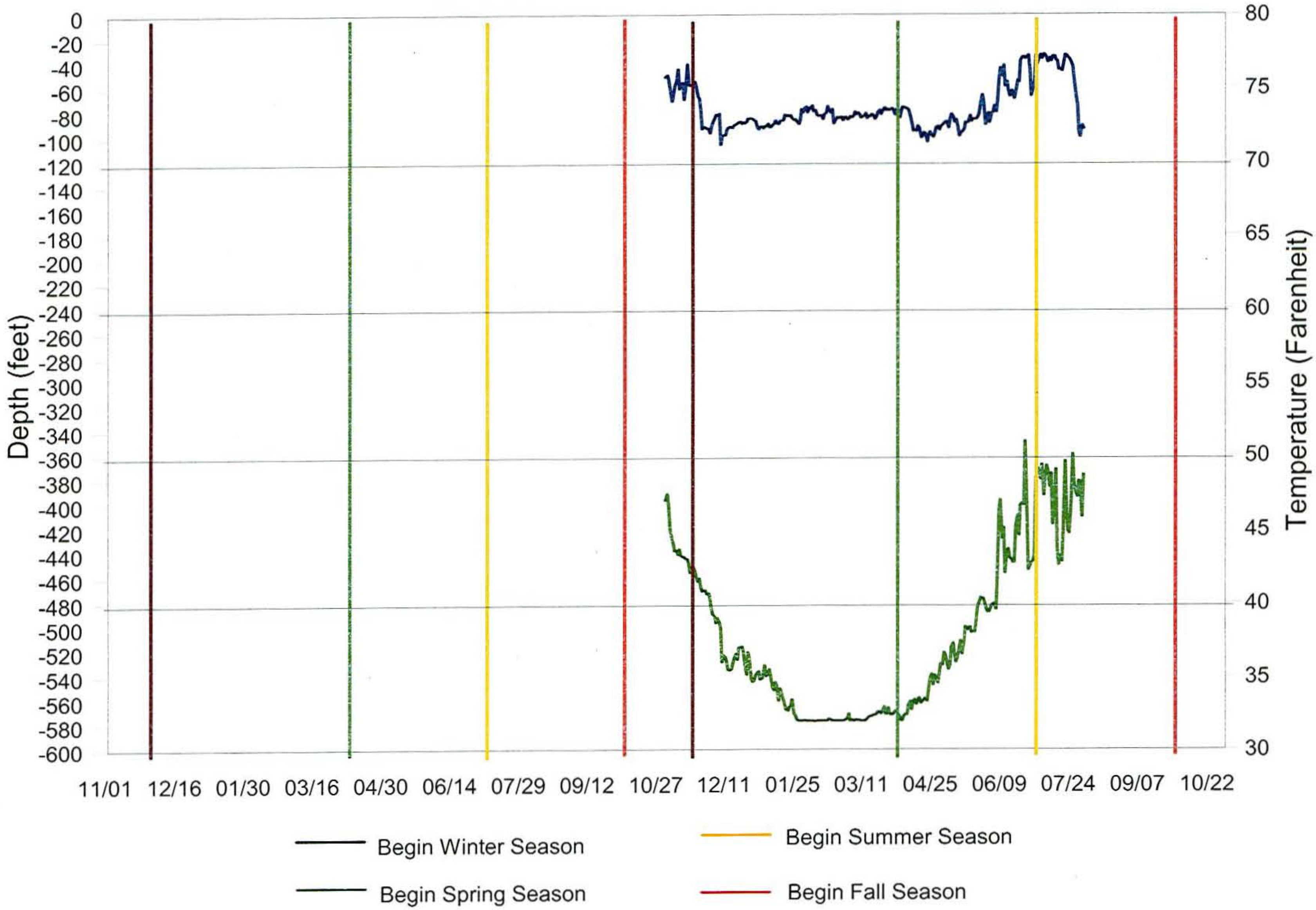

Figure 7. Depth (blue line) and temperature (green line) by season for lake trout with tag number 532.

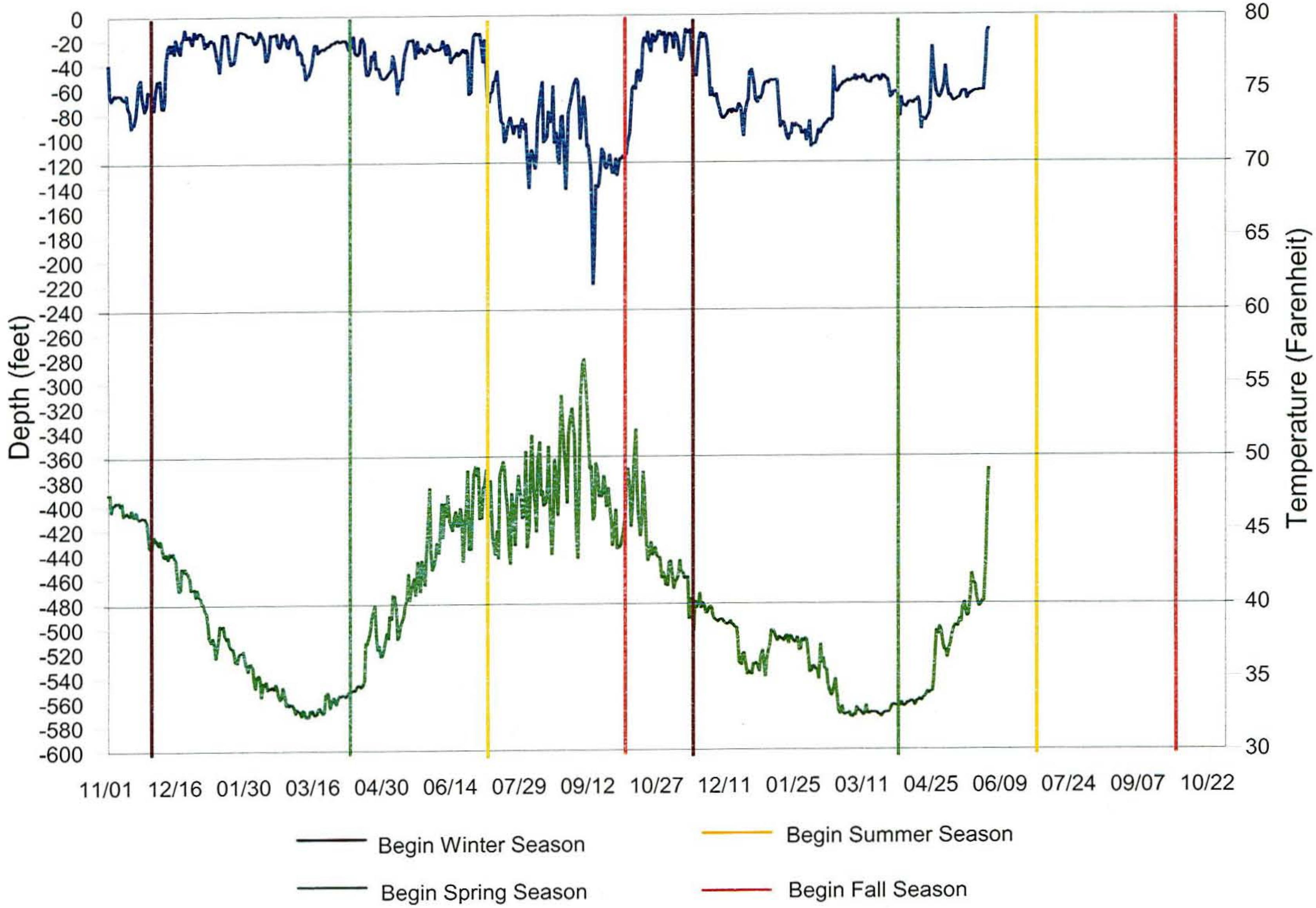

Figure 8. Depth (blue line) and temperature (green line) by season for lake trout with tag number 731.

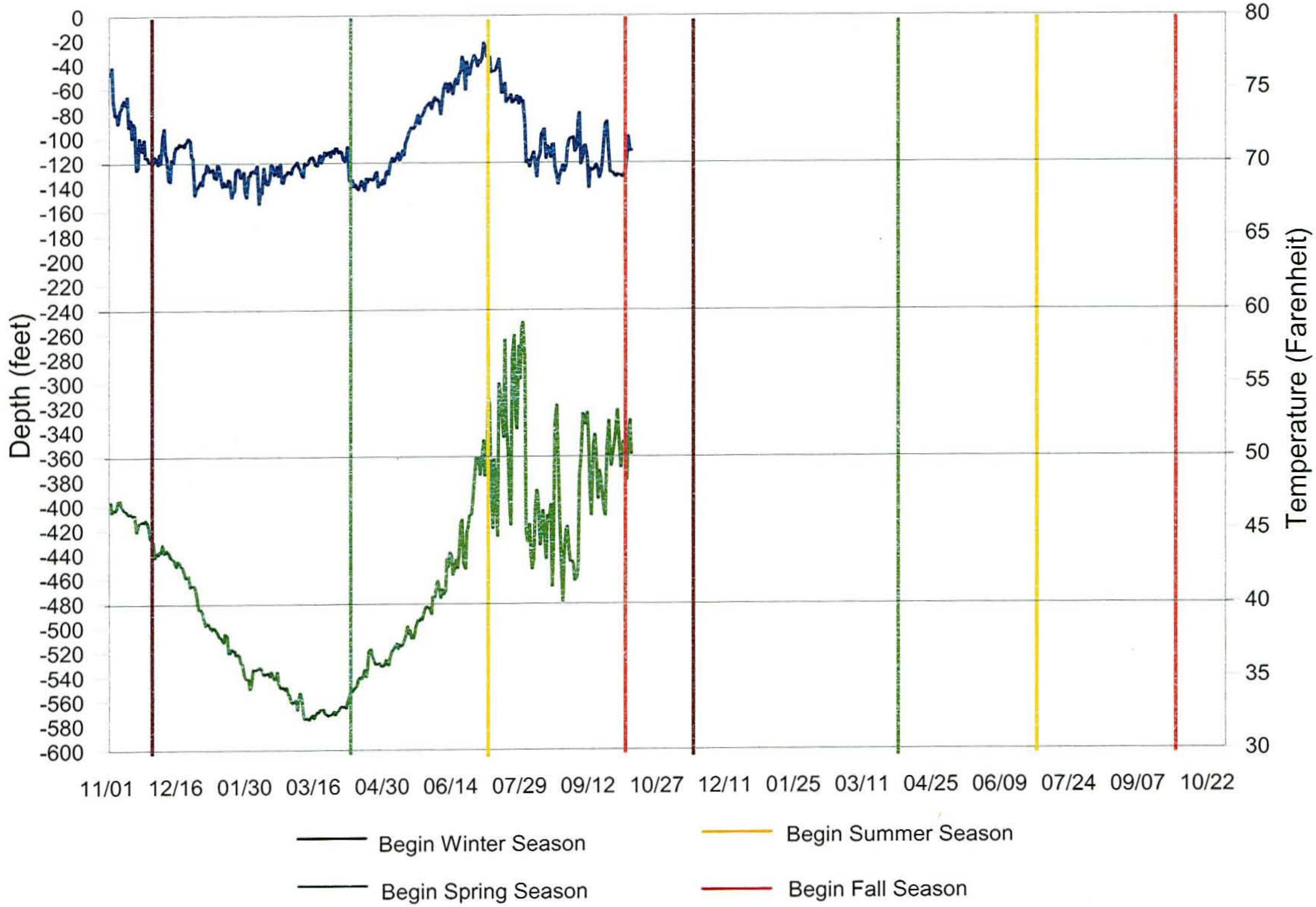

Figure 9. Depth (blue line) and temperature (green line) by season for lake trout with tag number 275.

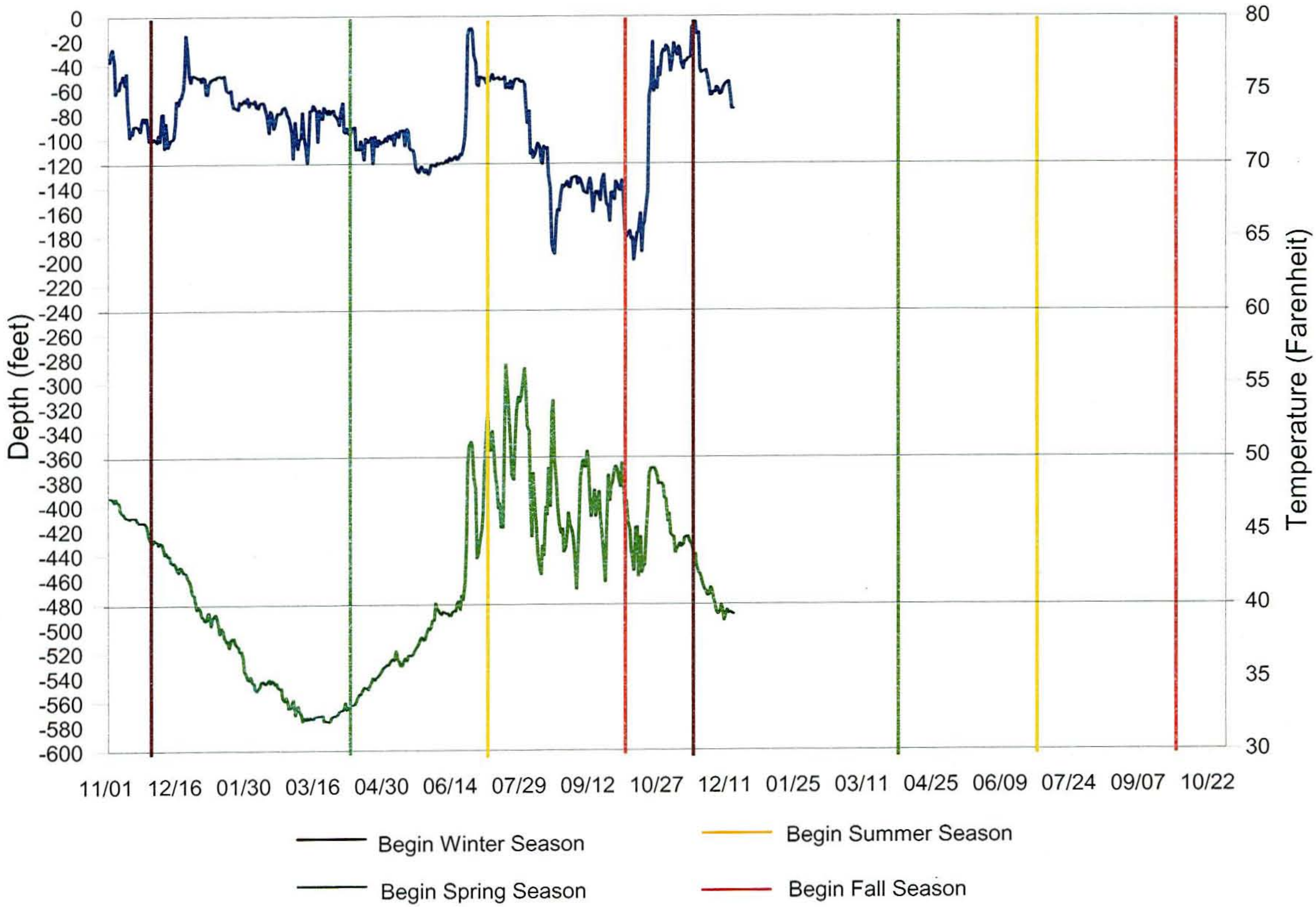

Figure 10. Depth (blue line) and temperature (green line) by season for lake trout with tag number 249.

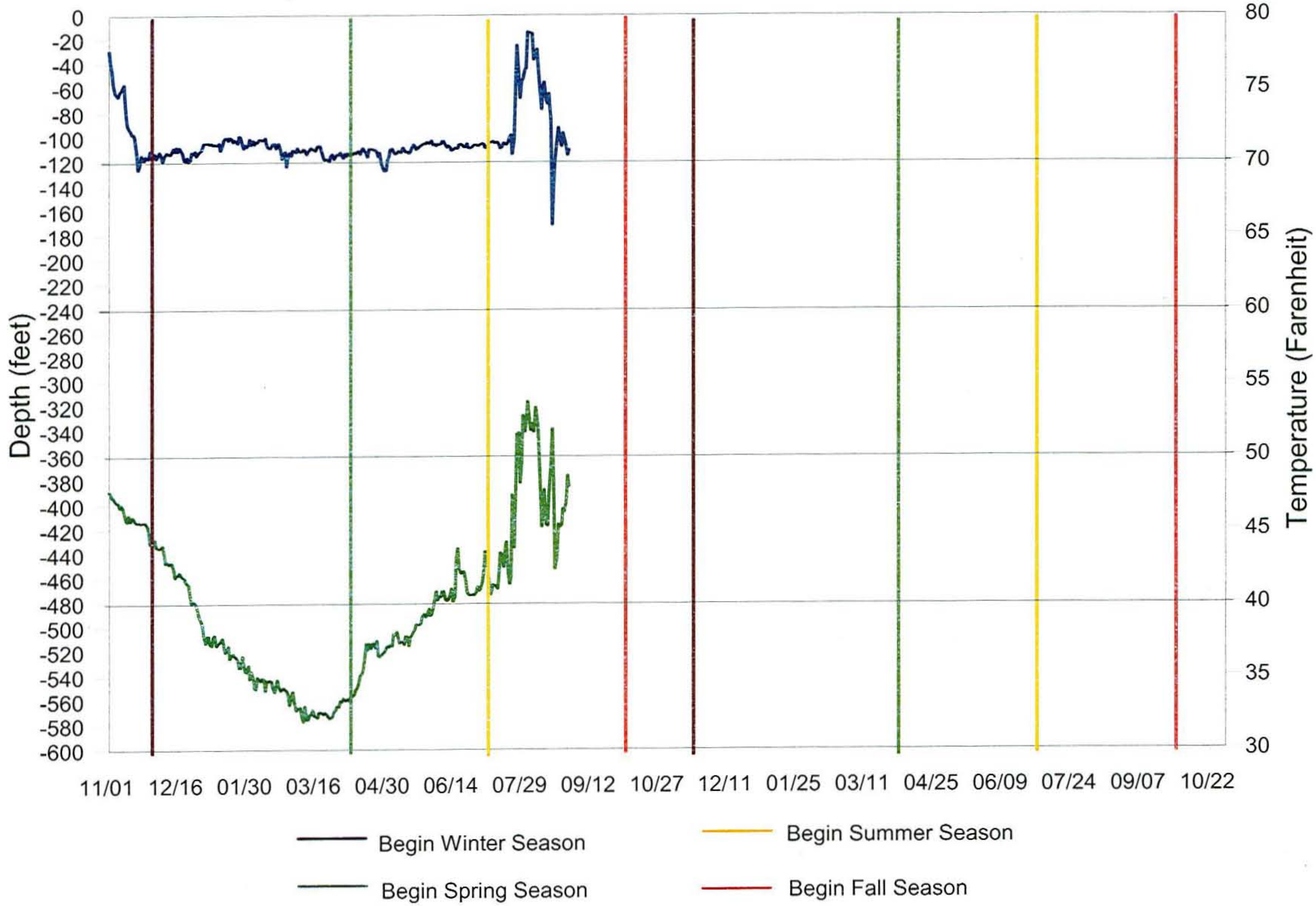

Figure 11. Depth (blue line) and temperature (green line) by season for lake trout with tag number 508.

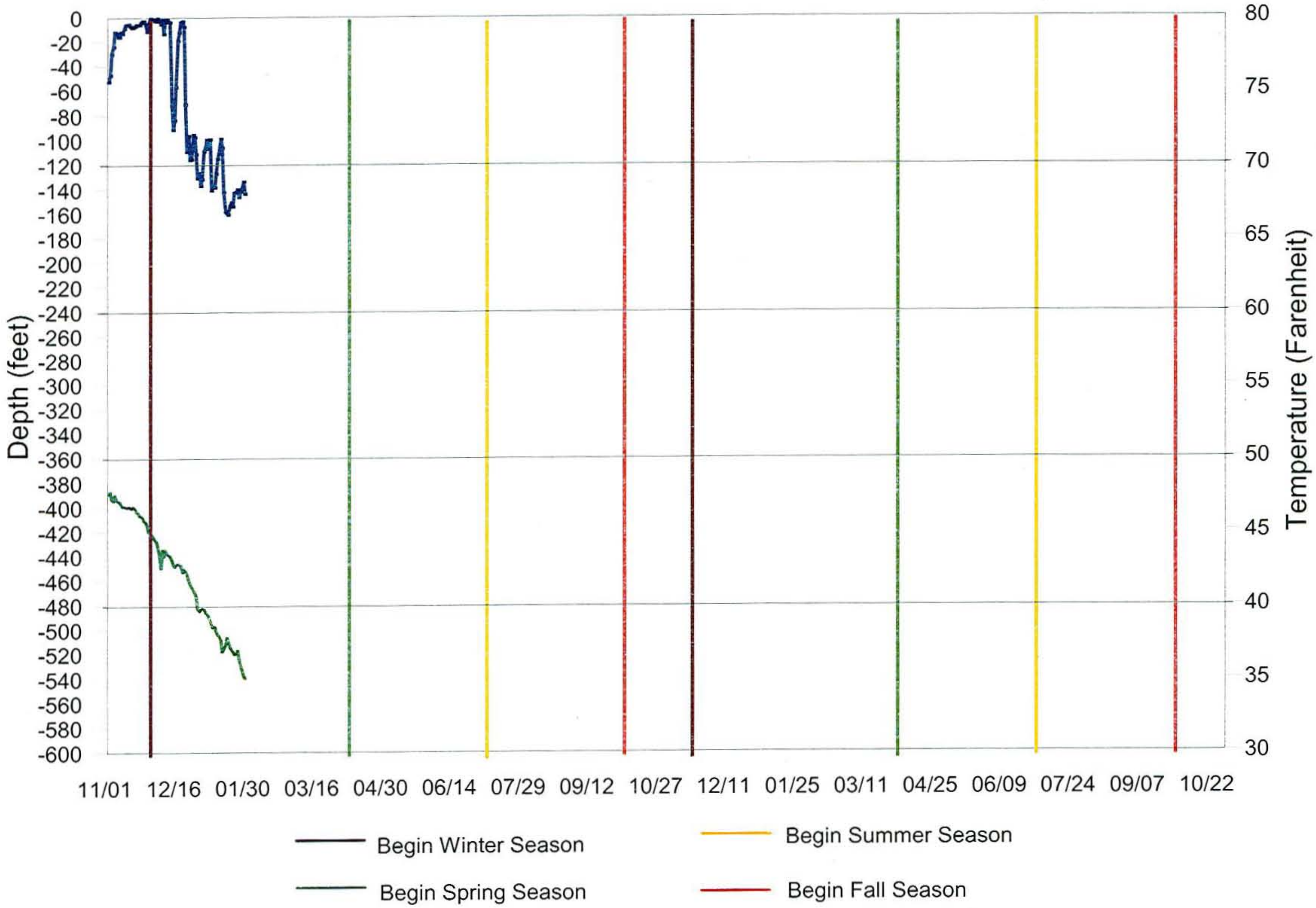

Figure 12. Depth (blue line) and temperature (green line) by season for lake trout with tag number 767.

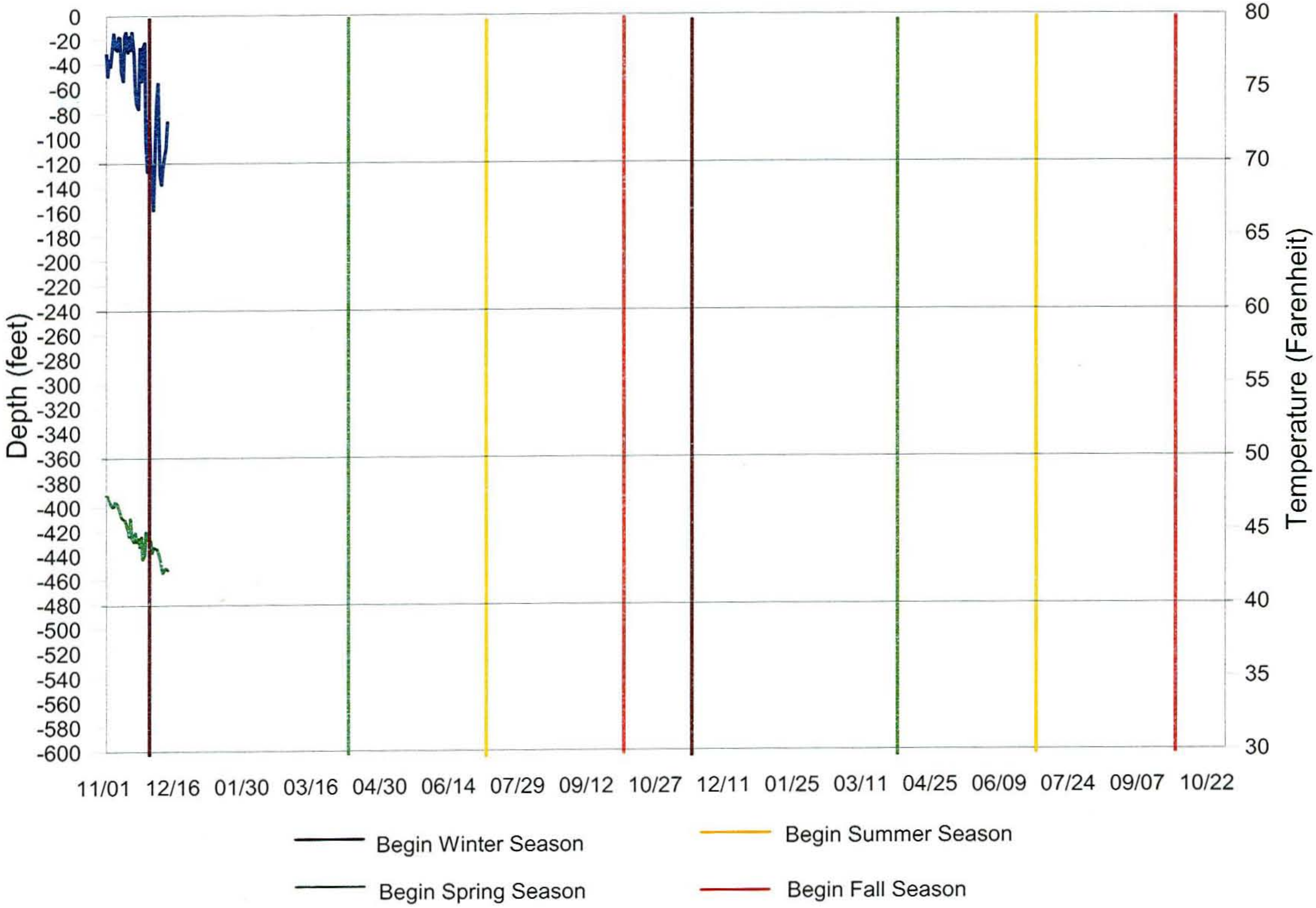

Figure 13. Depth (blue line) and temperature (green line) by season for lake trout with tag number 777.

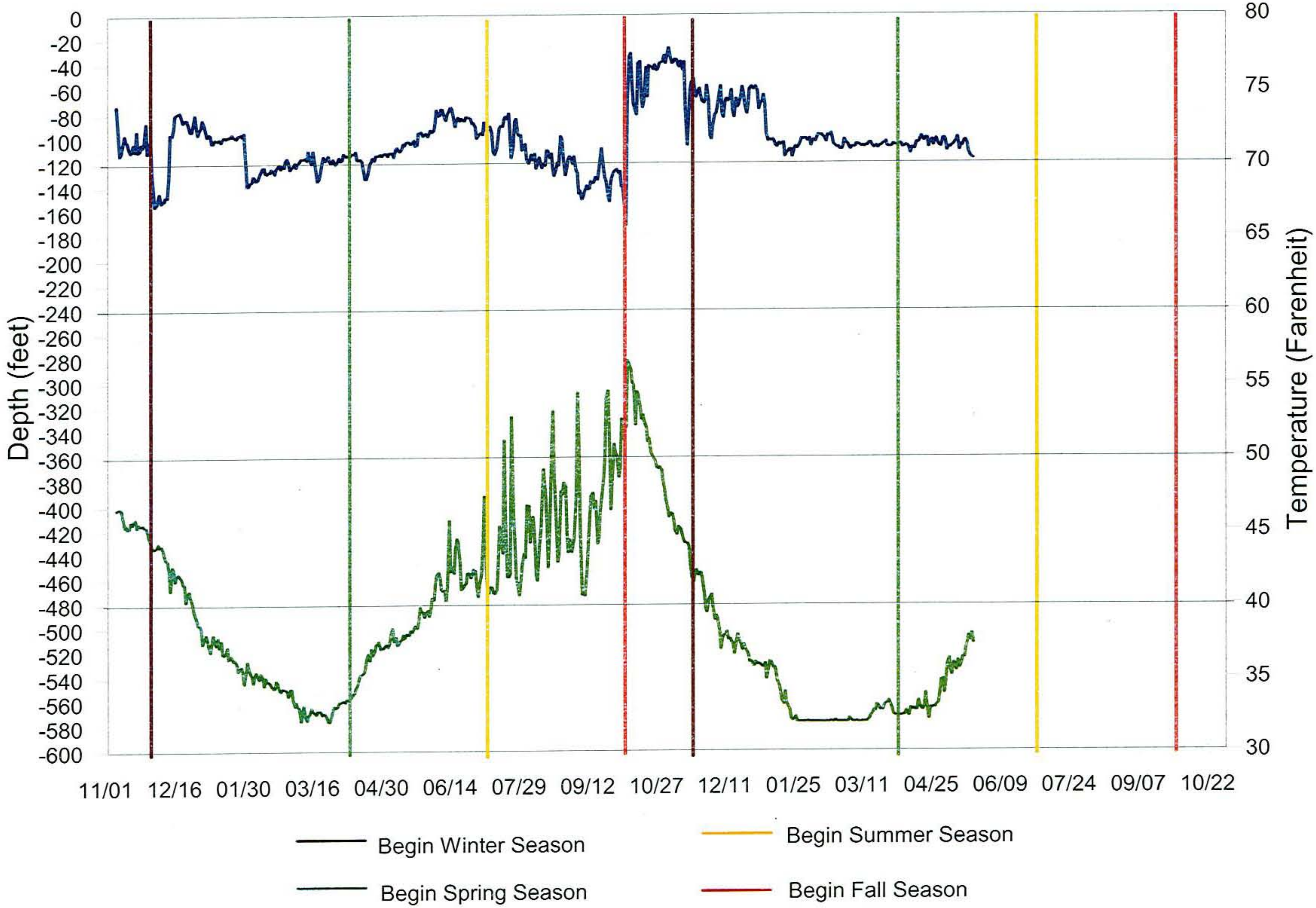

Figure 14. Depth (blue line) and temperature (green line) by season for lake trout with tag number 790.

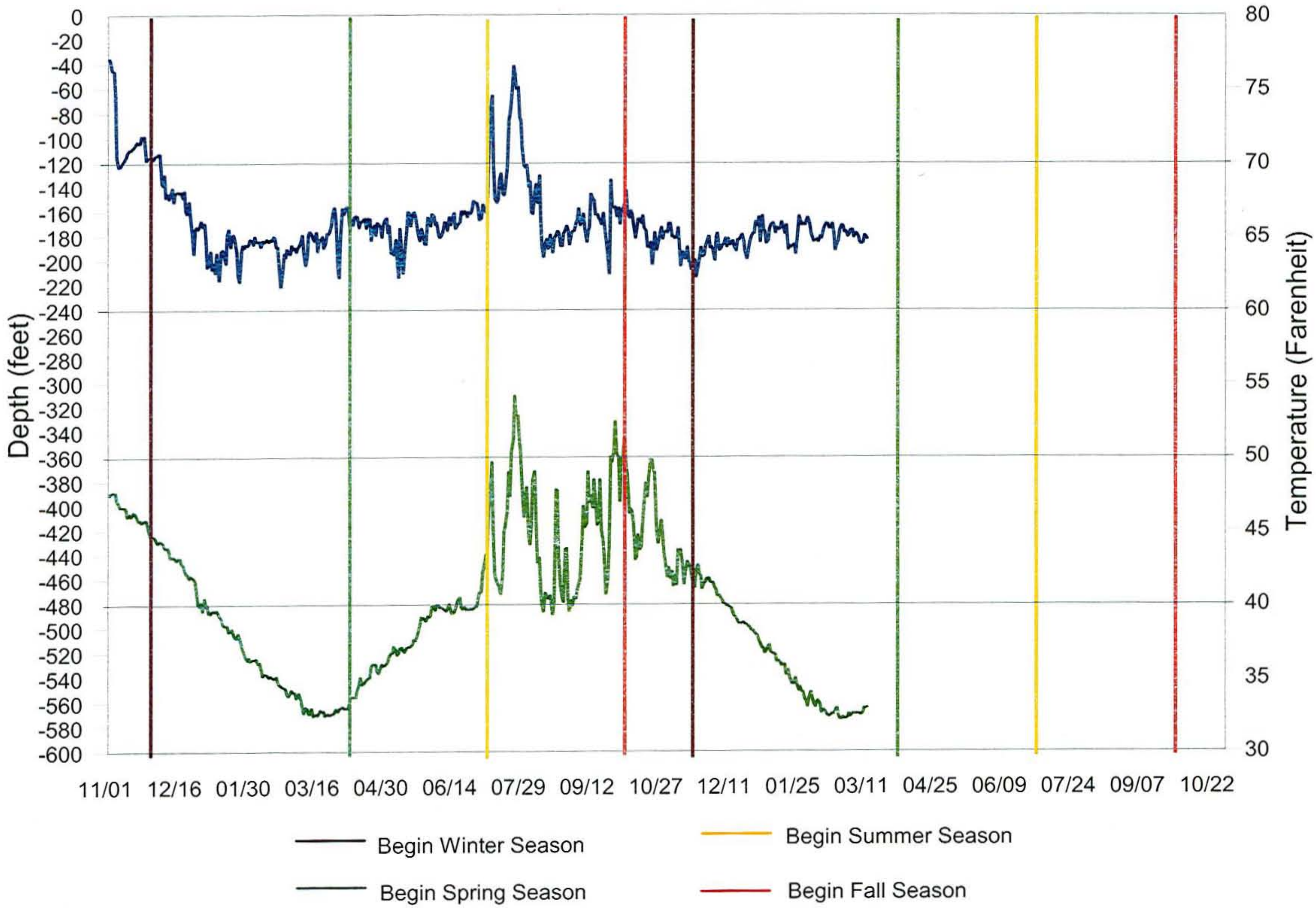

Figure 15. Depth (blue line) and temperature (green line) by season for lake trout with tag number 701.

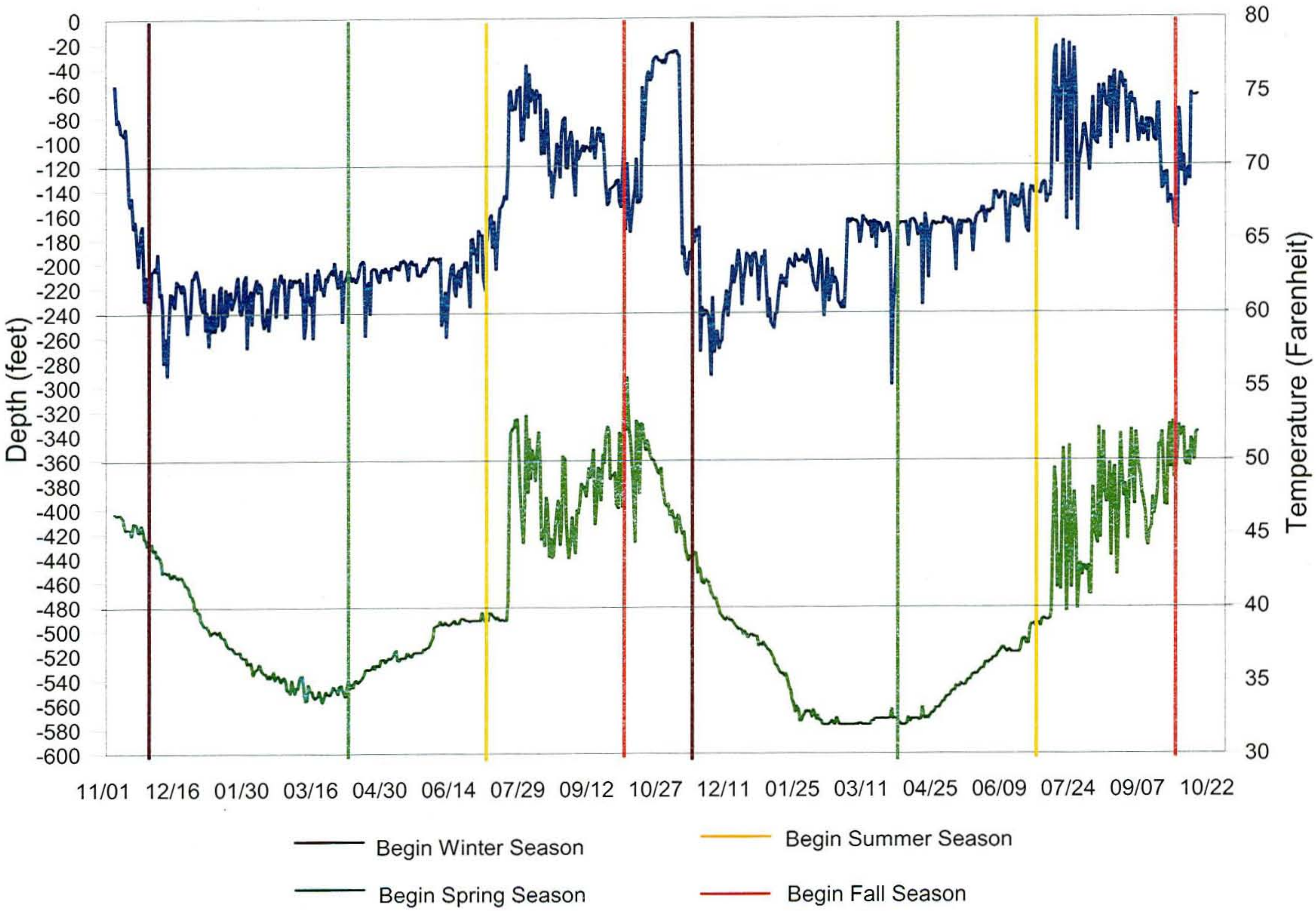

Figure 16. Depth (blue line) and temperature (green line) by season for lake trout with tag number 729.

Table 1. Capture, release, and biological data for 124 lake trout implanted with depth/temperature archival tags.

Unit of Release	Grid of Release	Location of Release	Location of Capture	Date of Capture*	Internal Tag Number	Origin (H=hatchery, N=native)	Sex	Length (inches)	Weight (pounds)
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	260	H	Female	26.7	5.3
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	263	H	Female	25.2	4.1
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	748	H	Female	29.2	9.3
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	201	H	Male	27.5	5.5
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	218	H	Male	25.7	5.4
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	261	H	Male	27.4	4.9
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	275**	H	Male	26.2	4.9
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	276	H	Male	25.1	4.5
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	285	H	Male	23.3	3.8
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	288	H	Male	24.4	4.1
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	226	N	Female	28.0	9.3
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	757	N	Female	35.0	13.1
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	215	N	Male	26.2	3.7
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	227	N	Male	29.6	7.8
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	230	N	Male	25.7	5.2
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	238	N	Male	24.2	4.2
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	243	N	Male	26.3	5.1
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	249**	N	Male	25.2	4.5
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	251	N	Male	25.0	4.9
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	252	N	Male	30.5	8.0
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	264	N	Male	25.1	4.7
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	282	N	Male	24.3	4.3
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	286	N	Male	24.4	4.0
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	295	N	Male	32.2	11.1
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	503	N	Male	25.9	4.7
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	509	N	Male	30.1	8.4
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	701**	N	Male	27.0	5.4
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	719	N	Male	26.1	5.1
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	739	N	Male	25.8	4.7
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	758	N	Male	29.0	6.5
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	767**	N	Male	26.9	6.2
MI-4	1125	Big Traverse Bay	Buffalo Reef	11/01/01	788	N	Male	26.0	5.2
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	23	H	Male	28.4	7.9
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	37**	H	Male	26.5	6.0
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	241	H	Male	25.7	5.0
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	309	H	Male	29.0	7.2
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	321**	H	Male	27.1	6.8
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	532**	H	Male	28.9	8.2
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	573	H	Male	27.7	5.9
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	913	H	Male	25.2	4.6
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	923	H	Male	29.6	8.2
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	304	H	Unknown	17.9	
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	519	H	Unknown	25.1	
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	871	H	Unknown	23.1	3.4
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	967	N	Female	32.8	12.9
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	204	N	Male	26.6	5.0
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	378	N	Male	23.4	3.5
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	779	N	Male	27.2	6.4
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	801	N	Male	28.3	6.6

Table 1. Continued.

Unit of Release	Grid of Release	Location of Release	Location of Capture	Date of Capture	Internal Tag Number	Origin (H=hatchery, N=native)	Sex	Length (inches)	Weight (pounds)
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	820	N	Male	24.3	4.2
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	849	N	Male	25.6	5.7
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	996	N	Male	27.3	
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	1400	N	Male	26.9	5.8
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	47	N	Unknown	38.6	20.2
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	533	N	Unknown	23.0	
MI-4	1125	Big Traverse Bay	Buffalo Reef	10/31/02	889	N	Unknown	24.8	4.8
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	514	H	Female	32.4	11.3
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	223	H	Male	25.4	4.8
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	248**	H	Male	28.2	8.0
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	271	H	Male	30.2	8.8
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	273	H	Male	24.4	4.2
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	280	H	Male	26.0	4.5
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	300	H	Male	32.7	11.6
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	292	H	Unknown	23.3	3.2
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	731**	H	Unknown	28.4	6.9
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	291	N	Female	29.8	9.1
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	797	N	Female	23.5	4.0
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	not recorded	N	Male	28.0	6.6
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	216	N	Male	28.9	6.7
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	244	N	Male	25.4	5.2
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	272	N	Male	24.6	4.9
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	283	N	Male	24.2	4.1
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	768	N	Male	27.5	5.7
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	769	N	Male	26.9	5.7
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	777**	N	Male	23.3	3.5
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	787	N	Male	29.4	8.1
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	799	N	Male	28.5	5.8
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	245	N	Unknown	26.2	5.3
MI-4	1125	Big Traverse Bay	Traverse Point	10/31/01	508**	N	Unknown	23.7	4.0
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	242**	H	Female	32.6	11.3
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	266	H	Female	25.4	4.6
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	219	H	Male	26.2	5.3
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	229**	H	Male	25.6	4.5
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	240	H	Male	25.7	4.7
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	246	H	Male	25.8	5.4
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	279	H	Male	24.4	4.3
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	294	H	Male	27.3	6.0
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	297	H	Male	26.1	4.8
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	513	H	Male	25.3	4.4
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	727	H	Male	25.8	4.2
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	778	H	Male	23.2	3.7
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	780	H	Male	23.3	3.8
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	796	H	Male	23.4	3.6
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	274	H	Unknown	33.8	12.9
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	287	H	Unknown	24.0	4.0
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	234	N	Female	15.8	4.7
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	265	N	Female	34.9	14.2
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	290	N	Female	26.5	6.1

Table 1. Concluded.

Unit of Release	Grid of Release	Location of Release	Location of Capture	Date of Capture	Internal Tag Number	Origin (H=hatchery, N=native)	Sex	Length (inches)	Weight (pounds)
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	299	N	Female	26.2	5.1
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	217	N	Male	32.4	11.2
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	221	N	Male	24.3	4.0
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	224	N	Male	29.1	7.5
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	231	N	Male	23.1	3.6
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	247	N	Male	27.6	6.3
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	250	N	Male	26.5	5.6
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	267	N	Male	25.9	5.5
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	269	N	Male	25.3	4.9
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	293	N	Male	27.8	6.4
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	296	N	Male	23.1	3.8
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	298	N	Male	28.0	6.6
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	505	N	Male	30.6	9.2
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	512	N	Male	30.4	7.8
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	729**	N	Male	27.9	6.6
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	730	N	Male	25.6	4.3
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	740	N	Male	26.8	5.6
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	742	N	Male	35.8	14.5
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	750	N	Male	23.8	3.8
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	751	N	Male	27.4	5.3
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	752	N	Male	33.1	12.6
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	759	N	Male	33.2	12.3
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	770	N	Male	27.5	6.2
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	790**	N	Male	23.8	3.8
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	800	N	Male	28.2	7.1
MI-5	1529	Marquette	Presque Isle Reef	11/06/01	256	N	Male	28.0	6.6

* Fish were released the day after capture.

** Indicates recaptured fish. Data were retrieved except for fish number 229.

Table 2. Length and weight data at capture by location for 124 lake trout implanted with depth/temperature archival tags.

Month and Year of Capture	Capture Location	Length (inches)			Weight (pounds)		
		number	avg.	min - max	number	avg.	min - max
October 2001	Traverse Point	23	27.0	23.3 - 32.7	23	6.2	3.2 - 11.6
November 2001	Buffalo Reef	32	26.8	23.3 - 35.0	32	5.9	3.7 - 13.1
	Presque Isle Reef	45	27.0	15.8 - 35.8	45	6.4	3.6 - 14.5
October 2002	Buffalo Reef	24	26.8	17.9 - 38.6	20	6.9	3.4 - 20.2
	Total:	**124**			**120**		
	Overall average:		**26.9**			**6.3**	
	Overall range:			**15.8 - 38.6**			**3.2 - 20.2**

Table 3. Length and weight data by origin (hatchery or native) and capture location for 124 lake trout implanted with depth/temperature archival tags.

Date	Location	Origin	Length (inches) number	Length (inches) avg	Length (inches) min - max	Weight (pounds) number	Weight (pounds) avg	Weight (pounds) min - max
		Hatchery						
October 31, 2001	Traverse Point		9	27.9	23.3 - 32.7	9	7.0	3.2 - 11.6
November 01, 2001	Buffalo Reef		10	26.1	23.3 - 29.2	10	5.2	3.8 - 9.3
November 06, 2001	Presque Isle Reef		16	26.1	23.2 - 33.8	16	5.5	3.6 - 12.9
October 31, 2002	Buffalo Reef		12	26.2	17.9 - 29.6	10	6.3	3.4 - 8.2
	Subtotal:		47	26.5	17.9 - 33.8	45	5.9	3.2 - 12.9
		Native						
October 31, 2001	Traverse Point		14	26.4	23.3 - 29.8	14	5.6	3.5 - 9.1
November 01, 2001	Buffalo Reef		22	27.2	24.2 - 35.0	22	6.2	3.7 - 13.1
November 06, 2001	Presque Isle Reef		29	27.5	15.8 - 35.8	29	6.9	3.6 - 14.5
October 31, 2002	Buffalo Reef		12	27.4	23.0 - 38.6	10	7.5	3.5 - 20.2
	Subtotal:		77	27.2	15.8 - 38.6	75	6.5	3.5 - 20.2
	Total:		**124**			**120**		
	Overall average:			**26.9**			**6.3**	
	Overall range:				**15.8 - 38.6**			**3.2 - 20.2**

Table 4. Length and weight data by sex (female, male, or unknown) and capture location for 124 lake trout implanted with depth/temperature archival tags.

Date of Capture	Capture Location	Sex	Length (inches) number	avg	min - max	Weight (pound) number	avg	min - max
		Female						
October 2001	Traverse Point		3	28.6	23.5 - 32.4	3	8.1	4.0 - 11.3
November 2001	Buffalo Reef		5	28.8	25.2 - 35.0	5	8.2	4.1 - 13.1
November 2001	Presque Isle Reef		6	26.9	15.8 - 34.9	6	7.7	4.6 - 14.2
October 2002	Buffalo Reef		1	32.8	32.8 - 32.8	1	12.9	12.9 - 12.9
	Subtotal:		15	28.3	15.8 - 35.0	15	8.3	4.0 - 14.2
		Male						
October 2001	Traverse Point		16	27.1	23.3 - 32.7	16	6.1	3.5 - 11.6
November 2001	Buffalo Reef		27	26.5	23.3 - 32.2	27	5.4	3.7 - 11.1
November 2001	Presque Isle Reef		37	27.0	23.1 - 35.8	37	6.1	3.6 - 14.5
October 2002	Buffalo Reef		17	26.9	23.4 - 29.6	16	6.1	3.5 - 8.2
	Subtotal:		97	26.8	23.1 - 35.8	96	5.9	3.5 - 14.5
		Unknown						
October 2001	Traverse Point		4	25.4	23.3 - 28.4	4	4.9	3.2 - 6.9
November 2001	Presque Isle Reef		2	28.9	24.0 - 33.8	2	8.4	4.0 - 12.9
October 2002	Buffalo Reef		6	25.4	17.9 - 38.6	3	9.5	3.4 - 20.2
	Subtotal:		12	26.0	17.9 - 38.6	9	7.2	3.2 - 20.2
	Total:		**124**			**120**		
	Overall average:			**26.9**			**6.3**	
	Overall range:				**15.8 - 38.6**			**3.2 - 20.2**

Table 5. Capture, recapture, and growth information for 15 of 124 lake trout implanted with depth/temperature archival tags and recaptured.

Tag number	Recapture date	Days at Large*	Origin H=hatchery N=native	Sex	Length (inches) at recapture	Length (inches) at tagging	Length (inches) change	Weight (pounds) at recapture	Weight (pounds) at tagging	Weight (pounds) change	Recapture Location	Recapture Grid
37	11/06/03	370	H	Male		26.5			6.0		BUFFALO REEF	1125
229**	10/27/03	719	H	Male	26.5	25.6	0.9		4.5		LITTLE PRESQUE ISLE	1529
242	06/29/02	234	H	Female	31.9	32.6	-0.7	11.1	11.3	-0.3	MARQUETTE HARBOR	1529
248	10/15/02	348	H	Male	27.5	28.2	-0.7	7.5	8.0	-0.5	TRAVERSE POINT	1224
249	12/15/02	408	N	Male	25.2	25.2	0	4.4	4.5	-0.1	TRAVERSE BAY	1224
275	10/09/02	341	H	Male	26.1	26.2	-0.1	5.5	4.9	0.6	GAY POINT	1125
321	10/11/03	344	H	Male	27.8	27.1	0.7	8.0	6.8	1.2	TRAVERSE POINT	1224
508	08/29/02	301	N	Unknown	24.0	23.7	0.3	3.9	4.0	-0.2	SHELTER BAY	1531
532	08/01/03	273	H	Male	29.2	28.9	0.3	9.0	8.2	0.8	KEWEENAW POINT	1027
701	03/13/03	496	N	Male	28.1	27.0	1.1	3.6	5.4	-1.7	KEWEENAW BAY	1323
729	10/14/03	706	N	Male	28.0	27.9	0.1	4.0	6.6	-2.6	MARQUETTE UPPER HARBOR	1529
731	05/31/03	576	H	Unknown		28.4			6.9		OFF AMNICON RIVER	1403
767	01/30/02	89	N	Male		26.9			6.2		GAY POINT	1125
777	12/11/01	40	N	Male	22.0	23.3	-1.3	1.6	3.5	-1.9	PANCAKE ISLAND	1345
790	05/21/03	560	N	Male	24.0	23.8	0.2	4.9	3.8	1.0	MARQUETTE	1529
				Averages:^	**26.7**	**26.8**	**0.1**	**5.8**	**6.0**	**-0.3**		

* Fish were released the day after capture and tagging.

** Data were not retrieved.

^ Average length and weight at tagging calculated only for recaptured fish with length or weight data.

Table 6. Depth and temperature data for 14 lake trout recaptured with depth/temperature archival tags.

Tag number	Days at large	Depth (feet) average	Depth (feet) min - max		Temperature (Farenheit) average	Temperature (Farenheit) min - max	
37	370	70.5	227.0 -	19.7	41.1	32.0 -	58.6
242	234	109.4	197.5 -	0.4	36.9	31.8 -	46.5
248	348	58.4	237.9 -	-0.6	40.8	31.8 -	56.7
249	408	91.4	369.5 -	-0.9	41.0	32.0 -	60.0
275	341	105.7	308.7 -	3.0	41.5	32.0 -	63.0
321	344	55.5	418.4 -	5.5	41.5	32.0 -	63.0
508	301	103.7	303.0 -	5.6	39.2	31.8 -	60.6
532	273	77.1	215.4 -	24.1	36.9	31.6 -	53.0
701	496	166.1	403.3 -	11.9	40.1	31.8 -	57.2
729	706	168.5	501.1 -	7.3	39.8	32.0 -	58.2
731	576	59.7	548.1 -	5.1	41.2	32.2 -	62.3
767	89	57.7	267.4 -	-4.0	42.5	35.0 -	47.8
777	40	66.6	283.8 -	-0.5	44.6	41.7 -	47.5
790	560	103.1	278.6 -	6.6	39.6	32.0 -	60.5
Average:	**372**	**93.1**			**40.4**		
Overall range:			**548.1 -**	**-4.0**		**31.6 -**	**63.0**

Table 7. Percentage of time spent in five depth ranges by season by 14 recaptured lake trout.

			Depth in Feet				
Origin	Tag	Season	0 to 120	120 to 240	240 to 360	360 to 480	480+
Hatchery	37	Fall	1.00	TR*	.00	.00	.00
		Spring	1.00	TR	.00	.00	.00
		Summer	.83	.17	.00	.00	.00
		Winter	.96	.04	.00	.00	.00
	242	Fall	1.00	TR	.00	.00	.00
		Spring	.78	.22	.00	.00	.00
		Summer					
		Winter	.86	.14	.00	.00	.00
	248	Fall	.77	.23	.00	.00	.00
		Spring	1.00	TR	.00	.00	.00
		Summer	.75	.25	.00	.00	.00
		Winter	1.00	.00	.00	.00	.00
	275	Fall	.71	.29	.00	.00	.00
		Spring	.70	.30	.00	.00	.00
		Summer	.73	.27	.00	.00	.00
		Winter	.47	.53	TR	.00	.00
	321	Fall	.84	.16	.00	.00	.00
		Spring	1.00	.00	.00	.00	.00
		Summer	.90	.09	TR	TR	.00
		Winter	1.00	TR	.00	.00	.00
	532	Fall	1.00	TR	.00	.00	.00
		Spring	.99	.01	.00	.00	.00
		Summer	1.00	TR	.00	.00	.00
		Winter	1.00	TR	.00	.00	.00
	731	Fall	.99	.01	.00	.00	TR
		Spring	1.00	TR	.00	TR	.00
		Summer	.83	.16	.01	.00	.00
		Winter	0.99	0.01	TR	0.00	0.00
	Means	Fall	0.90	0.10	0.00	0.00	TR
		Spring	0.92	0.08	0.00	TR	0.00
		Summer	0.84	0.16	TR	TR	0.00
		Winter	0.90	0.10	TR	0.00	0.00
Native	249	Fall	.76	.23	TR	.00	.00
		Spring	.83	.17	TR	.00	.00
		Summer	.50	.50	TR	TR	.00
		Winter	.96	.04	.00	.00	.00
	508	Fall	.92	.08	.00	.00	.00
		Spring	.94	.06	.00	.00	.00
		Summer	.92	.08	TR	.00	.00
		Winter	.94	.06	.00	.00	.00
	701	Fall	.27	.71	.02	TR	.00
		Spring	TR	.98	.01	.00	.00
		Summer	.17	.82	.01	.00	.00
		Winter	.02	.96	.02	TR	.00
	729	Fall	.45	.49	.05	.01	.00
		Spring	TR	.94	.05	.01	TR
		Summer	.66	.32	.02	TR	.00
		Winter	TR	.81	.17	.02	TR
	767	Fall	1.00	.00	.00	.00	.00
		Spring					
		Summer					
		Winter	.68	.32	TR	.00	.00
	777	Fall	.95	.05	TR	.00	.00
		Spring					
		Summer					
		Winter	.51	.49	TR	.00	.00
	790	Fall	.90	.10	TR	.00	.00
		Spring	.95	.05	.00	.00	.00
		Summer	.59	.41	TR	.00	.00
		Winter	.81	.19	.00	.00	.00
	Means	Fall	0.75	0.24	0.01	TR	0.00
		Spring	0.54	0.44	0.01	TR	TR
		Summer	0.57	0.43	0.01	TR	0.00
		Winter	0.56	0.41	0.03	TR	TR
ALL		Fall	.83	.17	.01	TR	TR
		Spring	.76	.23	.01	TR	TR
		Summer	.72	.28	TR	TR	.00
		Winter	.73	.26	.01	TR	TR

*TR= Trace or less than 0.005.

Table 8. Percentage of time spent in five temperature ranges by season by 14 recaptured trout.

Origin	Tag	Season	Temperature in Degrees Fahrenheit < 35	35 to 40	40 to 45	45 to 50	50+
Hatchery	37	Fall	.00	TR*	.41	.35	.24
		Spring	.38	.18	.09	.20	.14
		Summer	.00	TR	.21	.47	.32
		Winter	.65	.34	.01	.00	.00
	242	Fall	.00	.00	.20	.80	.00
		Spring	.16	.59	.24	TR	
		Summer					
		Winter	.48	.32	.20	.00	.00
	248	Fall	.00	.00	.16	.78	.06
		Spring	.14	.47	.29	.10	TR
		Summer	.00	.01	.41	.54	.04
		Winter	.47	.30	.23	.00	.00
	275	Fall	.00	.00	.10	.76	.14
		Spring	.16	.51	.24	.08	.01
		Summer	.00	.01	.25	.33	.41
		Winter	.37	.40	.23	.00	.00
	321	Fall	.00	.00	.49	.36	.15
		Spring	.17	.22	.25	.23	.13
		Summer	.00	.03	.22	.37	.39
		Winter	.55	.41	.04	.00	.00
	532	Fall	.00	.01	.90	.10	.00
		Spring	.28	.40	.22	.08	.01
		Summer	.00	.00	.25	.61	.14
		Winter	.71	.29	.00	.00	.00
	731	Fall	.00	.13	.45	.40	.02
		Spring	.27	.36	.22	.13	.01
		Summer	.00	.02	.26	.44	.28
		Winter	.42	.45	.13	.00	.00
Native	249	Fall	.00	.00	.46	.53	.02
		Spring	.25	.62	.08	.03	.04
		Summer	.00	.00	.29	.43	.28
		Winter	.40	.36	.24	.00	.00
	508	Fall	.00	.00	.13	.87	.00
		Spring	.15	.57	.27	.00	.00
		Summer	.00	.01	.50	.24	.25
		Winter	.47	.33	.21	.00	.00
	701	Fall	.00	.00	.48	.48	.04
		Spring	.20	.77	.03	.00	.00
		Summer	.00	.11	.49	.25	.15
		Winter	.42	.40	.18	.00	.00
	729	Fall	.00	.00	.26	.45	.29
		Spring	.30	.70	TR	.00	.00
		Summer	.00	.20	.19	.37	.24
		Winter	.41	.45	.14	.00	.00
	767	Fall	.00	.00	.04	.96	.00
		Spring					
		Summer					
		Winter	.00	.51	.49	TR	.00
	777	Fall	.00	.00	.43	.57	.00
		Spring					
		Summer					
		Winter	.00	.00	1.00	.00	.00
	790	Fall	.00	.02	.26	.48	.24
		Spring	.32	.46	.21	.01	.00
		Summer	.00	.00	.53	.34	.13
		Winter	.52	.37	.11	.00	.00
All		Fall	.00	.01	.34	.56	.09
		Spring	.23	.49	.18	.07	.03
		Summer	.00	.04	.33	.40	.24
		Winter	.42	.35	.23	TR	.00

*TR= Trace or less than 0.005.

Table 9. Results of mixed model analysis, with hatchery/native as fixed effect, and tagnumber (individual fish) as random effect.

Season	Hatchery/Native Effect (fixed) Degrees of Freedom Numerator	Denominator	F Value	P Value	Least Squares Means (feet) Mean Hatchery	Native	Standard Deviation Hatchery	Native	Covariance Parameter Estimates Tag Number	Residual
Winter	1	1991	4.35	0.04	78.0	125.9	16.2	16.2	1842	433
Spring	1	1282	11.20	0.00	65.8	134.5	13.3	15.7	1225	402
Summer	1	1001	6.71	0.01	80.1	112.6	8.5	9.3	414	1283
Fall	1	775	0.39	0.53	70.7	82.7	13.6	13.6	1254	1729

Oral Presentations:

Lake Superior Committee of the Great Lakes Fishery Commission Annual meeting, Ypsilanti, Michigan, March 2004. Thermal and Depth Distribution of Namaycush (Lake Trout) in MI-4 and MI-5.

Lake Superior Technical Committee of the Great Lakes Fishery Commission Bi-annual meeting, Ashland, Wisconsin, January 2004. Thermal and Depth Distribution of Namaycush (Lake Trout) in MI-4 and MI-5.

Lake Superior Committee of the Great Lakes Fishery Commission Annual meeting, Milwaukee, Wisconsin, March 2003. Thermal and Depth Distribution of Namaycush (Lake Trout) in MI-4.

Lake Superior Technical Committee of the Great Lakes Fishery Commission Bi-annual meeting, Duluth, Minnesota, January 2003. Thermal and Depth Distribution of Namaycush (Lake Trout) in MI-4.

Native American Fish and Wildlife Society Annual Meeting, Anchorage, Alaska, April 2002. Depth and Thermal Distribution of Lake Trout in Lake Superior.

Newspaper Articles:

Mazina'igan. Spring 2004. Three year depth/thermal study on lake trout wraps up.

Lake trout study finds healthy fish. Sunday, January 4, 2004. The Mining Journal. Marty Kovarik.

Study records Superior lake trout depth and water temps. February 13, 2004. Minnesota Outdoor News. Joe Noble.

Wisconsin Outdoor News. Joe Noble.

October, 2004. Outdoor Life.

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Lake trout angler gets quite a byte. Thursday, June 5, 2003. Duluth News Tribune. John Myers.

Radio Interviews:

WCCO Radio, Minneapolis/St. Paul. Al Shock (2 interviews).

North Shore Public Radio.