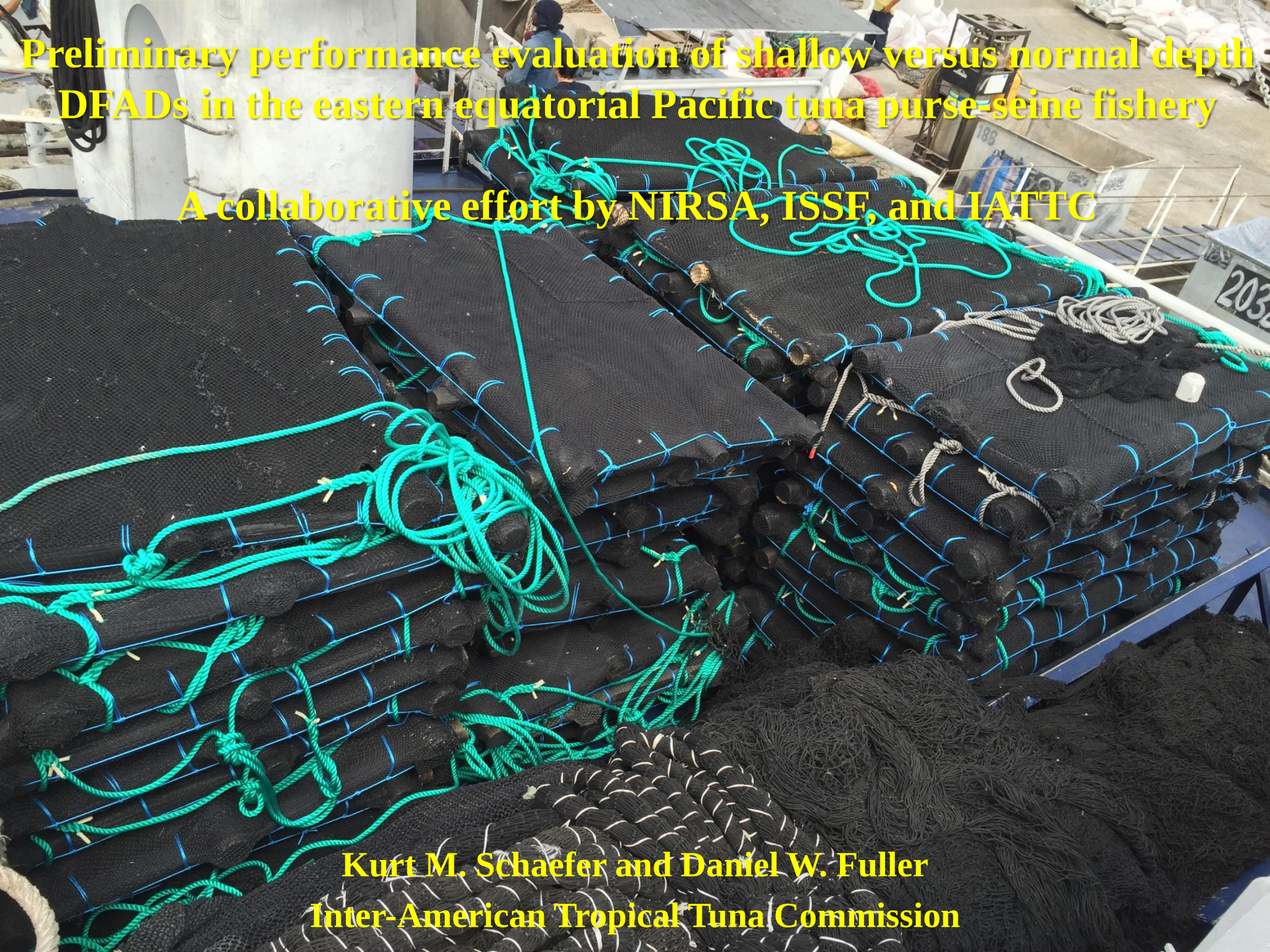
Preliminary performance evaluation of shallow versus normal depth DFADs in the eastern equatorial Pacific tuna purse-seine fishery

A collaborative effort by NIRSA, ISSF, and IATTC



Kurt M. Schaefer and Daniel W. Fuller
Inter-American Tropical Tuna Commission

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- Recent studies have been conducted to evaluate factors contributing to catches of BET by PS vessels in the Pacific, including investigations of spatio-temporal distribution of catch and effort (Sibert et al., 2012, 2015; Harley, 2015; Schaefer, 2015), fishing gear configurations (PS net and DFAD depths) (Lennert-Cody et al. 2007; Satoh et al., 2008; Delgado et al., 2010), as well as fine-scale behavior of BET relative to skipjack (SKJ) and yellowfin (YFT) tunas around DFADs (Schaefer and Fuller, 2005; 2013; Matsumoto et al., 2006); each attempting to reveal practical solutions for reducing BET fishing mortality.

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- Although large dynamic time-area closures in the Pacific may be effective at reducing BET fishing mortality, such measures would significantly reduce SKJ catch due to overlapping high catch areas. Also, it does not appear that reducing PS net depth is a viable solution because of the required minimum PS net depth to catch SKJ and the small differences in depth between SKJ and BET when associated with DFADs. The study by Satoh et al. (2008) reported that DFAD depth in the WCPO was not a significant factor in their general linear models (GLMs) as to BET catch, but area/time was significant. However, Lennert-Cody et al (2007) reported that DFAD depth in the EPO was a significant factor in their random forest model (RFM) as to BET catch, as were area/time effects.

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- The objective of this field experiment is to evaluate the performance of shallow versus normal depth DFADs in the EPO PS fishery, with an emphasis on the tuna species catch composition; seeking a practical solution to reduce purse-seine fishing mortality on BET

MATERIALS AND METHODS

- ISSF made arrangements for the field experiment to be undertaken in collaboration with Negocios Industriales Real S.A. (NIRSA), a vertically integrated large diverse seafood company located in Posorja, Ecuador, with a fleet of 11 PS tuna vessels and a large tuna cannery. Shortly before the departure of the fishing trip during which the 100 experimental DFADs were to be deployed, Kurt Schaefer (PI; IATTC senior scientist) spent a few days at the NIRSA facility to examine and confirm the construction specifications of the 100 DFADs and discuss the experimental design with the fleet manager and his assistant, the Captain of the FV Milena A, and the IATTC scientific observer assigned to that trip.


NIRSA
POLITICA DE SEGURIDAD
NIRSA
ES COMPROMISO DE NUESTRA ORGANIZACION EL CUMPLIMIENTO DE
ESTANDARES DE SEGURIDAD QUE PREVENGAN Y CONTROLEN QUE
ACCIONISTAS EMPLEADOS PROVEEDORES CLIENTES Y VISITANTES
SEAN INVOLUCRADOS EN ACTIVIDADES ILICITAS COMO EL
NARCOTRAFICO Y EL TERRORISMO POR LO QUE DEMOSTRAREMOS
PRODUCTOS Y PERSONAS.
10
VELOCIDAD MAXIMA

MATERIALS AND METHODS

- The rafts for the 50 shallow and 50 normal depth DFADs were all similar dimensions (1.2 x 2 m and1.5 x 2.3 m) and construction materials, consisting of dried bamboo tied together with nylon twine, covered with Saran black shade cloth, and then wrapped tightly with 30mm sardine netting. 6 PS floats were tied beneath each raft under the shade cloth, and plastic bait containers with either fish or pig parts included were tied underneath all DFADs at the time of deployments.


ING.
LEONARDO
AGUIRRE

MATERIALS AND METHODS

- The appendages hung beneath the normal depth DFADs were approximately 37 m, and consisted of 2 coils of twisted and tied scrap tuna or sardine netting weighted with chain.

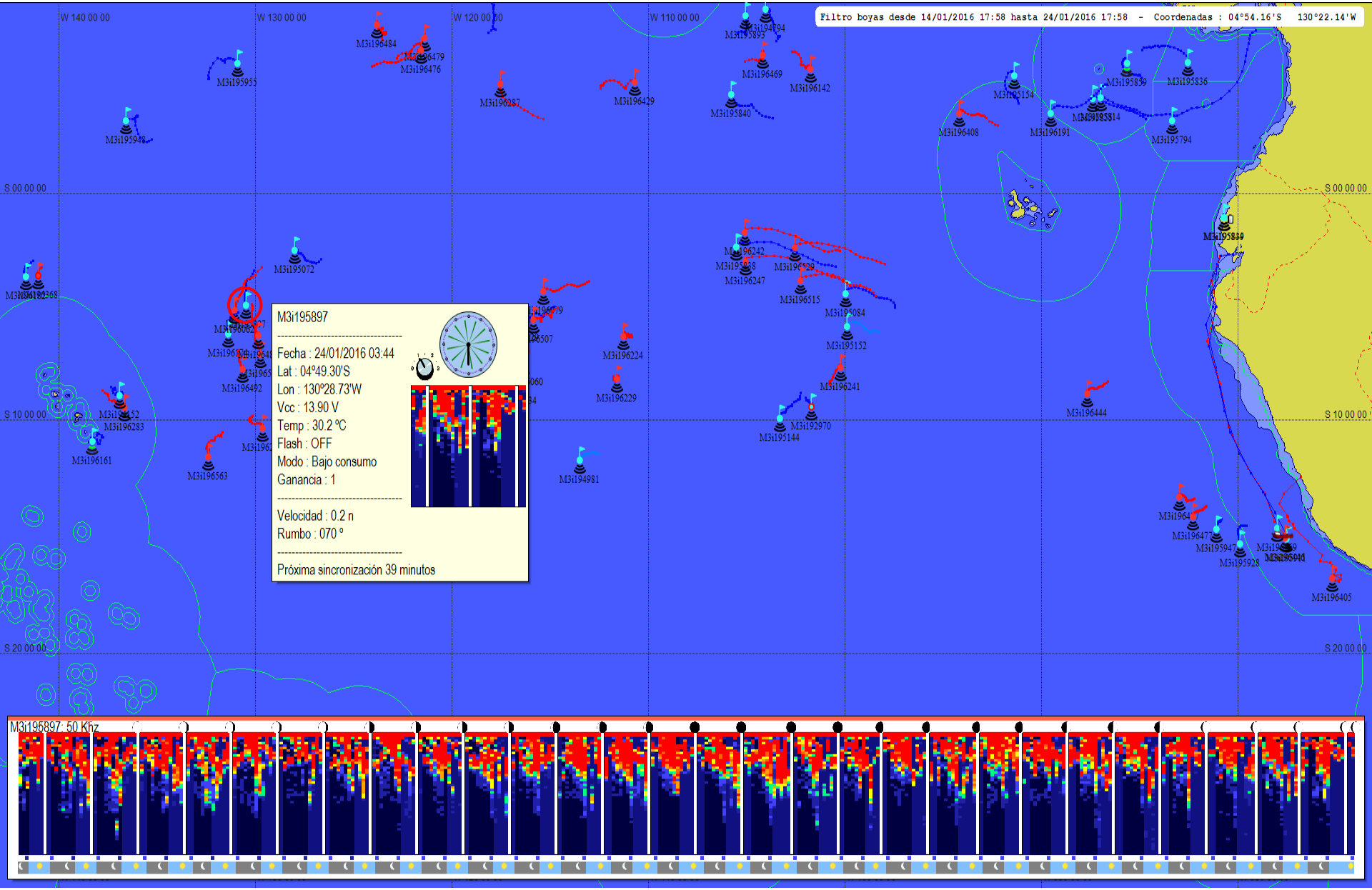
MATERIALS AND METHODS

- The appendages hung beneath the shallow depth DFADs were approximately 5 m, and consisted of 4 ropes (1-2” dia) with coconut palm fronds tightly laced, attached to a split bamboo frame weighted with chain.

MATERIALS AND METHODS

- Marine Instruments (MI) M3i echo-sounder buoys (50 kHz, 50 depth intervals 3m/ea, 5 min sampling frequency) were attached to each of the 100 DFADs. 50 of the M3i buoys were purchased with ISSF funding from the FAO/GEF program. Arrangements were made with NIRSA and MI so as to receive the M3i buoy data for the 100 DFADs real time, utilizing the MI software installed on an IATTC computer.


M3i195830
M3i195838
M3i 195903
M3i 195903

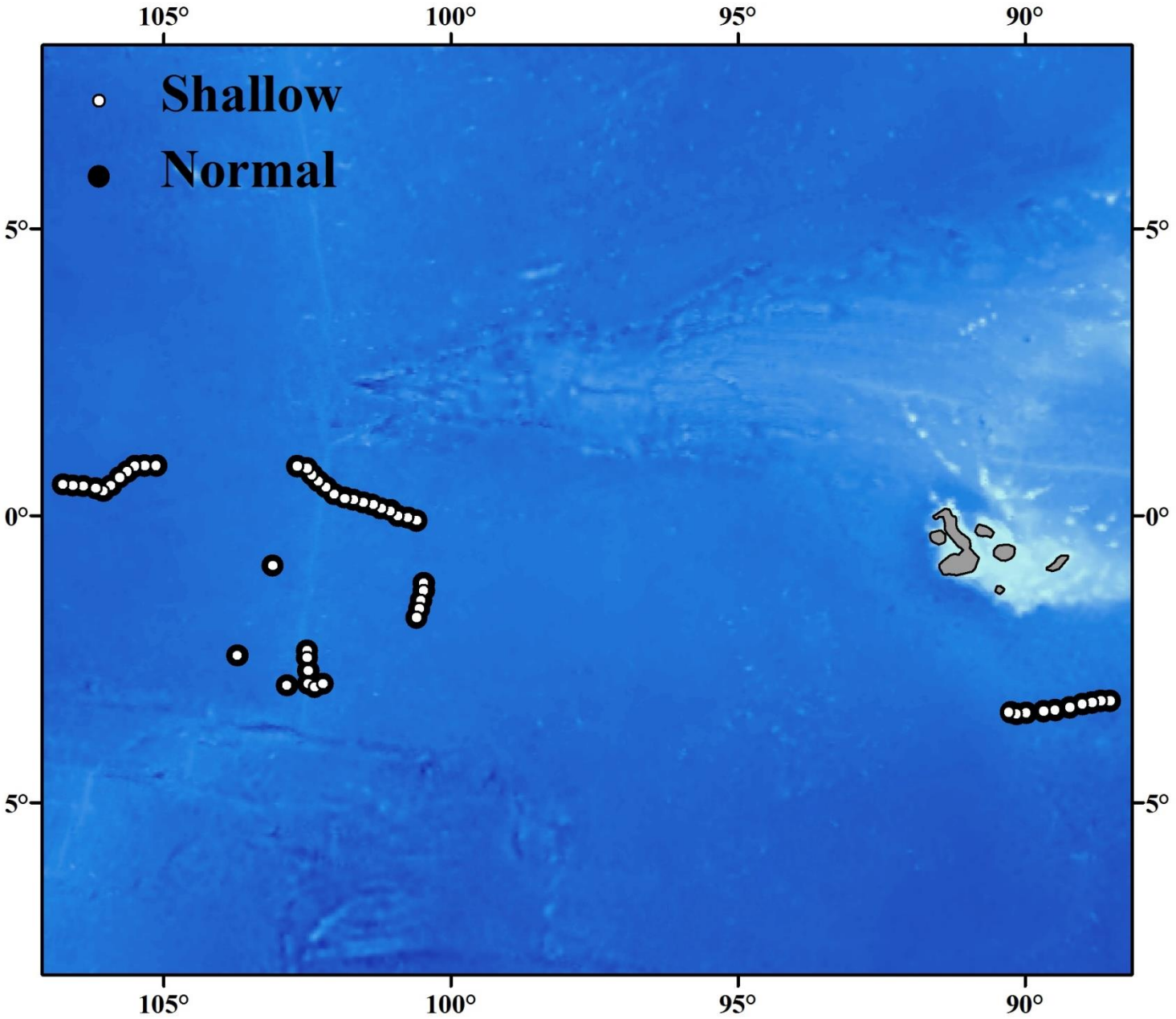

Filtro boyas desde 14/01/2016 17:58 hasta 24/01/2016 17:58 - Coordenadas : 04°54.16'S 130°22.14'W
W 140 00 00
W 130 00 00
W 120 00 00
W 110 00 00
S 00 00 00
S 10 00 00
S 20 00 00
M3i195897
Fecha : 24/01/2016 03:44
Lat : 04°49.30'S
Lon : 130°28.73'W
Vcc : 13.90 V
Temp : 30.2 °C
Flash : OFF
Modo : Bajo consumo
Ganancia : 1
Velocidad : 0.2 n
Rumbo : 070 °
Próxima sincronización 39 minutos
M3i195897: 50 Khz

MATERIALS AND METHODS

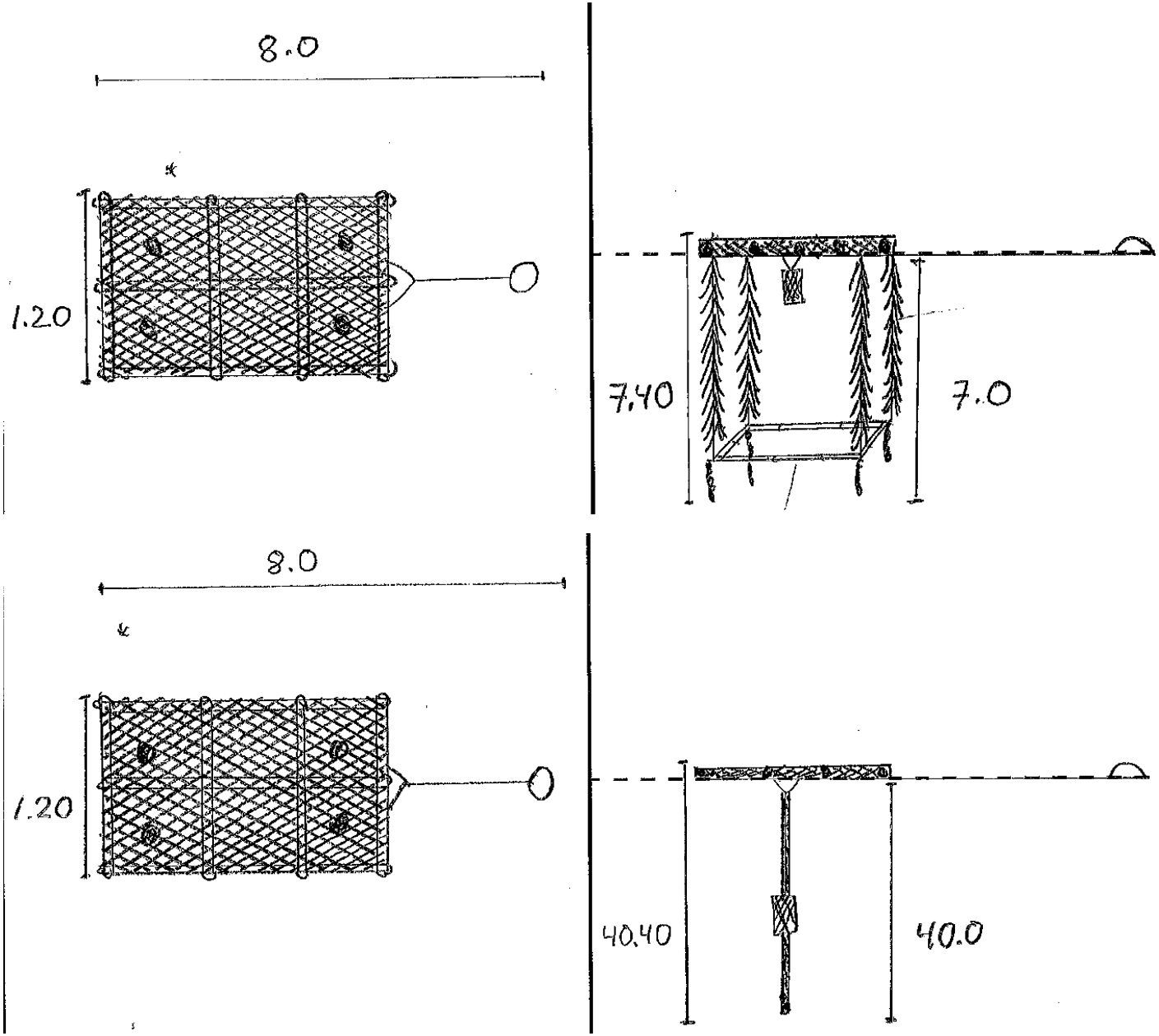
- The normal and shallow depth DFADs were deployed from the NIRSA FV Milena A (62m length, 900 t capacity) simultaneously in pairs along 7 transects between 3°S -1°N and 89°-107°W during 25 June through 20 July, 2015. Each deployment was recorded by the navigator on a data form created specifically for this project which included data fields for DFAD type, deployment position and date, M3i buoy number and the NIRSA ID numbers assigned and painted on each buoy. In addition, the IATTC observer aboard (with 8 years of experience) monitored and recorded each of the deployments so as to independently verify the DFAD types with the buoy ID numbers.


MILENA
MILENA A

Deployment locations for 50 shallow and 50 normal depth DFADs



Observer illustrations of the shallow (top) and normal depth DFADs



50 normal depth (37m) and 50 shallow depth (5m) DFAD deployments with Marine Instruments M3i echo-sounder buoys by the FV Milena A. Drift speeds, durations until set, and status also provided

M3i Number	Deploy Date	FAD Type	Latitude	Longitude	Avg. Speed 1st 60d (kn)	Days Until Set	Still Active (Y/N)
M3I196133	06/25/15	Normal	03º13'S	88º31'W	0.6		Y
M3I195058	06/25/15	Shallow	03º13'S	88º31'W	0.5		Y
M3I196234	06/25/15	Normal	03º13'S	88º41'W	0.7		Y
M3I195087	06/25/15	Shallow	03º13'S	88º41'W	0.6		N
M3I196062	06/25/15	Normal	03º15'S	88º50'W	0.4		Y
M3I195152	06/25/15	Shallow	03º15'S	88º50'W	0.6	132	Y
M3I196207	06/25/15	Normal	03º17'S	89º00'W	0.6		Y
M3I194930	06/25/15	Shallow	03º17'S	89º00'W	0.6		N
M3I196142	06/25/15	Normal	03º20'S	89º13'W	0.6	136	Y
M3I194981	06/25/15	Shallow	03º20'S	89º13'W	0.6		Y
M3I196229	06/25/15	Normal	03º23'S	89º29'W	0.5		Y
M3I195084	06/25/15	Shallow	03º23'S	89º29'W	0.5	126	Y
M3I196241	06/25/15	Normal	03º24'S	89º41'W	0.4	110	Y
M3I195144	06/25/15	Shallow	03º24'S	89º41'W	0.5	132	Y
M3I196060	06/25/15	Normal	03º26'S	89º59'W	0.5		Y
M3I192970	06/25/15	Shallow	03º26'S	89º59'W	0.6		Y
M3I196079	06/25/15	Normal	03º27'S	90º09'W	0.5		Y
M3I194794	06/25/15	Shallow	03º27'S	90º09'W	0.5	138	Y
M3I196224	06/25/15	Normal	03º25'S	90º17'W	0.4		Y
M3I195072	06/25/15	Shallow	03º25'S	90º17'W	0.6		Y
M3I195146	06/29/15	Shallow	00º05'S	100º36'W	0.9		N
M3I196242	06/29/15	Normal	00º05'S	100º36'W	0.8		Y
M3I194152	06/29/15	Shallow	00º02'S	100º45'W	0.8		Y
M3I196247	06/29/15	Normal	00º02'S	100º45'W	0.7	89	Y
M3I195158	06/29/15	Shallow	00º00'N	100º55'W	0.8		N
M3I196283	06/29/15	Normal	00º00'S	100º55'W	0.8		Y
M3I195171	06/29/15	Shallow	00º06'N	101º03'W	0.8		N
M3I196298	06/29/15	Normal	00º06'N	101º03'W	0.8		Y
M3I195638	06/29/15	Shallow	00º08'N	101º12'W	1.1		N
M3I196403	06/29/15	Normal	00º08'N	101º12'W	1.0		Y
M3I195151	06/29/15	Shallow	00º13'N	101º22'W	1.1		N
M3I196243	06/29/15	Normal	00º13'N	101º22'W	0.8		Y
M3I195154	06/29/15	Shallow	00º14'N	101º32'W	0.9		Y
M3I196257	06/29/15	Normal	00º14'N	101º32'W	1.2		Y
M3I195168	06/29/15	Shallow	00º17'N	101º42'W	1.1	81, 10	N
M3I196287	06/29/15	Normal	00º17'N	101º42'W	1.1	111	Y
M3I195794	06/29/15	Shallow	00º19'N	101º51'W	1.0		Y
M3I196404	06/29/15	Normal	00º19'N	101º51'W	1.0		Y
M3I195849	06/29/15	Shallow	00º23'N	102º02'W	1.0		N
M3I196444	06/29/15	Normal	00º23'N	102º02'W	1.0	78	Y
M3I195845	06/29/15	Shallow	00º30'N	102º10'W	1.0		N
M3I196431	06/29/15	Normal	00º30'N	102º10'W	0.9	82	N
M3I195844	06/29/15	Shallow	00º36'N	102º18'W	1.0	76	Y
M3I196429	06/29/15	Normal	00º36'N	102º18'W	0.9		Y
M3I195840	06/29/15	Shallow	00º43'N	102º25'W	0.9		Y
M3I196417	06/29/15	Normal	00º43'N	102º25'W	1.0	109	N
M3I195839	06/29/15	Shallow	00º50'N	102º30'W	0.9		N
M3I196414	06/29/15	Normal	00º50'N	102º30'W	1.0		N
M3I195838	06/29/15	Shallow	00º52'N	102º40'W	0.8	136	Y
M3I196412	06/29/15	Normal	00º52'N	102º40'W	0.9		N

50 normal depth (37m) and 50 shallow depth (5m) DFAD deployments with Marine Instruments M3i echo-sounder buoys by the FV Milena A. Drift speeds, durations until set, and status also provided

M3i Number	Deploy Date	FAD Type	Latitude	Longitude	Avg. Speed 1st 60d (kn)	Days Until Set	Still Active (Y/N)
M3I195838	06/29/15	Shallow	00º52'N	102º40'W	0.8	136	Y
M3I196412	06/29/15	Normal	00º52'N	102º40'W	0.9		N
M3I195814	06/30/15	Shallow	00º53'N	105º08'W	0.9		Y
M3I196405	06/30/15	Normal	00º53'N	105º08'W	1.0	101	Y
M3I195829	06/30/15	Shallow	00º53'N	105º20'W	0.9		Y
M3I196408	06/30/15	Normal	00º53'N	105º20'W	0.9		Y
M3I195830	06/30/15	Shallow	00º52'N	105º30'W	0.9		N
M3I196410	06/30/15	Normal	00º52'N	105º30'W	0.9		N
M3I195836	06/30/15	Shallow	00º46'N	105º38'W	0.9		Y
M3I196411	06/30/15	Normal	00º46'N	105º38'W	0.9		N
M3I195855	06/30/15	Shallow	00º40'N	105º46'W	0.8		Y
M3I196446	06/30/15	Normal	00º40'N	105º46'W	0.8		N
M3I195856	06/30/15	Shallow	00º32'N	105º55'W	0.9		Y
M3I196450	06/30/15	Normal	00º32'N	105º55'W	1.0		Y
M3I195859	06/30/15	Shallow	00º25'N	106º04'W	0.9		Y
M3I196469	06/30/15	Normal	00º25'N	106º05'W	0.8		Y
M3I195893	06/30/15	Shallow	00º29'N	106º11'W	1.0		Y
M3I196476	06/30/15	Normal	00º29'N	106º11'W	1.1		Y
M3I195899	06/30/15	Shallow	00º31'N	106º24'W	0.8		N
M3I196479	06/30/15	Normal	00º31'N	106º24'W	1.1		Y
M3I195903	06/30/15	Shallow	00º32'N	106º35'W	1.1		N
M3I196484	06/30/15	Normal	00º32'N	106º35'W	1.1		Y
M3I195911	06/30/15	Shallow	00º33'N	106º45'W	0.8		Y
M3I196487	06/30/15	Normal	00º33'N	106º45'W	1.1		Y
M3I196578	07/08/15	Normal	01º10'S	100º28'W	0.8		N
M3I196191	07/08/15	Shallow	01º10'S	100º28'W	1.0		Y
M3I196576	07/08/15	Normal	01º18'S	100º28'W	0.6	127	N
M3I196183	07/08/15	Shallow	01º18'S	100º28'W	0.7	30	Y
M3I196575	07/08/15	Normal	01º28'S	100º31'W	0.6	75	Y
M3I196182	07/08/15	Shallow	01º28'S	100º31'W	0.6		Y
M3I196368	07/08/15	Normal	01º37'S	100º33'W	0.6		Y
M3I195176	07/08/15	Shallow	01º37'S	100º33'W	0.6	13, 69	N
M3I196488	07/08/15	Normal	01º46'S	100º36'W	0.7		Y
M3I195915	07/08/15	Shallow	01º46'S	100º36'W	0.8	11	N
M3I196565	07/09/15	Normal	02º21'S	102º30'W	0.6		Y
M3I196174	07/09/15	Shallow	02º21'S	102º30'W	0.6		Y
M3I196563	07/09/15	Normal	02º28'S	102º30'W	0.9	8	Y
M3I196169	07/09/15	Shallow	02º28'S	102º30'W	0.9		N
M3I196536	07/09/15	Normal	02º42'S	102º29'W	0.9	102	N
M3I196161	07/09/15	Shallow	02º42'S	102º29'W	0.8		Y
M3I196529	07/09/15	Normal	02º56'S	102º29'W	0.8		Y
M3I196007	07/09/15	Shallow	02º56'S	102º29'W	0.8	89	N
M3I196515	07/09/15	Normal	02º59'S	102º22'W	1.0	82	Y
M3I195955	07/09/15	Shallow	02º59'S	102º22'W	1.0		Y
M3I196507	07/09/15	Normal	02º56'S	102º14'W	0.9		Y
M3I195948	07/09/15	Shallow	02º56'S	102º14'W	0.8		Y
M3I196504	07/10/15	Normal	02º57'S	102º51'W	0.8		N
M3I195947	07/10/15	Shallow	02º57'S	102º51'W	0.9	100	Y
M3I196477	07/18/15	Normal	02º28'S	103º43'W	0.7		Y
M3I195897	07/18/15	Shallow	02º27'S	103º43'W	0.6	60, 90	Y
M3I196492	07/20/15	Normal	00º52'S	103º06'W	0.7	63	Y
M3I195928	07/20/15	Shallow	00º53'S	103º05'W	0.7		Y

MATERIALS AND METHODS

- The deployment and fishing activity forms, also created at IATTC for this project, were provided to all 11 NIRSA PS vessels and the captains were instructed to complete when conducting any activities around the 100 experimental DFADs, including setting, checking, recovering and/or relocating DFADs.

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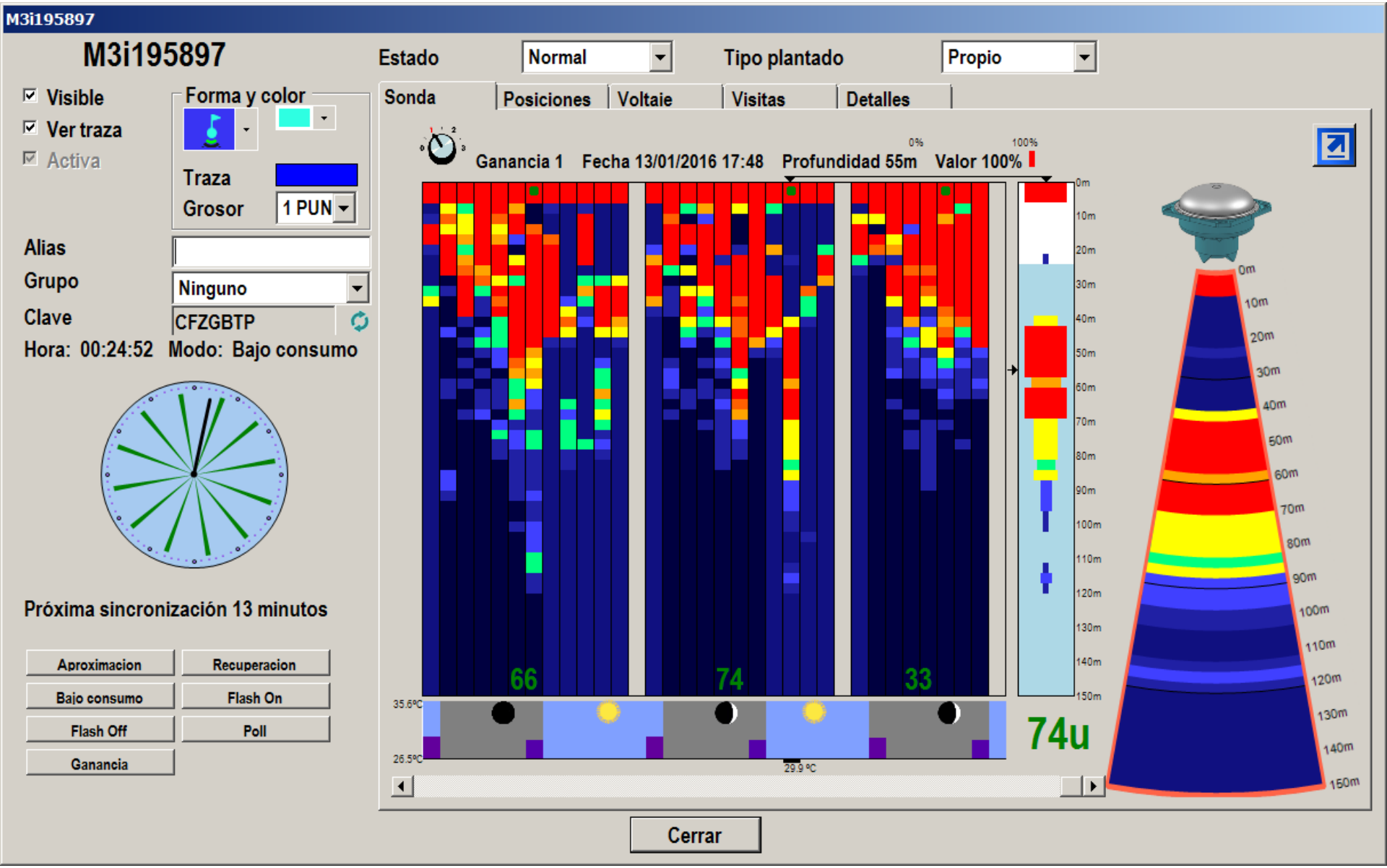
- The echo-sounder data from the M3i buoys, which is being saved on a computer hard drive at IATTC, is both graphical and numerical. A relative value (U) is provided as an estimation of total tuna abundance for each detection and for the highest value per day. In the raw data export format, there is a 0 to 7 value for each of the 50 layers (of 3 meter each), which we are planning to utilize in evaluating whether it is useful for estimation of tuna species catch composition.

Individual M3i echo-sounder buoy (50 KHz) display for a shallow depth DFAD with an associated aggregation

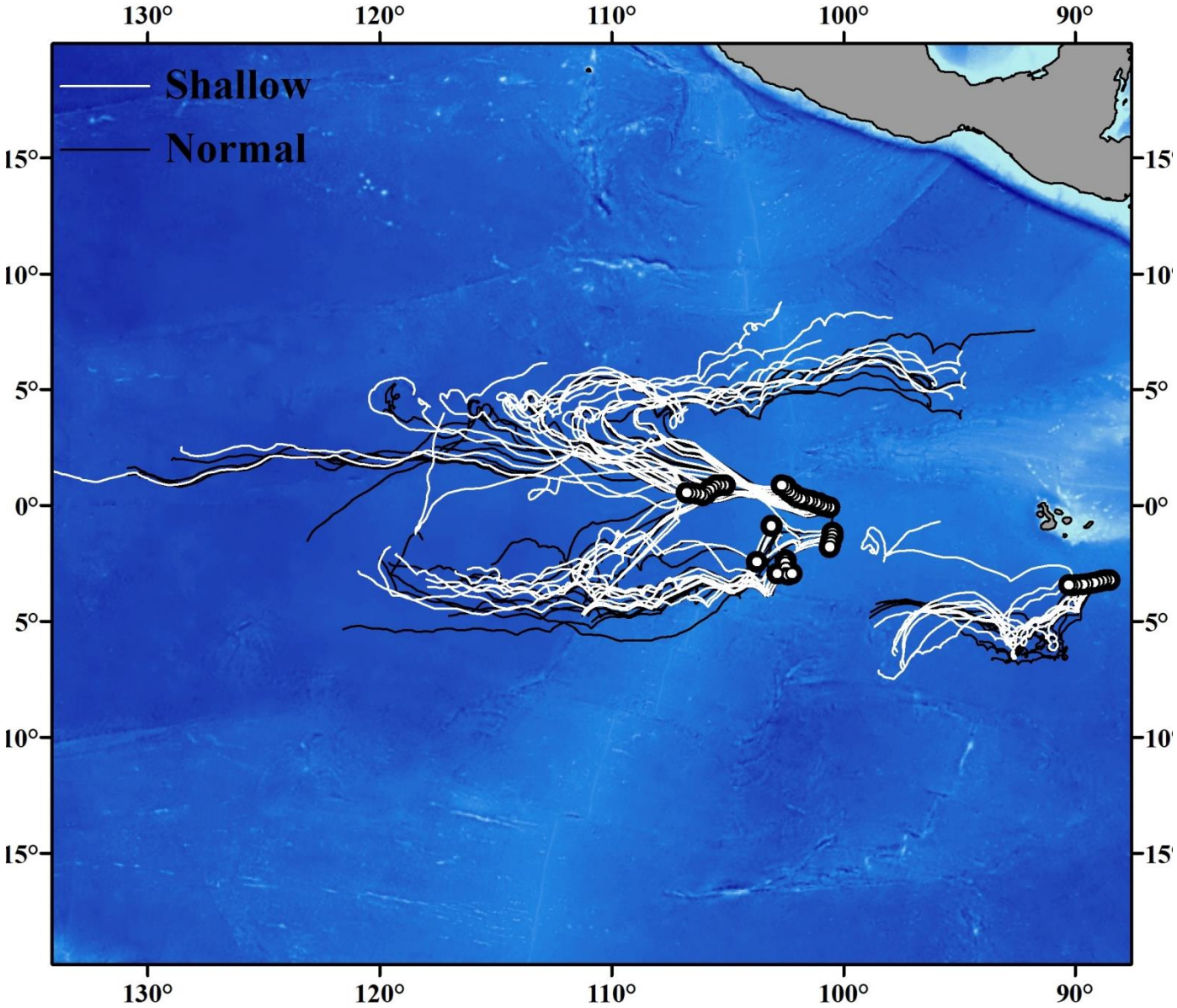


MATERIALS AND METHODS

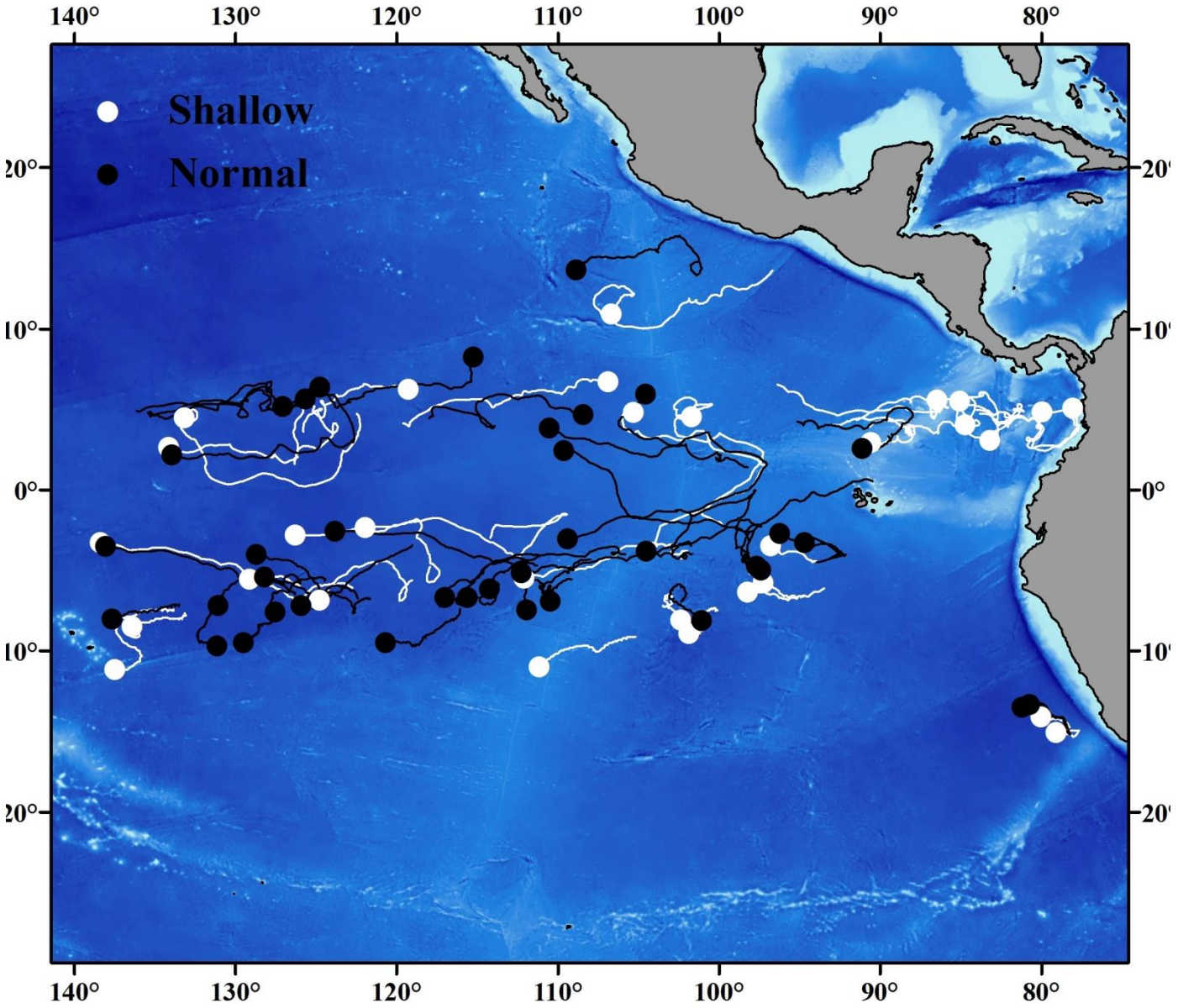
- We expect to continue this experiment for several more months, in order to attempt to obtain catch data from about 50 sets on each DFAD type. The catch information collected thus far from this experiment is inadequate for conducting valid statistical analyses, utilizing a general linear model (GLM) or another appropriate model, to evaluate whether DFAD depth is a significant variable with respect to BET catch composition.

PRELIMINARY RESULTS

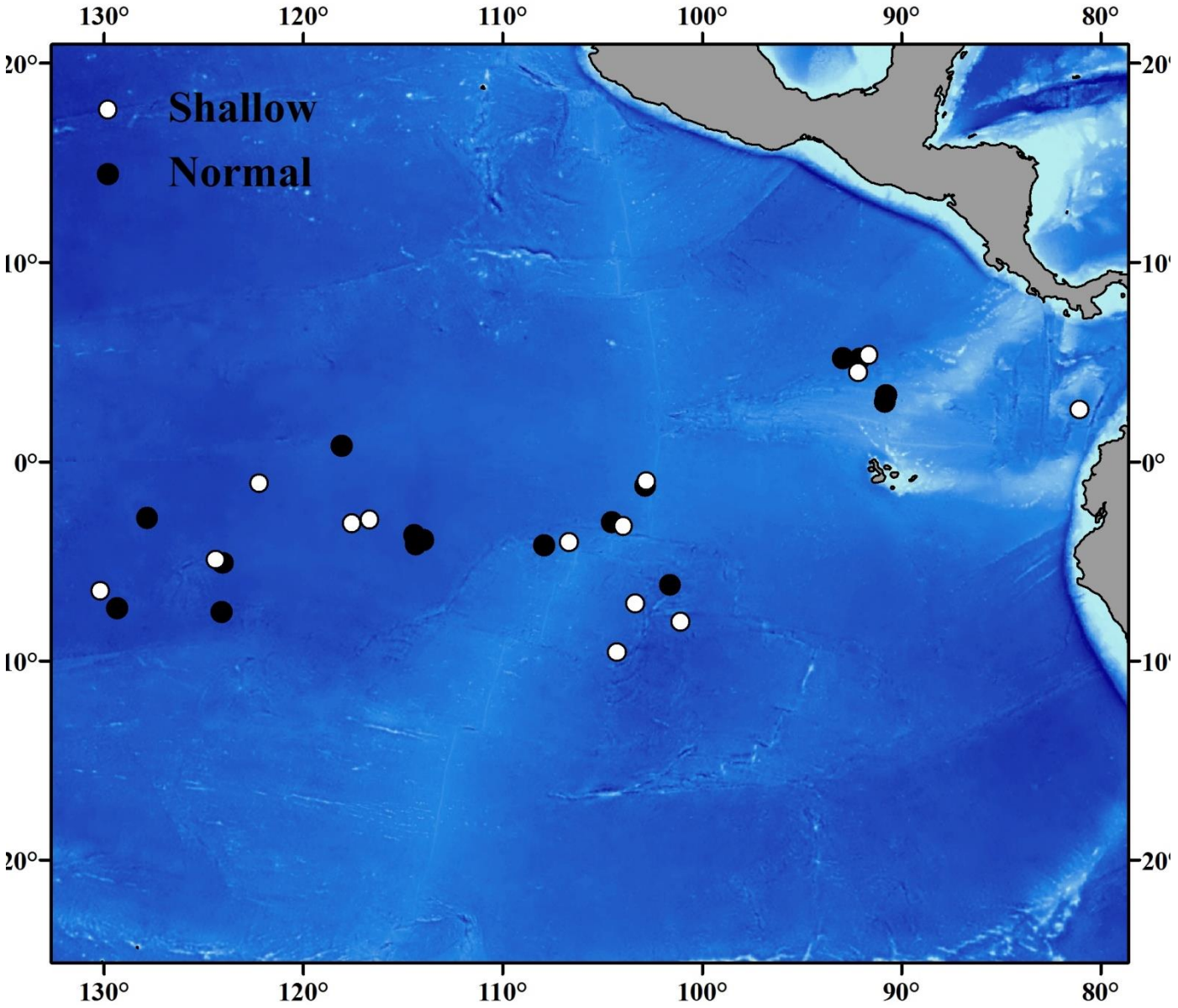
Deployment locations and drift trajectories during the first 60d for 50 normal and 50 shallow depth DFADs



Current Locations and drift trajectories during the previous 60d for 39 normal and 32 shallow depth DFADs



Set locations on 16 normal and 14 shallow depth DFADs



Tuna catch and M3i echo-sounder data for sets on 16 normal and 14 shallow depth DFADs by seven NIRSA vessels

			Set Information			Catch Information				M3i Echo-sounder buoy data		
											Numerical Data in 3m bins (0 – 150 m)	
M3i Number	FAD depth	Vessel	Date Time	Lat	Lon	SKJ	BET	YFT	Proportion BET	U value	Total	Proportion >30m
196563	Normal	Milena A.	7/16/15 6:15	3.03 S	104.53 W	6	5	0	0.45	19	69	0.42
196488	Normal	Milena A.	7/20/15 6:00	1.22 S	102.85 W	5	2	1	0.25	11	61	0.13
196444	Normal	Rafa	9/14/15 6:05	5.18 S	92.08 W	3	0	1	0.00	23	97	0.36
196488	Normal	Milena A.	9/14/15 13:49	4.12 S	114.35 W	3	5	0	0.63	13	76	0.28
196431	Normal	Rafa	9/18/15 10:25	5.22 N	92.93 W	2	0	1	0.00	20	84	0.35
196575	Normal	Milena A.	9/20/15 7:31	3.90 S	113.97 W	11	21	0	0.66	41	99	0.65
196492	Normal	Milena A.	9/20/15 13:31	3.68 S	114.43 W	0	0	0	0.00	47	104	0.63
196247	Normal	Milena A.	9/25/15 12:22	5.08 S	124.06 W	4	5	1	0.50	45	115	0.45
196515	Normal	Milena A.	9/28/15 6:17	0.80 N	118.08 W	14	13	3	0.43	31	53	0.36
196405	Normal	Milagros A	10/8/15 5:50	2.80 S	127.82 W	10	38	0	0.79	34	80	0.64
196241	Normal	Rosa F	10/13/15 5:21	6.17 S	101.6 W	5	0	0	0.00	1	32	0.00
196417	Normal	Roberto A	10/15/15 5:16	3.00 N	90.82 W	20	0	7	0.00	32	100	0.43
196287	Normal	Roberto A	10/17/15 10:17	3.35 N	90.77 W	1	0	0	0.00	7	25	0.59
196536	Normal	Milagros A	10/18/15 15:20	7.35 S	129.35 W	0	0	0	0.00	33	88	0.40
196142	Normal	Milena A.	11/8/15 5:25	4.17 S	107.92 W	16	2	0	0.11	28	98	0.35
196576	Normal	Drennec	11/11/15 6:15	7.54 S	124.10 W	1	4	0	0.80	12	57	0.42
195915	Shallow	Milena A.	7/19/15 5:55	0.98 S	102.80 W	20	8	3	0.26	11	68	0.21
196183	Shallow	Milena A.	8/6/15 6:37	4.03 S	106.67 W	0	0	0	0.00	6	50	0.12
195844	Shallow	Rafa	9/12/15 10:05	5.37 N	91.65 W	6	0	3	0.00	11	70	0.16
195897	Shallow	Milena A.	9/15/15 7:20	2.90 S	116.68 W	15	9	0	0.38	13	79	0.29
195168	Shallow	Rafa	9/17/15 7:55	4.50 N	92.18 W	3	0	2	0.00	4	26	0.31
195168	Shallow	Rafa	9/27/15	2.62 N	81.08 W	2	0	3	0.00	14	60	0.22
196007	Shallow	Milagros A	10/5/15 5:30	1.08 S	122.22 W	19	35	2	0.63	30	106	0.42
195897	Shallow	Drennec	10/16/15 6:16	3.08 S	117.57 W	3	2	1	0.33	12	61	0.15
195947	Shallow	Milagros A	10/18/15 5:47	6.47 S	130.18 W	13	0	2	0.00	4	56	0.08
195084	Shallow	Rosa F	10/29/15 6:01	9.55 S	104.28 W	1	5	0	0.83	6	28	0.07
195152	Shallow	Rosa F	11/3/15 11:53	8.02 S	101.10 W	0	0	1	0.00	12	75	0.00
195144	Shallow	Elizabeth F	11/4/15 6:11	7.10 S	103.35 W	3	7	0	0.70	13	44	0.25
194794	Shallow	Milena A.	11/9/15 10:05	3.20 S	103.95 W	8	4	0	0.33	15	35	0.14
195838	Shallow	Drennec	11/12/15 6:24	4.92 S	124.40 W	2	0	13	0.00	18	45	0.00

Summary of set and catch metrics for 30 sets by seven NIRSA vessels on normal and shallow depth DFADs

	Normal	Shallow
Number of sets	16	14
Range in set dates	7/16/2015 - 11/11/2015	7/19/2015 - 11/12/2015
Range in set locations	7.54 S - 5.22 N	9.55 S - 5.37 N
	90.77 - 129.35 W	81.08 - 130.18 W
Average (range) number of days until set	90.7 (7.5 - 136.5)	80.8 (10.0 - 137.6)
Average (range) SKJ catch (t)	7.2 (1 - 20)	7.3(0 - 20)
Average (range) BET catch (t)	6.8 (0 - 38)	5.4 (0 - 35)
Average (range) YFT catch (t)	1.0 (0 - 7)	2.3 (0 - 13)
Average (range) total tuna catch (t)	15.0 (1 - 48)	15.0 (1 - 56)
Average (range) proportion of BET	0.33 (0 - 0.80)	0.27 (0 - 0.83)
Number DFADs active	39	32

PRELIMINARY RESULTS

- ANOVA indicated there was no significant difference in the average daily drift speeds between the normal depth (0.80 kn; 0.41-1.18) and shallow depth (0.81 kn; 0.45-1.10) DFADs, for the first 60 days following deployments ($F = 0.45$, $P = 0.50$)

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- ANOVA on the proportions transformed to arcsine values indicated there was no significant difference in the proportion of BET caught in successful sets on the normal depth (0.33; 0 - 0.80) and shallow depth (0.27; 0 - 0.83) DFADs ($F = 0.29$, $P = 0.60$)

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- Also, the timing of this experiment is not optimal since it is occurring during anomalous oceanographic conditions, one of the strongest El Nino-Southern Oscillation (ENSO) events in history. This has caused some substantial changes in the physical oceanography of the equatorial EPO, including elevated surface and subsurface water temperatures, substantially deeper mixed layer and thermocline depths, and shifts in current patterns; which can influence BET behavior and habitat utilization.

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- A transition to ENSO-neutral is anticipated by summer 2016. It seems sensible to repeat this experiment, starting in January 2017, if NIRSA is willing to continue this collaboration under a similar agreement as the ongoing experiment. That should substantially increase the number of sets on shallow and normal depth DFADs and enable an appropriate statistical test of the null hypothesis under normal and abnormal oceanographic conditions in the equatorial EPO.