

**FINE-SCALE BEHAVIOR OF BIGEYE, SKIPJACK, AND YELLOWFIN
TUNAS WITHIN MIXED-SPECIES AGGREGATIONS ASSOCIATED WITH
DRIFTING FISH-AGGREGATING DEVICES IN THE EQUATORIAL
EASTERN PACIFIC OCEAN**



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Inter-American Tropical Tuna Commission**



YOLANDA L

CAPTAIN RICARDO DIAZ



Length: 66.46 m

Width: 12.20 m

Draft: 8.32 m

Well Volume: 1, 168 m³

Capacity (t): 1041

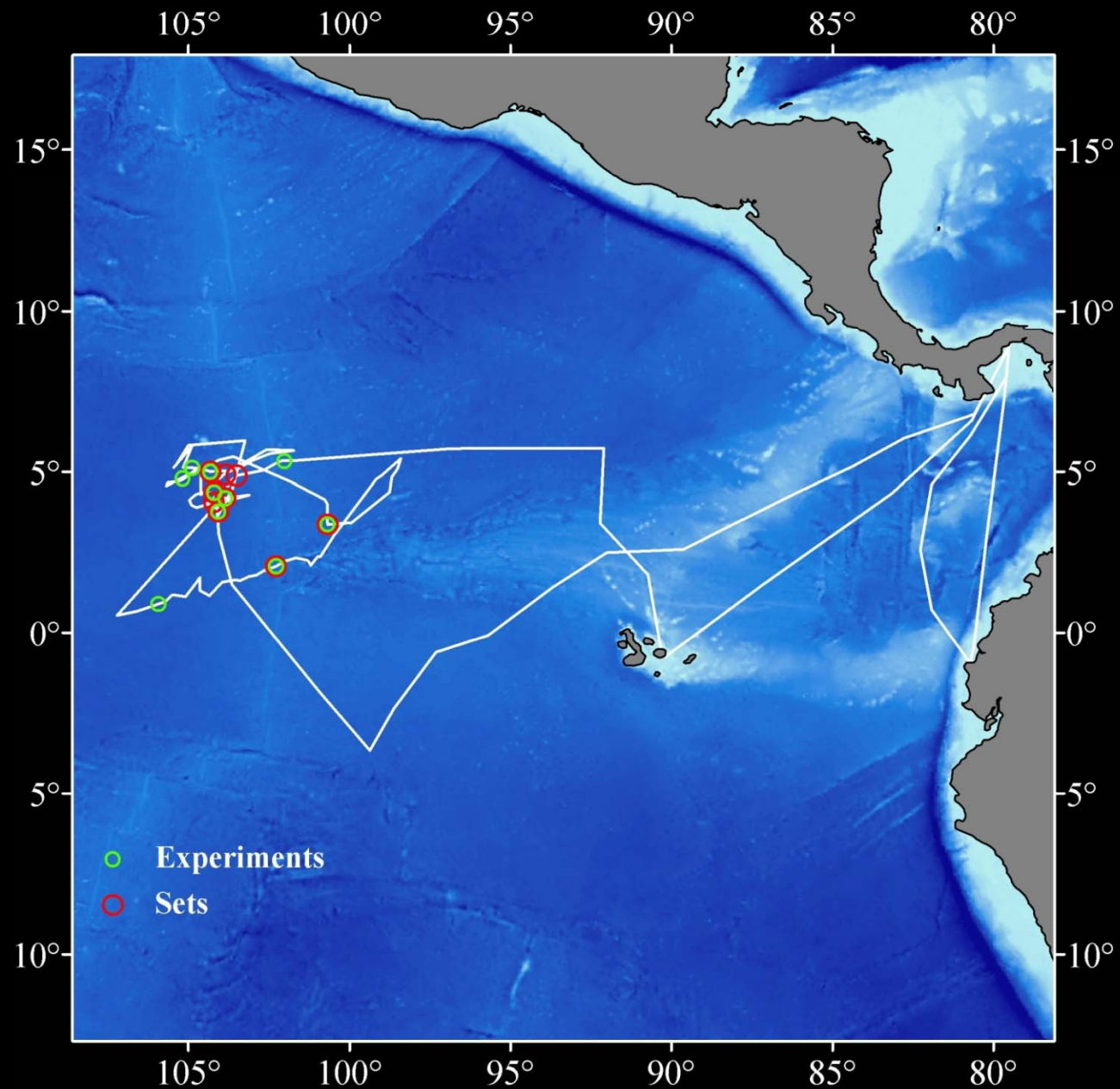
HP: 3, 600

Cruise Speed: 12 Knots

Drifting FAD with Zunibal Satellite Buoy



Cruise Track, Locations of Experiments, and Sets During the ISSF/IATTC Research Cruise (Duration = 73 d)



ISSF AND IATTC 2011 EPO PURSE-SEINE RESEARCH CRUISE

OVERALL OBJECTIVE:

INVESTIGATE POTENTIAL SOLUTIONS FOR REDUCING FISHING MORTALITY ON UNDESIRABLE SIZES OF BIGEYE AND YELLOWFIN TUNAS, AND SHARKS, IN FISHING OPERATIONS BY PURSE-SEINE VESSELS SETTING ON TUNA AGGREGATIONS ASSOCIATED WITH DRIFTING FISH-AGGREGATING DEVICES (FADS)

EXPERIMENTS WERE DESIGNED AND UNDERTAKEN TO FOCUS ON THE KEY QUESTION:

ARE THERE WAYS TO MODIFY PURSE-SEINE FISHING METHODS TO REDUCE THE CATCHES OF THOSE SPECIES OF CONCERN, ASSOCIATED WITH DRIFTING FADS, WHILE OPTIMIZING CATCHES OF SKIPJACK TUNA?

BEHAVIOR OF TUNAS ASSOCIATED WITH FADS

Objective: To elucidate spatial and temporal differences in the simultaneous behavior of skipjack, bigeye, and yellowfin tunas within mixed species aggregations associated with drifting FADs, in order to reveal potential opportunities for avoiding the capture in purse-seine sets of small bigeye and yellowfin, and other species of concern, while optimizing the capture of skipjack

BEHAVIOR OF TUNAS ASSOCIATED WITH FADS

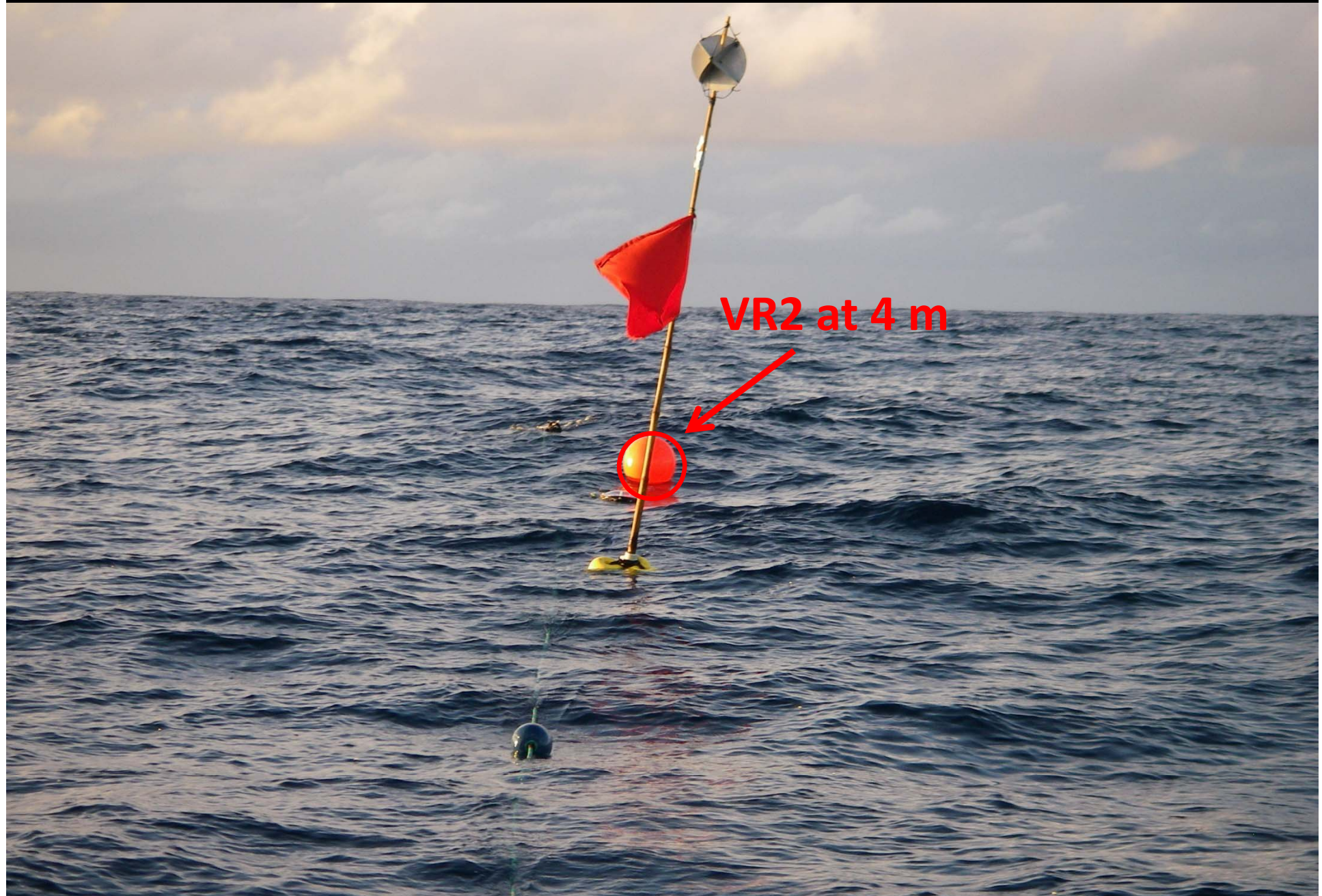
Materials and Methods:

- Workboat with GPS
- Panasonic Toughbook (TB31) portable computers
- Simrad ES 70 echo-sounder aboard workboat
- Vemco VR28 acoustic tracking system aboard workboat
- Vemco VR2W acoustic receivers attached to FADs
- Vemco V13 1HP-A69-9002 coded transmitters
- Vemco V13 1HP continuous transmitters
- Furuno CSH 5 (50-60 kHz) sonar aboard purse-seine vessel
- Conduct simultaneous ultrasonic telemetry experiments with SKJ, BET, and YFT at ten drifting FADs
- Implant 3 coded acoustic tags each in SKJ, BET, and YFT and continuous acoustic tags in 3 additional SKJ. Experiments conducted for ≥ 48 h.
- Should a mono-specific skipjack school be observed, while active tracking, to move ≥ 1 nm away from a FAD the purse-seine vessel would target that school for capture

Workboat



FAD with VR2 and Radar Reflector Attached



FAD with VR2 and Radar Reflector Attached, *YOLANDA L.* Nearby



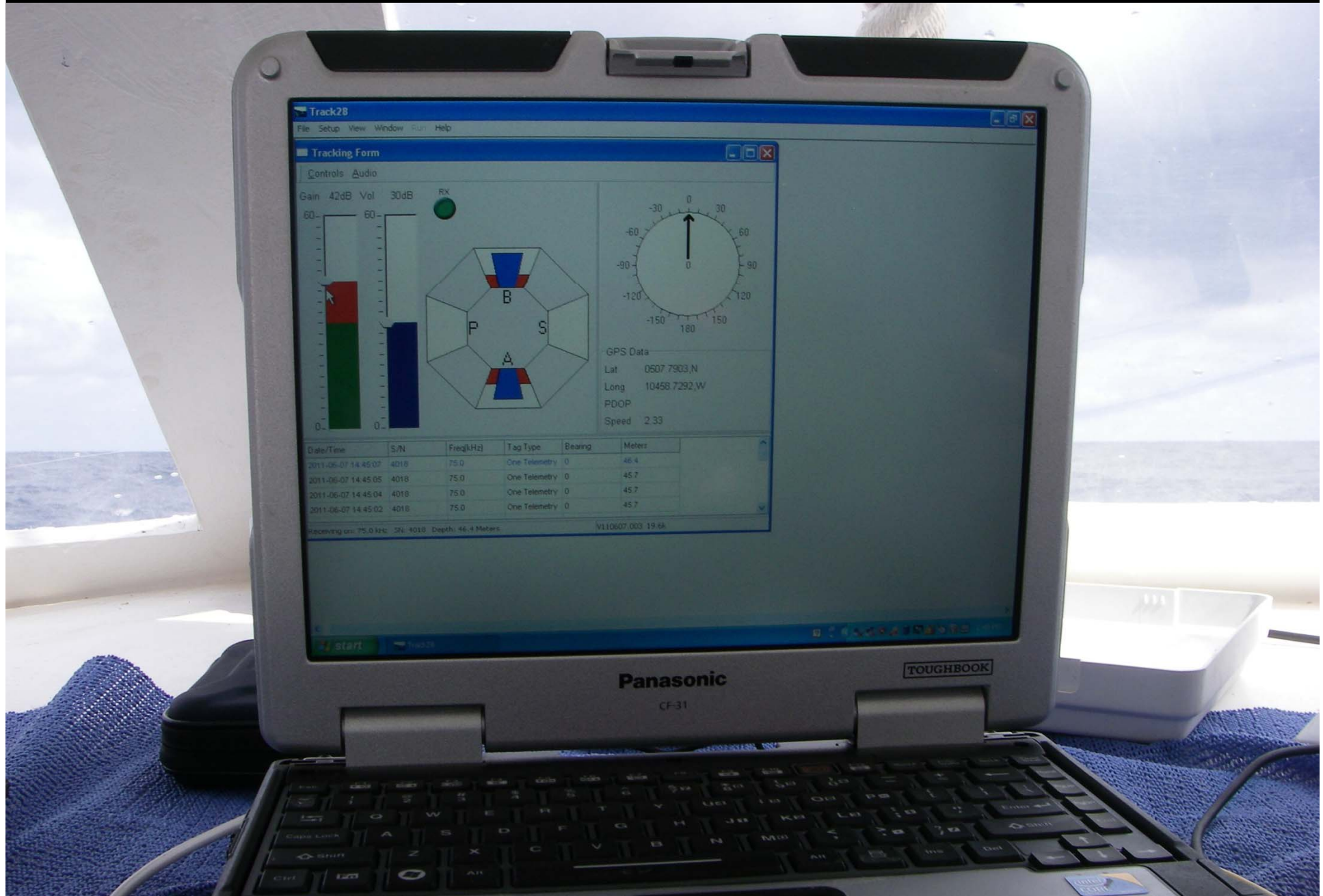
Vemco VR-2W Hydrophone and V-13P Ultrasonic Transmitter



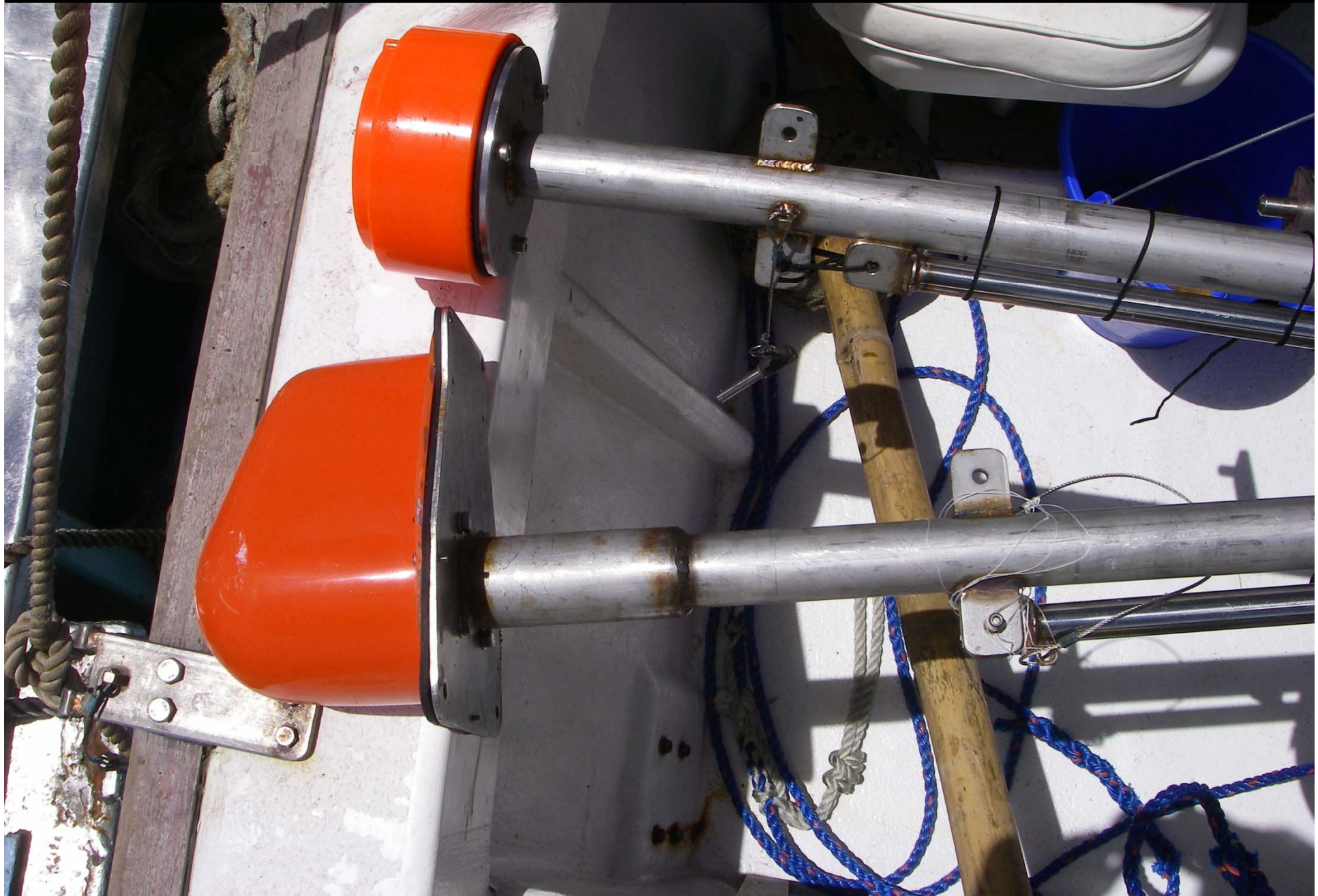
Vemco VR-28 Receiver



Track 28 Software Showing the Direction of the Tagged Skipjack



Vemco V – 40 Hydrophone and Simrad ES-70 120 KHz Transducer



Fishing Operations on Board the Workboat



SKIPJACK



BIGEYE



BIGEYE Surgery



BIGEYE Tagged with a V-13P Ultrasonic Transmitter



Summary of the 10 Ultrasonic Telemetry Experiments and Associated Catches

Experiment	Date	Duration (h)	Location			Catch (mt)			
			Latitude	Longitude	Depth (20° C)	SKJ	BET	YFT	Total
1	5/25/2011	32.5	3°53 N	104°06 W	78.5	50.9	6.3	14.2	71.5
2	5/28/2011	65.4	4°19 N	104°43 W	79.1	55.1	5.9	13.4	74.5
3	6/1/2011	71.1	3°58 N	104°16 W	76.5	115.1	13.8	18.0	146.9
4	6/7/2011	46.4	5°07 N	105°18 W	90.1	14.5	11.7	12.8	39.0
5	6/10/2011	95.1	5°22 N	102°59 W	85.6	NA	NA	NA	NA
6	6/16/2011	93.8	5°04 N	104°45 W	84.4	NA	NA	NA	NA
7	6/21/2011	44.5	4°08 N	100°46 W	87.1	166.9	6.6	8.9	182.4
8	6/27/2011	70.4	2°13 N	102°02 W	64.5	110.9	2.0	29.9	142.8
9	7/5/2011	70.4	0°40 N	106°35 W	NA	NA	NA	NA	NA
10	7/11/2011	29.0	5°21 N	101°45 W	NA	NA	NA	NA	NA

Numbers of Tunas, by Species, Released and Recaptured with Acoustic Tags

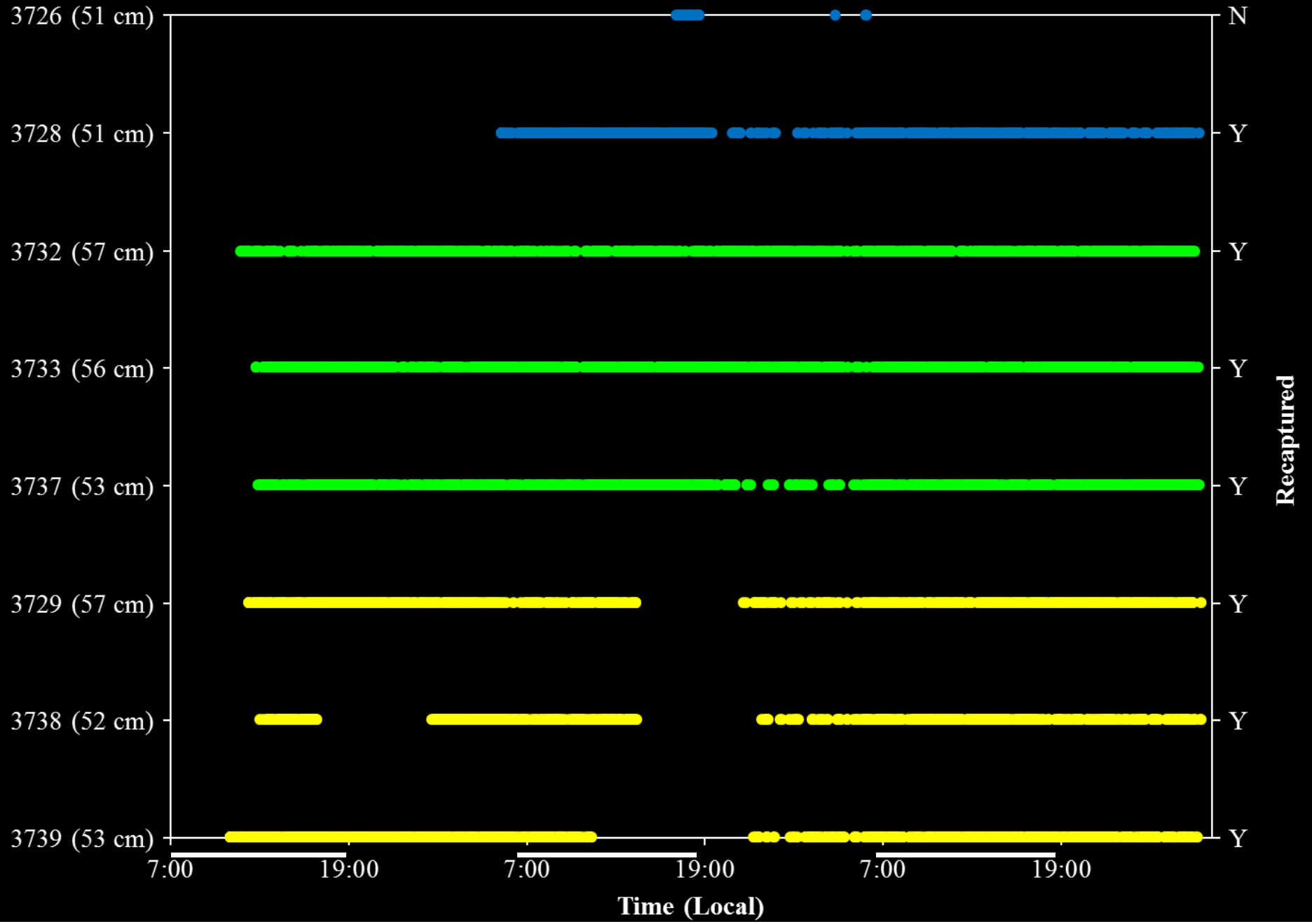
Experiment	SKJ			BET		YFT	
	Coded	FL (cm)	Continuous	Coded	FL (cm)	Coded	FL (cm)
1	0 (0)	50 – 58	2 (0)	3 (1)	53 – 59	3 (2)	60 – 66
2	2 (1)	51	0 (0)	3 (3)	53 – 57	3 (3)	52 – 57
3	4 (2)	47 – 53	2 (0)	3 (3)	64 – 67	3 (2)	57 – 65
4	1 (0)	47 – 49	2* (0)	3 (3)	59 – 72	3 (2)	52 – 60
5	2	49 – 51	2*	3	53 – 56	3	55 – 59
6	3	41 – 57	2*	1	92	3	52 – 57
7	2 (1)	42 – 51	2 (0)	0	0	4 (2)	41 – 51
8	1 (1)	52 – 65	2* (1)	3 (1)	57 – 63	3 (1)	55 – 62
9	2	50 - 54	0	6	47 – 62	6	45 – 62
10	1	44	0	1	55	2	39 – 42
Totals Released	18	41 - 65	14*	26	47 - 92	33	39 - 66
Percent Recaptured	50.0			73.3		63.2	

* = Skipjack received both coded and continuous tags

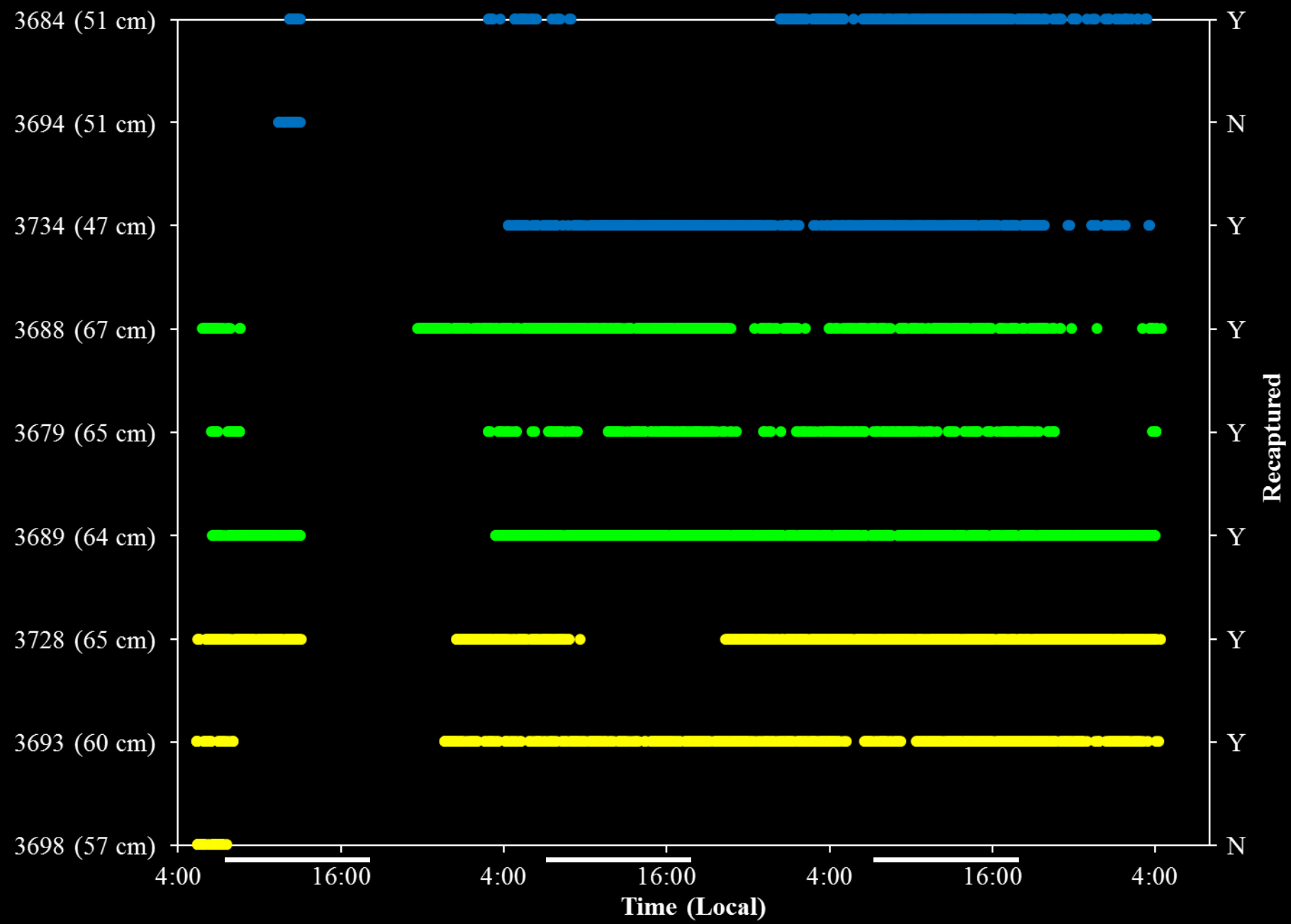
Detection Range for V13P Transmitters

Receiver	Predicted Range (m)	Observed Range (m)	% Difference
VR 28	1163	460 - 686	87 - 52
VR 2W	686	480?	70

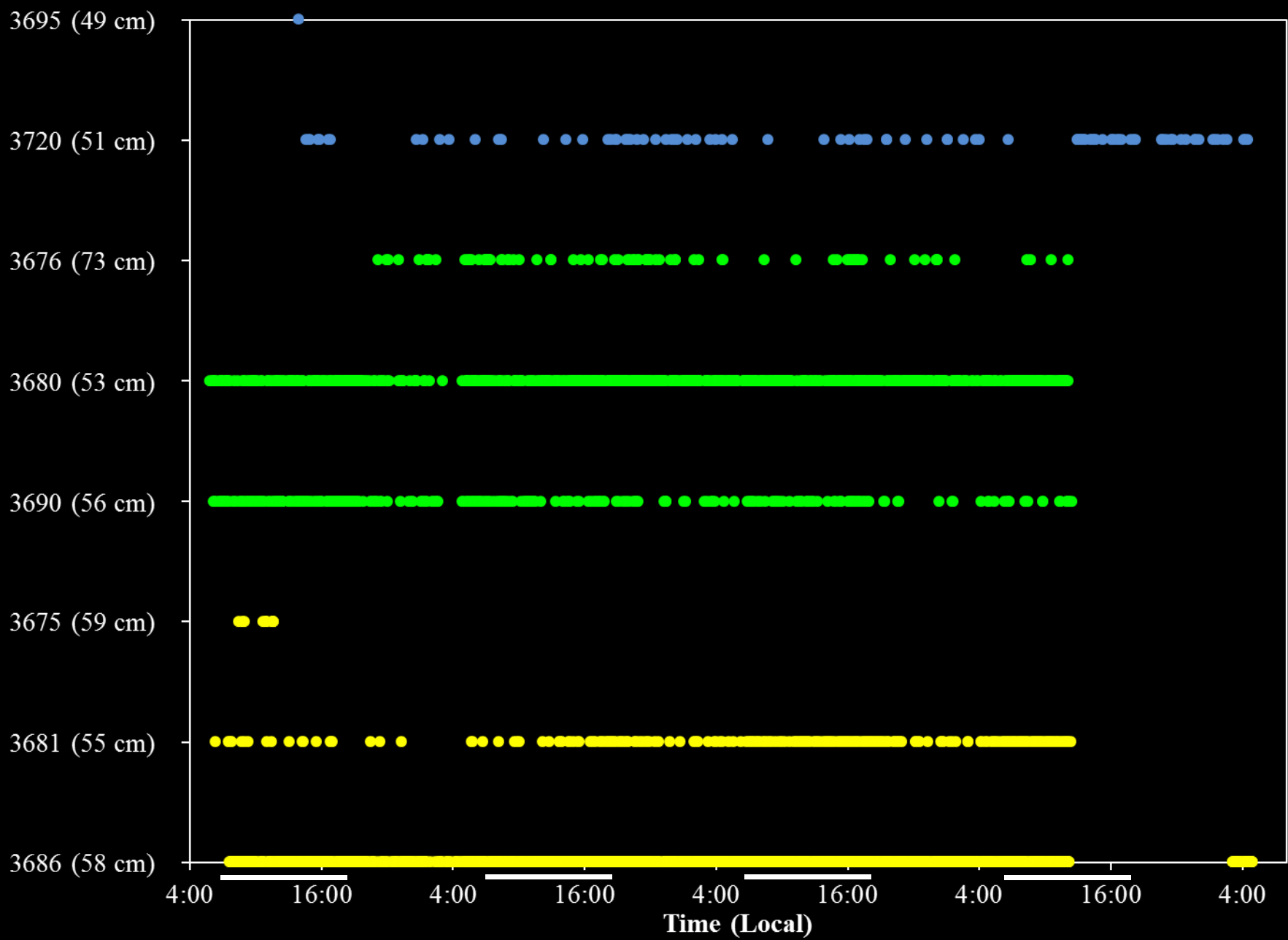
VR2 Detections for Skipjack, Bigeye, and Yellowfin During Experiment 2



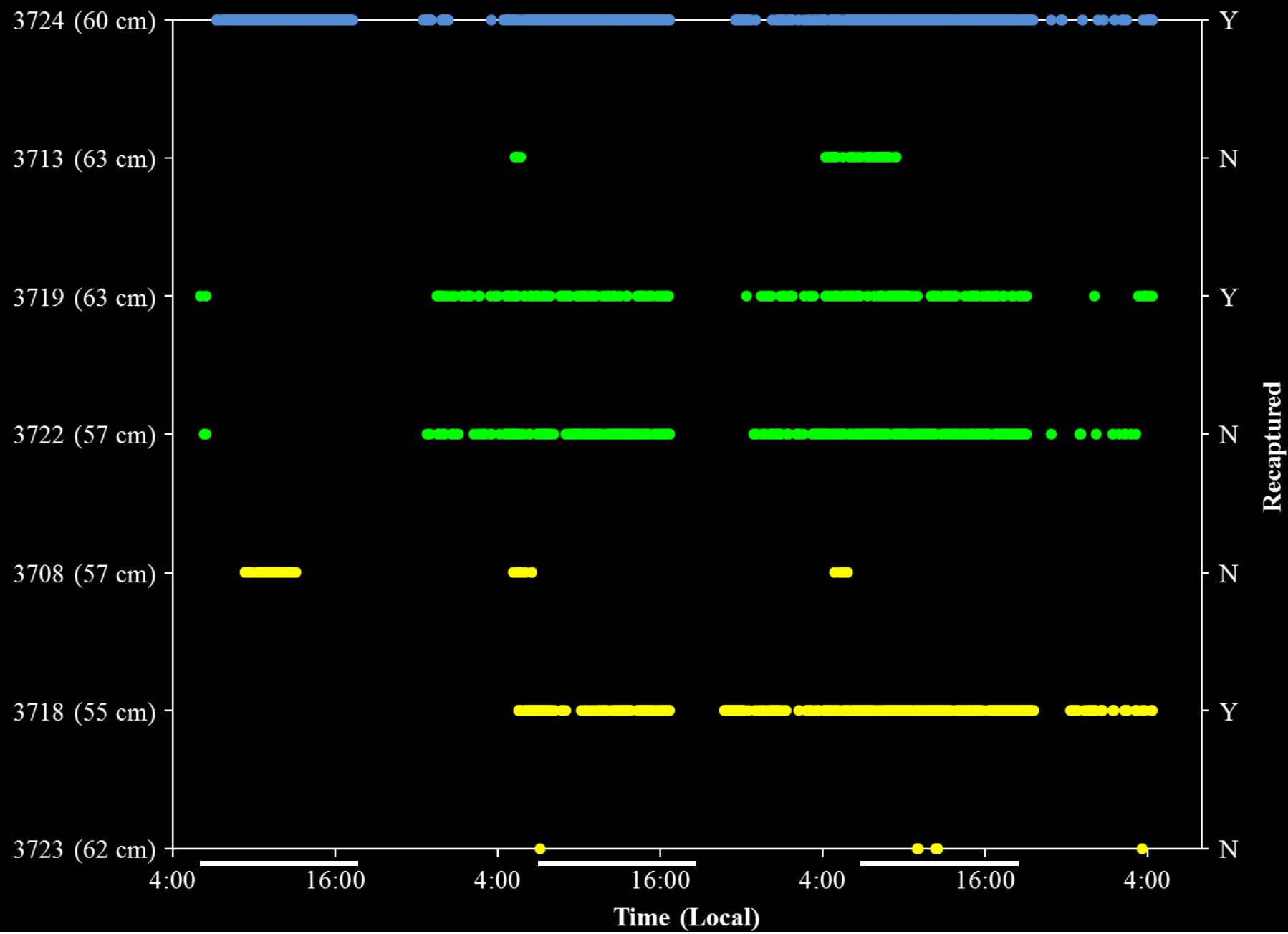
VR2 Detections for Skipjack, Bigeye, and Yellowfin During Experiment 3



VR2 Detections for Skipjack, Bigeye, and Yellowfin During Experiment 5



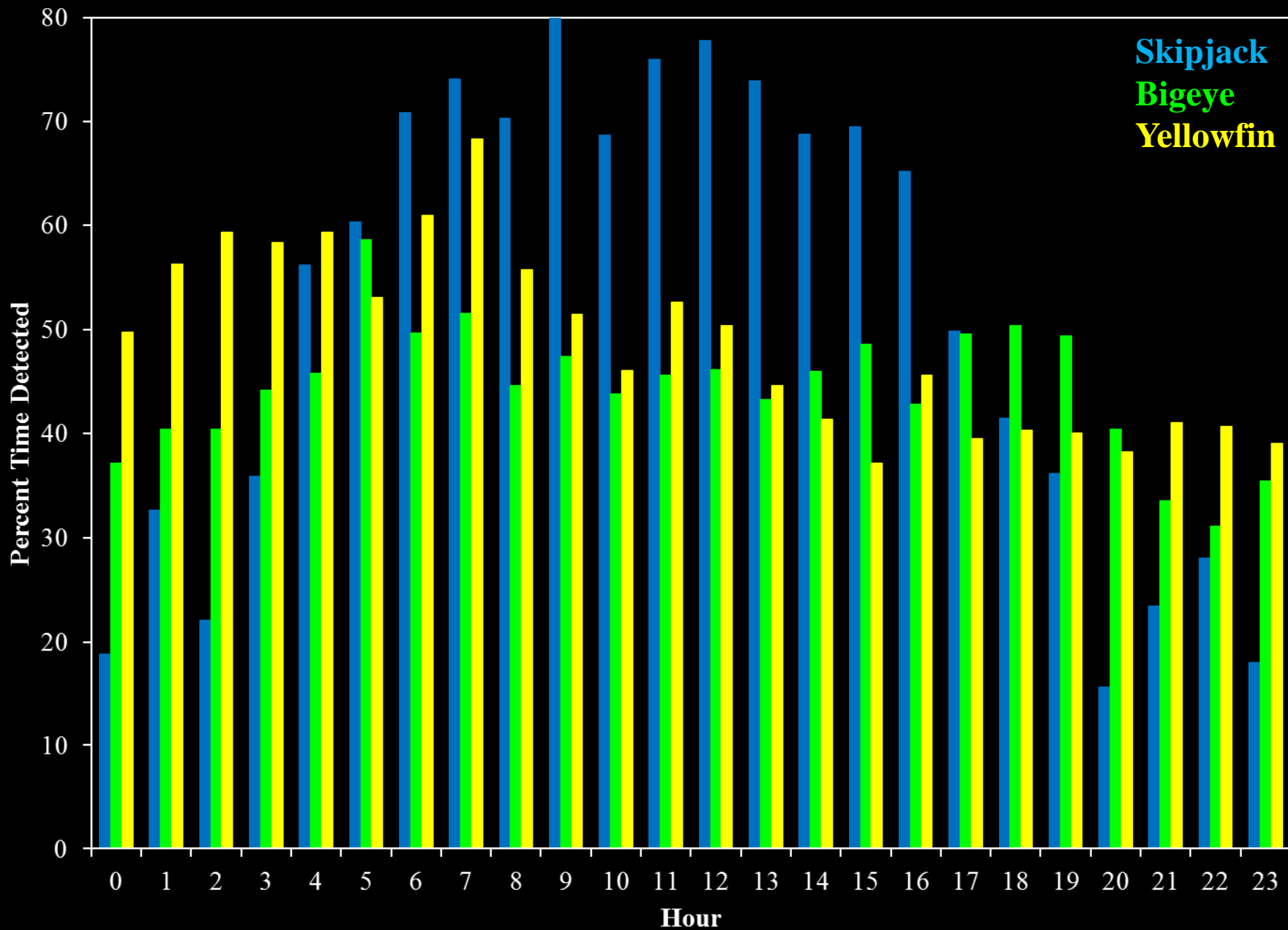
VR2 Detections for Skipjack, Bigeye, and Yellowfin During Experiment 8



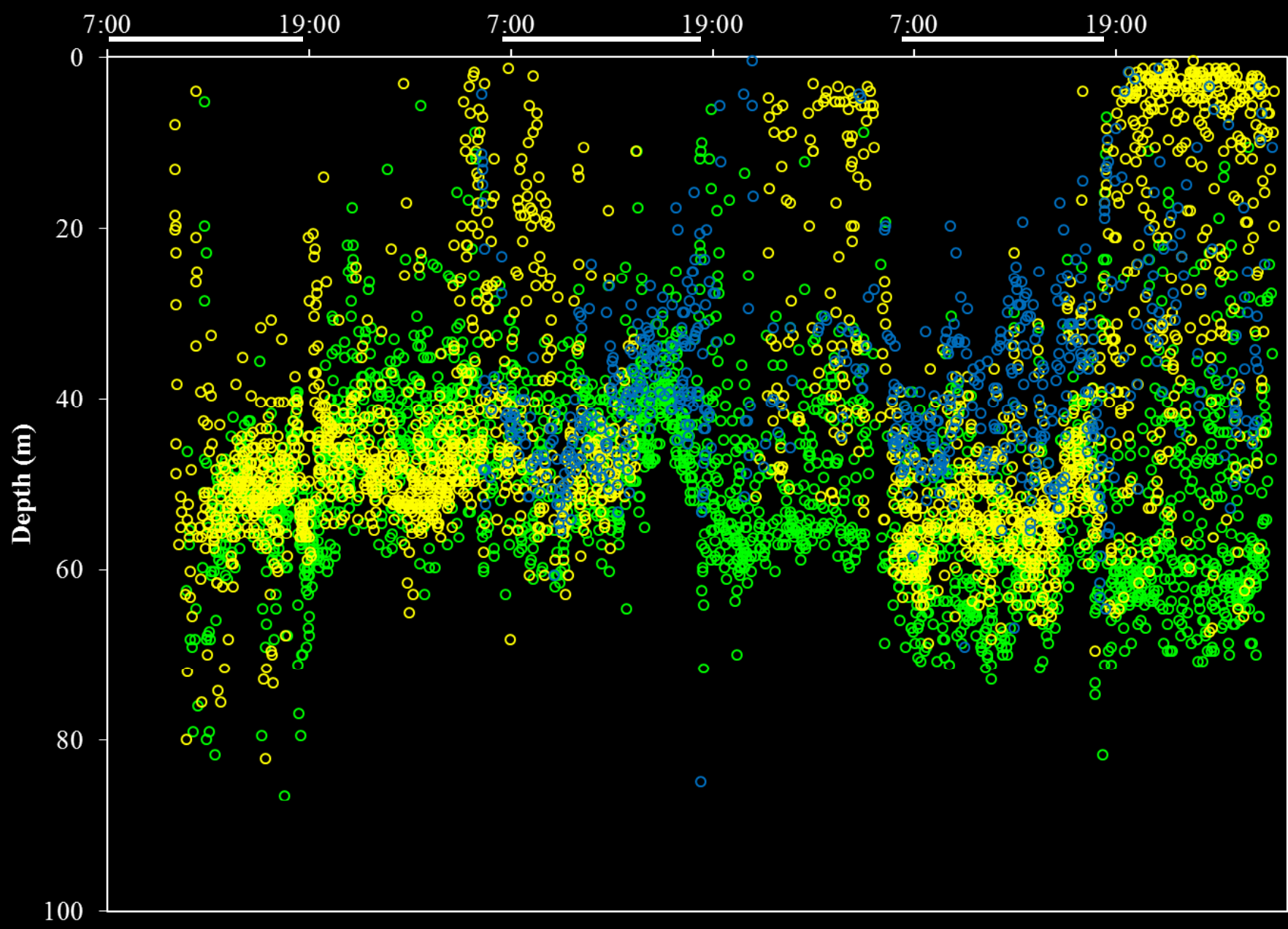
Percent Time Detected by Day and Night, For Recaptured Tunas

Species	Day (%)	Night (%)
Skipjack	67.9	29.7
Bigeye	42.3	36.8
Yellowfin	42.4	46.7

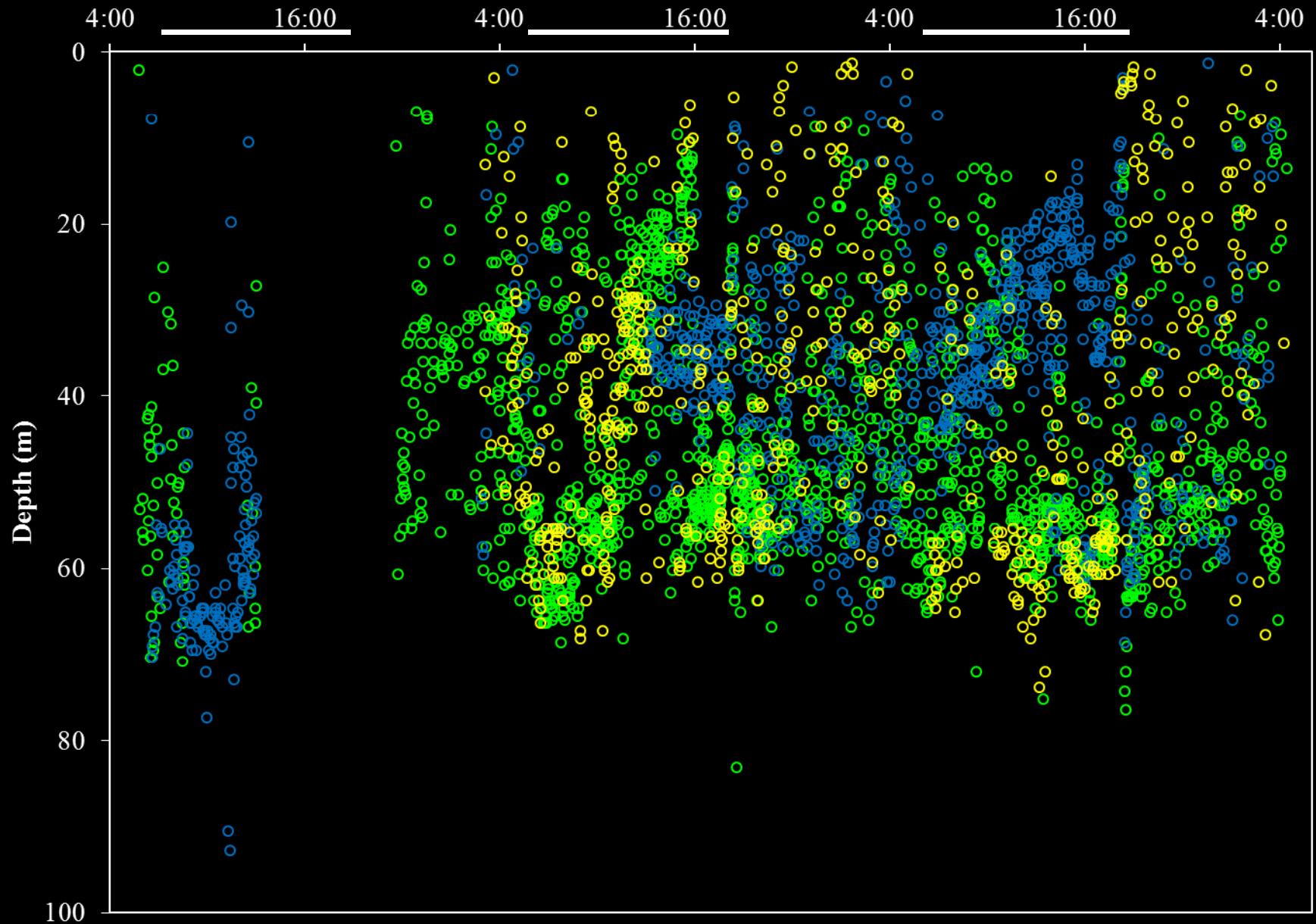
Percent Time Detected, by Hour, for Recaptured Tunas



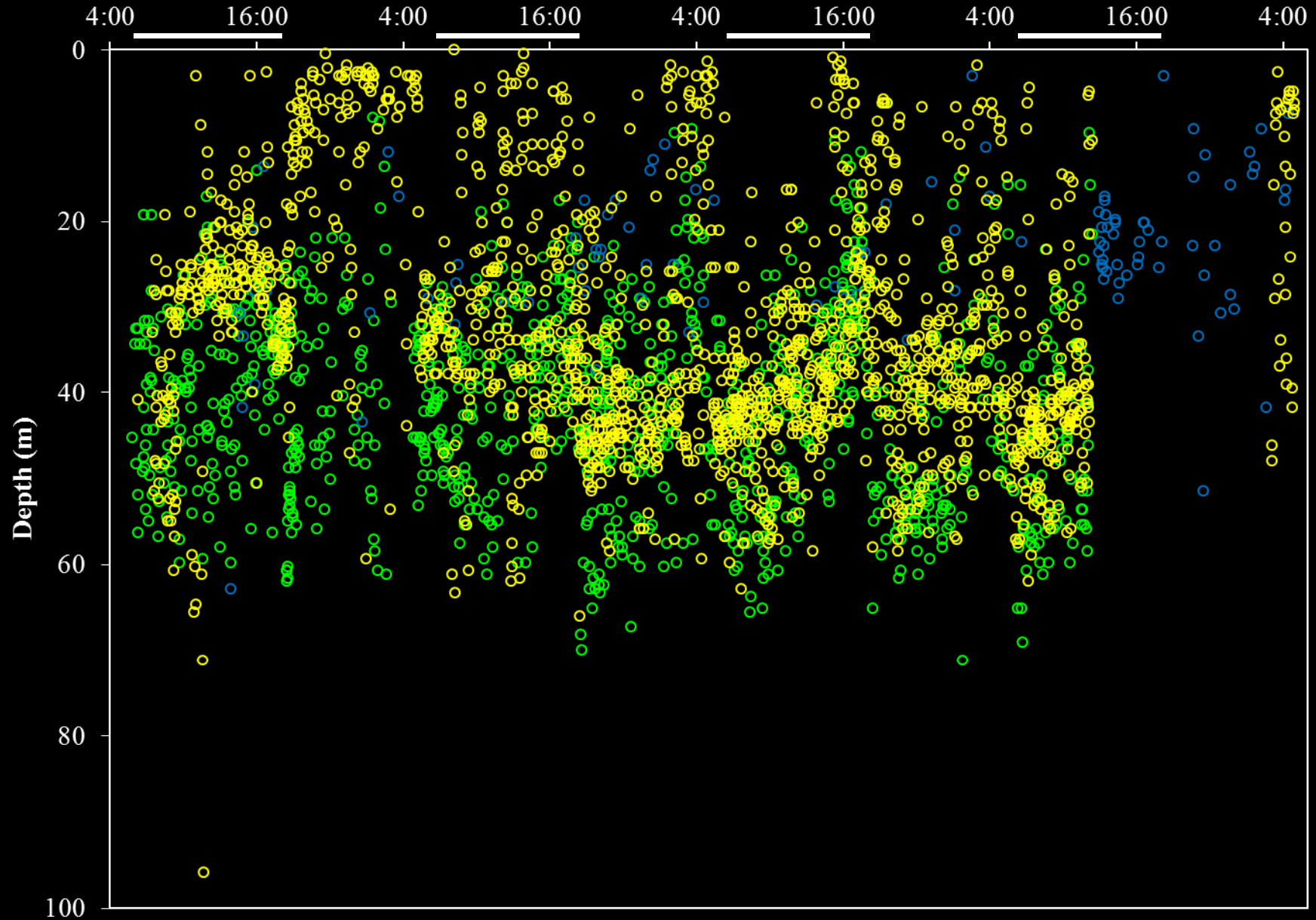
Depth Records from VR2 for Skipjack, Bigeye, and Yellowfin During Experiment 2



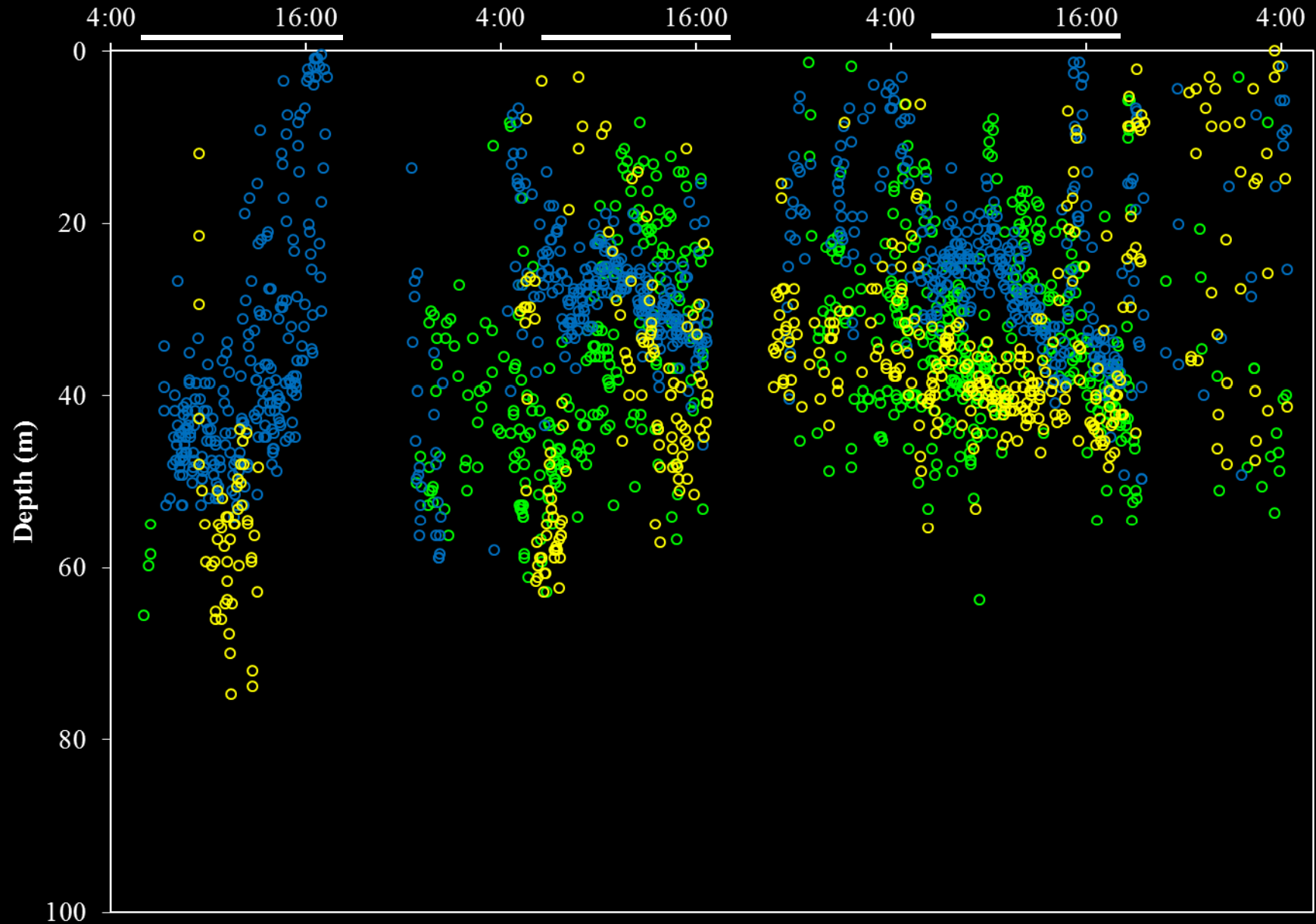
Depth Records from VR2 for Skipjack, Bigeye, and Yellowfin during Experiment 3



Depth Records from VR2 for Skipjack, Bigeye, and Yellowfin during Experiment 5



Depth Records from VR2 for Skipjack, Bigeye, and Yellowfin during Experiment 8



Mean Depths (m) by Species and Day and Night

Experiment	Skipjack			Bigeye			Yellowfin		
	<i>n</i>	Day Mean	Night Mean	<i>n</i>	Day Mean	Night Mean	<i>n</i>	Day Mean	Night Mean
1	NA	NA	NA	3	42.2	23.3	3	48.7	47.8
2	2	39.9	30.1	3	50.6	48.8	3	47.9	32.4
3	5	53.7	40.0	3	47.2	44.1	3	48.3	35.7
4	3	51.2	53.1	3	43.1	42.0	3	44.0	32.8
5	3	30.4	27.7	3	40.6	42.3	3	33.9	30.8
6	3	33.3	32.5	NA	NA	NA	3	31.7	20.9
7	3	52.7	24.2	NA	NA	NA	4	57.1	36.5
8	2	29.4	29.3	3	34.4	34.6	3	40.6	27.3
9	2	24.1	12.1	5	27.7	18.3	5	21.1	10.1
10	1	55.3	48.1	1	55.6	53.2	2	60.6	34.8
Combined	24	37.4	30.9	24	42.0	40.0	32	37.7	27.7

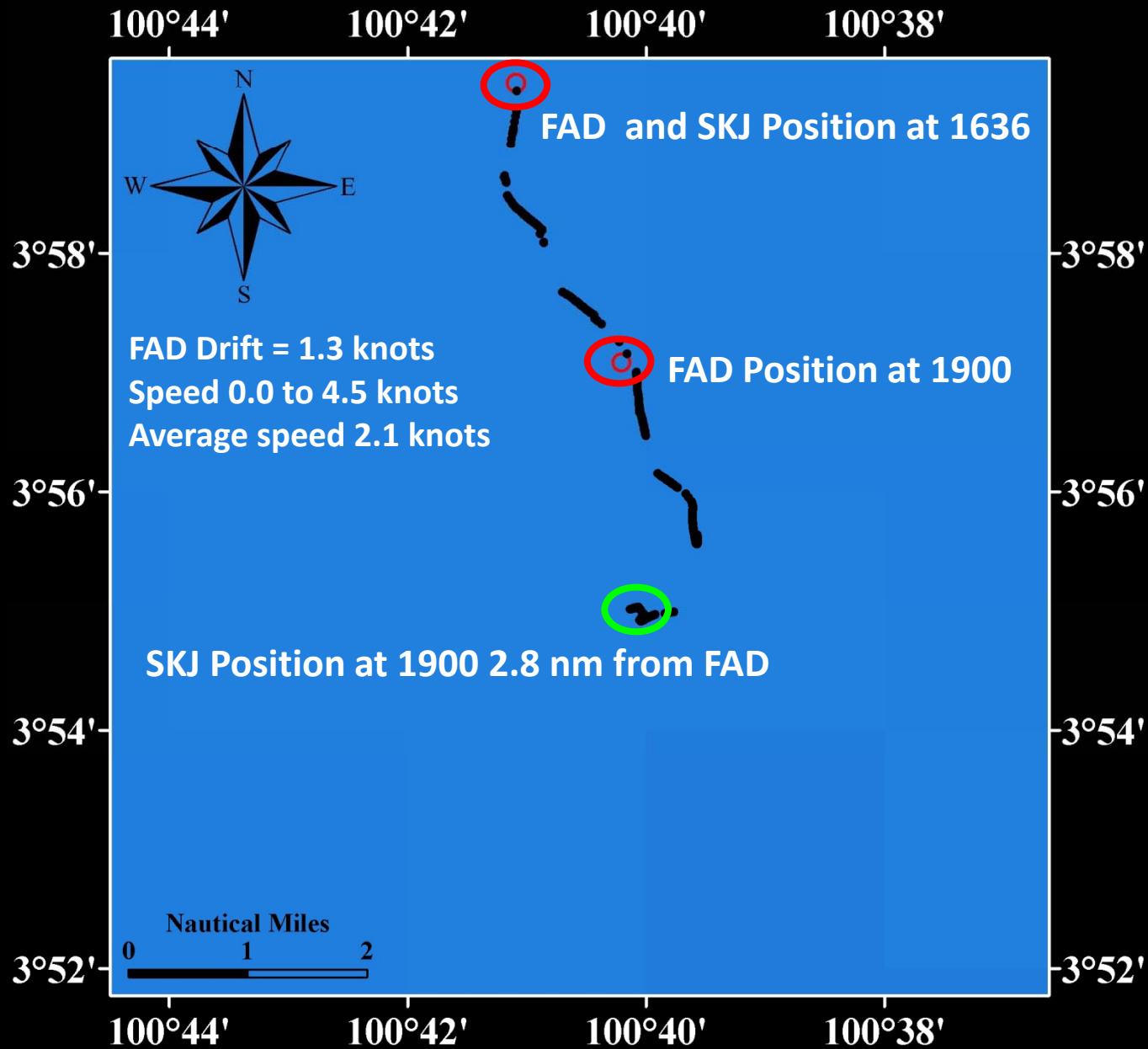
ANOVA's Between Day and Night Depths by Species

Experiment	Skipjack		Bigeye		Yellowfin	
	<i>F</i>	<i>P</i>	<i>F</i>	<i>P</i>	<i>F</i>	<i>P</i>
1	NA	NA	95.1	<0.0001	0.3	0.58
2	94.3	<0.0001	16.0	<0.0001	478.8	<0.0001
3	5081.3	<0.0001	18.5	<0.0001	184.3	<0.0001
4	0.1	0.77	0.6	0.44	75.1	<0.0001
5	1097.2	<0.0001	5.1	0.02	18.1	<0.0001
6	106.2	<0.0001	NA	NA	365.6	<0.0001
7	529.9	<0.0001	NA	NA	174.5	<0.0001
8	1.5	0.23	0.02	0.89	88.1	<0.0001
9	94.9	<0.0001	223.2	<0.0001	552.2	<0.0001
10	3.1	0.08	1.2	0.27	247.7	<0.0001
Pooled	9470.2	<0.0001	34.5	<0.0001	897.8	<0.0001

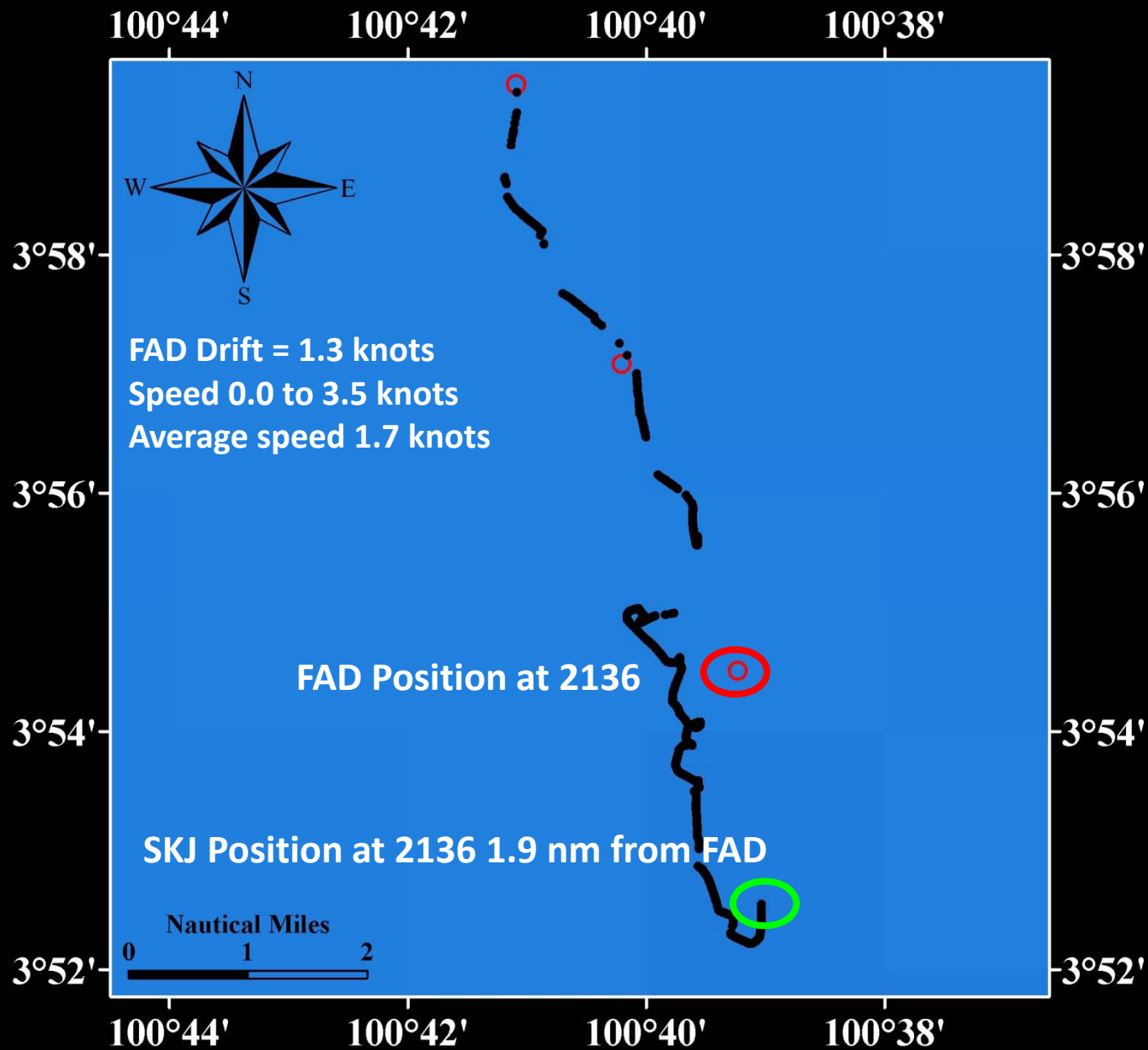
ANOVA's Between Species by Day and Night

Experiment	Day		Night	
	<i>F</i>	<i>P</i>	<i>F</i>	<i>P</i>
1	10.0	0.002	258.7	<0.0001
2	177.3	<0.0001	303.7	<0.0001
3	191.0	<0.0001	43.5	<0.0001
4	68.4	<0.0001	11.1	<0.0001
5	825.0	<0.0001	360.4	<0.0001
6	37.8	<0.0001	911.9	<0.0001
7	104.4	<0.0001	36.5	<0.0001
8	348.2	<0.0001	11.0	<0.0001
9	95.3	<0.0001	125.2	<0.0001
10	4.1	0.017	44.9	<0.0001
Pooled	267.6	<0.0001	744.0	<0.0001

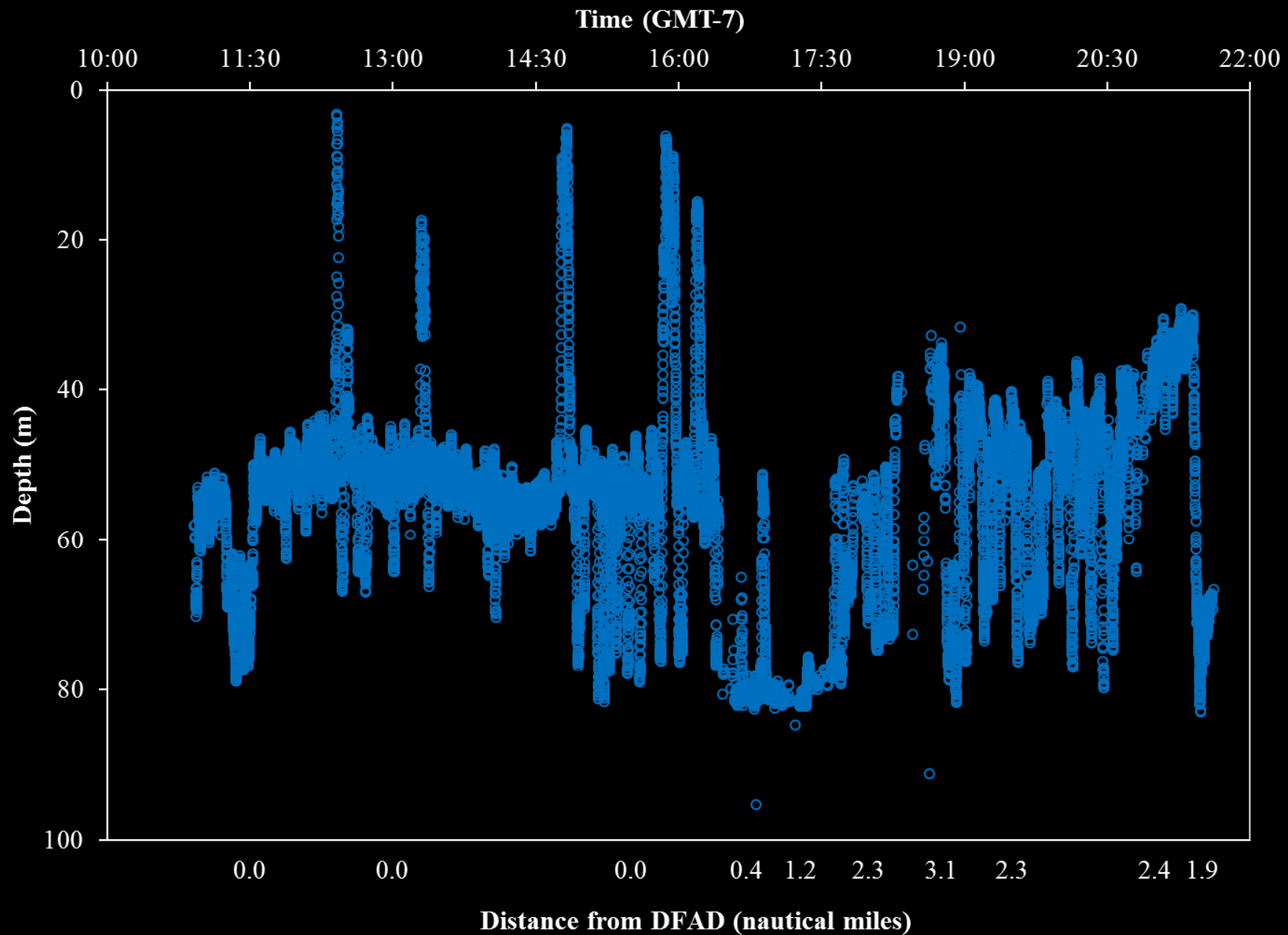
SKJ (51 cm) tracked on 21 June (16:30 to 19:00) as it Moved Away from a FAD



SKJ (51 cm) tracked on 21 June (16:30 to 21:36) as it Moved Away from a FAD



Depth Records from Same SKJ tracked on 21 June (10:42 to 21:36)



Events when Skipjack spent ≥ 2 h Outside Detection Range

Experiment	Tag ID	FL	Time Departed	Duration	Detection Method	Returned	Recaptured
2	3726	51	5/29/11 18:39	9:09	VR2	Yes	No
2	3726	51	5/30/11 3:48	2:22	VR2	Yes	No
2	3726	51	5/30/11 18:33	NA	VR2	No	No
3	3684	51	6/1/11 13:02	13:52	VR2	Yes	Yes
3	3684	51	6/2/11 9:00	15:02	VR2	Yes	Yes
3	4009	52	6/1/11 13:32*	1:39	VR28	Yes	No
3	4009	52	6/3/11 10:24	NA	VR28	No	No
5	4008	50	6/10/11 13:35	14:18	VR28	Yes	NS
5	4008	50	6/11/11 8:08	4:02	VR28	Yes	NS
5	4008	50	6/11/11 17:47	2:19	VR28	Yes	NS
5	3720	51	6/10/11 16:51	7:48	VR2	Yes	NS
5	3720	51	6/11/11 3:38	2:23	VR2	Yes	NS
5	3720	51	6/11/11 6:02	2:11	VR2	Yes	NS
5	3720	51	6/11/11 8:27	3:50	VR2	Yes	NS
5	3720	51	6/11/11 15:53	2:14	VR2	Yes	NS
5	3720	51	6/12/11 5:29	3:13	VR2	Yes	NS
5	3720	51	6/12/11 8:42	5:06	VR2	Yes	NS
5	3720	51	6/13/11 3:58	2:38	VR2	Yes	NS
5	3720	51	6/13/11 6:37	6:19	VR2	Yes	NS
5	3720	51	6/13/11 18:15	2:21	VR2	Yes	NS
8	4005**	60	6/27/11 17:34	4:56	VR28	Yes	Yes
8	4005**	60	6/28/11 18:45	2:05	VR28	Yes	Yes

* = fish was actively tracked 0.6 nm from FAD ** = fish carrying both coded and continuous tags, only continuous reported here

SUMMARY OF RESULTS

- 10 separate ultrasonic telemetry experiments were conducted with tagged skipjack, bigeye, and yellowfin tunas within large aggregations associated with drifting FADs in the equatorial eastern Pacific Ocean
- Fine-scale spatial and temporal differences in the simultaneous behavior of skipjack, bigeye, and yellowfin tunas were documented
- Although there are significant differences in the day and night depth distributions, both within and between these species when associated with drifting FADs, the differences are small
- Percent time by day and night in which bigeye and yellowfin tunas, with acoustic tags, were within detection range of the VR2W receiver was similar. Skipjack, however, exhibited much lower detection rates at night, versus during the day, apparently due to much greater dispersion away from the FADs at night
- Based on the ultrasonic telemetry data coupled with visual and acoustic observations from the purse-seine vessel, skipjack aggregations at drifting FADs are very dynamic and are not cohesive units.
- Targeting skipjack schools when they move away from FADs does not appear to be a feasible solution to reduce fishing mortality on undesirable sizes of bigeye, yellowfin, and sharks, and maintain any reasonable level of catch.

Acknowledgements

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