



UCLA

Dive Profiles and Decompression Stress Among Artisanal Fishermen of the Yucantán Peninsula

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Financial Disclosure

- Employment

- Program Director for OxyHeal Health Group

Funding and IRB

➤UCLA Medical IRB-approved

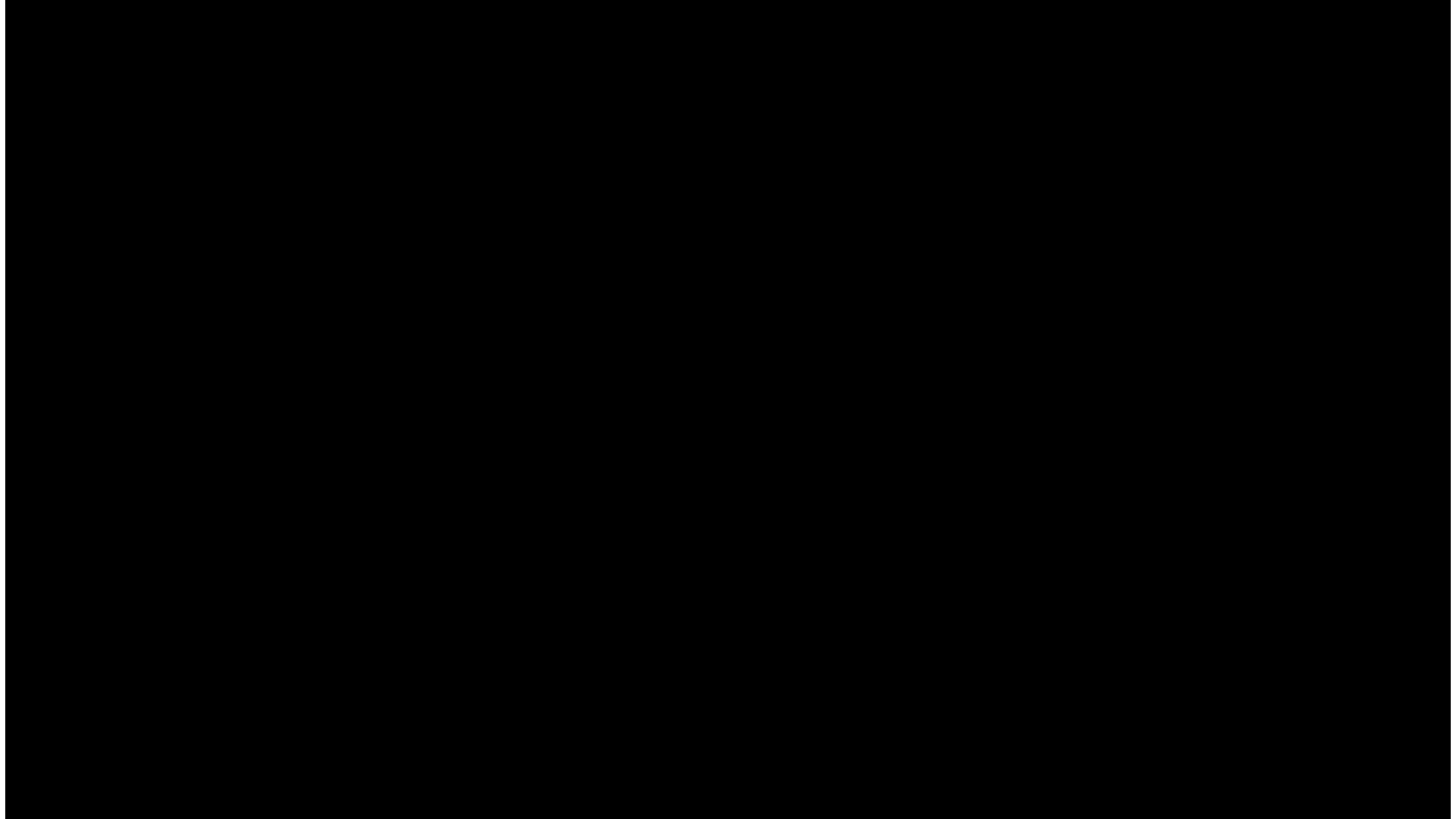
–IRB Number: 13-00532

OxyHeal Health Group



UCSD Center for Diving Excellence

UC San Diego



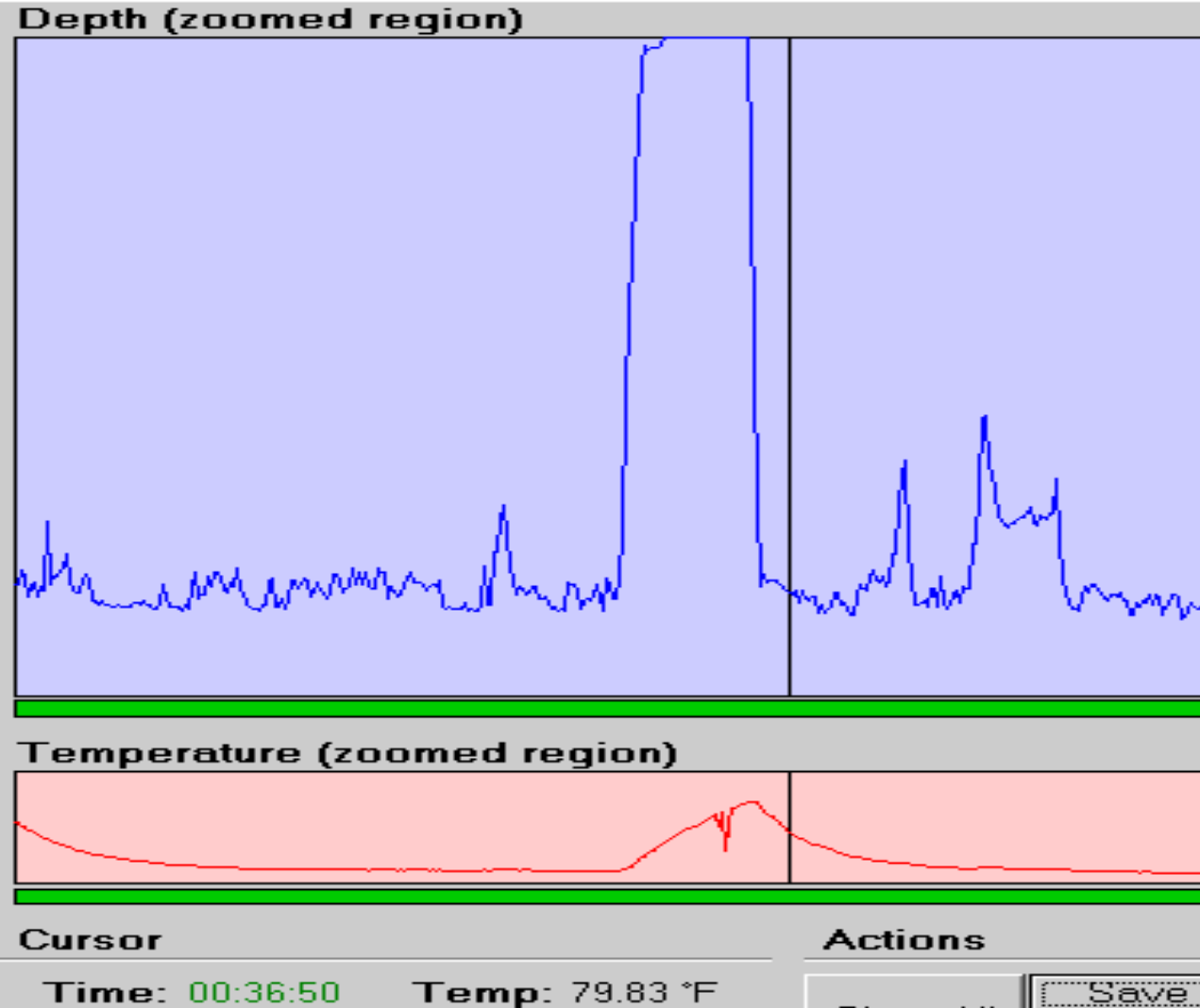
Annual Incidence of DCS

# Fishermen in Yucatan	# Fishermen in Rio Lagartos and San Felipe	# DCS Cases/Year	# Deaths/Year
1,300	200-250	~200	10-15

Source: Huchim et. al. "Diving behavior and fishing performance: the case of lobster artisanal fishermen of the Yucatan coast, Mexico" (2014)



Interval		
10 second(s)		
Time		
05:23:30 B.T.		
00:59:00 B.T.		
>24 hrs S.I.		
Depth		
Avg	27.73 ft	40.68 ft
Max	50.24 ft	48.00 ft
Temperature		
Avg	80.22 °F	78.35 °F
Min	77.47 °F	77.68 °F
Ascent Rate		
67.55 ft/min	64.63 ft/min	
(max)	(max)	
Tank Pressure		
IN:	<input type="text"/>	PSI
OUT:	<input type="text"/>	
SAC Rate		



➤How could we increase our efficiency at managing the data?

➤4 million data Points

➤Input:

Column-

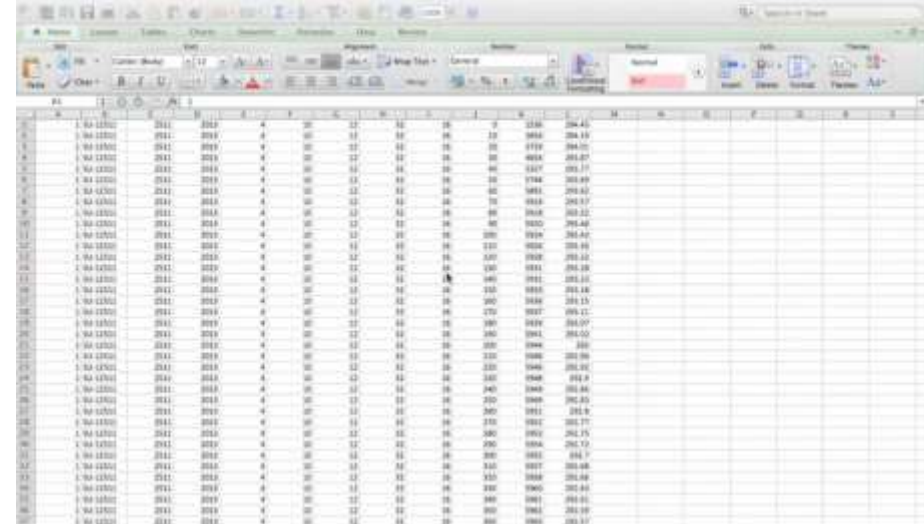
1-3: ID fishermen

4-9: Time stamp in the form of (year, month, days, hour, minute, second)

10: Seconds elapsed during dive profile

11: Pressure (mbar)

12: Data of temperature (Kelvin)



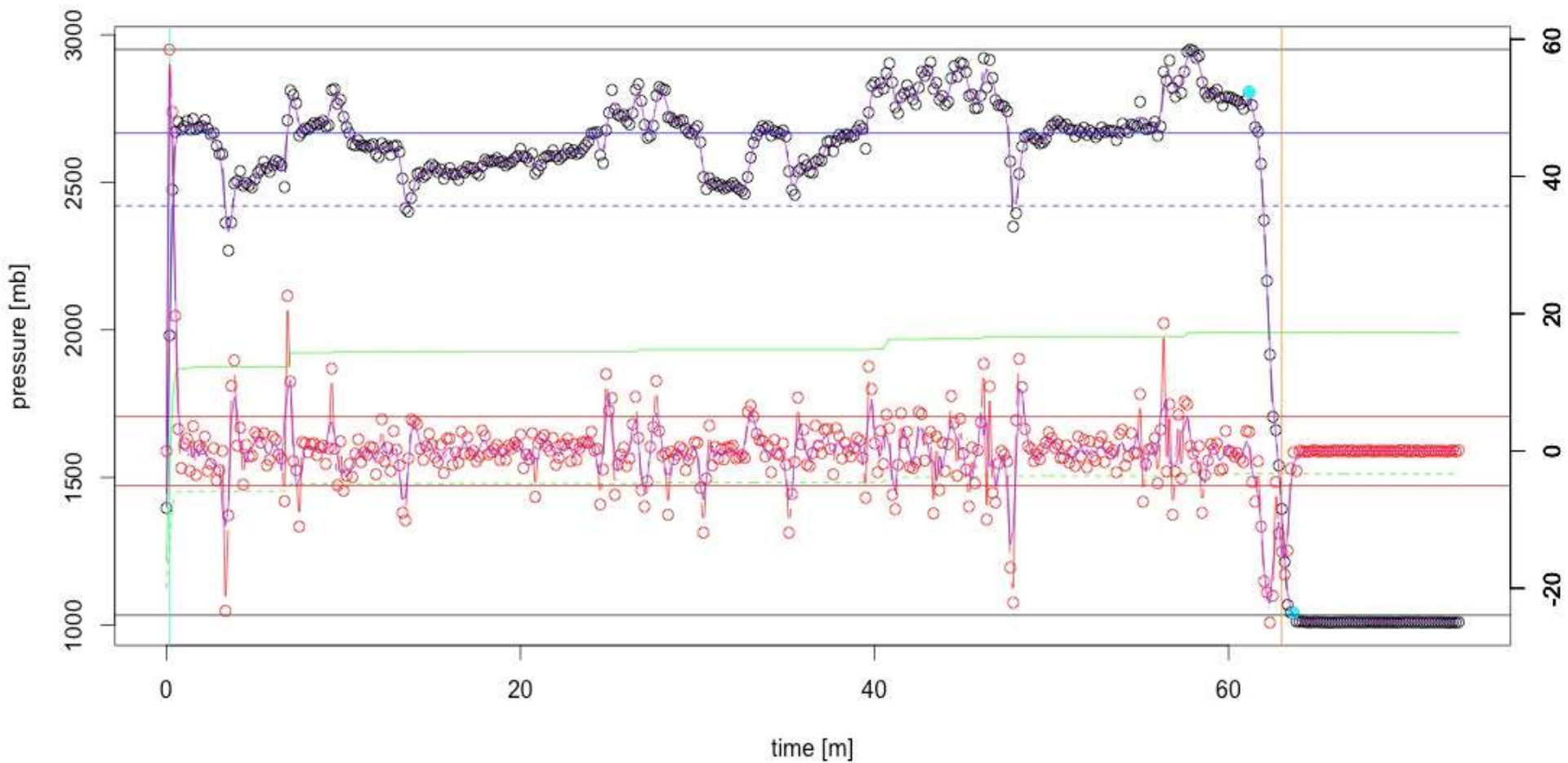
The screenshot shows a Microsoft Excel spreadsheet with a large dataset. The spreadsheet has 12 columns and many rows of data. The columns are labeled as follows: 1. ID fishermen, 2. ID fishermen, 3. ID fishermen, 4. Year, 5. Month, 6. Days, 7. Hour, 8. Minute, 9. Second, 10. Seconds elapsed during dive profile, 11. Pressure (mbar), 12. Data of temperature (Kelvin). The data is organized into groups, with each group starting with a row where the first column contains a value like 1, 2, 3, etc., followed by rows where the first column is blank. The data appears to be a time-series recording of dive profiles for multiple fishermen.

Methods

- Microsoft Visual Basic © was used to extract the following parameters:
 - depth, bottom time (BT), dives, diving days (DD), repetitive dives
- R
- Statistical Analysis: Stata 13.1



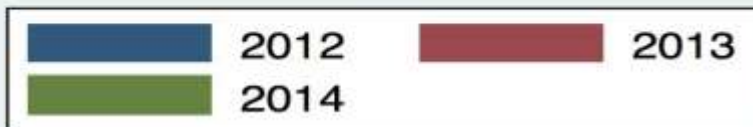
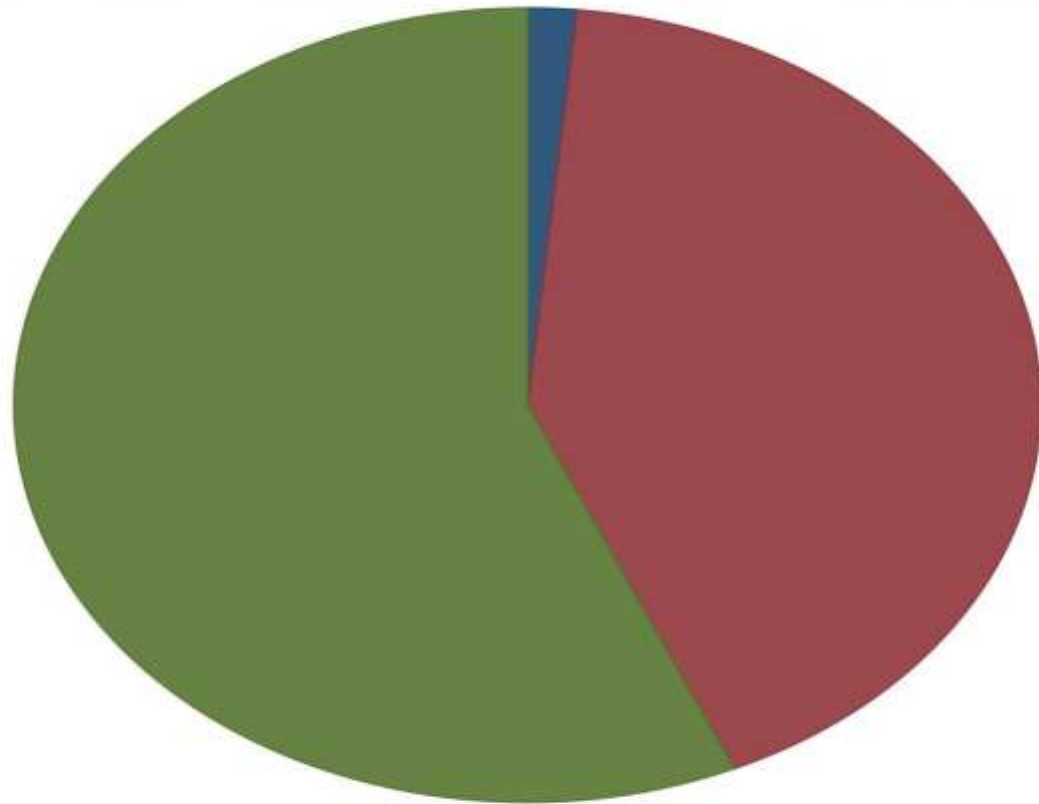
2014-09-20 08:15:15



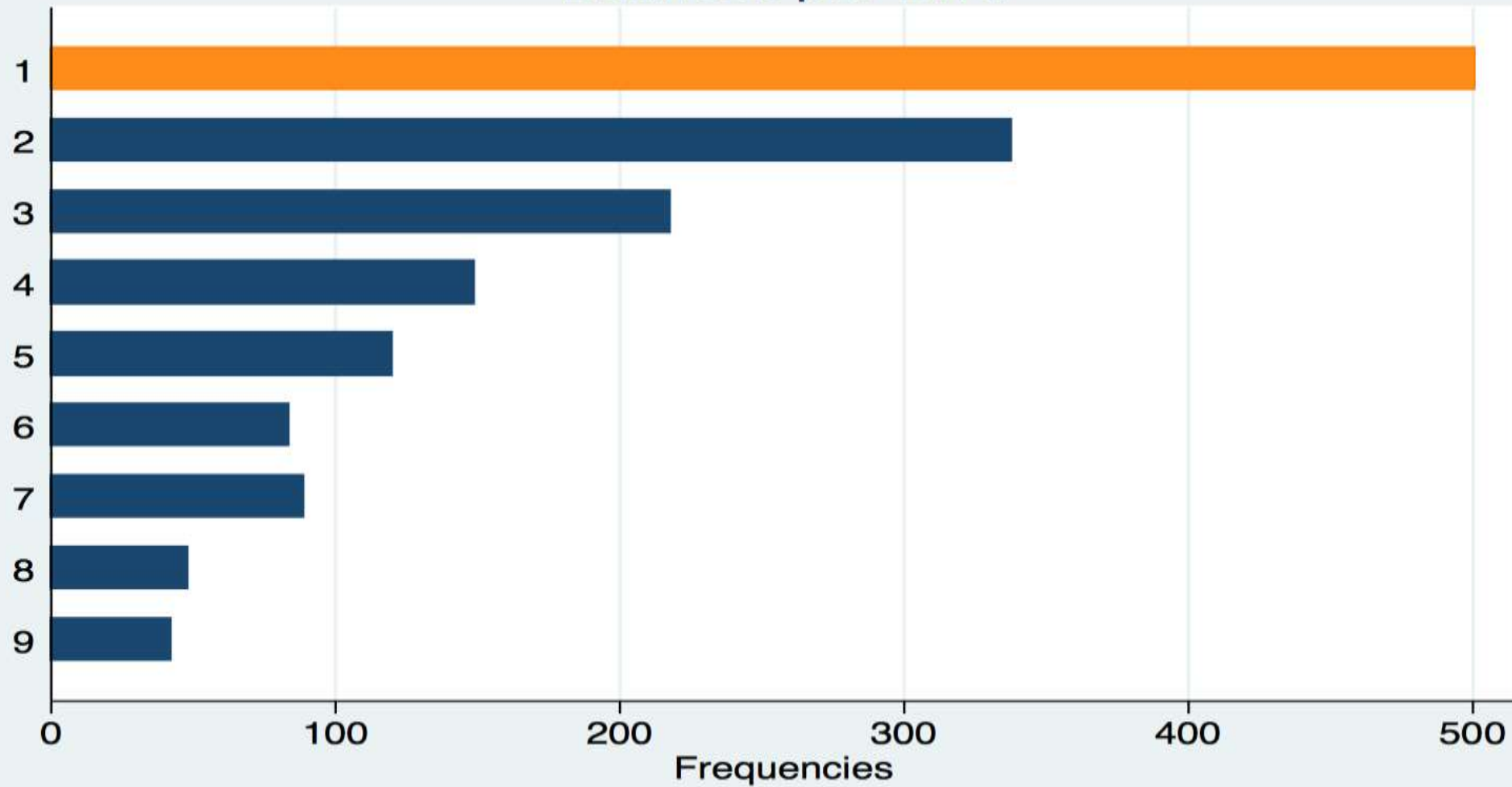
Diving Behavior

Subjects	Dives	Diving Days	Single Dives	Multiple Dives	FSW	BT	Bounces
					Mean	Mean	
SU-10527	404	141	138	266	50.04	94.69	1.83
SU-10779	116	66	60	56	34.37	195.29	3.44
SU-10782	441	153	62	379	42.58	117.98	4.88
SU-11156	46	36	35	11	34	198.77	2.02
SU-11160	339	106	9	330	42.4	110.88	2.73
SU-12511	260	90	9	251	38.41	117.92	3.4
SU-12512	186	105	186	0	29.57	183.36	3.36
SU-12514	366	88	366	0	51.77	73.73	2.32
SU-12515	353	118	353	0	40.63	106.1	3.28
SU-13241	49	15	49	0	37.78	105.67	1.62
TOTAL	2,560	918	1267	1293	42.79	114.86	2.99

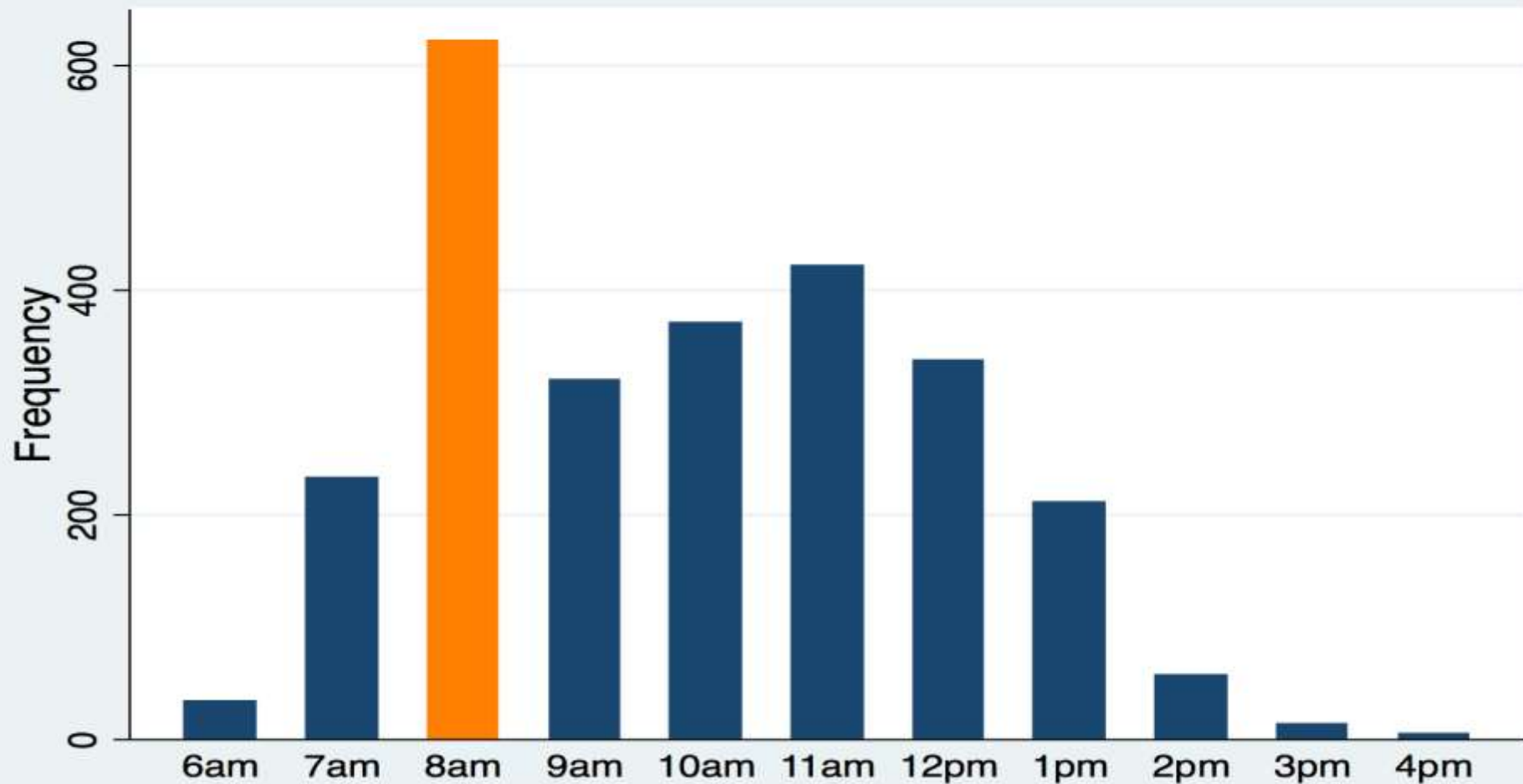
Frequency of Dives by Year (N=2,263)



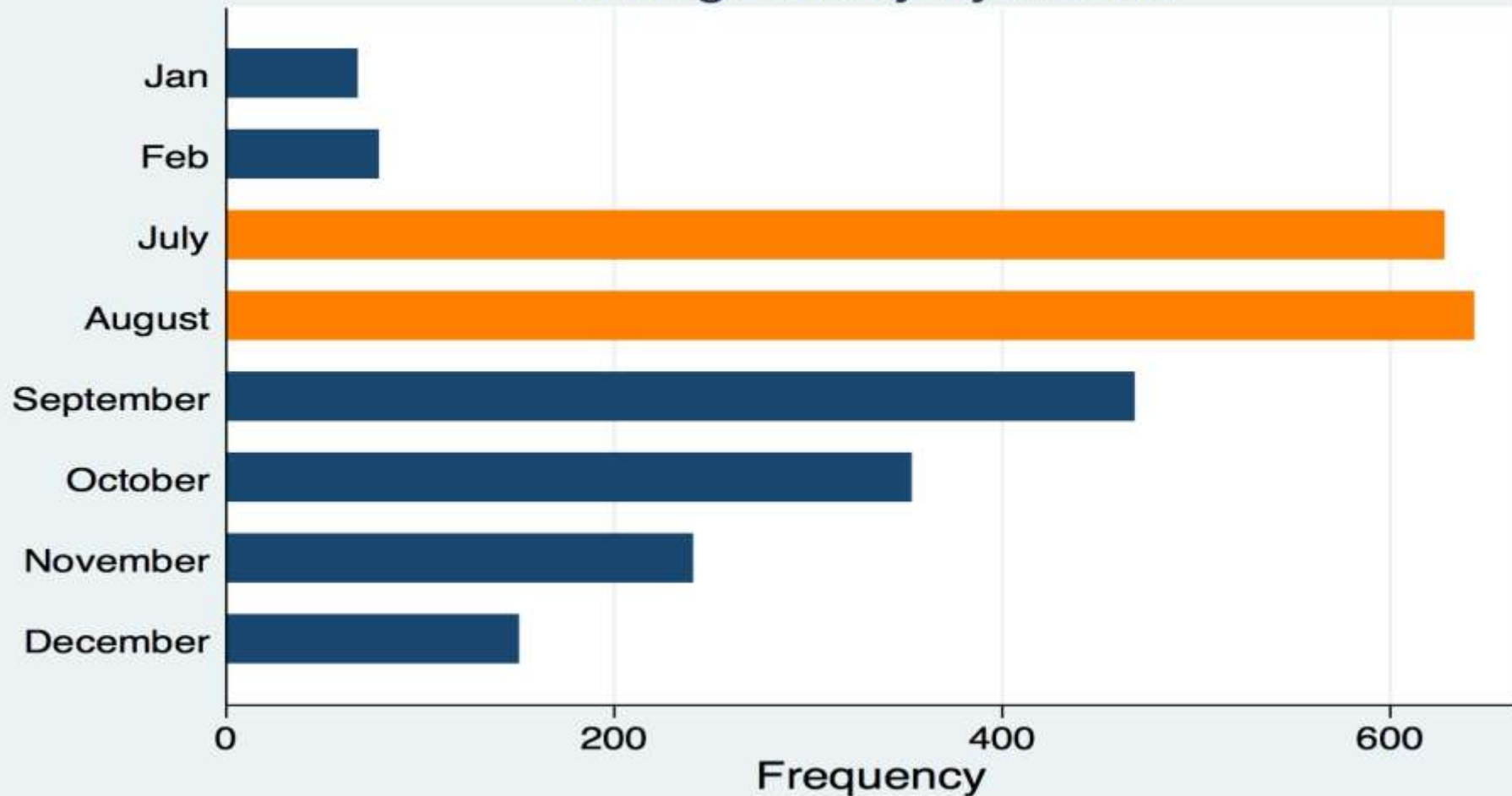
Bounces per Dive



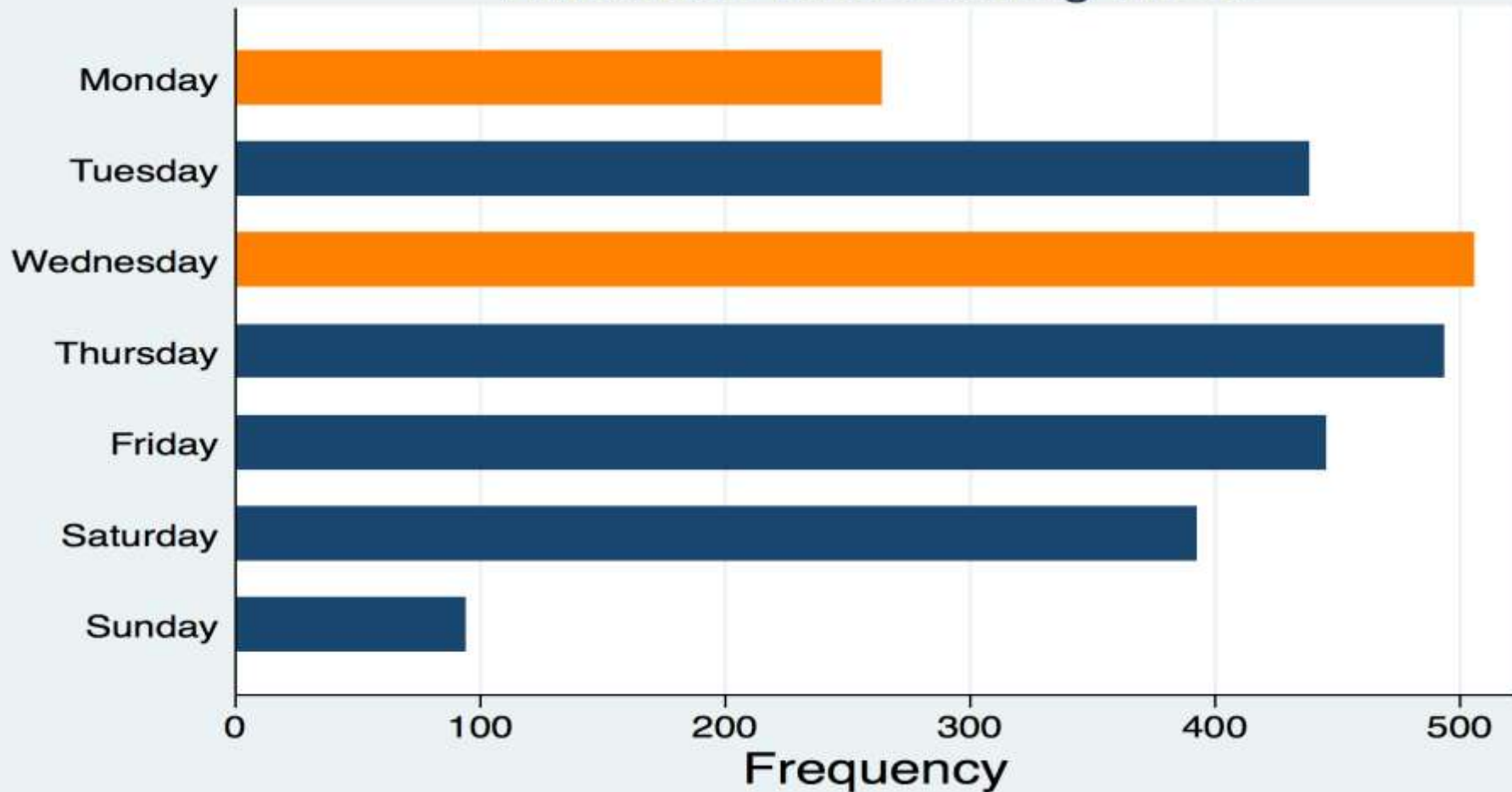
Start Times of Dives



Diving Activity by Month

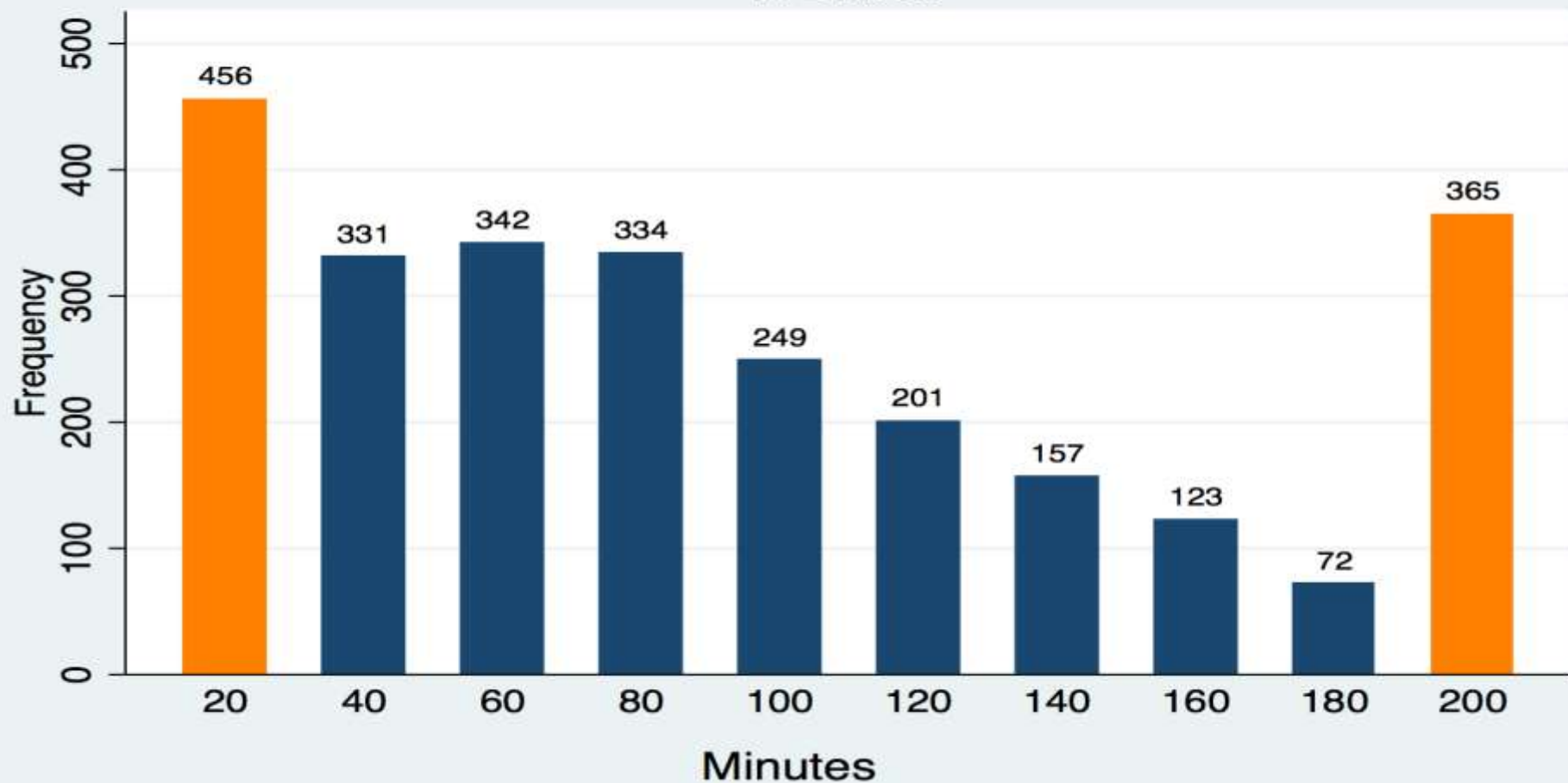


Amount of Dives During Week

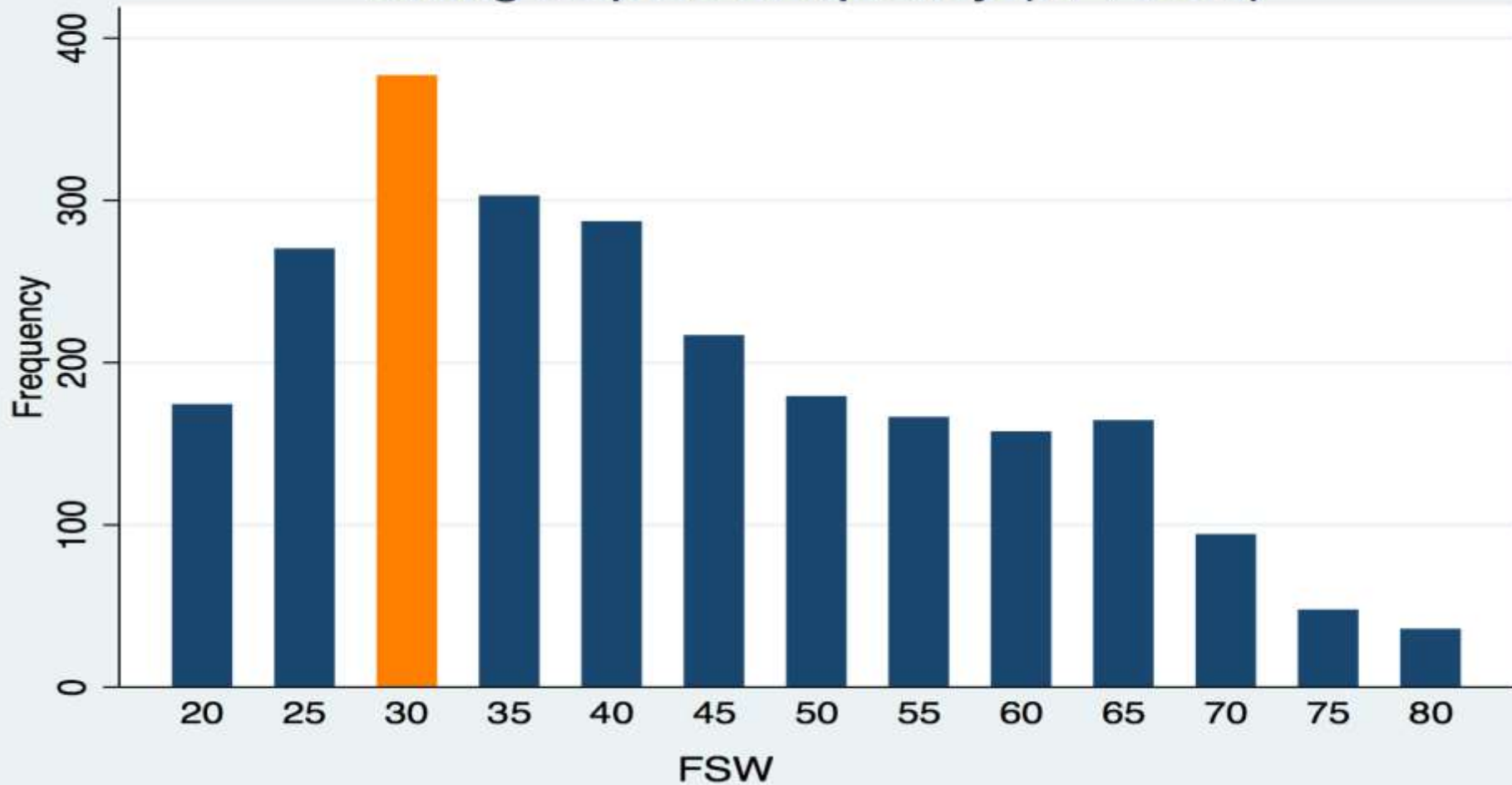


Bottom Time Frequencies

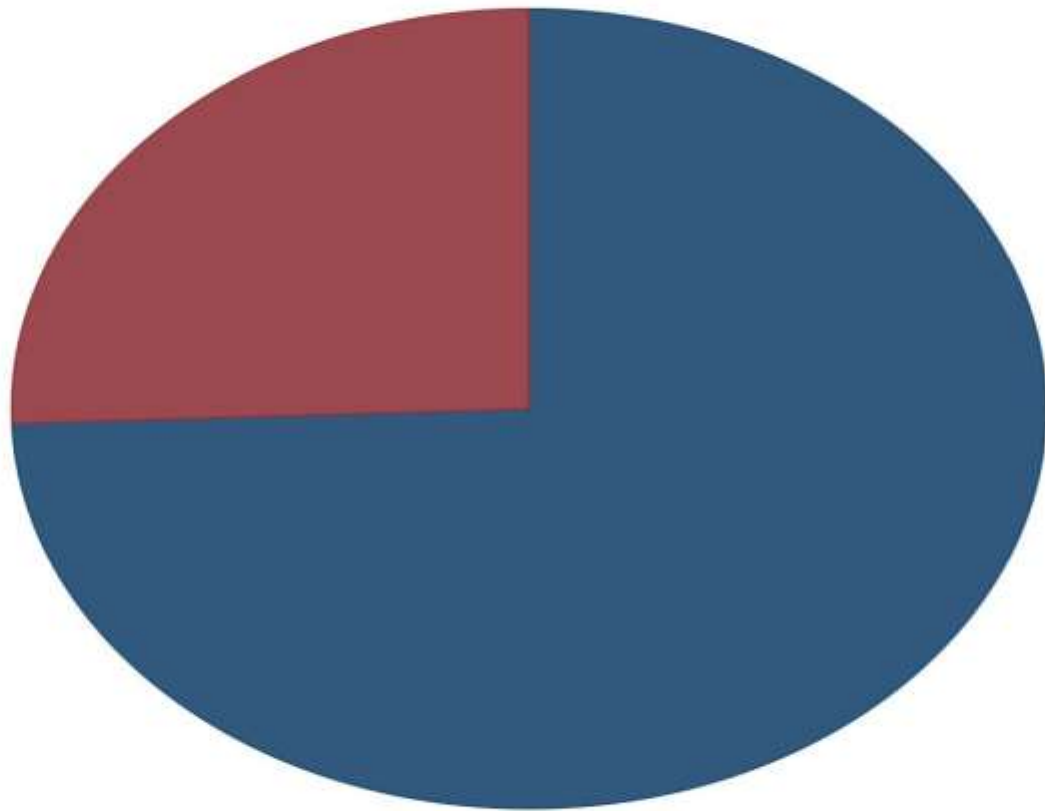
N = 2630



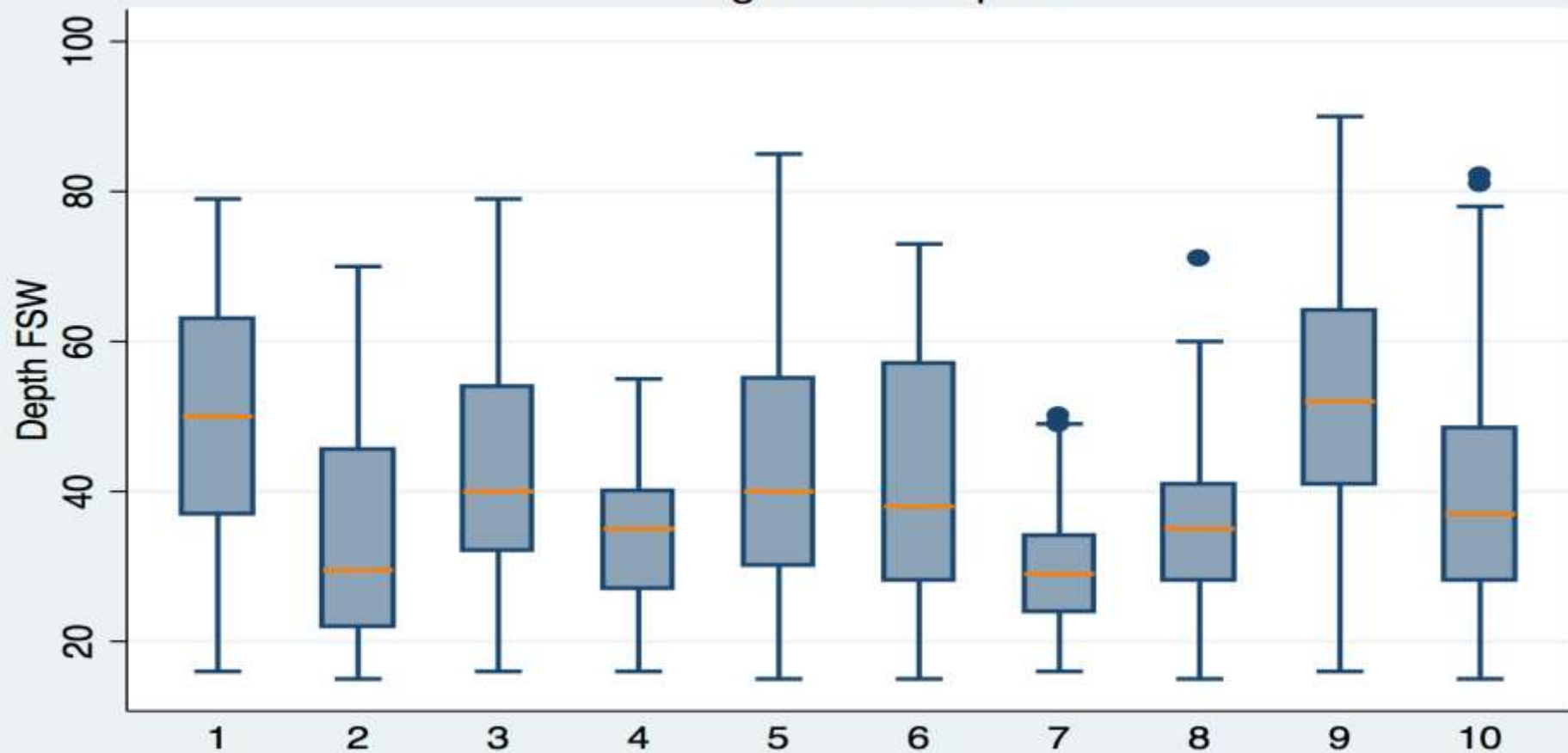
Diving Depths Frequency (N=2,560)



Violation of US NAVY No Decompression Limits (N=13 Fishermen)
Dives (N =2,360)

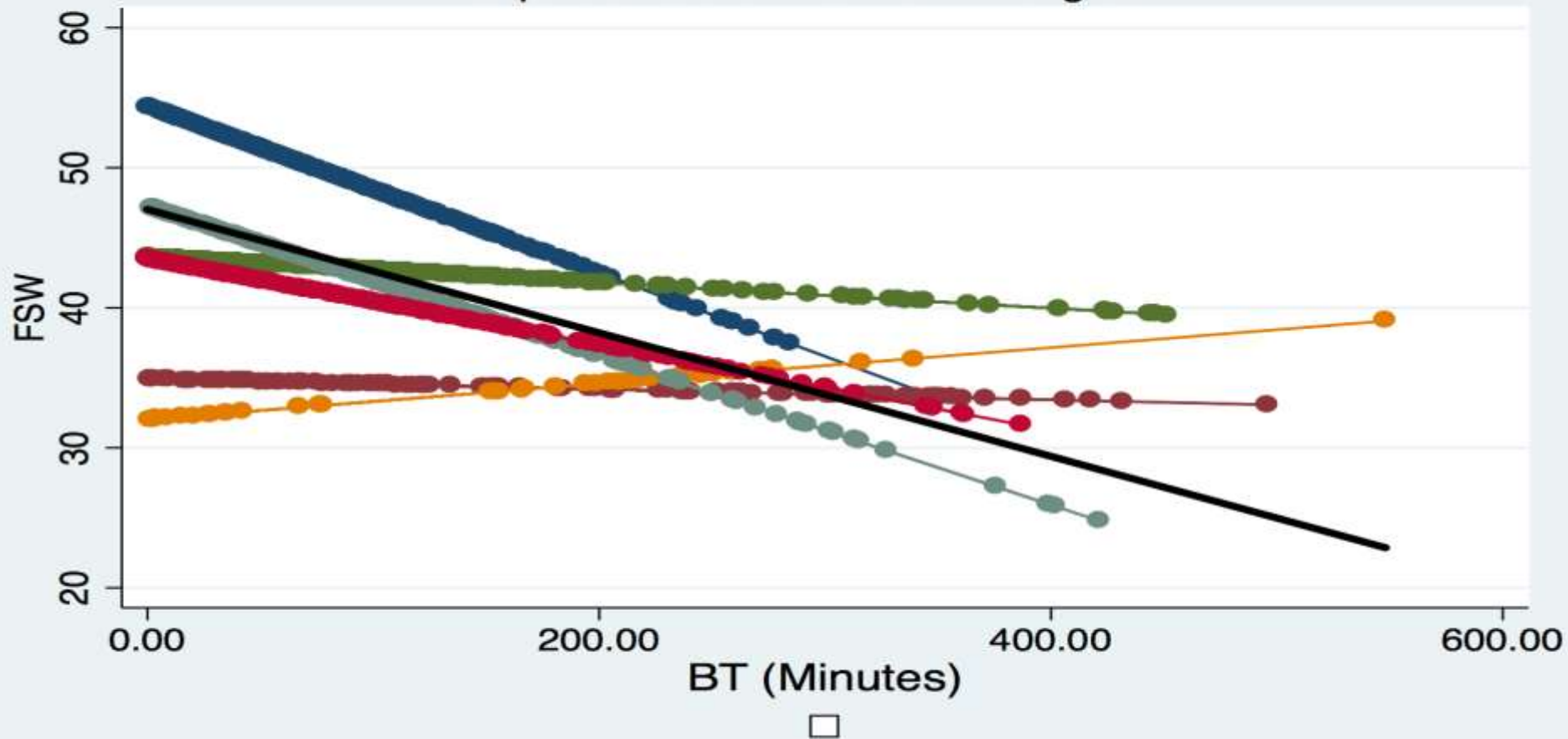


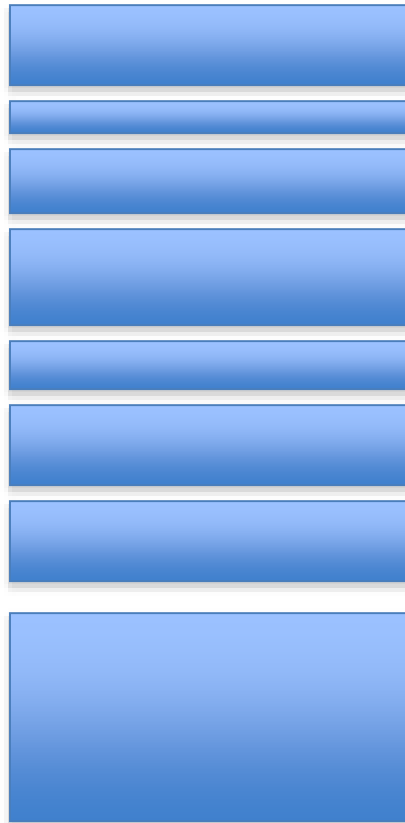
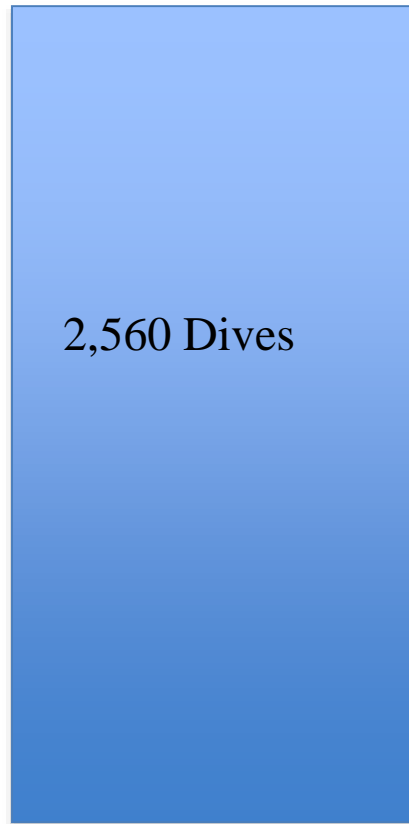
Box-Plot by Fishermen
Categories of Depths



Individual Regressions (no-pooling approach)

Depth as a function of BT Using OLS





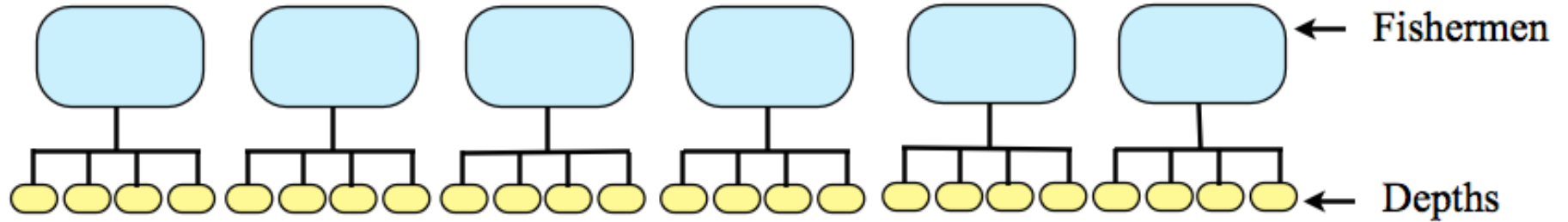
Fails iid

Repeated dives from same subjects

Different subject contribute different weights

Linear regression leads to incorrect Coefficients and betas

Levels



The observations, (depths/BT) are nested within fishermen.

Mixed-effects ML			
regression	Number of obs	=	2661
Group variable: sub	Number of groups	=	13
	Obs per group:		
	min	=	1
	avg	=	204.7
	max	=	446
	Wald chi2(23)	=	682.24
Log likelihood = -			
15070.331	Prob > chi2	=	0

BT= Month, Dive Sequence, Depth, ||subjects

month	Coef.	Std. Err	Z	P> z	[95% Conf. Interval]	
Feb	37.1264	11.53566	3.22	0.001	14.51693	59.73587
March	5.344418	21.84156	0.24	0.807	-37.46426	48.1531
April	-101.3766	70.61532	-1.44	0.151	-239.7801	37.0269
July	15.38668	9.032264	1.7	0.088	-2.316232	33.08959
August	17.28824	9.030002	1.91	0.056	-0.4102392	34.98672
September	17.50568	9.218599	1.9	0.058	-0.5624395	35.5738
October	17.71385	9.388827	1.89	0.059	-0.6879126	36.11561
November	19.08449	9.633022	1.98	0.048	0.20411	37.96486
December	22.61515	10.31021	2.19	0.028	2.407505	42.8228

depth	-0.5830837	0.0918699	-6.35	0.000	-0.7631454	-0.403022
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Dive	Coef.	Std. Err	Z	P> z	[95% Conf. Interval]	
2	-59.87782	3.44064	-17.4	0.000	-66.62135	-53.13429
3	-69.86663	3.885185	-17.98	0.000	-77.48145	-62.25181
4	-78.8284	4.868564	-16.19	0.000	-88.37061	-69.28619
5	-82.80465	6.841711	-12.1	0.000	-96.21416	-69.39515

cons	163.9817	10.54753	15.55	0.000	143.3089	184.6545
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Random-effects Parameter		Estimate	Std. Err.	[95% Conf. Interval]	
sub: Identity	sd(_cons)	27.07249	6.527238	16.87725	43.4265
	sd(Residual)	69.23466	0.9514218	67.3948	71.12475

Mixed-effects ML regression	Number of obs	=	2661
Group variable: sub	Number of groups	=	13
	Obs per group:		
	min	=	1
	avg	=	204.7
	max	=	446
	Wald chi2(15)	=	302.91
Log likelihood = -10916.1	Prob > chi2	=	0

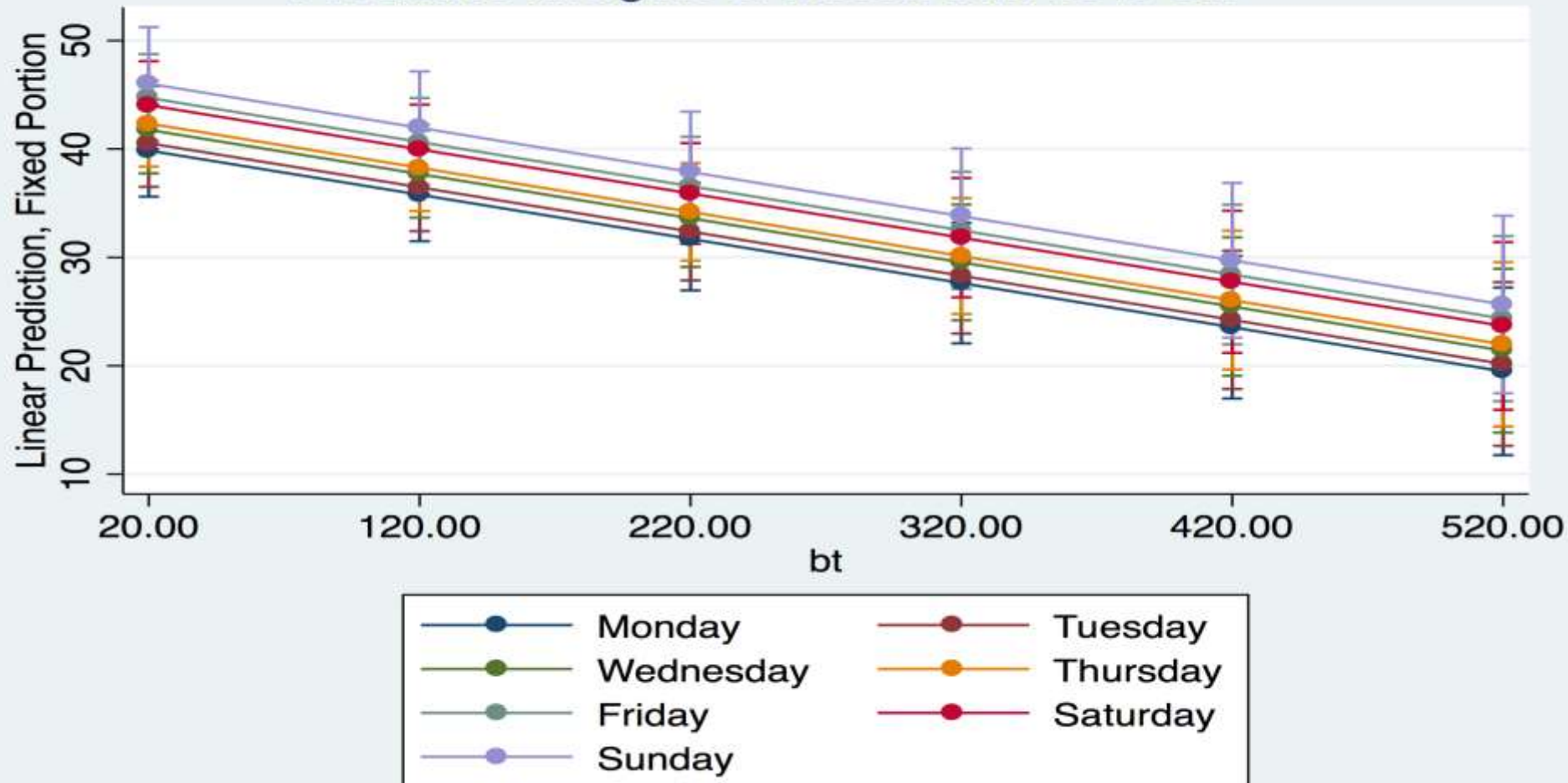
Depth= Month, Day of the week ||subjects

depth month	Coef.	Std. Err.	z	P> z	[95% Conf.	Interval]
Feb	-3.694229	2.477267	-1.49	0.136	-8.549582	1.161125
March	-15.2575	4.596728	-3.32	0.001	-24.26693	-6.248082
April	34.9306	14.82222	2.36	0.018	5.879581	63.98161
July	-14.80289	1.940835	-7.63	0	-18.60686	-10.99892
August	-11.70465	1.946613	-6.01	0	-15.51994	-7.889355
September	-12.95036	1.968239	-6.58	0	-16.80804	-9.09268
October	-5.343469	2.027754	-2.64	0.008	-9.317794	-1.369144
November	-1.658967	2.070296	-0.8	0.423	-5.716673	2.398738
December	-11.3636	2.185017	-5.2	0	-15.64615	-7.081041

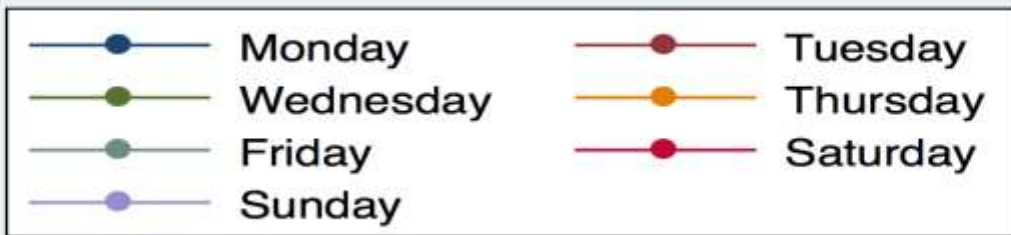
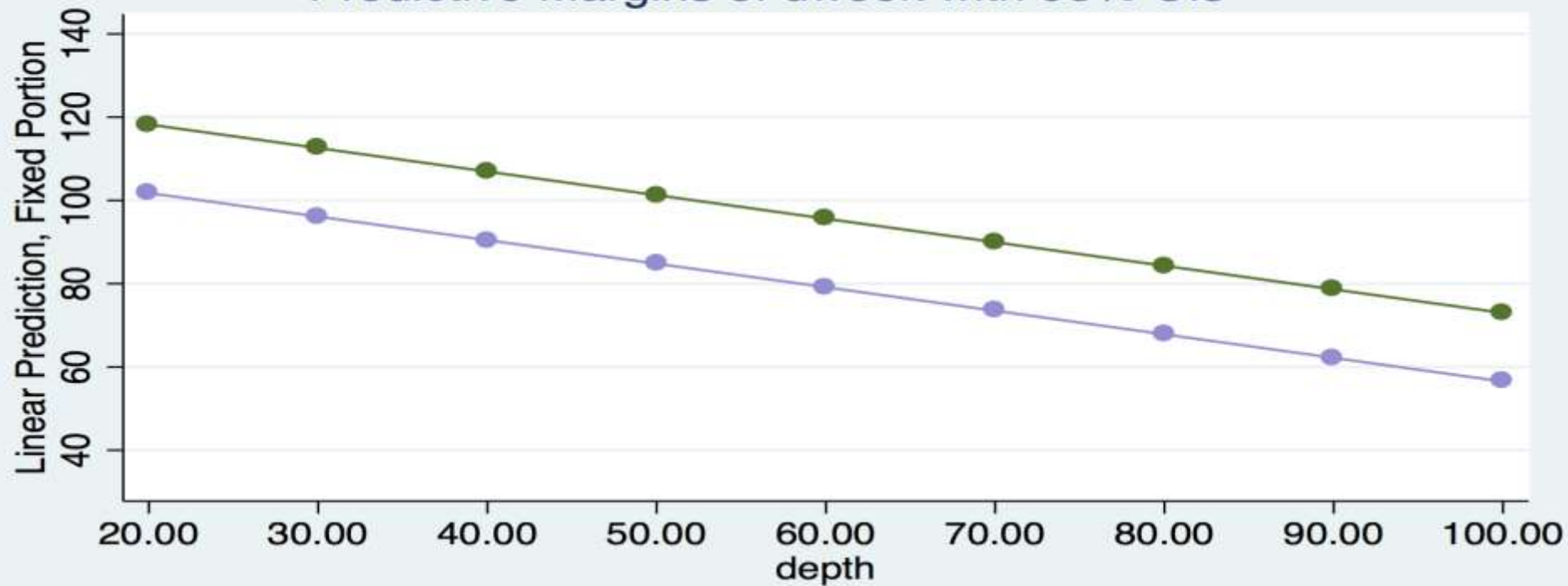
dwack

Random-effects Parameters	Estimate	Std. Err.	[95% Conf. Interval]	
sub: Identity				
var(_cons)	42.85328	19.19091	17.81525	103.0804
var(Residual)	210.9334	5.795773	199.8743	222.6043

Predictive Margins of dweek with 95% CIs



Predictive Margins of dweek with 95% CIs

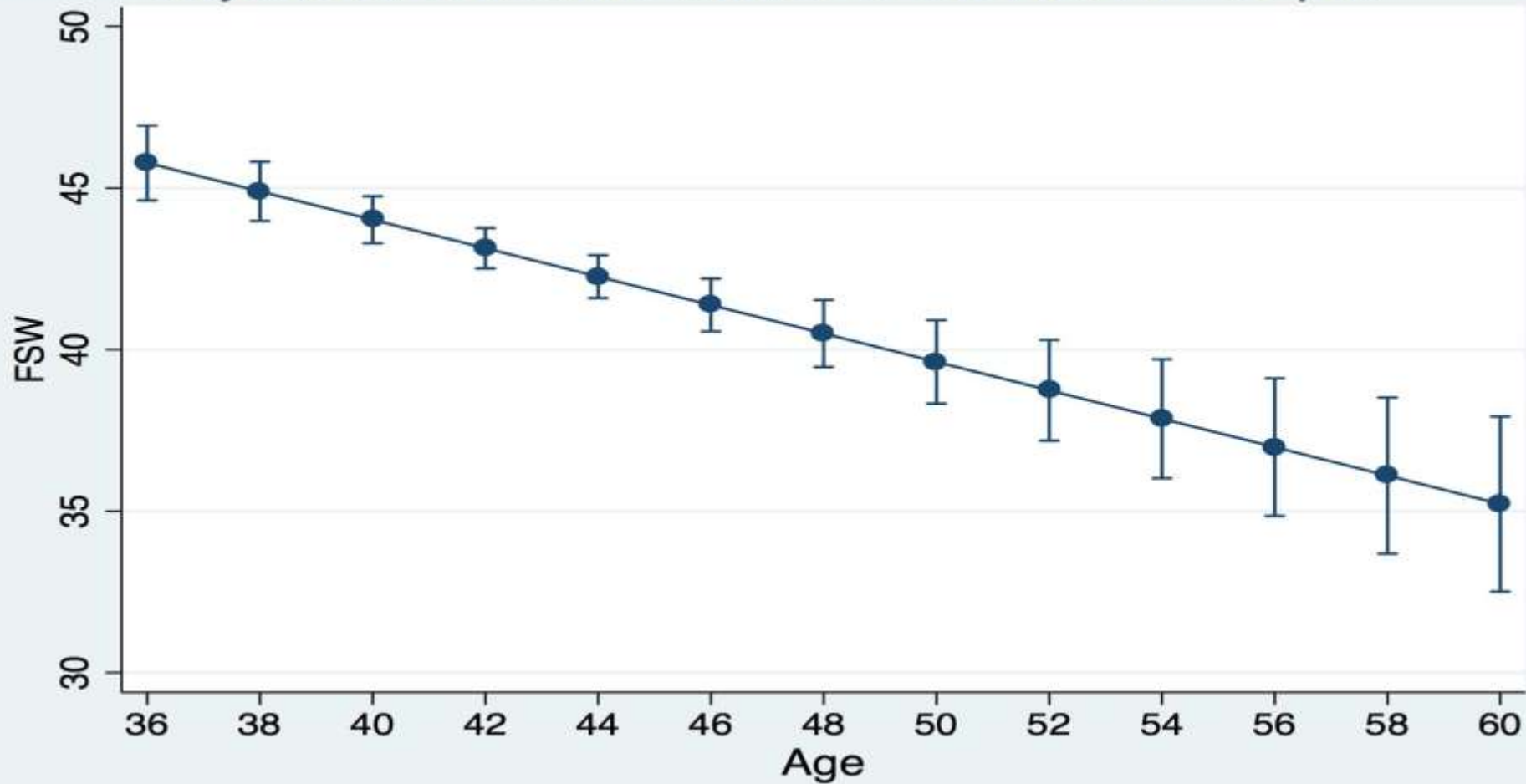


Mixed-effects logistic regression	Number of obs	=	2630
Group variable: sub	Number of groups	=	13
	Obs per group: min	=	1
	avg	=	202.3
	max	=	446
Integration method: mvaghermite	Integration points	=	7
	Wald chi2(9)	=	472.42
Log likelihood = -624.65734	Prob > chi2	=	0

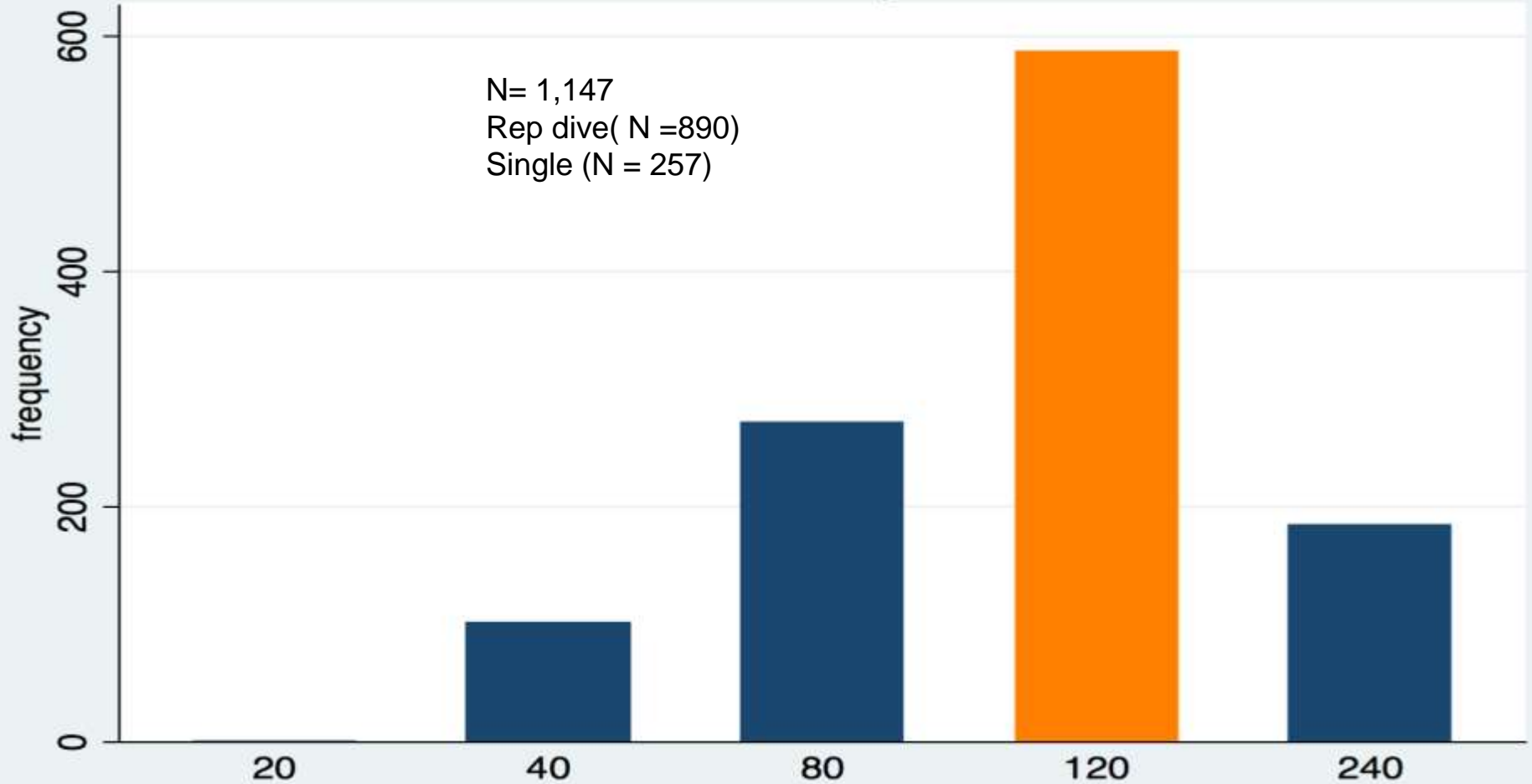
Violation of USN No Deco	Odds Ratio	Std. Err.	z	P> z	[95% Conf. Interval]	
Depth	1.22	0.012	21	0.00	1.20	1.25
Bottom Time	1.04	0.002	20	0.00	1.04	1.04
Month						
Feb	2.70	1.575	2	0.09	0.86	8.47
July	1.39	0.686	1	0.50	0.53	3.66
August	3.76	1.765	3	0.01	1.50	9.43
September	4.32	2.076	3	0.00	1.69	11.08
October	4.64	2.212	3	0.00	1.82	11.81
November	2.81	1.416	2	0.04	1.05	7.54
December	10.46	5.830	4	0.00	3.51	31.19
_cons	0.00	0.000	-18	0.00	0.00	0.00
var(_cons)	0.83	0.419	0	2.23		

LR test vs. Logistic Regreression chibar 2(01) 72.41 Prob>=chibar2=0.00

Adjusted Predictions with 95% CIs AGE vs. Depth



M Values on all Repetative Dives



Limitations

1. Low number of subjects
2. Need to connect how this diving behavior leads to DCS
3. Focus groups with the fishermen have demonstrated that they are willing to do a deco stop.
 1. Where, What depth, How long?

Conclusion

- We recorded 2,560 dives. These exposures clarify the level of decompression stress these fishermen undergo. These dives, fishing yields, and diving behaviors will serve as input for a deterministic decompression table for these AFD.
- Our data indicated that the fisherman violate the no decompression limit during more than 25% of dives (based on US Navy models). There is a strong, negative, linear relationship between the age of the fisherman and the depth of the dive. Younger fisherman dove deeper than older ones and were more likely to perform repetitive dives than their older AFD.

