Automated monitoring of yellowfin tuna at Hawaiian FADs

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Progress Report: Year 2

for

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I. Summary of Overall Progress

During the second year of the grant, "Automated monitoring of yellowfin tuna at Hawaiian FADs," APK and CH have accomplished the following objectives.

A. Yellowfin tuna tagged with coded Ultrasonic Transmitters

Forty-four yellowfin tuna have been tagged during the period from 23 June 1995 to 23 April 1996. Thirty-one tags were supplied by Ultrasonic Telemetry Systems (UTS) of Placentia, California (Table I) and 14 by VEMCO, Ltd. of Halifax, Canada (Table II). These fish were tagged by CH as well as recreational and commercial fishermen (for description of methods, see Year 1 Final Rept.). CH supplied each fisherman with a plastic tool box containing the following: (1) scalpel and surgical staples for making an incision in the fish, inserting the tag into its body cavity, and closing the wound, (2) measuring tape and scale to determine the length and weight of the tagged fish, and (3) a form for recording capture data. The tagged fishes ranged in length from 71.1 to 124.5 cm TL and weight from 4.6 to 22.8 kg. The depth of the water in which the fish were captured varied from 280.5 to 1738 m.

The numbers of fish were tagged at each fish aggregating device (FAD) are given below:

FAD	Number of Fish
K	5
V	11
R	19
S	1
CO	8

B. Subsurface FAD Deployed at Kaena Point

Fishermen frequently caught yellowfin tuna near the 50-fathom depth contour at the edge of the shelf near Kaena Point (Fig. 1). The slope to the seafloor southwest of the shelf is very steep, dropping quickly to a depth of 750 m. Fishermen believe that tuna migrate around the coast of Oahu near the edge of the shelf. Tuna were often captured near the edge of the shelf near Kaena Point when fishing was poor at the three FADs with monitors. These inshore tuna could not be tagged at that time because there was no FAD at the site on which to place a monitor to detect of the fish once they returned. On 27 August, APK and CH dropped a large concrete block from the R/V Moana Wave with a line and chain that lead to a large buoy that remains 8 m below the surface, away from interference from passing fishing boats. An UTS monitor, purchased with Year 2 funds, was attached to the mooring just below the buoy.

C. Records of Tuna Attendance from Automated Monitors

UTS monitors have been deployed at V, R, and S FADs since June 1995 (Fig. 2). In September 1995, a fourth monitor was placed on the K FAD, the subsurface mooring deployed off Kaena Point. After several tuna were tagged at the CO FAD, located considerably farther from shore than the other FADs, a monitor was briefly deployed late March through early March of 1996. Early March 1996, a VEMCO monitor was placed on the R FAD and in May, another VEMCO monitor was put on the K FAD. Short-term attendance ($\leq$9 days) records from the UTS monitors are shown from the S FAD, referred to as "Sierra" (Fig. 3), the R FAD, denoted by "Romeo" (Fig. 4), and K, called "Kaena" (Fig. 5) as well as from the VEMCO monitor at the Romeo FAD (Fig. 6). In these records, the presence of tuna within the range of the monitor on the FAD is indicated by solid red in any of the 2-6 concentric circles indicating 24-hr periods. For example, notice that the tunas with UTS tags 25 and 3 were present around Sierra from 0000 hrs to 0620 hrs on 18 February (see red in circles 1 and 2). A long-term record of the daily attendance at Romeo of 10 VEMCO tags is shown for the period from 11 March to 24 April (Fig. 7). In this record, the detection of a tagged tuna at the FAD is indicated by a colored circles on

the different concentric circle for each tagged fish. This representation permits easy identification of the same individual on successive days.

The 10 yellowfin tunas tagged at Romeo returned on 28 days during a 1.5 month period. They visited the FADs at all hours of the day, and their visits ranged from minutes to 8 hrs. Individuals tagged at the same time often returned together. For instance, the five tunas tagged on 6 March 1996 often returned together. This is apparent in Fig. 7 from repeated co-occurrence of the yellow, orange, green, light blue, dark blue dots in the first five concentric rings of the day records. Individuals such as the first tuna tagged that day (see yellow dot) often visited the FADs at the same time of day on successive days. It will be necessary to statistically analyze the data from several monitor records before we can make definitive statements about the temporal patterning of tuna attendance at the FADs.

D. Range Tests on UTS and VEMCO Monitors

CH determined the distance from the FADs at which the UTS and VEMCO monitors at R FAD detected the coded transmitters. Tests were carried out during two sea conditions for the UTS monitor, a Beaufort Sea State of "0" (waters: flat calm) and "4" (wave heights: 2 m). The range of the VEMCO monitors was determined during a sea state of "1" (wave heights: 0.5 m). A tag was lowered at the end of a line to a depth of 10 m and the boat with the tag was permitted to slowly drift away from the monitor on the buoy with its position was frequently determined by radar. The record of the times of tag detection from both monitors were compared with the times when the boat was at increasing distances from the buoy. During calm seas, the UTS monitor could detect tags to a distance of 500 m (see Fig. 1), and during the rougher seas, it could detect the tags to a distance of 300 m. The range of the VEMCO monitor 1,100 m, considerably greater than that of the UTS monitor in calmer seas with the lower corresponding ambient noise levels that adversely affect receiver sensitivity. CH will conduct more range tests with the VEMCO receiver in "0" and "4" sea states. The ranges of the two monitors are shown by concentric colored circles around the R FAD on Fig. 1

E. Comparison of UTS and VEMCO System Performance

Three out of four UTS tags recovered from tuna were not functioning. All of these tags had been on fish for less than three months. The poor reliability of the UTS tags led us to purchase a monitor and tags from another vendor, VEMCO Ltd. of Halifax. In comparative tests, the VEMCO monitor had a range of 2 X of the UTS monitor. On 12 March, we tagged a large tuna (96.5 cm TL, 18.1 kg body mass) with UTS tag 11 and VEMCO tag 2337 at R FAD where had both UTS and VEMCO monitors. This tuna visited the FAD on seven days from 18 to 24 April, permitting a comparison of the ability of the two monitors to detect this tag (Fig. 8). The UTS monitor, with its more limited range, less often detected the tuna than the VEMCO monitor. In fact, on three of the seven days (21, 22, and 24 April) the VEMCO monitor detected the tag over substantial periods ranging from 3 to 8 hrs whereas the UTS monitor did not detect the tagged fish at all. Based upon these tests, we are converting from UTS to VEMCO monitors and tags. A VEMCO monitor has been placed upon the subsurface buoy at Kaena Point. We have also purchased 20 more VEMCO tags.

II. Plans for Year 3

In year 3, we intend to use only the more reliable VEMCO tags on tunas. Tagging will be concentrated at the R and K FADs where VEMCO monitors are presently deployed. We are asking for funds to acquire 20 more coded transmitters. We have 27 tags in our possession (3 UTS, 24 VEMCO), and this increase our total to 47. Two budgets are included with this report, one without and one budget including these 20 tags.

Not only will we increase our knowledge of the short-term attendance (weekly, monthly), but we will start to get an idea of the attendance patterns of tunas at the FADs on a seasonal and annual basis. A six-month continuation of our project will permit us to monitor returns of tunas tagged with the reliable VEMCO tags over a period of nine months, giving us an idea of returns on a seasonal basis. Hopefully, the project will be continued in the future so that we can

determine the rate of return on an annual basis. Both the UTS and VEMCO tags have a longevity of 18 months.

APK and CH will start analyzing the records of tag returns. They will determine if the temporal pattern of tuna returns is non-random, and if so, will examine the relationship between them and the long-term records of water temperature and light levels collected at the FADs at the same time. They will prepare a manuscript based upon the results from the study and publish it in the scientific literature.

As evident from the records, tunas return to the FADs and remain within acoustic range for periods reaching several hours in duration, sufficient to acoustically offload data that are stored within tags. In the future, we hope to work with the engineers at VEMCO and Wildlife Computers to develop an acoustic tag capable of downloading its records of geolocations to a monitor on a FAD. An obstacles to the use of archival tags that are capable of storing position determinations of a fish for a periods of up to five years is the low recovery rates of tagged fish. The recovery rate would be improved substantially if archival tags were used in conjunction with listening stations at sites to which fish return. We feel that such a system should be developed and tested with yellowfin tuna at the FADs surrounding the Hawaiian Islands, that is, if we find in this important study that the tagged yellowfin tuna continue to return over increasing time scales.

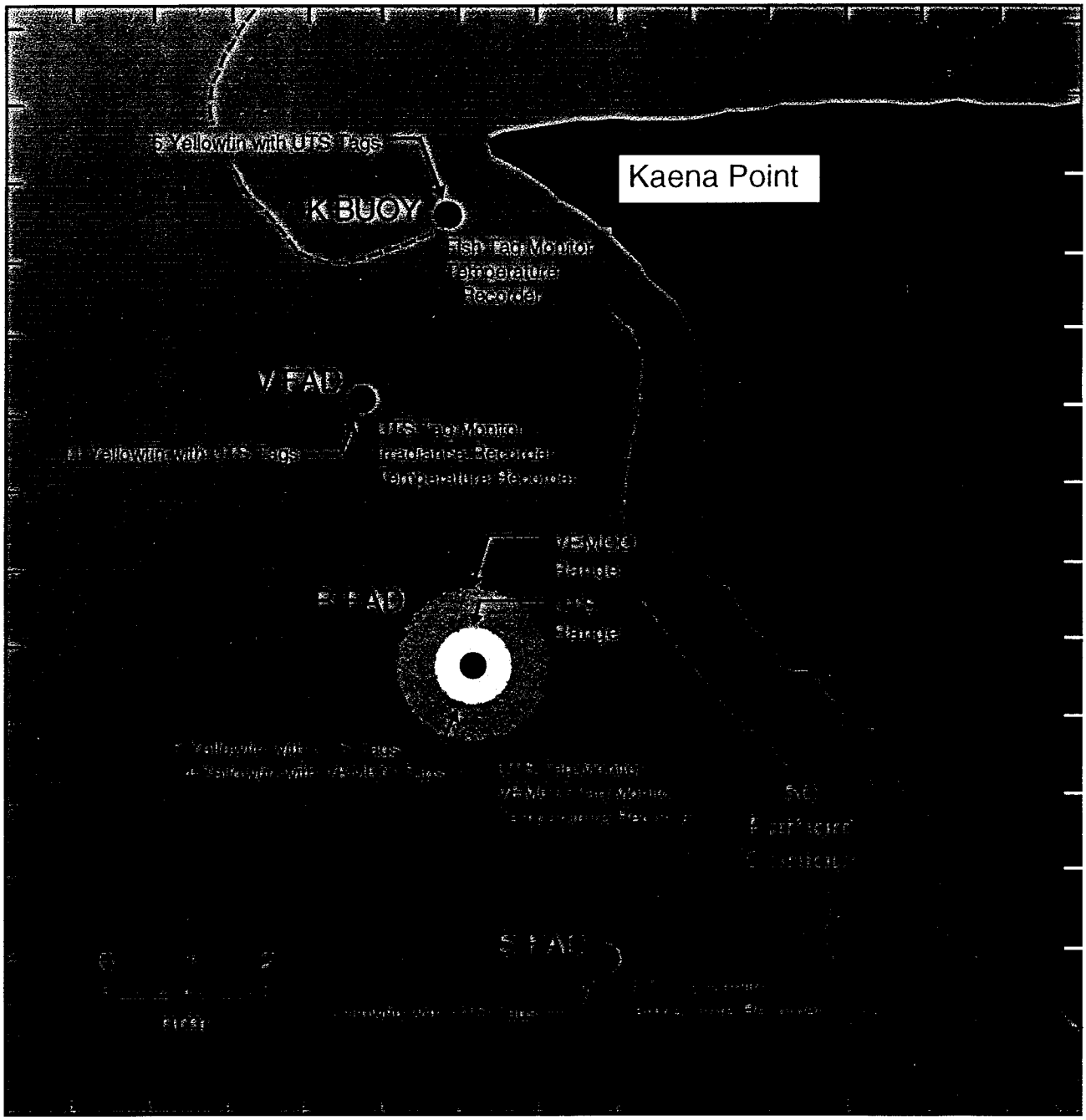

Fig. 1. Chart of Kaena Point showing the S, R, and V FAD and K buoy where UTS and VEMCO monitors were deployed and yellowfin tuna were tagged with coded ultrasonic transmitters.

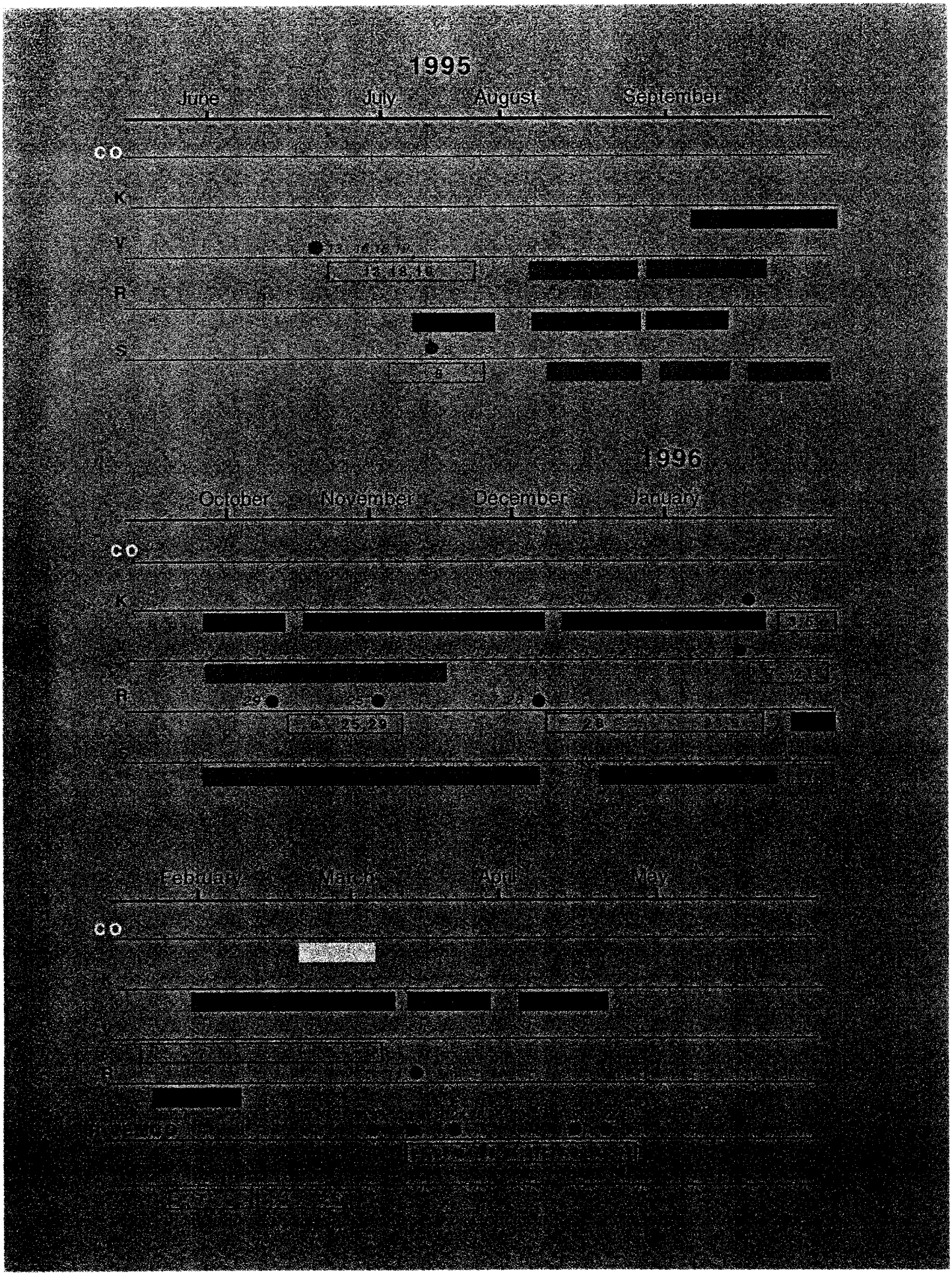

Fig. 2. Chronology of tagging and monitor deployment.

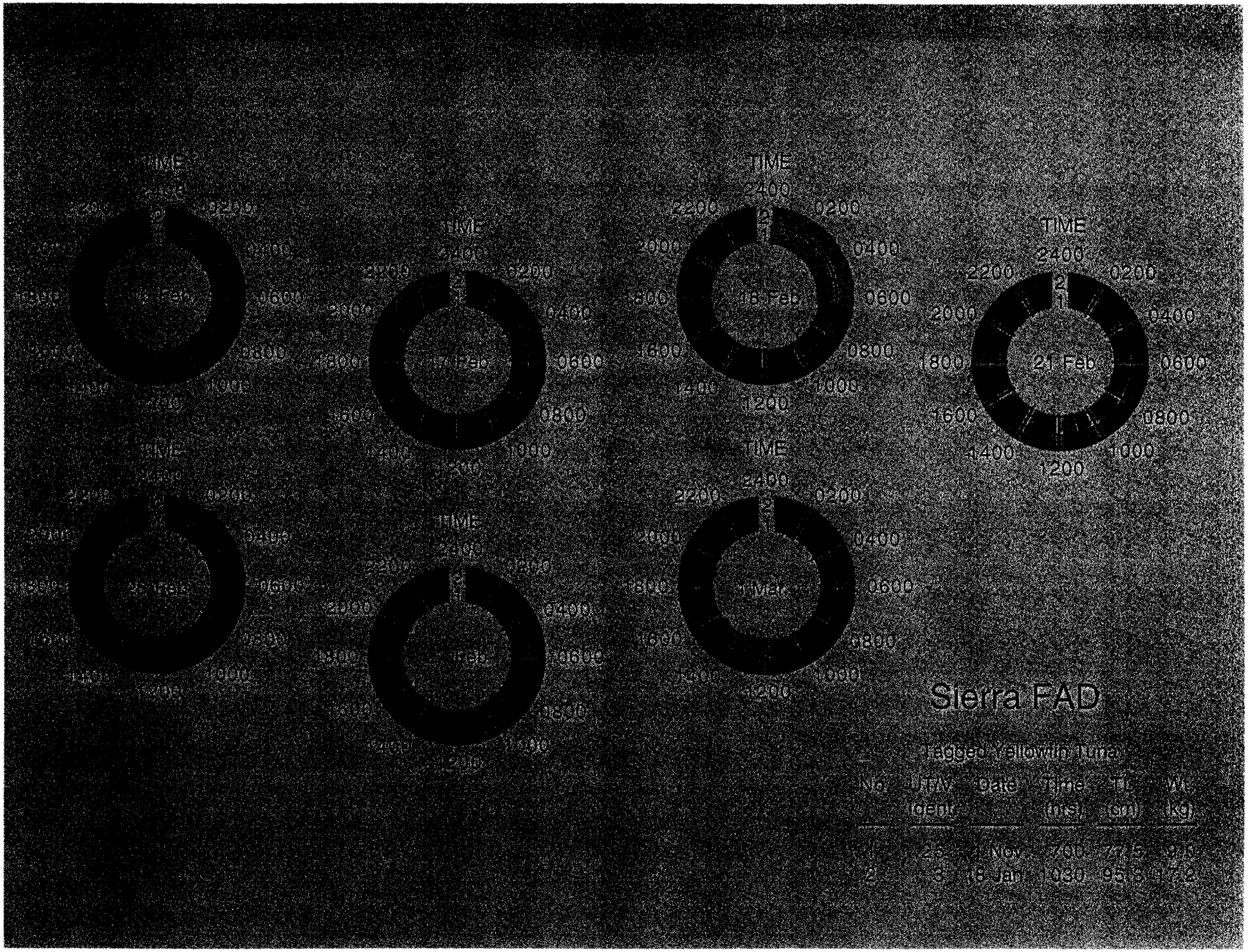

Fig. 3. Short-term attendance record of UTS monitor at S FAD of yellowfin tuna with coded ultrasonic tags.

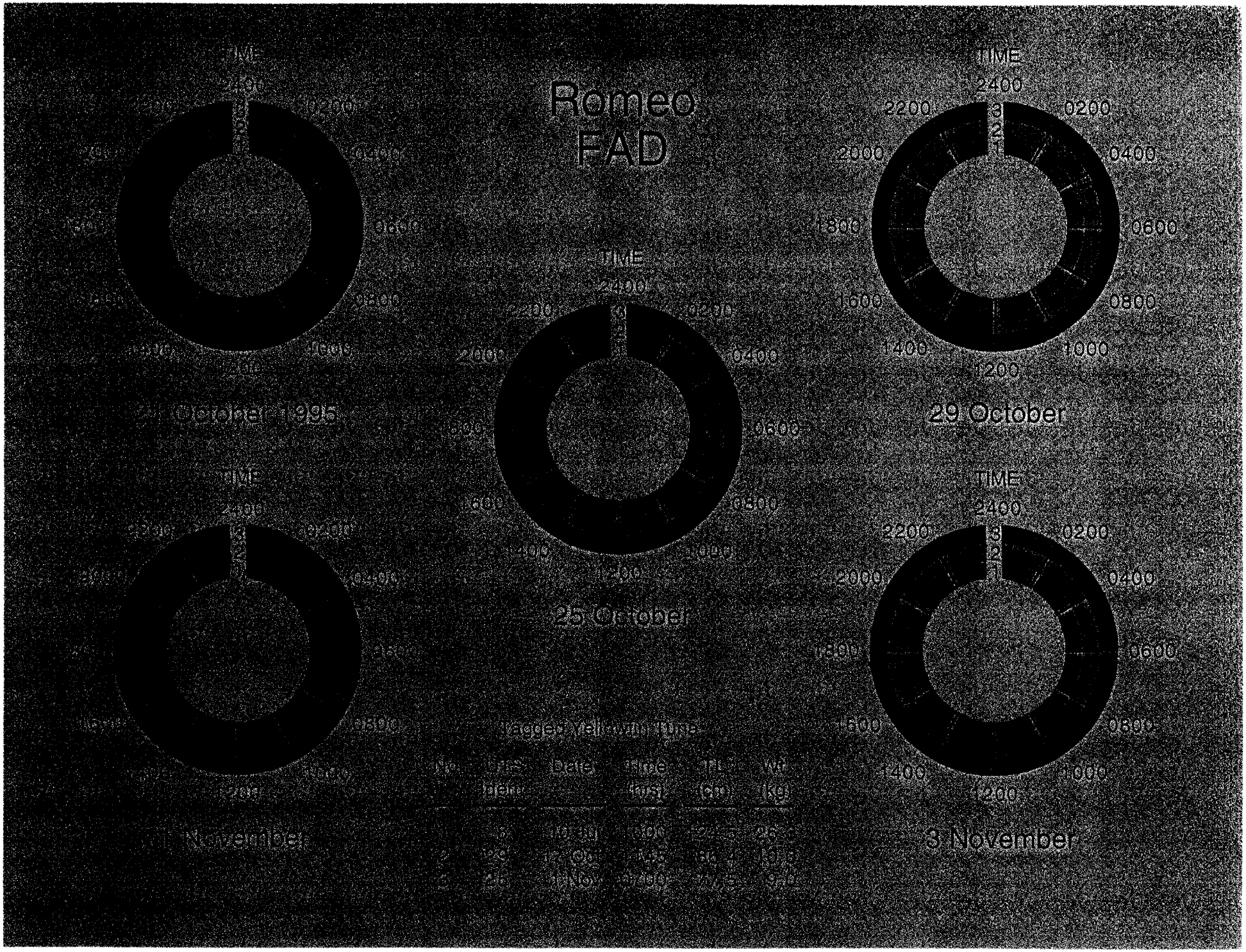

Fig. 4. Short-term attendance record of UTS monitor at R FAD of yellowfin tuna with coded ultrasonic tags.

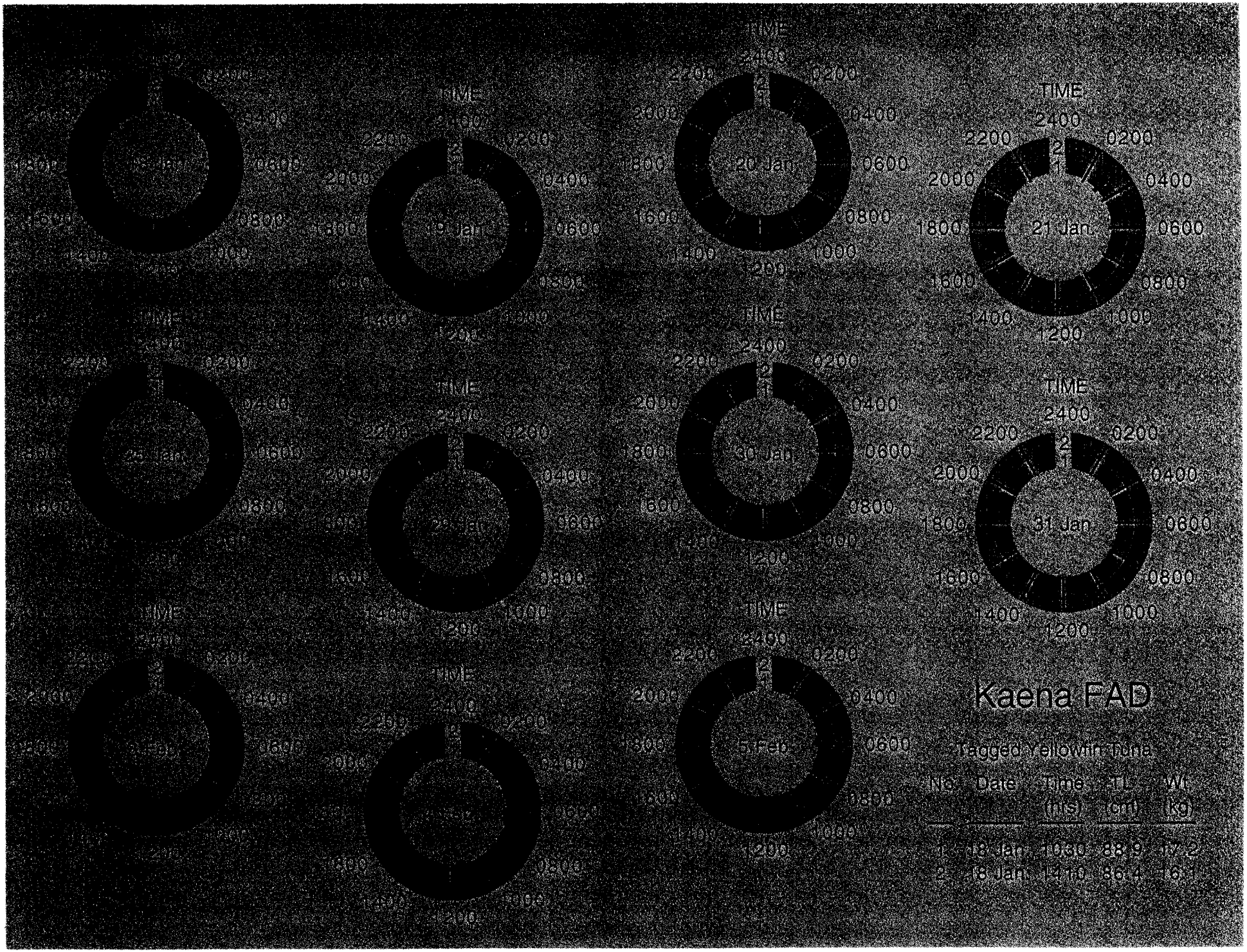

Fig. 5. Short-term attendance record of UTS monitor at subsurface K buoy of yellowfin tuna with coded ultrasonic tags.

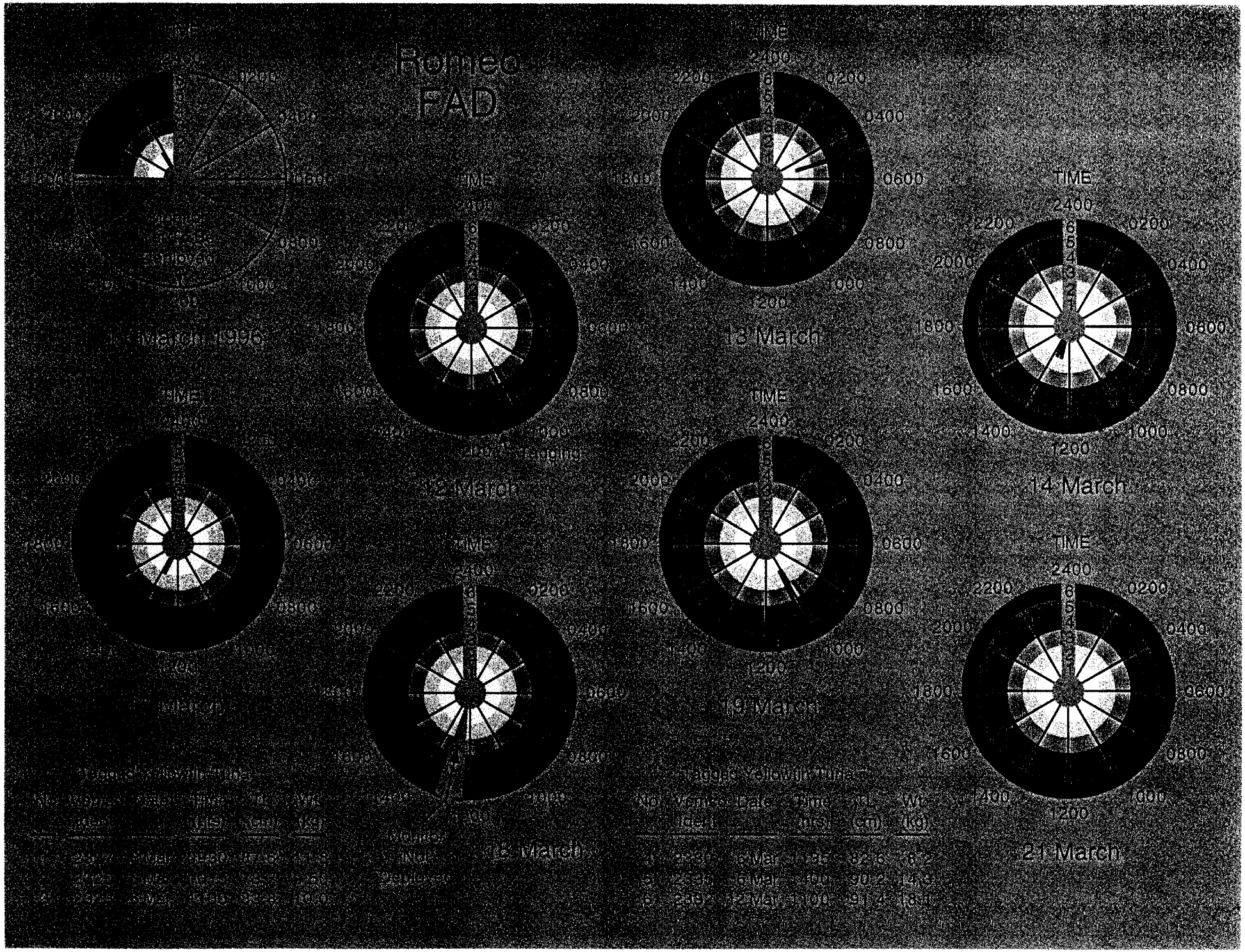

Fig. 6. Short-term attendance record of VEMCO monitor at R FAD of yellowfin tuna with coded ultrasonic tags.

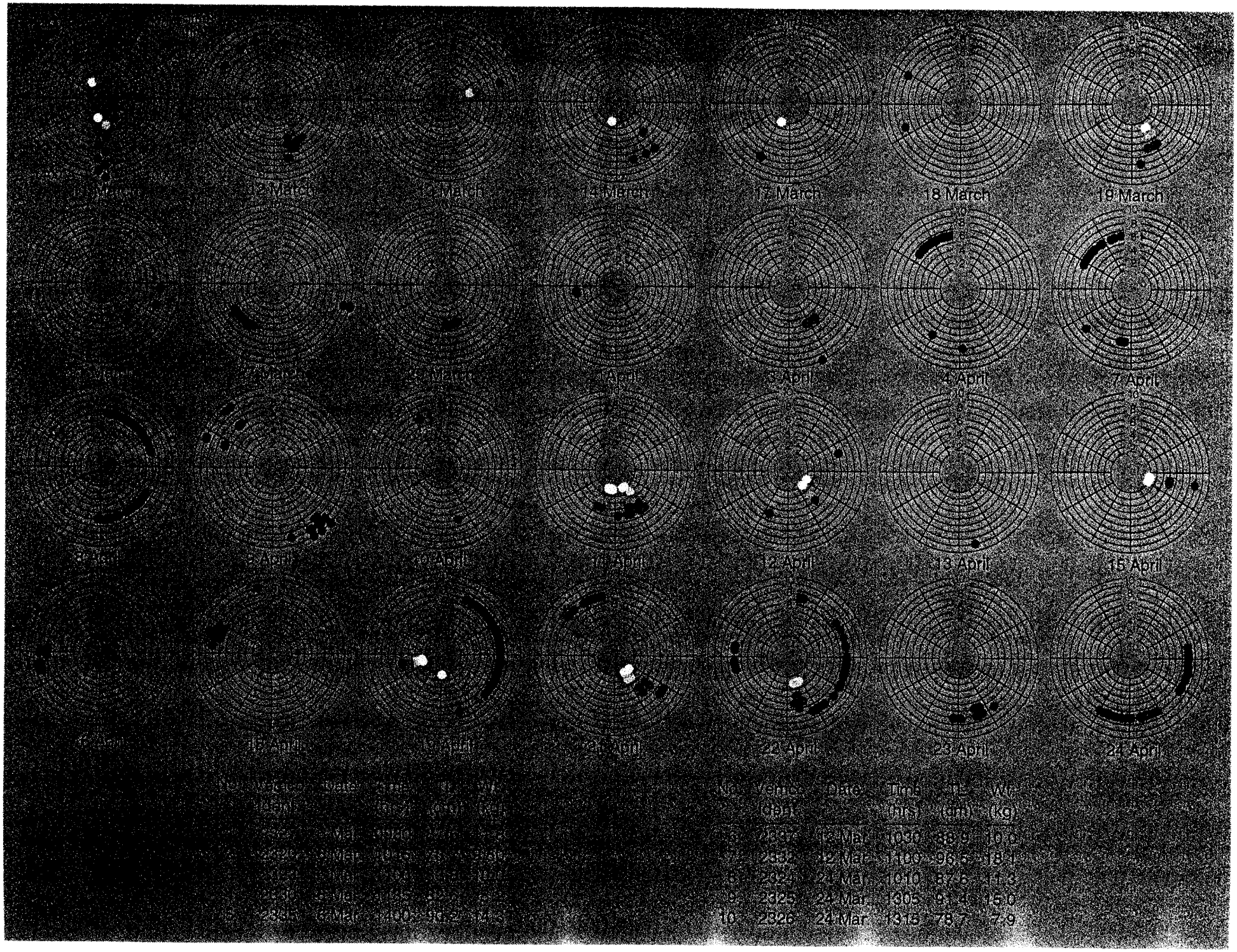

Fig. 7. Long-term attendance record of VEMCO monitor at R. FAD of yellowfin tuna with coded ultrasonic tags.

Table 1. Catch information for 31 yellowfin tuna tagged with Ultrasonic Telemetry Systems coded ultrasonic transmitters.

Tag #	Date (mm/dd/yy)	Time (hh:mm)	Total Length (inches)	Total Length (cm)	Fork Length (inches)	Fork Length (cm)	Weight (lbs)	Weight (Kg)	Longitude (deg min.dec)	Latitude (deg min.dec)	FAD (S,R,V,K)	Depth (feet)	Depth (meters)	Tag Retrieved?
1	12/10/95	1113	31.0	78.74	28.0	71.12	16.0	7.3			∞	5700	1738	
2	01/13/96	1011	33.0	83.82	31.0	78.74	22.5	10.2	158 18.480	21 32.620	V	1900	579	
3	01/18/96	820	37.5		35.0		38.0	17.3	158 17.049	21 33.146	K	920	281	
4	01/13/96	1032	34.0	86.36	31.5	80.01	20.0	9.1	158 18.501	21 32.438	V	1900	579	
5	01/18/96	1000	37.0	93.98	34.0	86.36	35.5	16.2	158 18.035	21 32.965	K	1040	317	
6	12/10/95	1108	35.0	88.90	32.0	81.28	26.0	11.8			∞	5700	1738	
7	12/05/95	1548	49.0	124.46	45.0	114.30	58.0	26.4	158 16.985	21 27.734	R	2500	762	
8	07/10/95	1000	34.0	86.36	28.5	72.39	25.0	11.4	158 14.830	21 33.050	S	2400	732	
9	01/13/96	915	34.0	86.36	31.0	78.74	20.0	9.1	158 18.493	21 32.601	V	1900	579	
10														
11	03/12/96	1100	38.0	96.52	34.5	87.63	40.0	18.2	158 16.988	21 27.751	R	2500	762	
12	03/29/96	1115	37.0	93.98	34.5	87.63	32.0	14.6	158 18.041	21 32.955	K	1040	317	
13	06/23/95	1037	31.0	78.74	29.5	74.93	18.0	8.2	158 18.490	21 32.830	V	1900	579	yes
13	01/13/96	1035	34.5	87.63	32.0	81.28	21.5	9.8	158 18.458	21 32.642	V	1900		
14	03/29/96	1120	34.0	86.36	32.0	81.28	21.5	9.8	158 18.048	21 32.916	K	1040	317	
15	03/29/96	1200	35.0	88.90	33.0	83.82	30.5	13.9	158 18.051	21 32.938	K	1040	317	
16	06/23/95	1030	28.0	71.12	26.0	66.04	15.0	6.8	158 18.490	21 32.830	V	1900	579	
17	12/10/95	1048	38.0	96.52	35.0	88.90	36.0	16.4			∞			
18	06/23/95	730	33.5	85.09	29.0	73.66	22.0	10.0	158 18.58	21 32.196	V	1900	579	
19	06/23/95	1035	23.0	58.42	21.5	54.61	10.0	4.6	158 18.490	21 32.830	V	1900	579	
20	12/10/95	1034	35.0	88.90	32.0	81.28	25.0	11.4			∞	5700	1738	
21	01/13/96	1118	35.0	88.90	32.5	82.55	21.5	9.8	158 18.287	21 32.745	V	1900	579	
22	12/10/95	1051	34.0	86.36	31.0	78.74	20.0	9.1			∞			yes
23	01/13/96	1115	33.5	85.09	31.0	78.74	19.0	8.6	158 18.329	21 32.569	V	1900	579	
24	12/10/95	900	35.0	88.90	32.5	82.55	28.0	12.7	158 27.060	21 33.160	∞	5700	1738	
25	11/01/95	700	30.5	77.47	29.0	73.66	20.0	9.1	158 14.920	21 27.490	R	2400	732	
26	12/10/95	1019	44.0	111.76	40.0	101.60	36.0	16.4			∞			
27	01/13/96	1015	32.5	82.55	30.0	76.20	16.0	7.3	158 18.501	21 32.580	V	1900	579	yes
28	12/05/95	1530	49.0	124.46	46.5	118.11	50.0	22.8	158 16.940	21 27.507	R	2400	732	
29	10/17/95	1145	34.0	86.36	30.5	77.47	22.0	10.0	158 14.914	21 27.831	R	2400	732	yes
30	12/10/95	953	32.0	81.28	30.0	76.20	18.0	8.2			∞	5700	1738	
31	12/10/95	942	32.0	81.28	30.0	76.20	19.0	8.6	158 27.100	21 33.210	∞	5700	1738	

Table II. Catch information for 14 yellowfin tuna tagged with VEMCO coded ultrasonic transmitters.

Tag #	Date (mm/dd/yy)	Time (hh:mm)	Total Length (inches)	Total Length (cm)	Fork Length (inches)	Fork Length (cm)	Weight (lbs)	Weight (Kg)	Longitude (deg min.dec)	Latitude (deg min.dec)	FAD (S,R,V,K)	Depth (feet)	Depth (meters)	Tag Retrieved?
2320	03/06/96	1015	29.0	73.7	33.0	83.8	21.0	9.6	158 16.913	21 27.507	R	2300	701	NO
2321	04/18/96	1410	32.0	81.3	30.0	76.2	20.0	9.1	158 16.754	21 27.520	R	2300	701	NO
2322	04/23/96	1645	35.0	88.9	32.0	81.3	30.0	13.7	158 16.926	21 27.577	R	2300	701	NO
2323	03/06/96	1100	33.0	83.8	29.5	74.9	22.0	10.0	158 16.911	21 27.501	R	2300	701	NO
2324	03/24/96	1010	34.5	87.6	28.5	72.4	25.0	11.4	158 16.893	21 27.489	R	2300	701	NO
2325	03/24/96	1505	36.0	91.4	30.0	76.2	33.0	15.0	158 16.902	21 27.511	R	2300	701	NO
2326	03/24/96	1315	31.0	78.7	28.0	71.1	17.5	8.0	158 16.910	21 27.508	R	2300	701	NO
2327	03/06/96	0930	34.5	87.6	31.0	78.7	26.0	11.8	158 16.920	21 27.517	R	2300	701	NO
2328	04/23/96	1655	32.0	81.3	29.5	74.9	21.0	9.6	158 16.836	21 27.562	R	2300	701	NO
2329														
2330	03/06/96	1135	32.5	82.6	30.0	76.2	18.0	8.2	158 16.921	21 27.501	R	2300	701	NO
2331														
2332	03/12/96	1100	38.0	96.5	34.5	87.6	40.0	18.2	158 16.901	21 27.497	R	2300	701	NO
2333														
2334														
2335	03/06/96	1400	35.5	90.2	33.0	83.8	31.5	14.3	158 16.917	21 27.526	R	2300	701	NO
2336														
2337	03/12/96	1030	35.0	88.9	32.0	81.3	22.0	10.0	158 16.909	21 27.500	R	2300	701	NO
2338	04/18/96	1730	38.5	97.8	37.5	95.3	34.0	15.5	158 16.788	21 27.600	R	2300	701	NO
2339														