AN OVERVIEW OF THE 2011 ISSF AND IATTC PURSE-SEINE RESEARCH CRUISE IN THE EQUATORIAL EASTERN PACIFIC OCEAN

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CIAT IATTC

BIP PANCHITO L
B/P MALULA
B/P FIORELLA L
B/P DOMENICA L
TEAM TUNA
B/P YOLANDA L
B/P ROSSANA L
B/P CLAUDIA L

International Seafood Sustainability Foundation

YOLANDA L

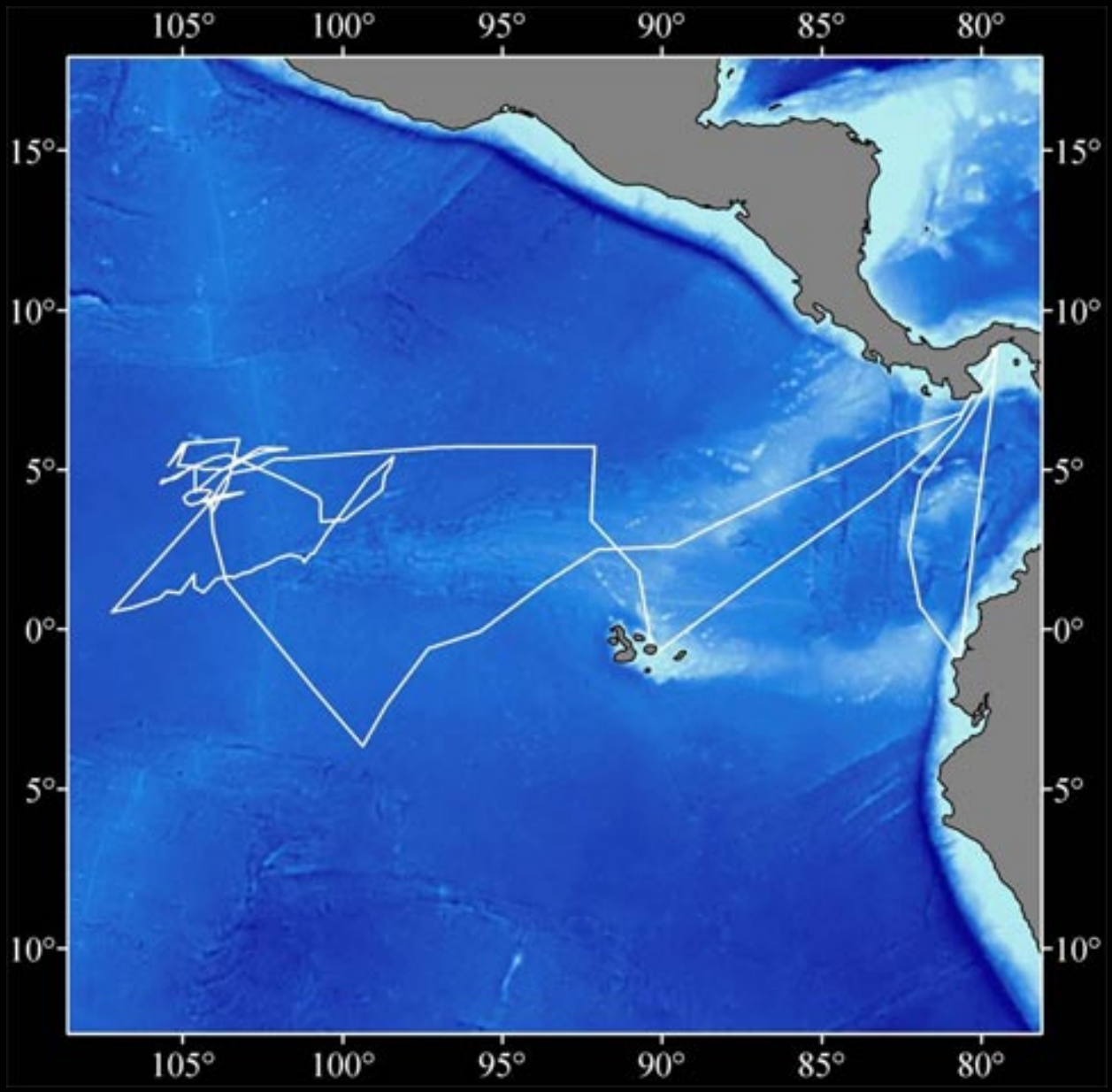
CAPTAIN RICARDO DIAZ

Length: 66.46 m
Width: 12.20 m
Draft: 8.32 m
Well Volume: 1, 168 m^3
Capacity (t): 1041
HP: 3, 600
Cruise Speed: 12 Knots

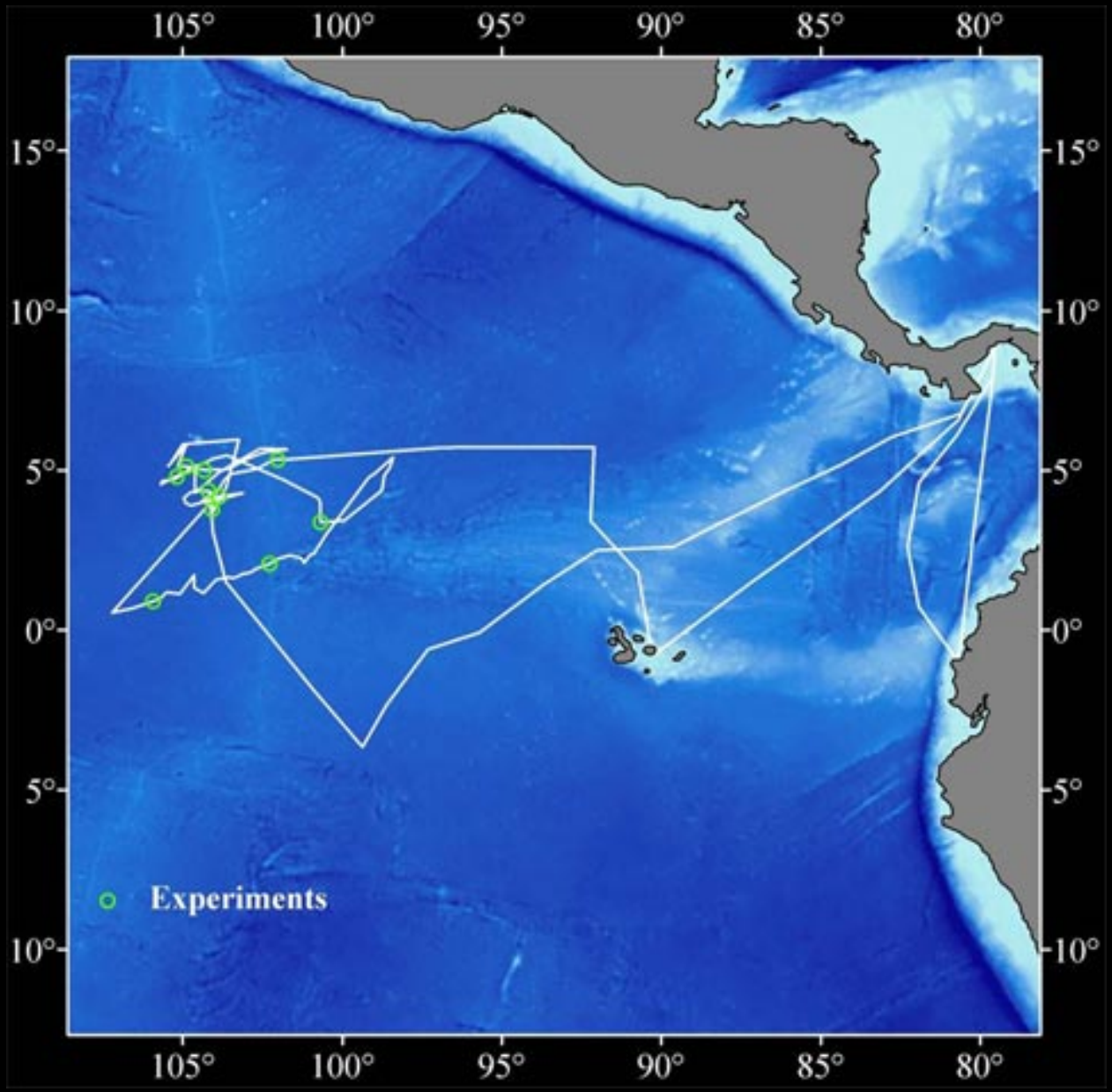
Drifting FAD with Zunibal Satellite Buoy

Zunibal Screen Showing the Distribution of 85 Drifting FAD's Potentially Available During the ISSF/IATTC Cruise

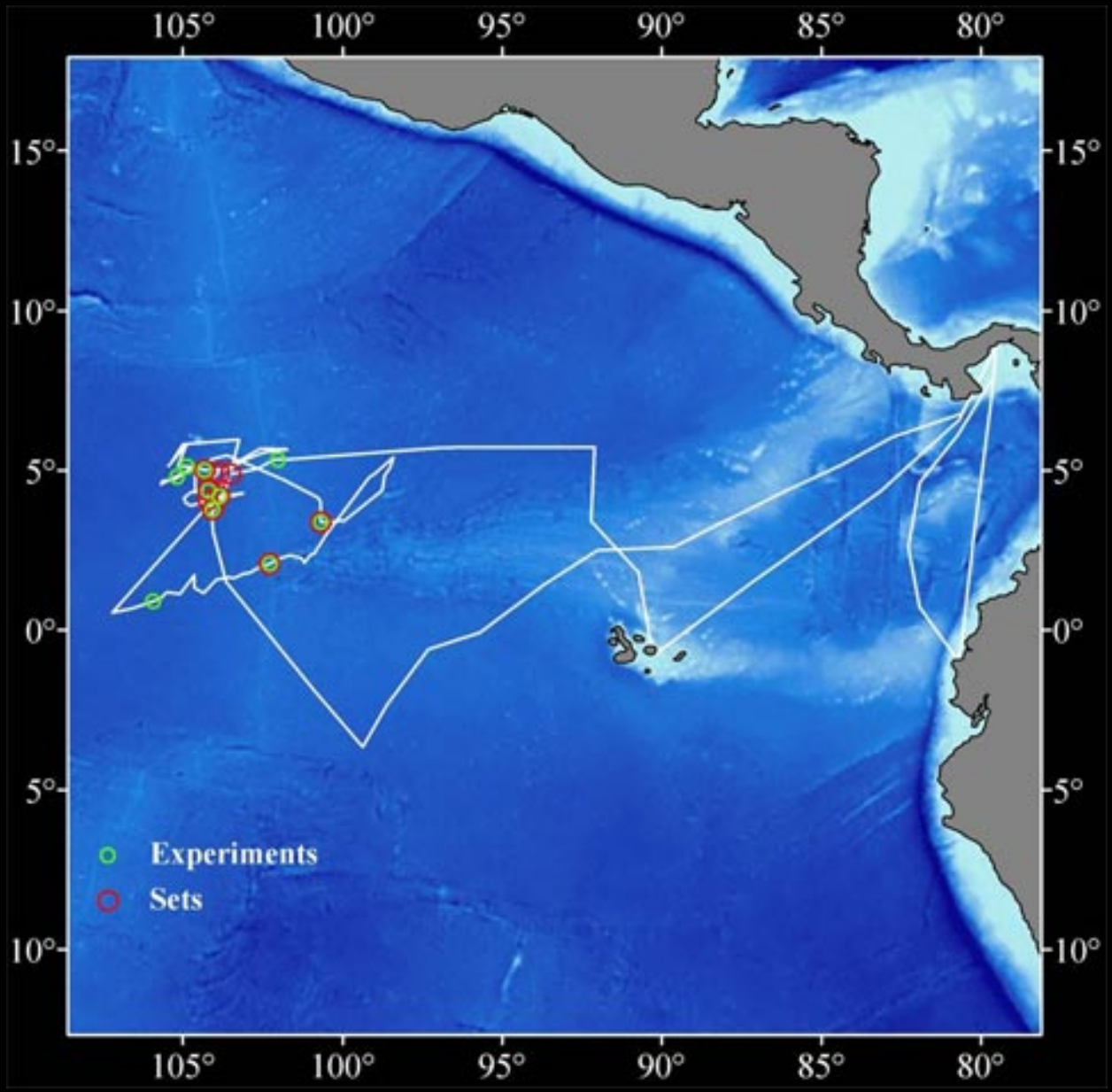
Cruise Track and Locations of Experiments and Sets



Cruise Track, Experiments, and Locations of Sets During the ISSF/IATTC Research Cruise



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 OPTIMIZNG CATCHES OF SKIPJACK TUNA?

PROPOSED RESEARCH ACTIVITIES DURING THE CRUISE

ACTIVITY 1: ECOLOGICAL FADS

Objective: To test different designs of FADs that may not entangle turtles or sharks, potentially using biodegradable materials

Results: Ten “ecological” FADs and 51 “standard” FADs were deployed during the routine fishing trip, preceding the research cruise. Two of the “ecological” FADs were constructed of all natural materials. The other 8 “ecological “ FADs had 2” stretch purse-seine mesh net hung from the FADs, versus the common 4.5” or larger mesh net.

All FADs checked during the cruise were evaluated as to their design, condition, presence of any entangled animals, and tuna biomass.

There were no turtles or sharks observed entangled in the netting of any FADs during this cruise.

ACTIVITY 2: CATCH PREDICTION

Objective: To evaluate the accuracy of the fishing captain's catch predictions from sets on tuna aggregations associated with drifting FADs, and the potential for improvements in those estimates through the use of additional complimentary equipment and methods

Results: To be discussed in detail

ACTIVITY 3: BEHAVIOR OF TUNAS ASSOCIATED WITH FADS

Objective: To elucidate spatial and temporal differences in the 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 bigeye, yellowfin, and sharks, while optimizing the capture of skipjack

Results: To be discussed in detail

ACTIVITY 4: BEHAVIOR OF TUNAS AND SHARKS WITHIN A PURSE-SEINE NET

Objective: To investigate the behavior of tunas and sharks captured within a purse-seine net, and determine if species-specific segregations occur, and if so the spatial and temporal characteristics of such segregations

Results: The scientific workboat was to remain adjacent to the FAD during a set at pre-dawn. After dawn the ROV was to be deployed with adequate light to observe and record the behavior of tunas and sharks within the net.

Observations and recordings were intended to be conducted for up to 6 hours, after the rings were aboard and at 25% of the net in the water.

No experiments were undertaken for this activity, because the precautionary requirements of the Captain did not occur during the cruise. Those included sets on small tuna aggregations (< 20 t), and calm seas.

ACTIVITY 5: SURVIVAL OF RELEASED SHARKS AND ASSESSMENT OF CAPTURE STRESS

Objective: Determine the at-vessel mortality, post-release survival, and the physiological, biochemical, and molecular responses of sharks incidentally captured by purse seiners

Results: The numbers, species composition, at-vessel mortality, and physical condition of sharks loaded aboard the vessel were assessed during the cruise

There were 40 silky sharks loaded aboard, from 7 of the 9 sets during the cruise, and 8 sharks which appeared alive were tagged and released with mini-PATs. The post-release mortality rates were to be determined by directly recording the shark's vertical and horizontal movement patterns for 30-45 days with the mini-PATs.

2 of the 8 sharks released survived, based on evaluations of the mini-PAT data sets

Silky Sharks Loaded, Released, and Survived, by Set

Set #	# Observed	FL (cm)	mPSAT	Survived	Tuna Captured (t)
1	0	NA	NA	NA	72
2	5	74 - 122	0	NA	75
3	3	60 - 87	1	0	22
4	4	77 - 131	2	1	147
5	1	134	1	0	39
6	0	NA	NA	NA	29
7	17	67 - 165	2	1	182
8	4	113 - 154	0	NA	142
9	6	53 - 126	2	0	72

ACTIVITY 3: 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 $\geq$ 48 h.
- Should a mono-specific skipjack school be observed, while active tracking, to move $\geq$1 nm away from a FAD the purse-seine vessel would target that school for capture

Workboat

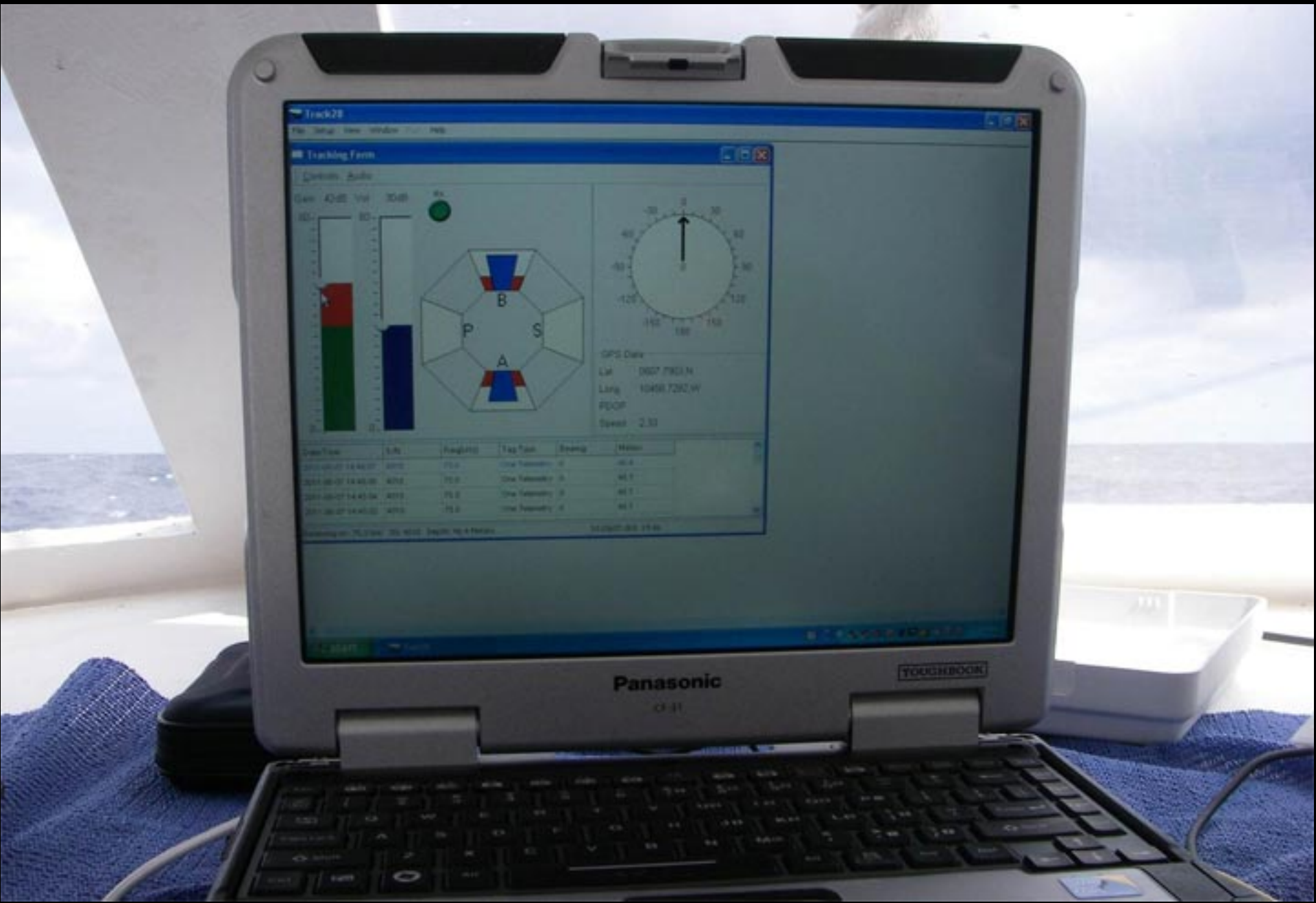
FAD with VR2 and Radar Reflector Attached

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

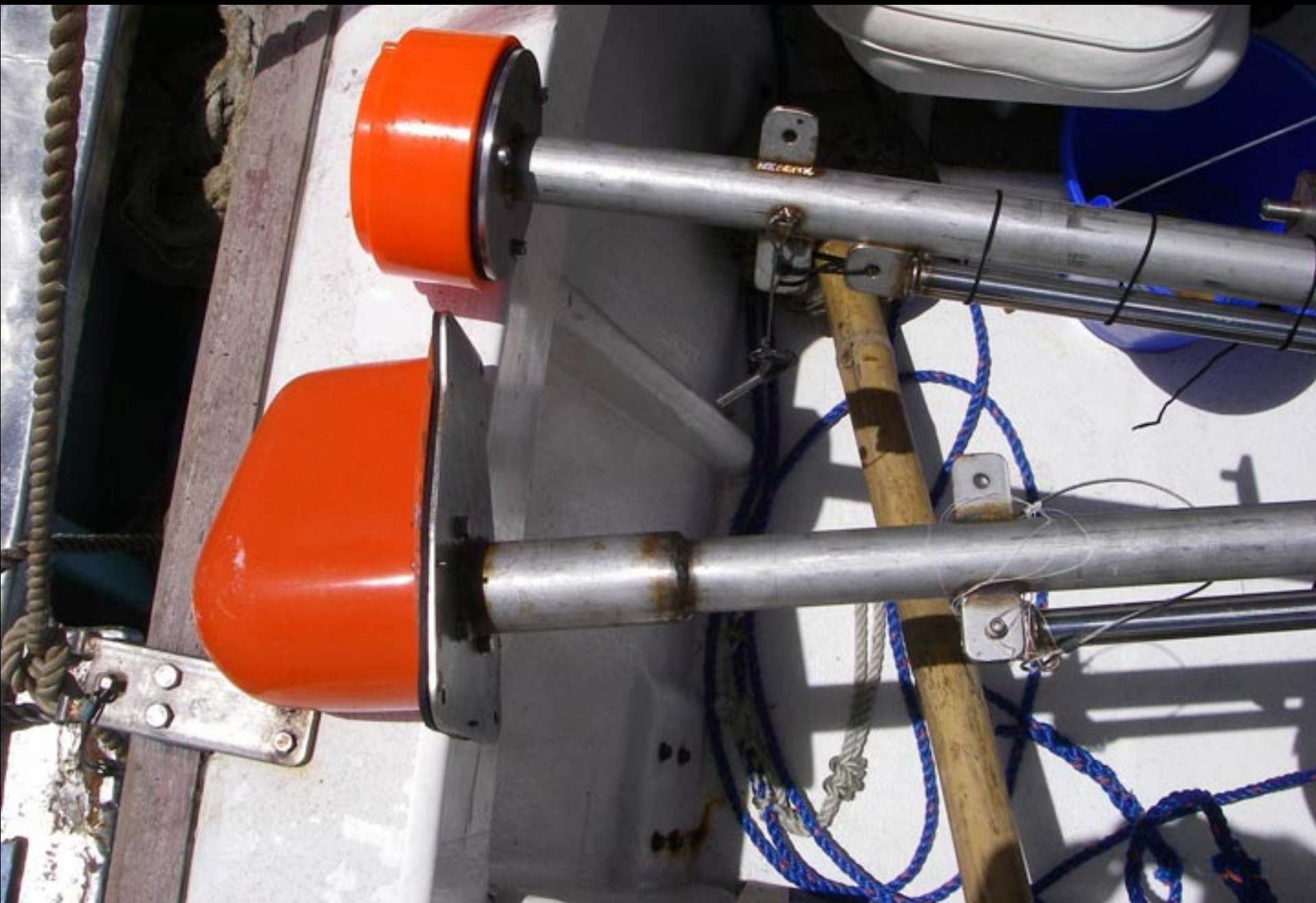
Vemco V-13P Ultrasonic Transmitter, VR 2W Hydrophone, and Wildlife Computers mini PAT

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

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

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

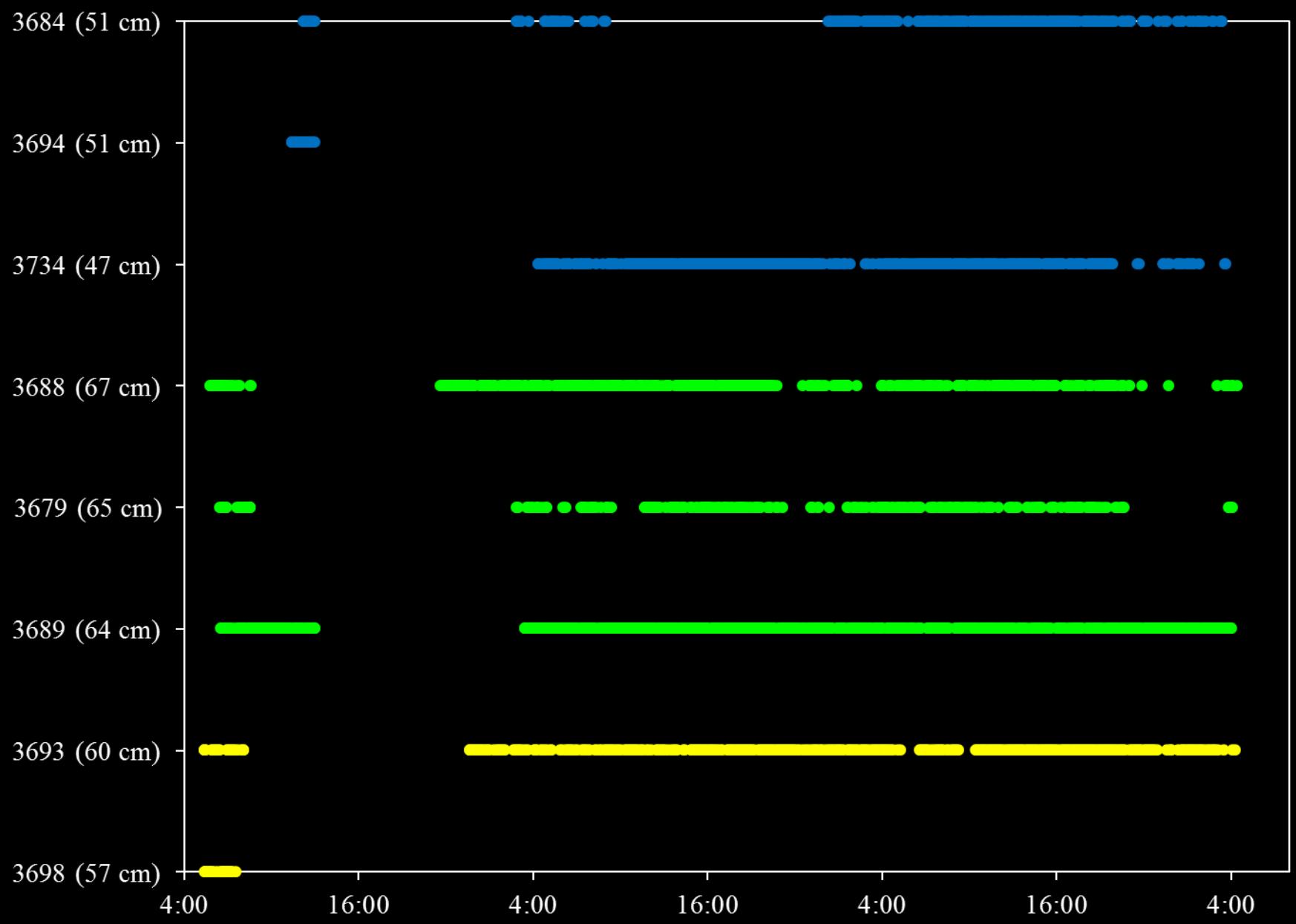
	SKJ			BET		YFT	
Experiment	Coded	FL (cm)	Continuous	Coded	FL (cm)	Coded	FL (cm)
1	0 (0)	50 – 58	2 (0)	3 (1)	53 – 59	3 (2)	60 – 66
2	2 (1)	51	0 (0)	3 (3)	53 – 57	3 (3)	52 – 57
3	4 (2)	47 – 53	2 (0)	3 (3)	64 – 67	3 (2)	57 – 65
4	1 (0)	47 – 49	2* (0)	3 (3)	59 – 72	3 (2)	52 – 60
5	2	49 – 51	2*	3	53 – 56	3	55 – 59
6	3	41 – 57	2*	1	92	3	52 – 57
7	2 (0)	42 – 51	2 (0)	NA	NA	4 (1)	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		**27.8**			**73.3**		**57.9**

* = 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

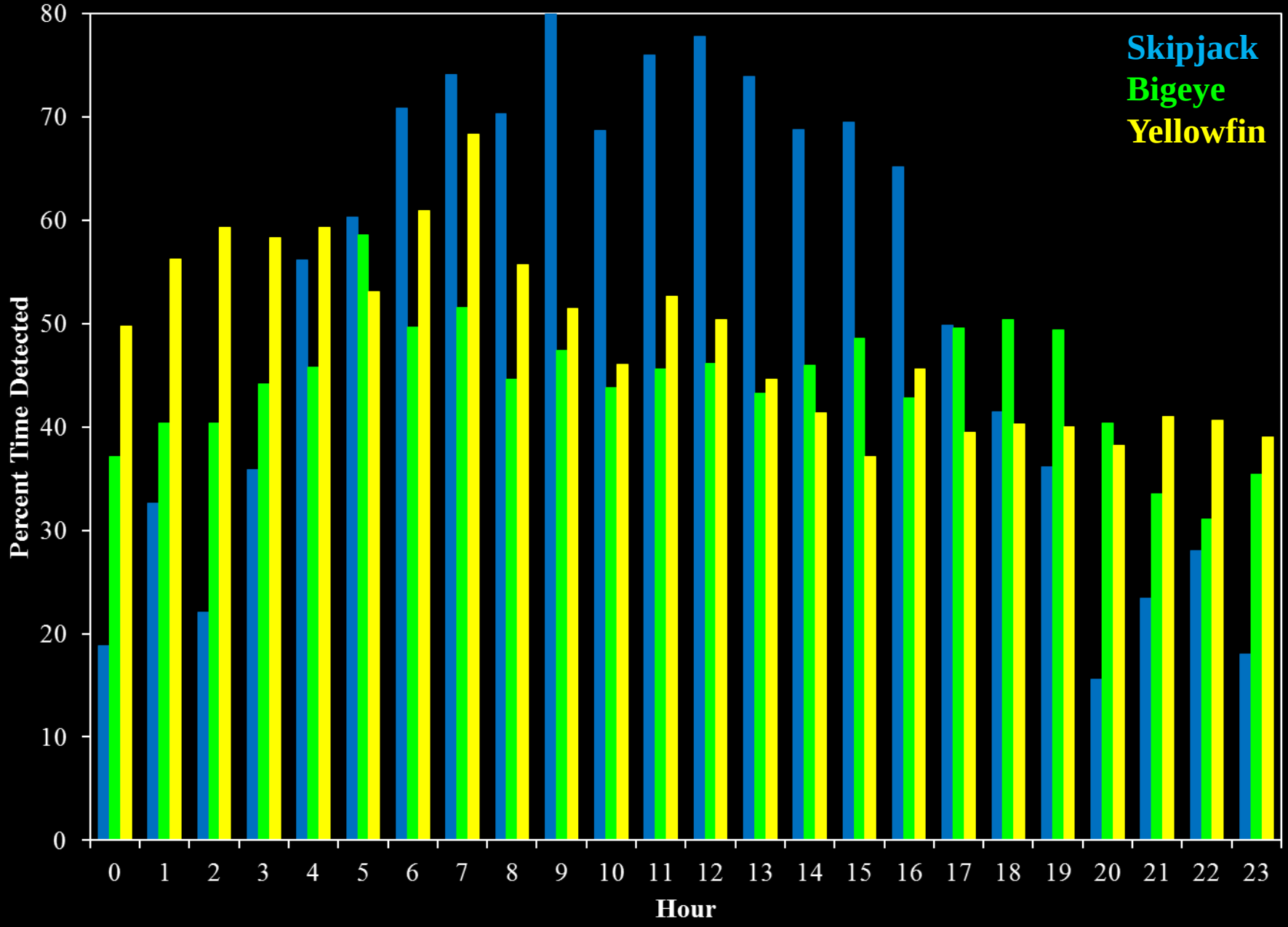
VR2 Detections for Skipjack, Bigeye, and Yellowfin During Experiment 3



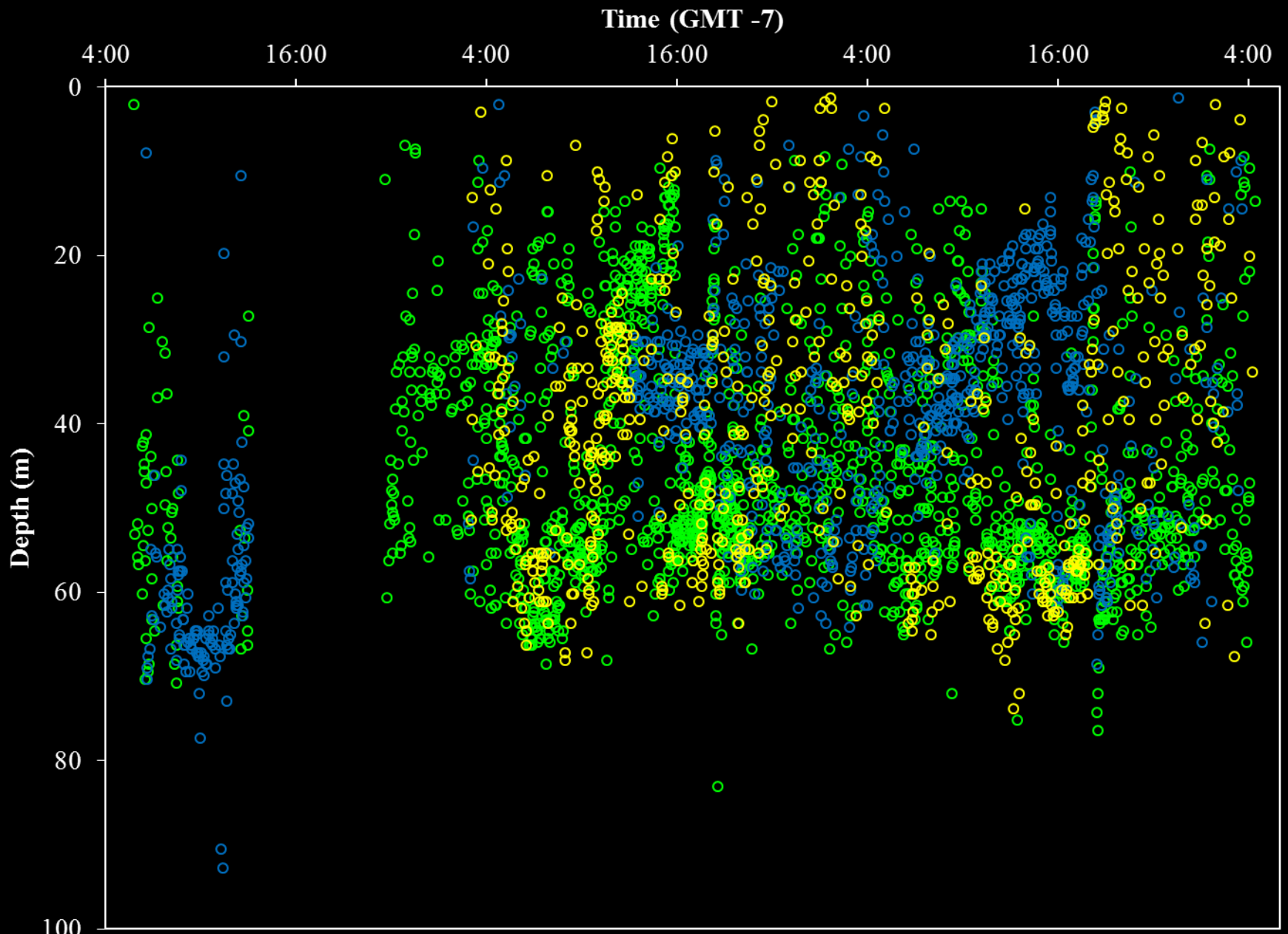
Percent Time Detected by by Day and Night, For Recaptured Tunas

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 3



Mean Depths (m), by Species, by Day and Night

	Skipjack			Bigeye			Yellowfin	
		DAY	NIGHT		DAY	NIGHT		DAY	NIGHT
Experiment	*n*	Mean	Mean	*n*	Mean	Mean	*n*	Mean	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

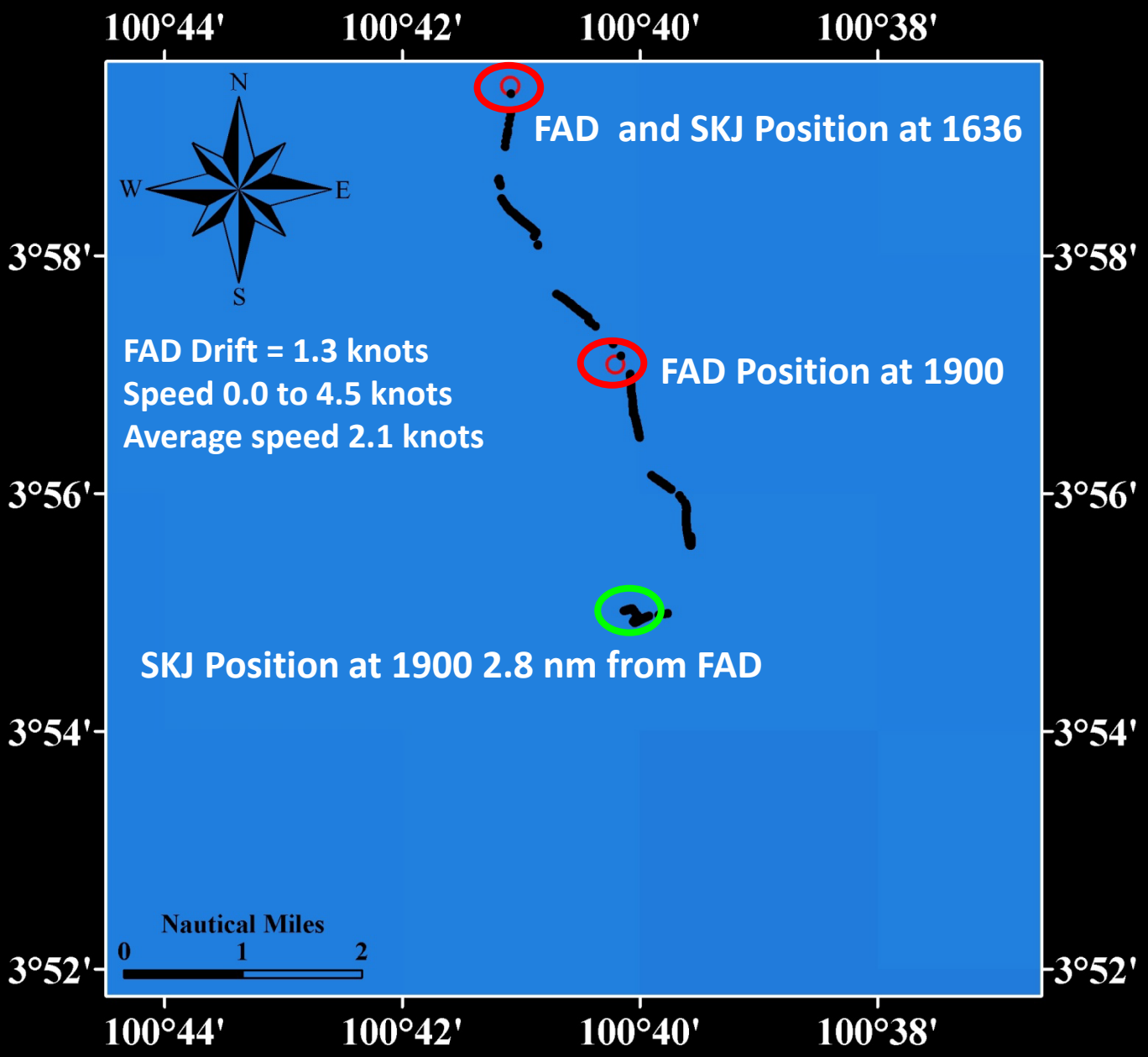
ANOVA's Between Day and Night Depths by Species

	Skipjack		Bigeye		Yellowfin	
Experiment	***F***	***P***	***F***	***P***	***F***	***P***
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

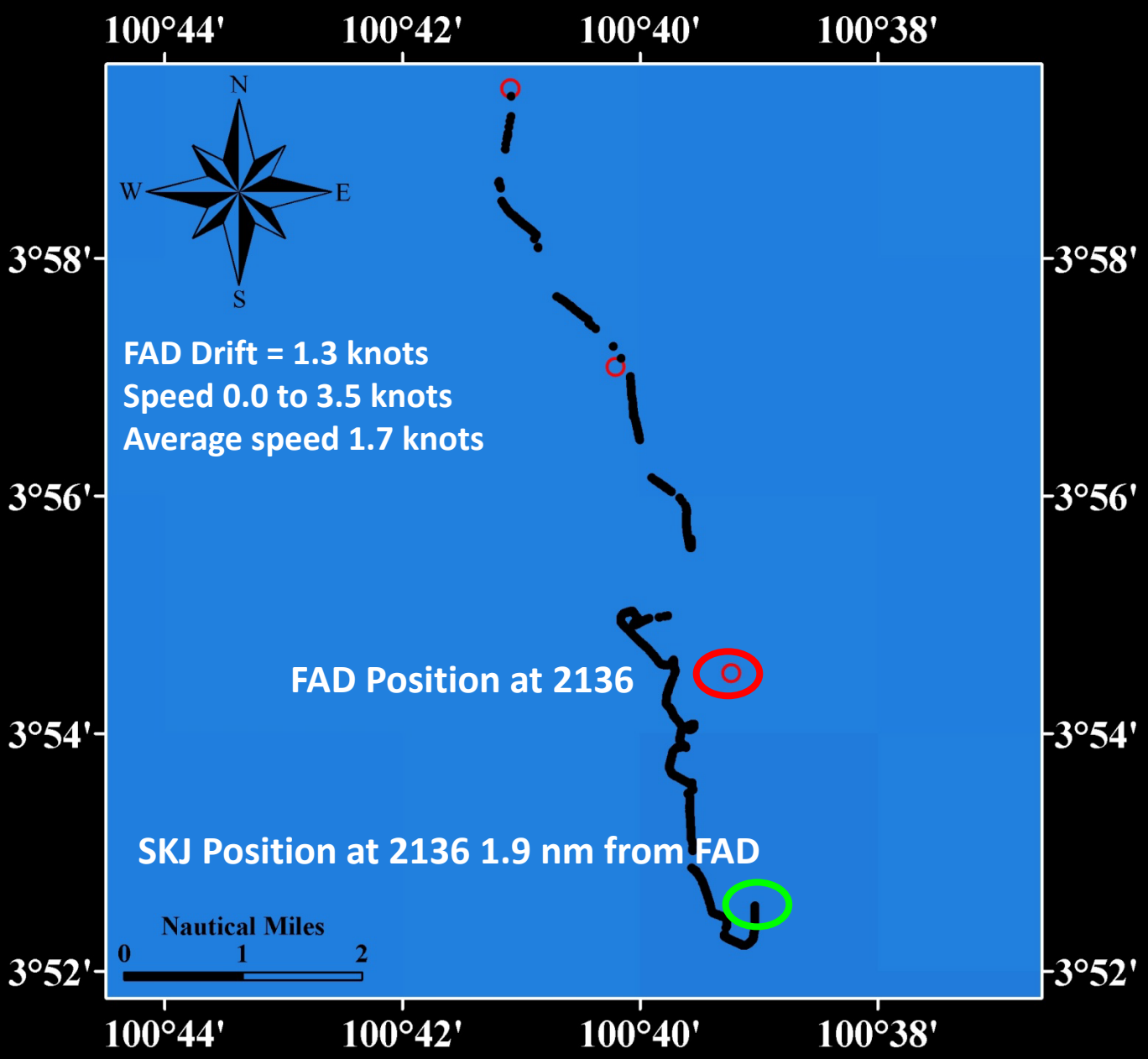
ANOVA’s Between Species by Day and Night

	Day		Night	
Experiment	***F***	***P***	***F***	***P***
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

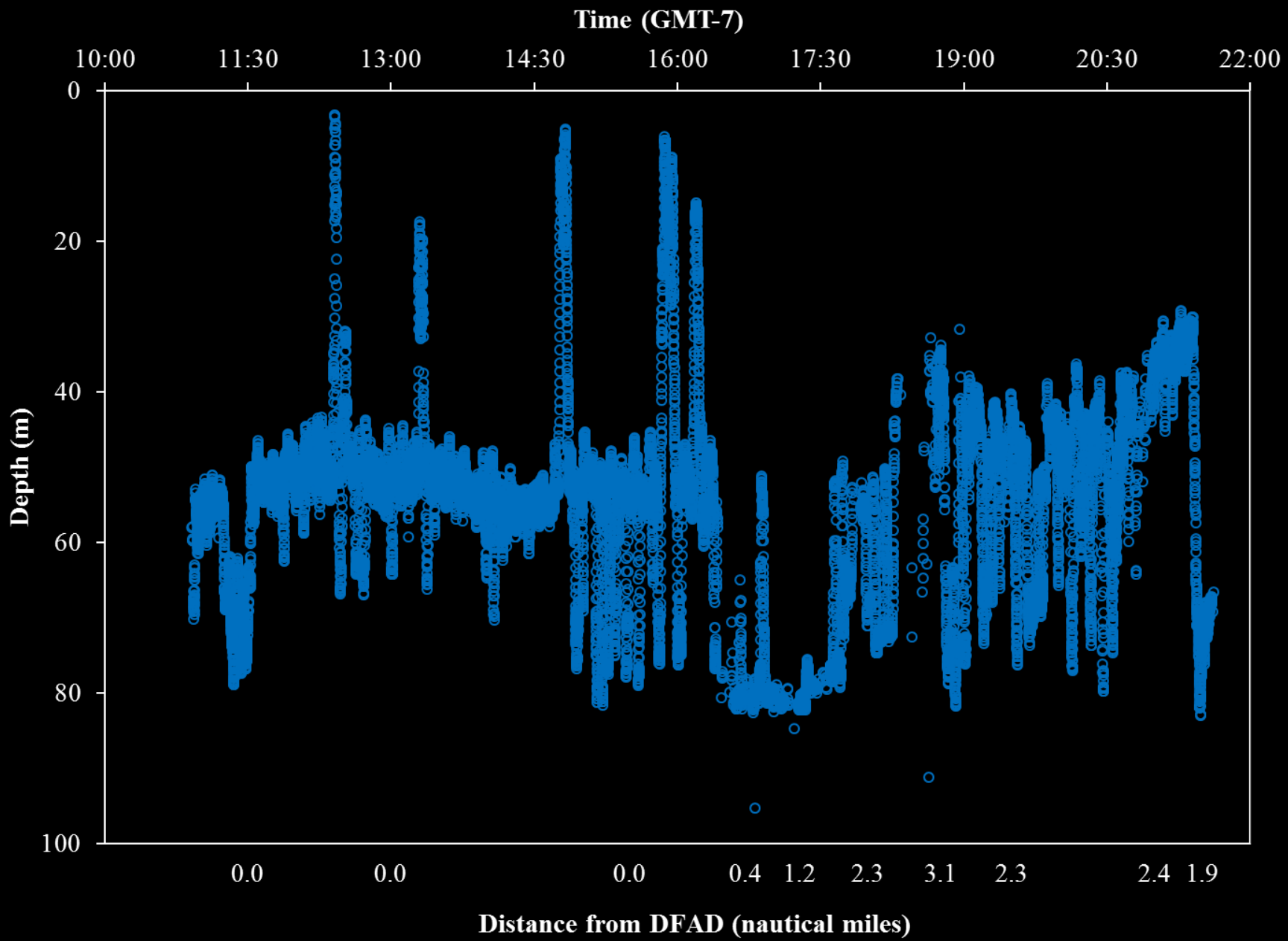
SKJ (51 cm) tracked on 21 June (16:30 to 19:00) as it Moved Away from a FAD



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)



Movements away from FADs by Tagged and non-Tagged Skipjack

	Tagged SKJ					Non-Tagged SKJ	
Exp	**Detected**	**Outside Range**	**Time**	**Observed**	**Distance**	**Moved Away**	**Distance**
1	0	0	NA	VR 28	NA	Not Observed	NA
2	2	2	18:26	VR 2	Not Determined	Not Observed	NA
3	4	3	6:20, 8:30, 12:44	VR 2, VR 28	0.6 nm+	Not Observed	NA
4	2	2	17:00, 17:48	VR 2, VR 28	Not Determined	Not Observed	NA
5	3	3	10:27, 17:05, 18:50	VR 2, VR 28	Not Determined	Not Observed	NA
6	3	3	01:00, 16:10, 16:30, 18:50	VR 2, VR 28	Not Determined	Not Observed	NA
7	2	2	16:30	VR 28	3+ nm	Yes	1+ nm
8	3	3	12:00, 16:48, 17:16, 17:45	VR 2, VR 28	Not Determined	Yes	7+ nm
9	1	1	17:51, 18:24	VR 2	Not Determined	Not Observed	NA
10	1	1	17:56	VR 2	Not Determined	Not Observed	NA

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 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 and yellowfin, nor sharks, and maintain any reasonable level of catch.

ACTIVITY 2: CATCH PREDICTION

Materials and Methods:

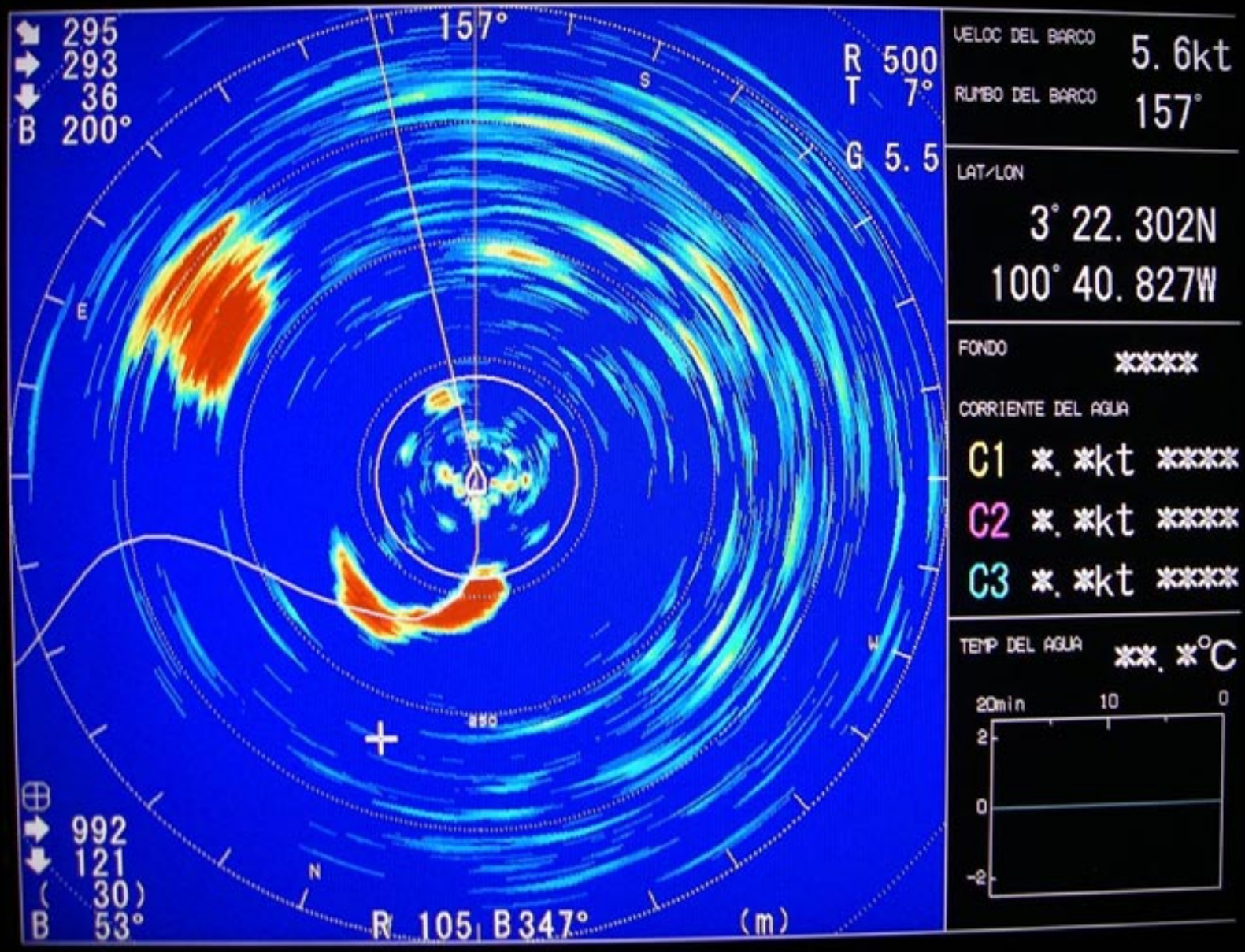
- Furuno CSH-5 sonar (60 kHz) aboard the purse-seine vessel
- Furuno FCV-261 echo-sounder (200 kHz) aboard the purse-seine vessel
- Furuno FCV-620 echo-sounder (50 kHz) aboard light boat
- Workboat (7.5 m fiberglass, enclosed pilothouse, 150 hp Yamaha outboard)
- Simrad ES-70 echo-sounder configured with a split beam 120 kHz transducer installed aboard workboat
- SEABOTIX LBV 200 mini ROV system equipped with sonar, cameras, and lasers, aboard workboat
- Acoustic and optical surveys of tuna aggregations utilizing the ES70 echo-sounder and SEABOTIX ROV aboard the workboat.
- Pre-set estimates of the species composition, sizes, and quantities of tunas provided by Captain, based on acoustics from purse-seine vessel and light boat, and visual observations from mast men.
- Tunas loaded and separated by sets within wells, so as to obtain weights by species weight classes within set, from Starkist cannery in Manta, Ecuador

YOLANDA L

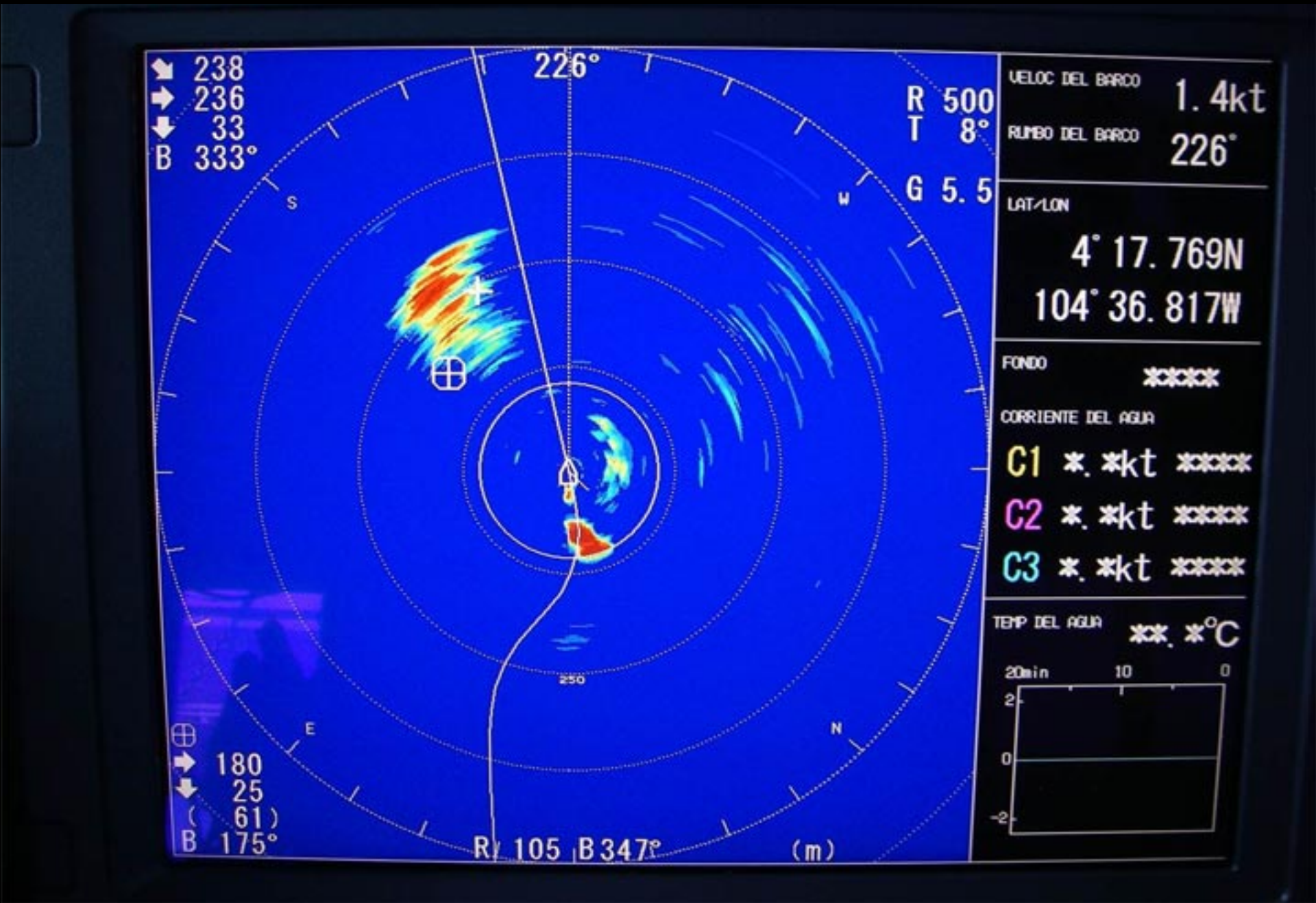
CAPTAIN RICARDO DIAZ

Length: 66.46 m
Width: 12.20 m
Draft: 8.32 m
Well Volume: 1, 168 m^3
Capacity (t): 1041
HP: 3, 600
Cruise Speed: 12 Knots

Furuno CSH-5 SONAR Showing a Large Tuna Aggregation



Furuno CSH-5 SONAR Showing a Tuna Aggregation



YOLANDA L Light-Boat

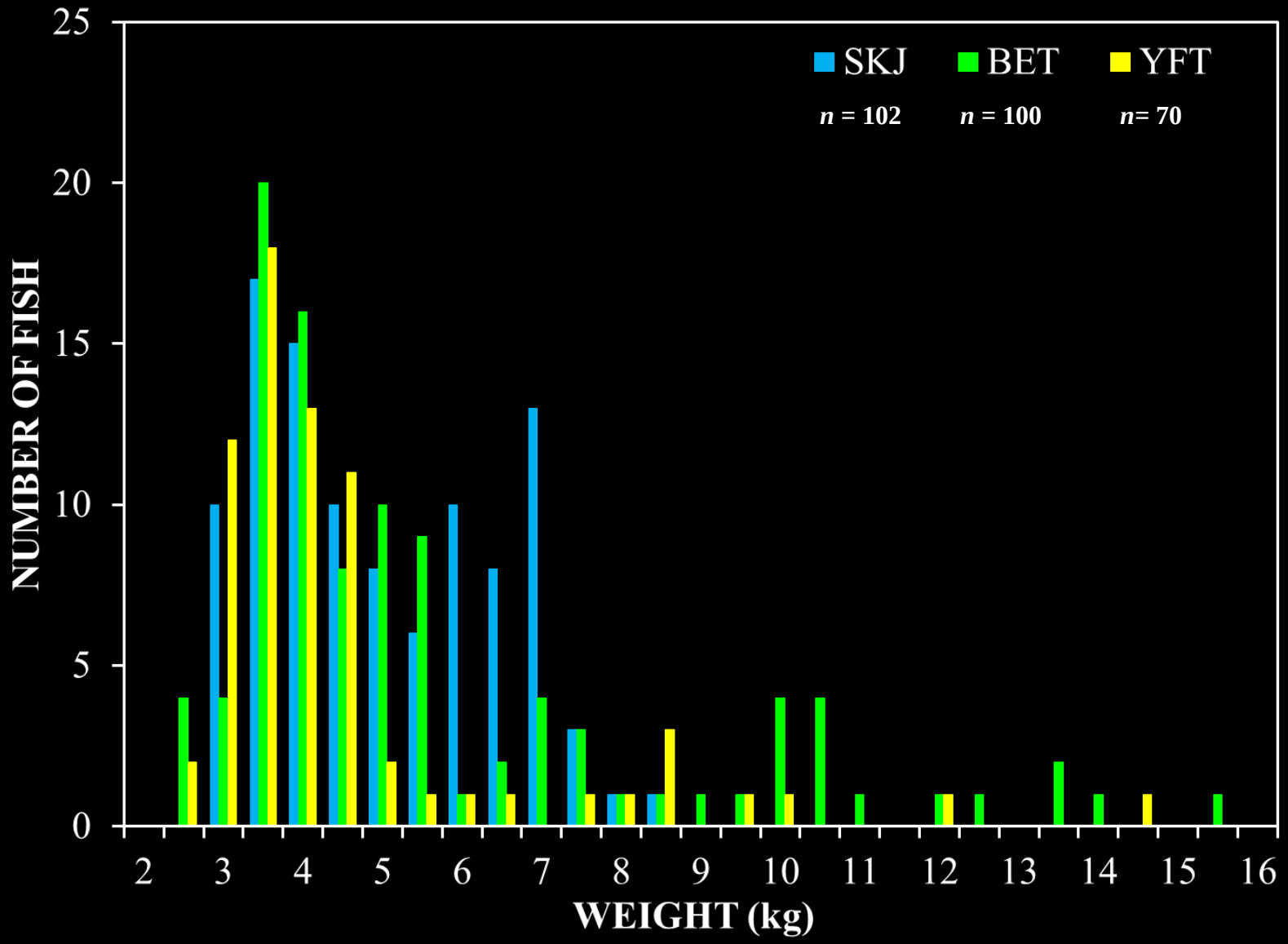
YOLANDA L Mast men


YOLANDA L

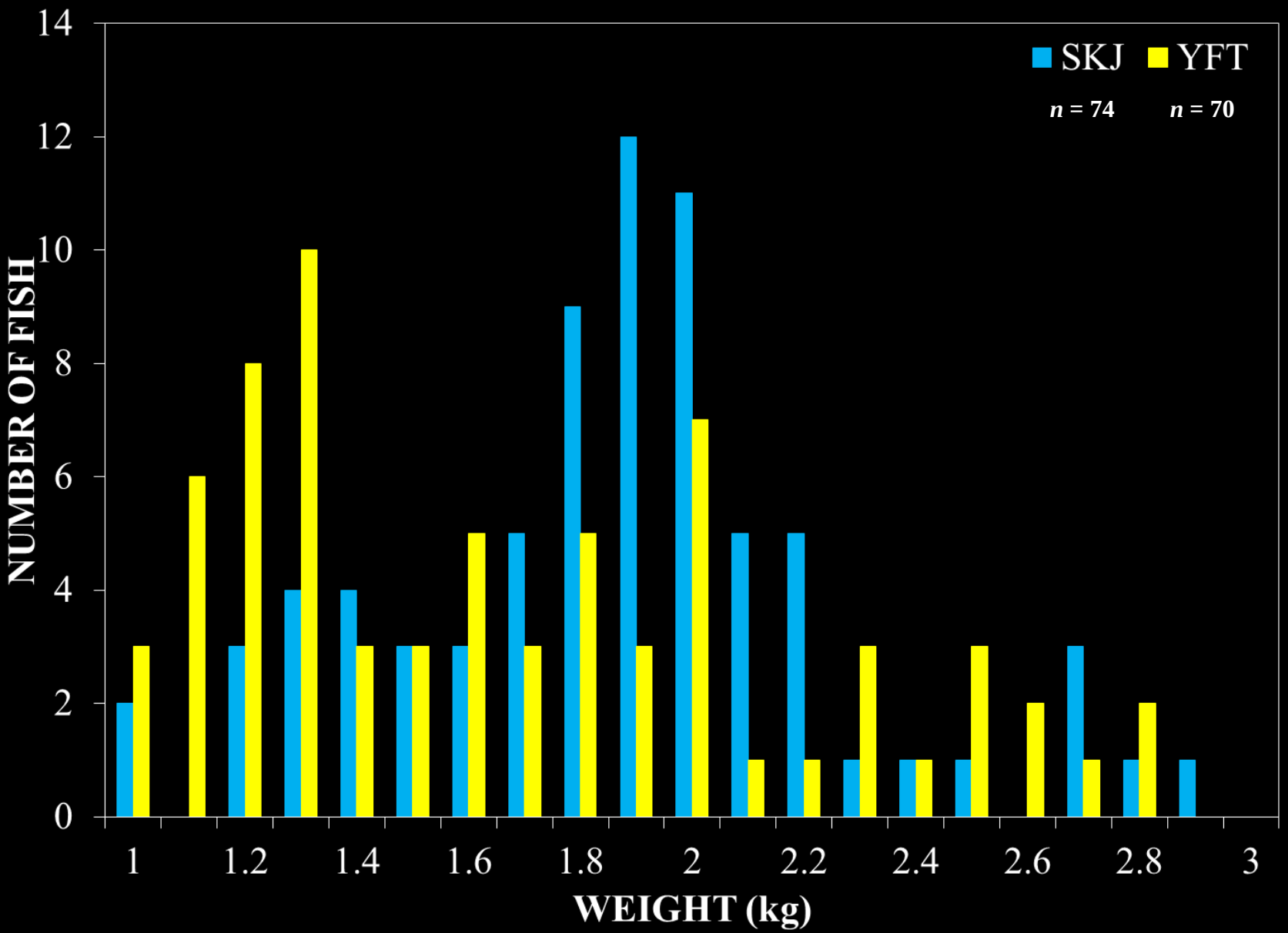
SUMMARY OF PURSE-SEINE SETS WHERE CATCH PREDICTIONS WERE CONDUCTED

		Position		Catch (mt)			
Set	Date	Latitude	Longitude	SKJ	BET	YFT	Total
1	27-May-2011	4°10 N	103°50 W	50.9	6.3	14.2	71.5
2	31-May-2011	4°20 N	104°09 W	55.1	5.9	13.4	74.5
3	01-June-2011	4°03 N	104°11 W	16.4	1.0	4.6	21.9
4	04-June-2011	3°45 N	104°03 W	115.1	13.8	18.0	146.9
5	09-June-2011	4°59 N	104°09 W	14.5	11.7	12.8	39.0
6	23-June-2011	3°22 N	100°40 W	166.9	6.6	8.9	182.4
7	30-June-2011	2°04 N	102°17 W	110.9	2.0	29.9	142.8
8	10-July-2011	4°52 N	103°30 W	56.3	2.3	13.7	72.3

WEIGHT FREQUENCY DISTIBUTIONS OF MANUALLY SORTED (2.5 – 15 kg) SKJ, BET, AND YFT SAMPLED AT THE STARKIST FACILITY IN ECUADOR



WEIGHT FREQUENCY DISTIBUTIONS OF MANUALLY SORTED (<2.5 kg) SKJ AND YFT SAMPLED AT THE STARKIST FACILITY IN ECUADOR

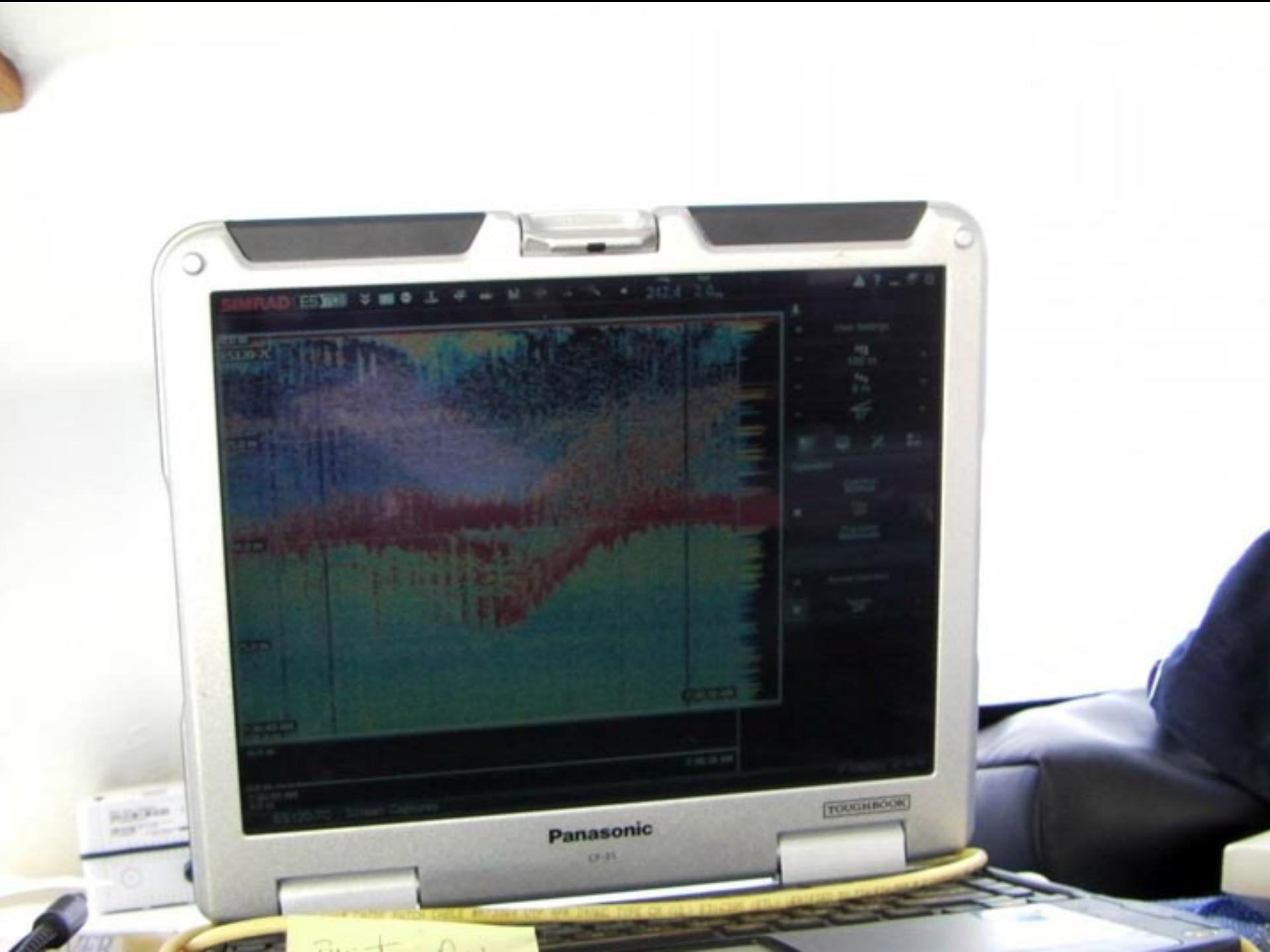


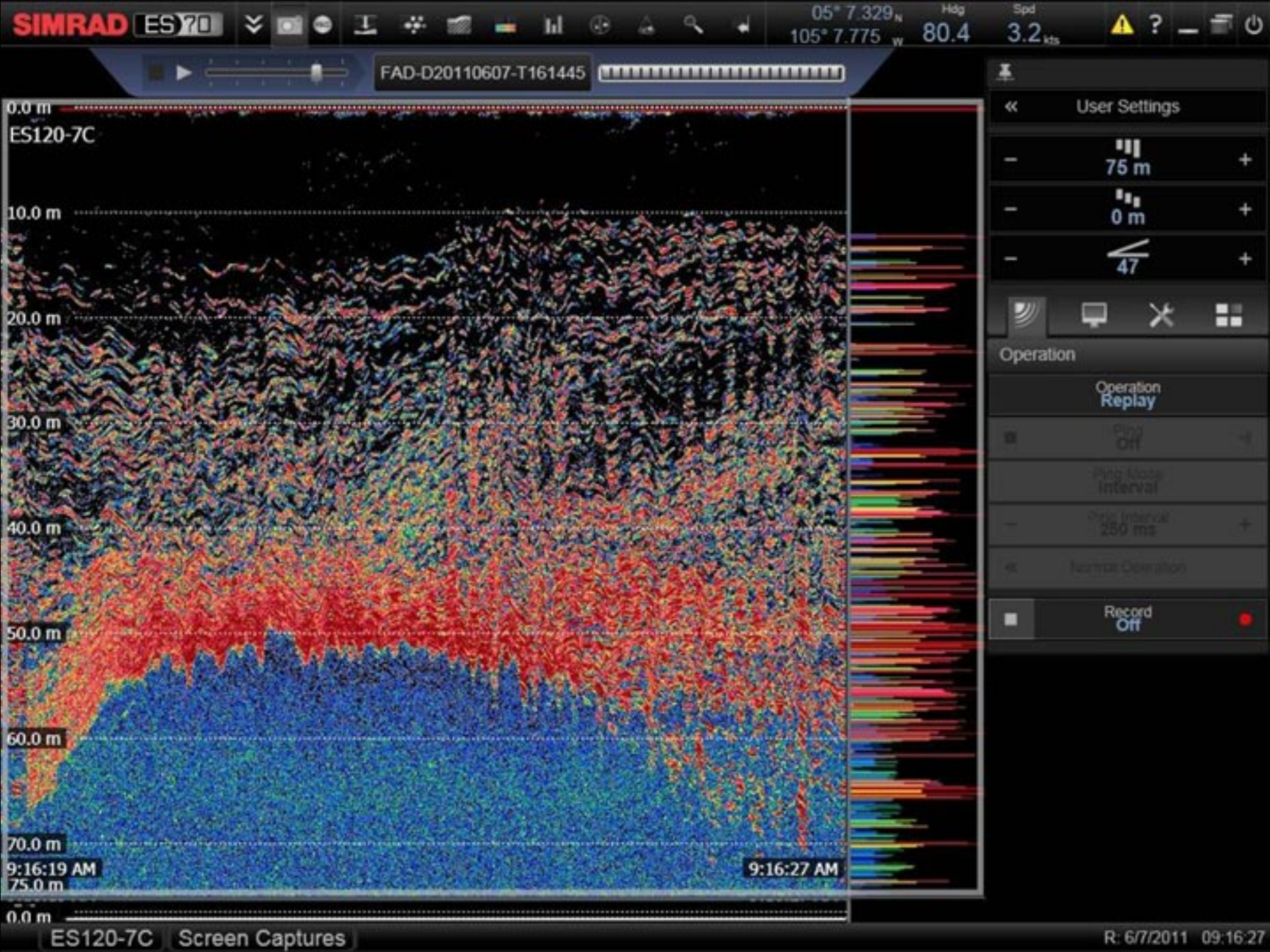
PREDICTED CATCH BY CAPTAIN FOR EACH OF THE 8 SETS AND THE ASSOCIATED *CV*'s

	Predicted Catch (mt)							
	SKJ		BET		YFT		Total	
Set	Prediction	*cv*	Prediction	*cv*	Prediction	*cv*	Prediction	*cv*
1	35	0.057	18	0.111	22	0.091	75	0.080
2	45	0.111	7	0.286	11	0.182	63	0.143
3	13	0.154	5	0.200	2	0.500	20	0.200
4	93	0.215	33	0.303	34	0.353	160	0.263
5	8	0.750	30	0.400	20	0.350	58	0.500
6	90	0.078	35	0.343	37	0.405	162	0.210
7	65	0.385	35	0.486	30	0.500	130	0.438
8	25	0.280	9	0.667	12	0.667	46	0.457

CAPTAIN'S PREDICTED CATCH IN WEIGHT BY SPECIES, AND PERCENT DIFFERENCES FROM ACTUAL CATCH

	SKJ			BET			YFT			YFT and BET		
Set	Estimated	Captured	% Dif	Estimated	Captured	% Dif	Estimated	Captured	% Dif	Estimated	Captured	% Dif
1	35.0	50.9	37.0	18.0	6.3	96.3	22.0	14.2	43.1	40.0	20.5	64.5
2	45.0	55.1	20.2	7.0	5.9	17.1	11.0	13.4	19.7	18.0	19.3	7.0
3	13.0	16.4	23.1	5.0	1.0	133.3	2.0	4.6	78.8	7.0	5.6	22.2
4	93.0	115.1	21.2	33.0	13.8	82.1	34.0	18.0	61.5	67.0	31.8	71.3
5	8.0	14.5	57.8	30.0	11.7	87.8	20.0	12.8	43.9	50.0	24.5	68.5
6	90.0	166.9	59.9	35.0	6.6	136.5	37.0	8.9	122.4	72.0	15.5	129.1
7	65.0	110.9	52.2	35.0	2.0	178.4	30.0	29.9	0.3	65.0	31.9	68.3
8	25.0	56.3	77.0	9.0	2.3	118.6	12.0	13.7	13.2	21.0	16.0	27.0
Average % Difference			43.5			106.3			47.9			57.2

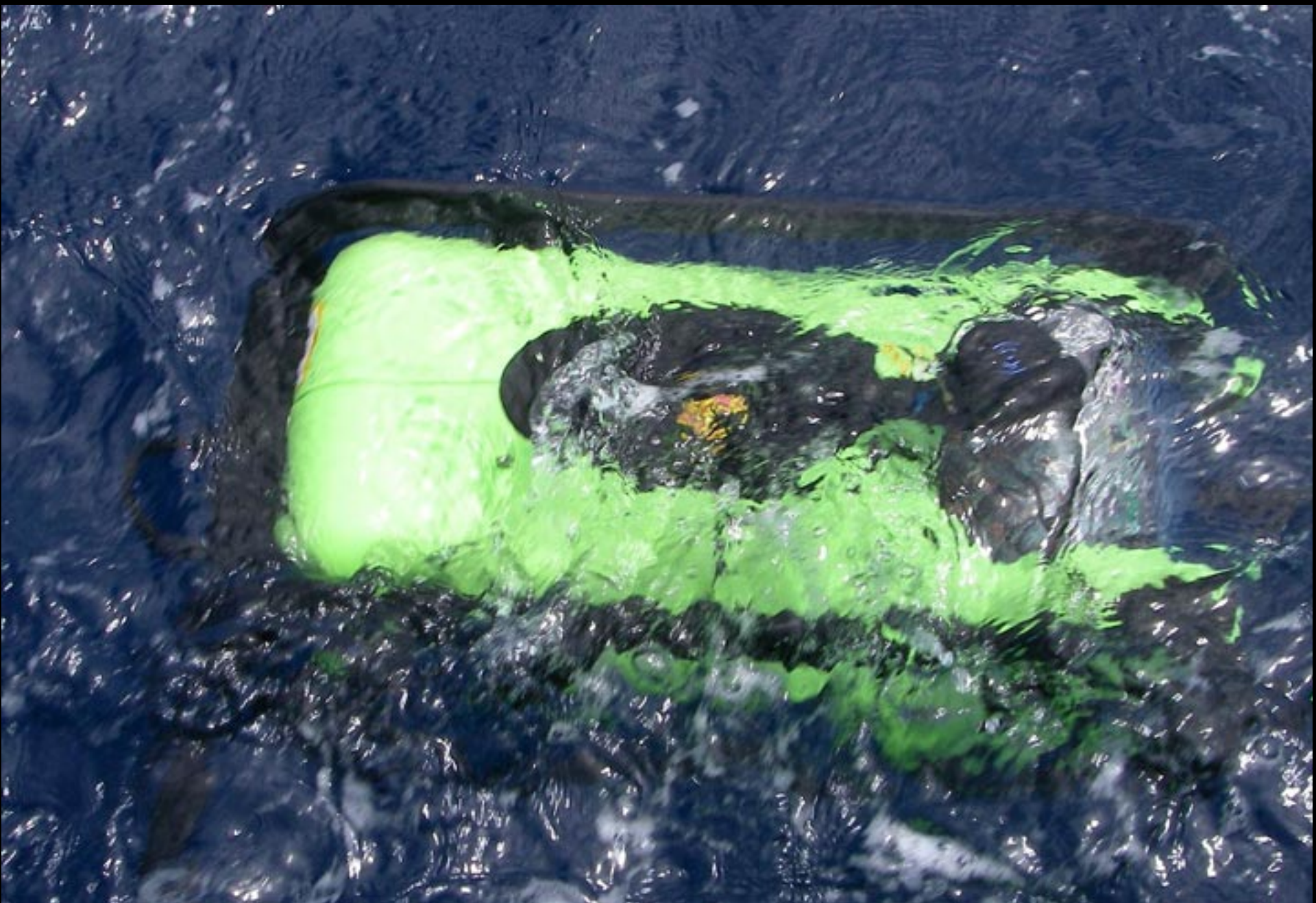

SIMRAD
Panasonic
TOUGHBOOK


SIMRAD ES70
05° 7.329 N
105° 7.775 W
Hdg
80.4
Spd
3.2 kts
FAD-D20110607-T161445
0.0 m
ES120-7C
10.0 m
20.0 m
30.0 m
40.0 m
50.0 m
60.0 m
70.0 m
9:16:19 AM
75.0 m
9:16:27 AM
0.0 m
User Settings
75 m
0 m
47
Operation
Operation
Replay
Record
Off
ES120-7C
Screen Captures
R: 6/7/2011 09:16:27

Seabotix LBV – 200 ROV

LBV – 200, Umbilical, and Honda Generator

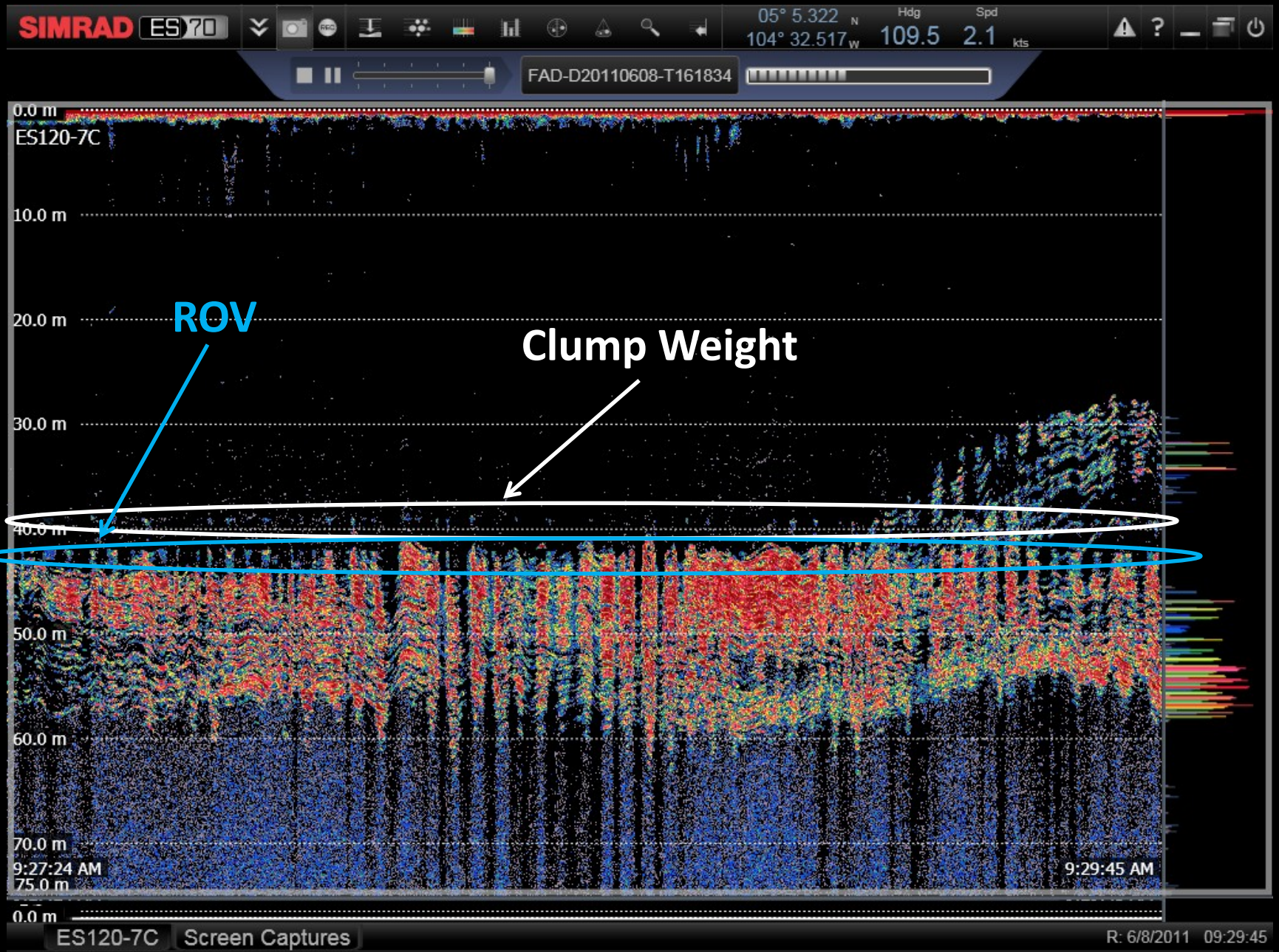
LBV – 200 Deployed for Mission



Summary of Acoustic and Video Imagery with Species Observed on Video

Exp. #	Date	Simrad ES-70	ROV Video	Species Observed
1	5/25/2011	Y	Y	BET, SKJ, YFT
2	5/29/2011	Y	N	NA
3	6/2/2011	Y	Y	BET, SKJ, YFT
4	6/7/2011	Y	N	NA
4	6/8/2011	Y	Y	BET, SKJ, YFT
5	6/10/2011	Y	N	NA
6	6/16/2011	Y	N	NA
7	6/22/2011	Y	Y	BET, SKJ, YFT
8	6/29/2011	Y	N	NA
9	7/7/2011	Y	N	NA
10	7/11/2011	Y	N	NA

Simrad ES-70 Showing Clump Weight, ROV, and Tuna



PREDICTED CATCH IN PROPORTIONS BY SPECIES AND PERCENT DIFFERENCES FROM ACTUAL CATCH

	Captain's			Scientist's			Actual		
SET	SKJ (% DIF)	BET (% DIF)	YFT (% DIF)	SKJ (% DIF)	BET (% DIF)	YFT (% DIF)	SKJ	BET	YFT
1*	47 (41)	24 (93)	29 (37)	20 (112)	50 (140)	30 (40)	71	9	20
2	71 (4)	11 (32)	17 (6)	75 (1)	10 (23)	15 (18)	74	8	18
4*	65 (19)	25 (91)	10 (20)	80 (2)	10 (6)	10 (20)	78	9	12
5	58 (44)	21 (35)	21 (44)	10 (115)	40 (29)	50 (42)	37	30	33
6	56 (49)	22 (142)	22 (129)	48 (63)	4 (0)	48 (163)	91	4	5
7*	50 (43)	27 (180)	23 (10)	65 (18)	15 (166)	20 (5)	78	1	21
MEAN % DIF	**33**	**96**	**41**	**52**	**61**	**48**			

* Sets where ROV operations were conducted

SUMMARY OF RESULTS

- Catch prediction experiments require rigorous logistics and validation
- The sorting of landings by species and size classes, by cannery workers, at Starkist facility, Manta, Ecuador, were verified to be highly accurate
- The overall percent differences between the Captain's predicted and actual catches, by species, indicate some were fairly accurate
- The overall percent differences between the Scientist's predicted and actual catches, as a proportion of the catch, were no better than that of the Captain's
- If the bigeye and yellowfin predicted catches are combined, and compared to the actual catches, then the accuracy in estimates is slightly improved
- Additional catch prediction experiments, in areas with higher proportions of bigeye present within tuna aggregations, is probably warranted

Acknowledgements

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