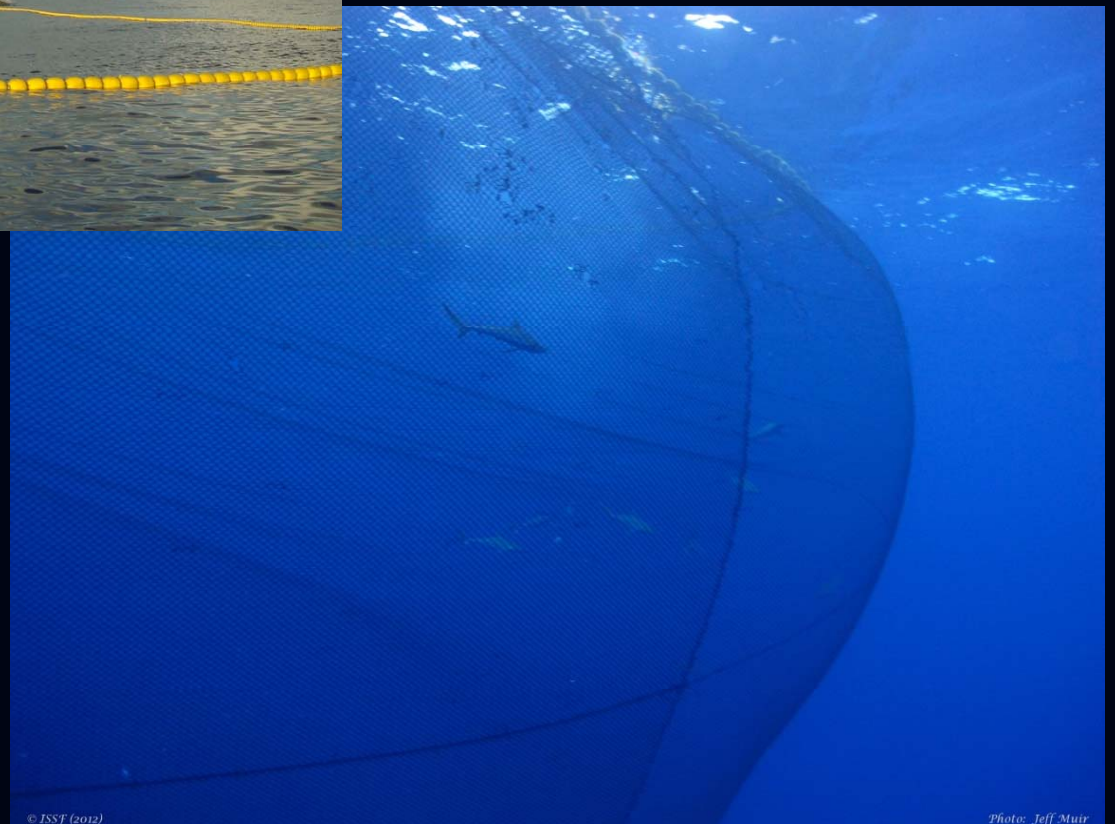


Post release survival of silky sharks caught in tuna purse seine gear



Melanie Hutchinson

Dave Itano

Jeff Muir

Bruno LeRoy

Kim Holland



Western Pacific Regional
Fishery Management Council
ECOSYSTEM-BASED MANAGEMENT OF FISHERIES
IN THE U.S. PACIFIC ISLANDS

ISSF #Bycatch Project WCPO Objectives

1. UNDERWATER VISUAL CENSUS AT FADS
2. ESTIMATION OF CATCH AND BYCATCH
3. NATURAL BEHAVIOR OF TUNA AND BYCATCH IN THE NET
4. VERTICAL AND HORIZONTAL BEHAVIOR OF TUNA AND BYCATCH SPECIES ON FAD AGGREGATIONS
5. TARGETING SKIPJACK AFTER DAWN – WHILE AVOIDING BIGEYE AND BYCATCH
6. INITIAL RELEASE OF FISH FROM THE NET BY TOWING THE FAD
7. BEST PRACTICES FOR THE HANDLING AND LIVE RELEASE OF WHALE SHARKS AND MANTA RAYS
8. **CONDITION AND POST-RELEASE SURVIVAL OF SHARKS**

Condition and post-release survival of silky sharks

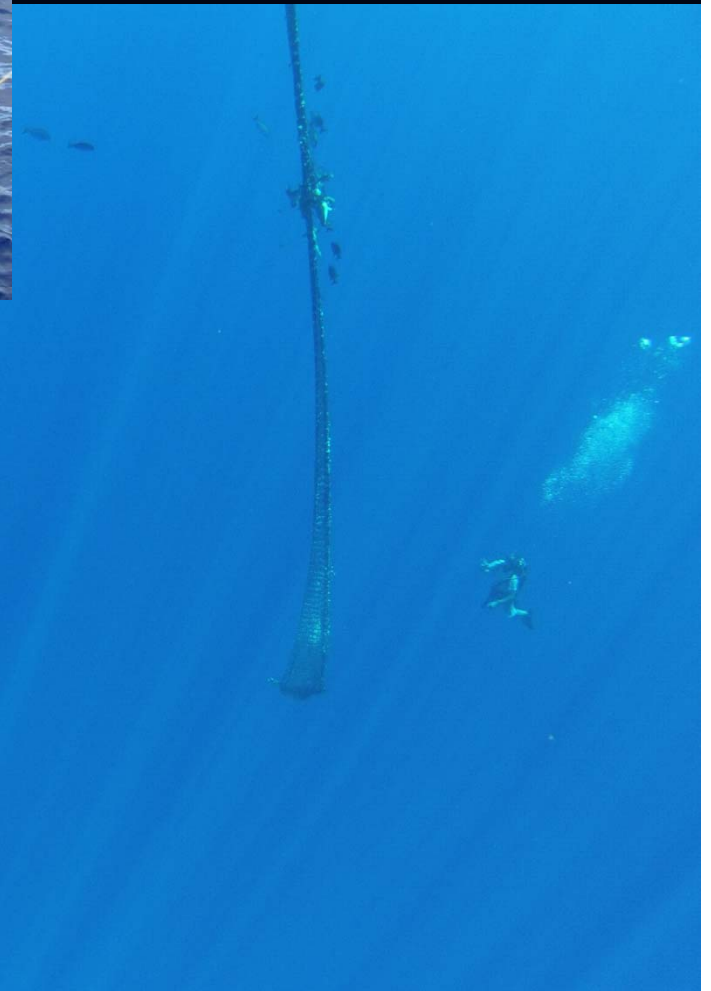
Methods:

- Tag types:
 - ♦ Pop-off Archival Satellite Tags
 - ♦ Survival Satellite Tags
 - ♦ Conventional Dart Tags
- Blood analysis:
 - ♦ pH
 - ♦ Lactate
- Sampling design
 - ♦ By stage of fishing operations:
 1. Pre-Assessments of FADs
 2. Fished inside net
 3. Entangled in net
 4. 1st Brail
 5. Later Brail



Condition and post-release survival of silky sharks

Methods:



- Sampling design
 - ◆ By stage of the fishing operations:
 1. Pre-Assessments of FADs
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Condition and post-release survival of silky sharks

Methods:

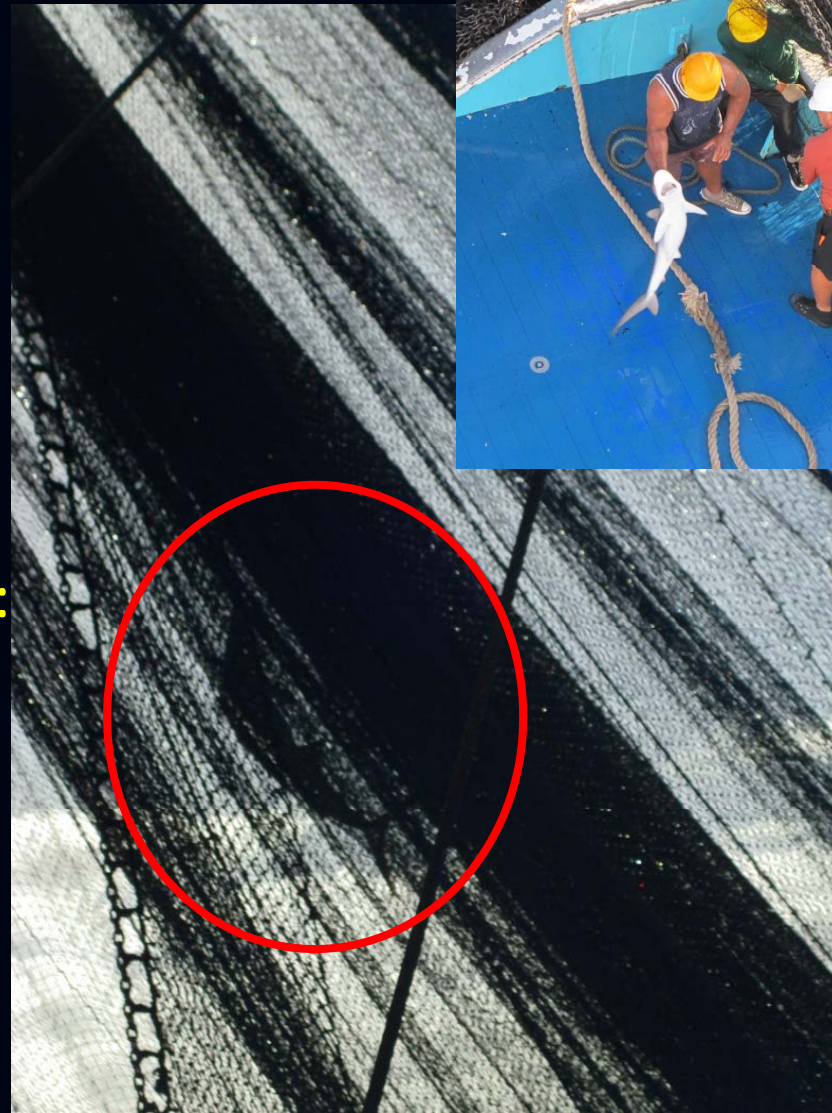
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 5. Later Brail



Condition and post-release survival of silky sharks –

Methods:

- Tag types:
 - ◆ Pop-off Archival Satellite Tags
 - ◆ Survival Satellite Tags
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 - ◆ Lactate
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Condition and post-release survival of silky sharks

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Condition and post-release survival of silky sharks

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- Tag types:
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 - ♦ Survival Satellite Tags
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- Blood analysis:
 - ♦ pH
 - ♦ Lactate
- Sampling design
 - ♦ By stage of fishing operations:
 1. Pre-Assessments of FADs
 2. Fished inside net
 3. Entangled in net
 4. 1st Brail
 5. **Later Brail**



Condition and post-release survival of silky sharks

Methods: Release Condition

- **Excellent (4):** Shark swims away quickly without any visible signs of physical trauma
- **Good (3):** Swims well but may appear slower or disoriented
- **Fair (2):** Swimming appears labored with visible signs of trauma
- **Poor (1):** Is able to right itself and makes efforts to swim
- **Dead (0):** Sinks upside down



Methods: Blood Chemistry

CHEM8+

Sodium (Na)	●
Potassium (K)	●
Chloride (Cl)	●
TCO ₂	●
Anion Gap*	●
Ionized Calcium (iCa)	●
Glucose (Glu)	●
Urea Nitrogen (BUN)/Urea	●
Creatinine (Crea)	●
Hematocrit (Hct)	●
Hemoglobin* (Hgb)	●



CG4+

Lactate	●
pH	●
PCO ₂	●
PO ₂	●
TCO ₂ *	●
HCO ₃ *	●
Base Excess (BE)*	●
sO ₂ *	●

i-STAT portable blood analyzer



* = Values are calculated

Results: Sampling Effort

Sharks tagged and/or blood chemistry by stage of fishing operation						
	Pre-Assessment of FAD	Fished from inside the net	Entangled in the net	First brail	Later brail	Total
Survival PAT	0	2	1	2	0	5
MiniPAT	3**	2	1	0	0	6
MT PAT + Blood	0	0	2	0	1 [†]	3
SPAT + Blood	1	0	4	4	1	10
MiniPAT + Blood	0	0	5	0	0	5
Blood Only	6*	3	9	15	36	69
Total for each stage	10	7	22	21	38	98

Total sharks caught: $n = 296$

Satellite tags deployed: $n = 29$

Blood samples: $n = 87$

Conventional ID tags: $n = 125$

Acoustic tags: $n = 3$ (* in table)

† = OWT



Condition and post-release survival of silky sharks

Results: Age Composition

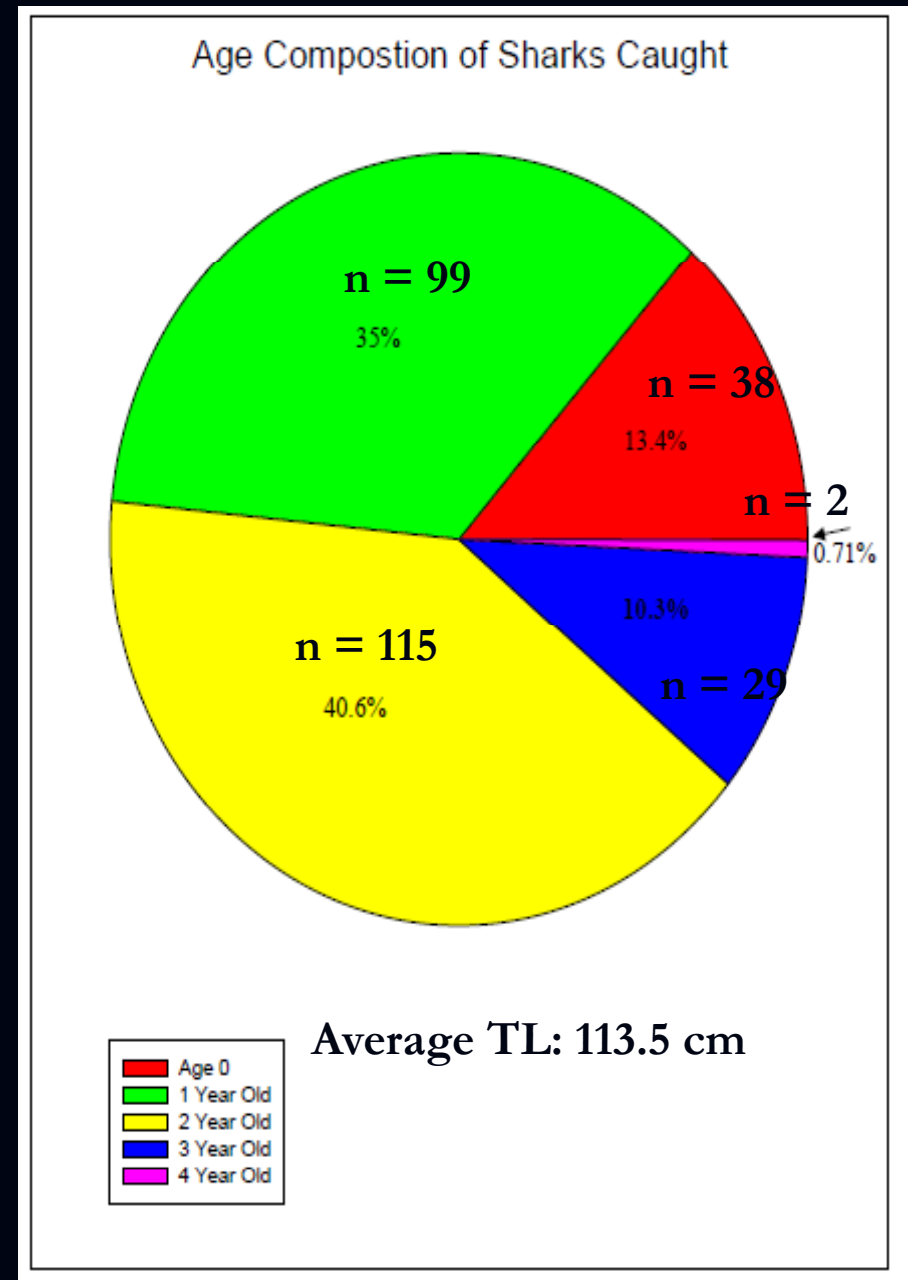


Size at maturity: 210-220 cm TL

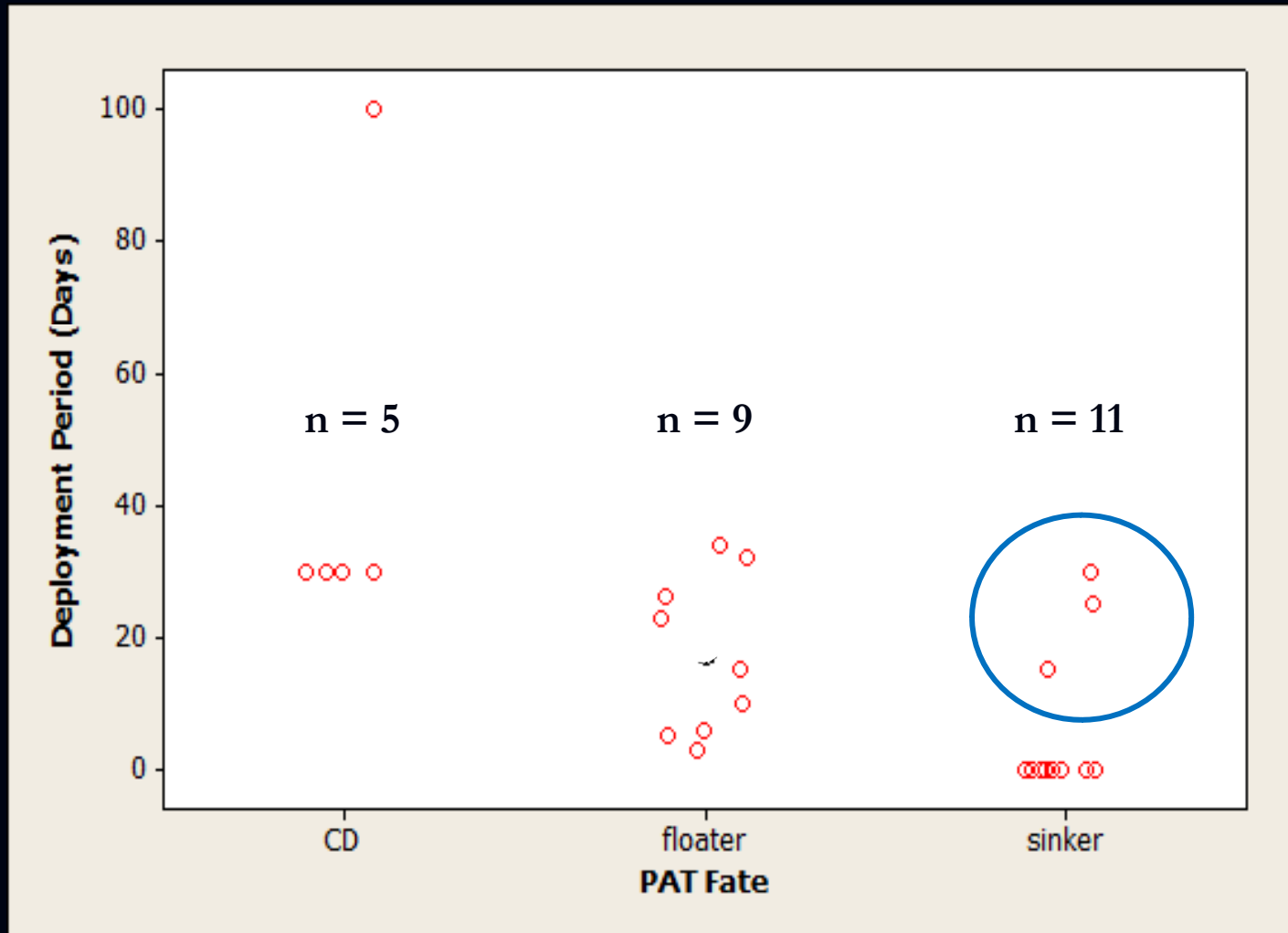
Litter size: 1-10

Parturition: May – July

ALL sharks encountered during cruise were juveniles.



PAT Deployment Period



PAT Fate Designations:

CD = Completed deployment

Floater = Tag shed

Sinker = Animal died, tag release initiated at depth

28 Tags:

- 15 sPATs (30 day),
- 11 miniPATs (100 - 300 day),
- 2 MT PATs (180 day)
- 3 in situ



Survival Assessed by PAT Data

Release Condition

SURVIVAL



Release Condition	n	Survival: ≤ 1 Day	Survival: $1 \leq 10$ Days	Survival: $11 \leq 29$ Days	Survival: 30+ Days
Excellent (4)	14	0	4****	4***25	6*30
Good (3)	2	1	0	1 ¹⁵	0
Fair (2)	3	1	0	0	2*
Poor (1)	3	3	0	0	0
Dead (0)	3	3	0	0	0

Tag fate: sinker, floater, CD

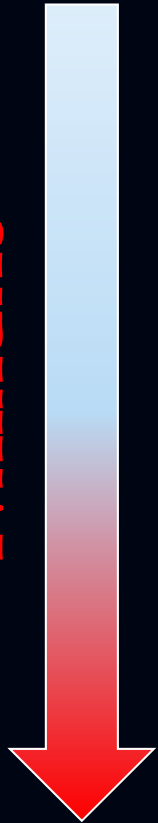
* = floater (tag shed)

= days (post release mortality)



Survival - Landing Stage

SURVIVAL



Stage of Fishing Op	n	Survival: ≤ 1 Day	Survival: $1 \leq 10$ Days	Survival: $11 \leq 29$ Days	Survival: 30+ Days
Pre-Assess	4	0	1*	2**	1 ³⁰
Fished from Net	3	0	1*	0	2*
Entangled	11	2	2**	3* ^{15, 25}	4*
1 st Brail	4	4	0	0	0
Later Brail	3	2	0	0	1

Tag fate: sinker, floater, CD

* = floater (tag shed)

= days (post release mortality)



Preliminary Results: Blood Chemistry

CHEM8+	CG4+
Sodium (Na)	Lactate
Potassium (K)	pH
Chloride (Cl)	PCO ₂
TCO ₂	PO ₂
Anion Gap*	TCO ₂ *
Ionized Calcium (iCa)	HCO ₃ *
Glucose (Glu)	Base Excess (BE)*
Urea Nitrogen (BUN)/Urea	sO ₂ *
Creatinine (Crea)	
Hematocrit (Hct)	
Hemoglobin* (Hgb)	

i-STAT portable blood analyzer



* = Values are calculated

Survival using Blood Chemistry – building the model

Shark Category	Survivor	Death	Survivor	Death
Blood Parameter	pH		Lactate (mmol/L)	
Mean	7.129	6.585	5	14.66
SE	0.1	0.059	1.7	0.89
n	8	5	8	5
t test: <i>p</i> - value	0.001*		0.000*	

Survivor = ≥ 10 days

Binary Logistic Regression

Predictor:

pH

Log-Likelihood = -4.035

p-value = 0.001

Predictor:

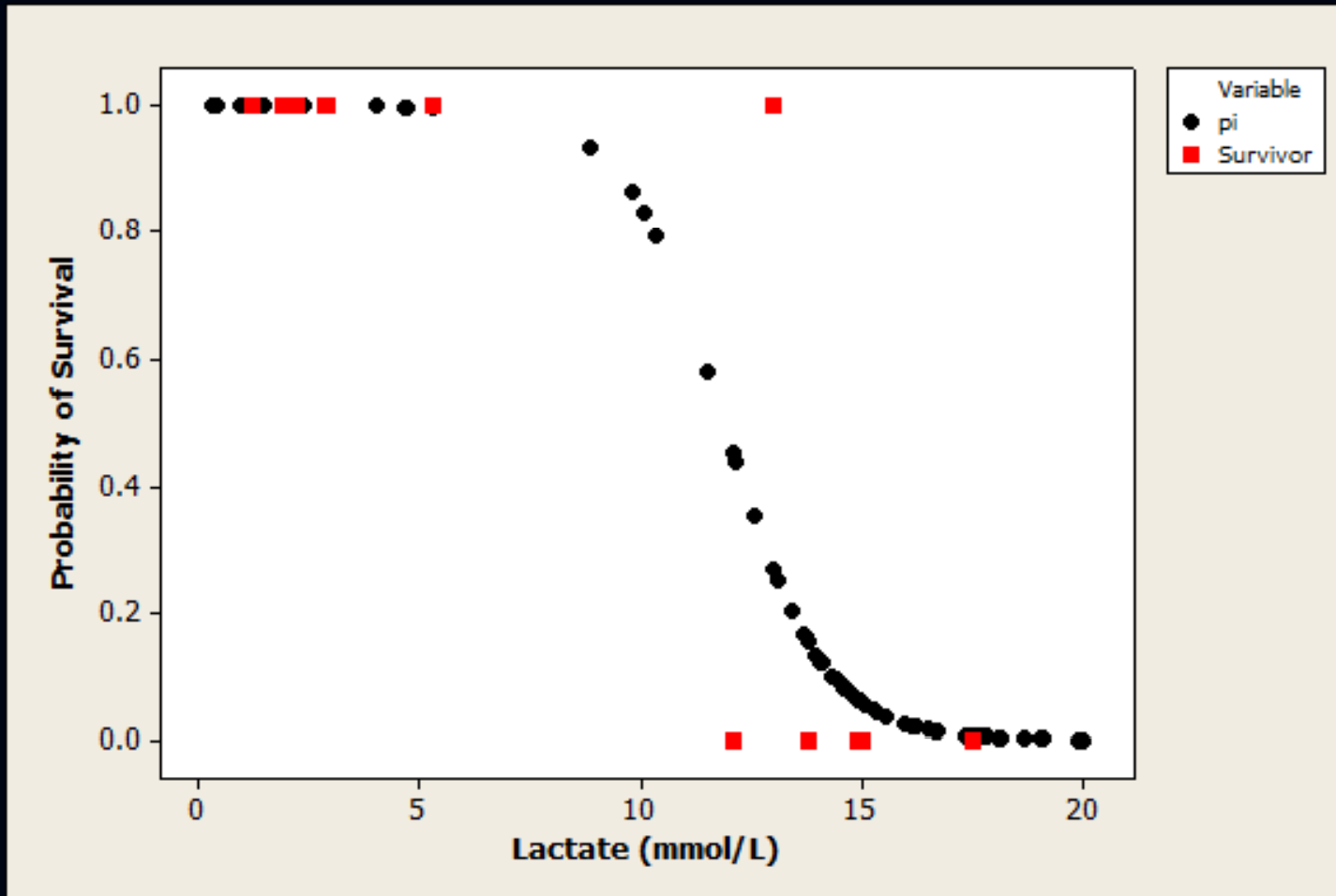
Lactate

Log-Likelihood = -3.994

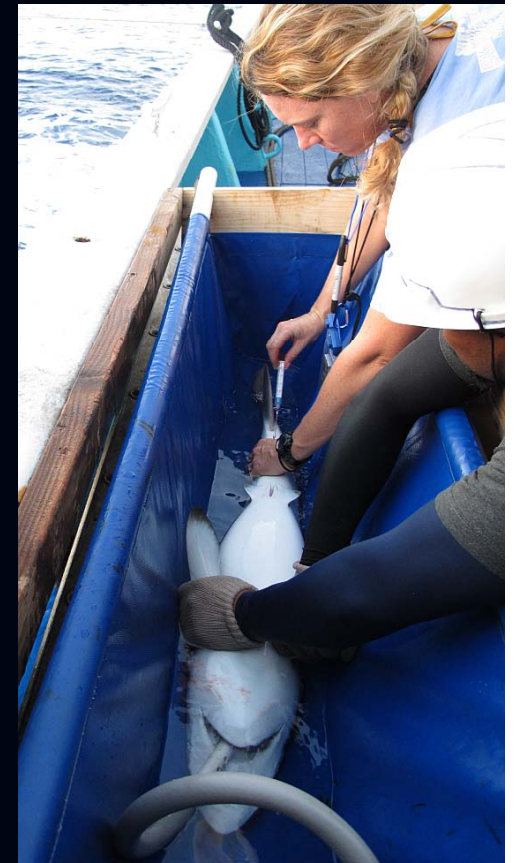
p-value = 0.001



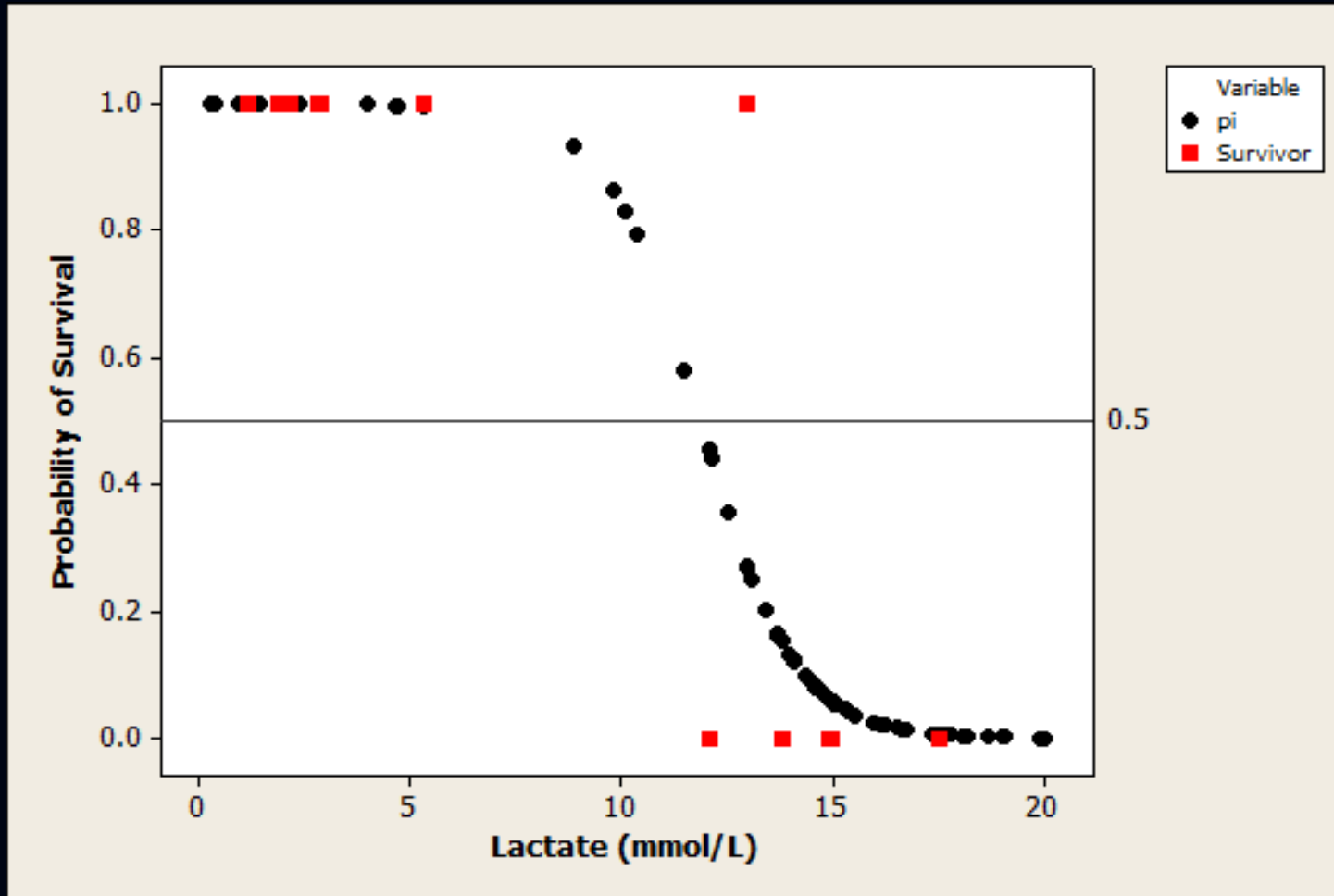
Survival and Predicted Survival from Lactate Levels



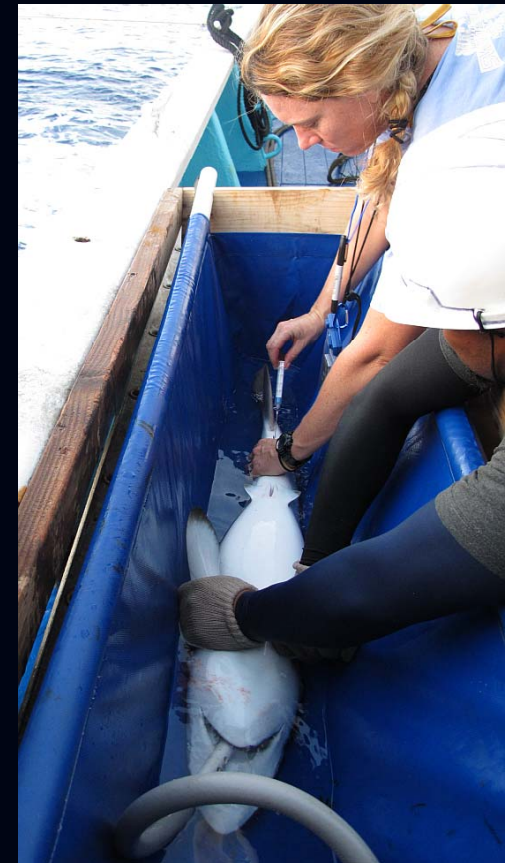
Sharks PAT tagged & blood sampled	Sharks blood sampled only
13	83



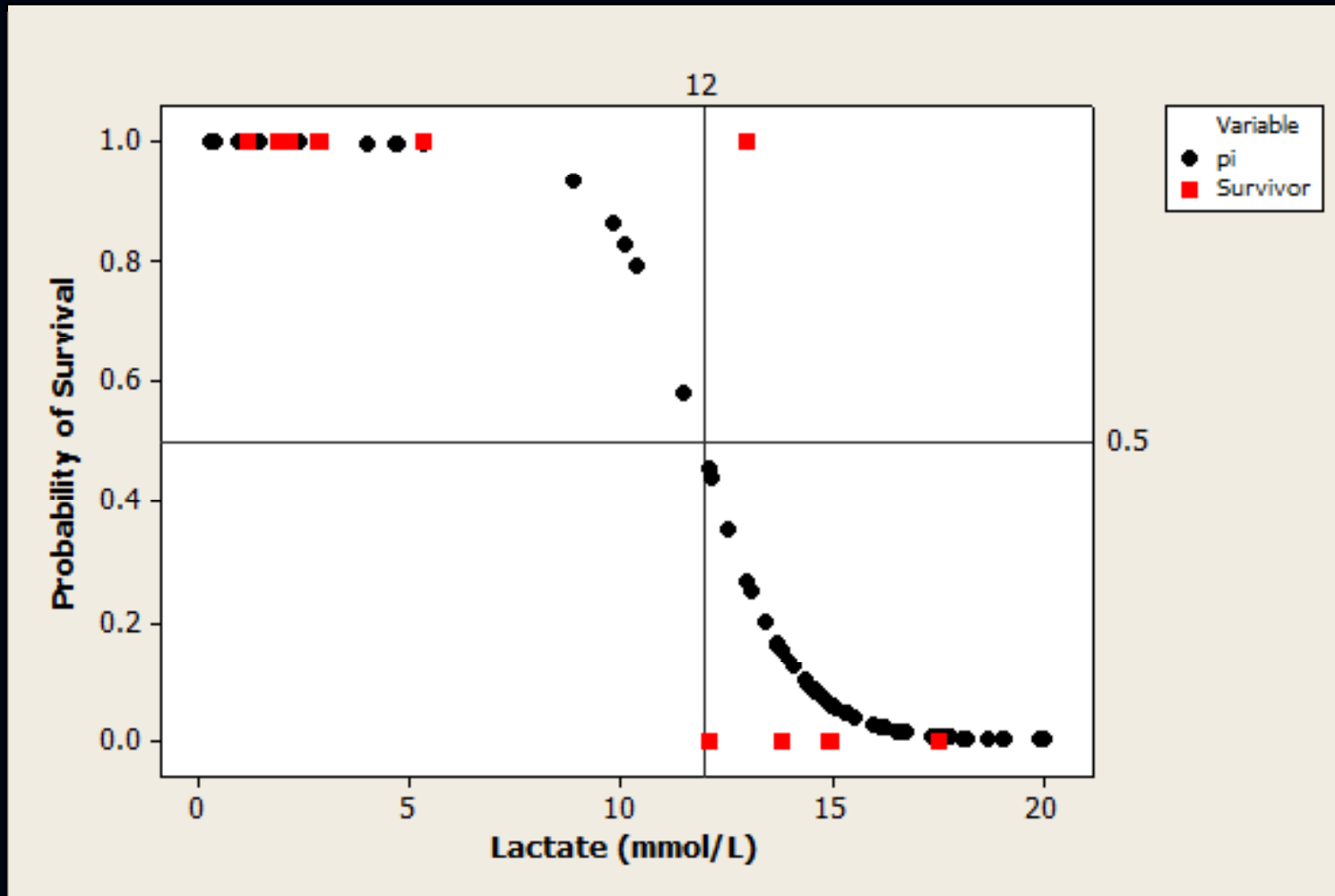
Survival and Predicted Survival from Lactate Levels



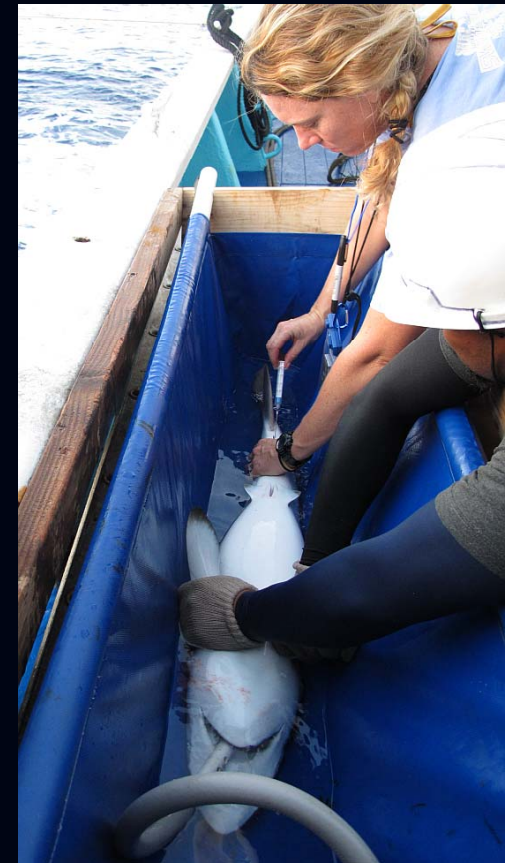
Sharks PAT tagged & blood sampled	Sharks blood sampled only
14	83



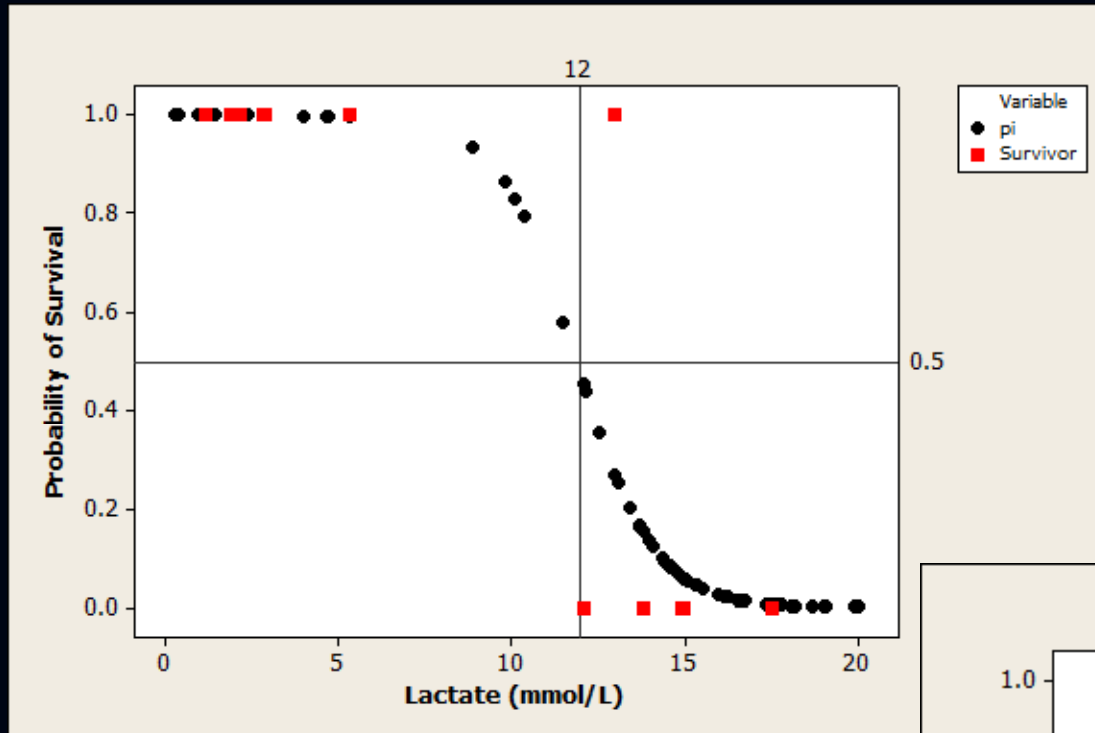
Survival and Predicted Survival from Lactate Levels



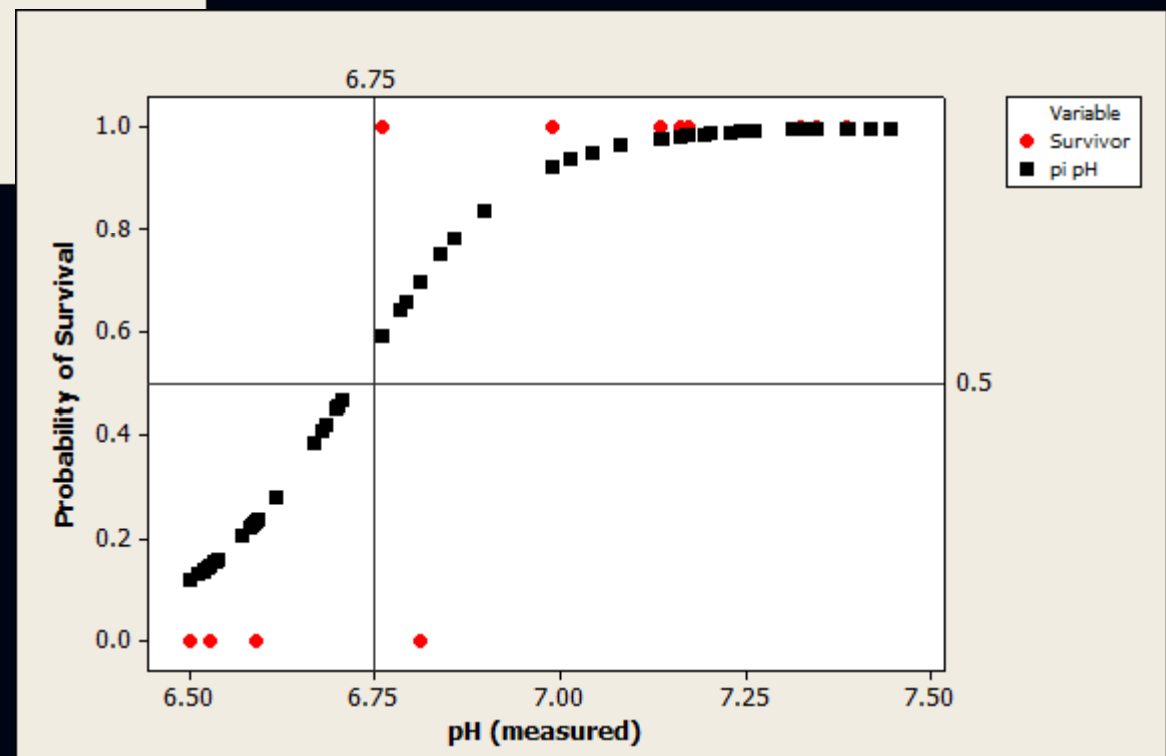
$pi > 0.5$, Lactate (mmol/L) = 12



Survival and Predicted Survival from Lactate & pH Levels

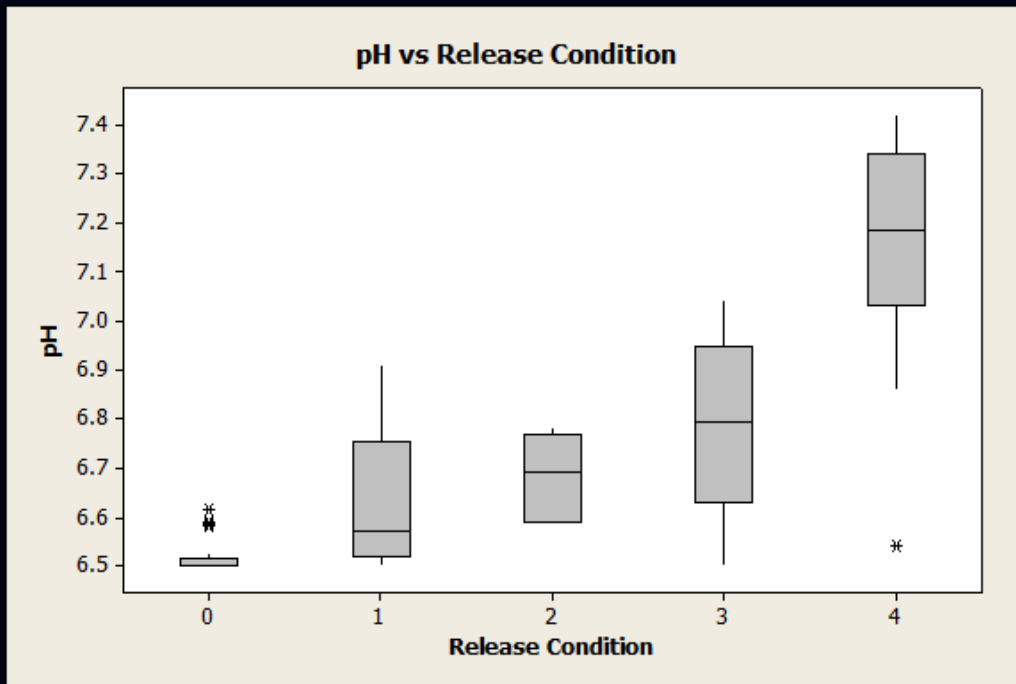


predicted survival	Lactate	pH
Mean	0.304878	0.353659
SE	0.051151	0.053123
Paired t test	p - value= 0.159	

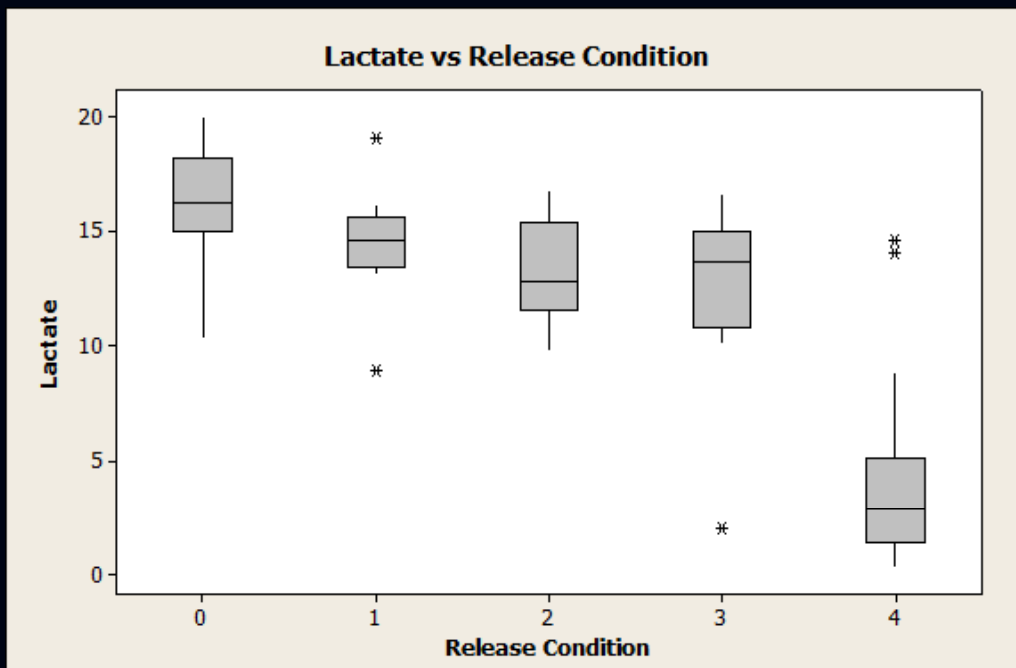
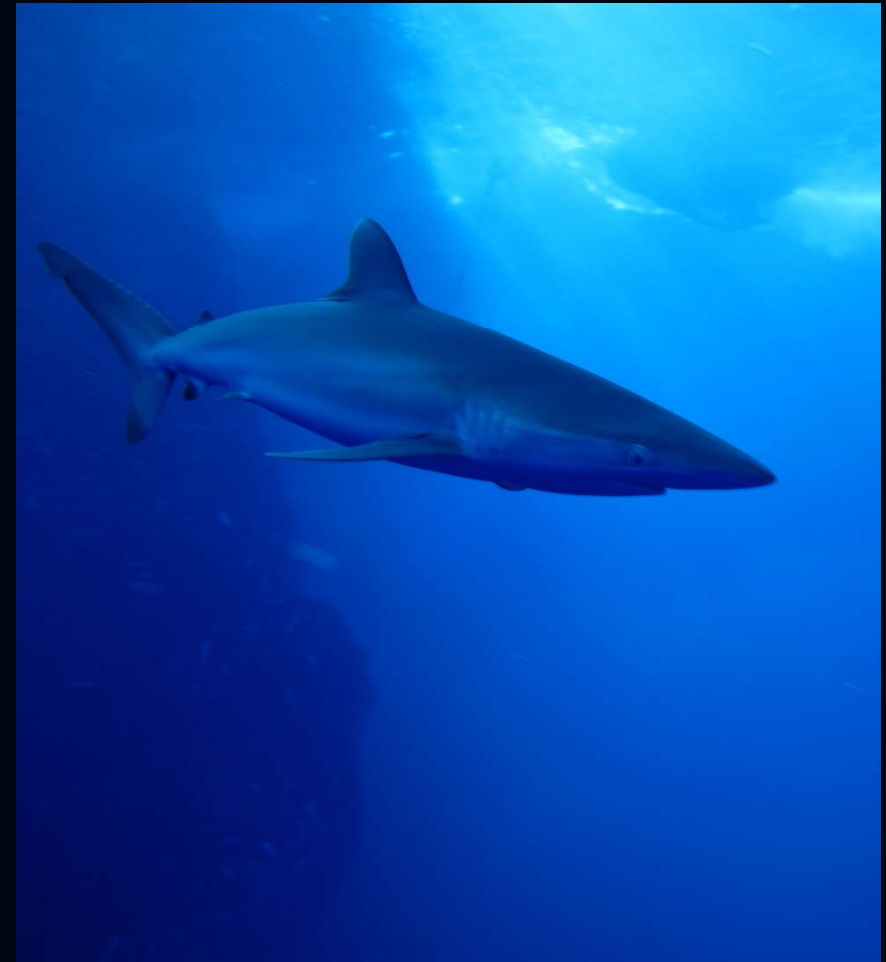


$pi > 0.5, pH = 6.75$

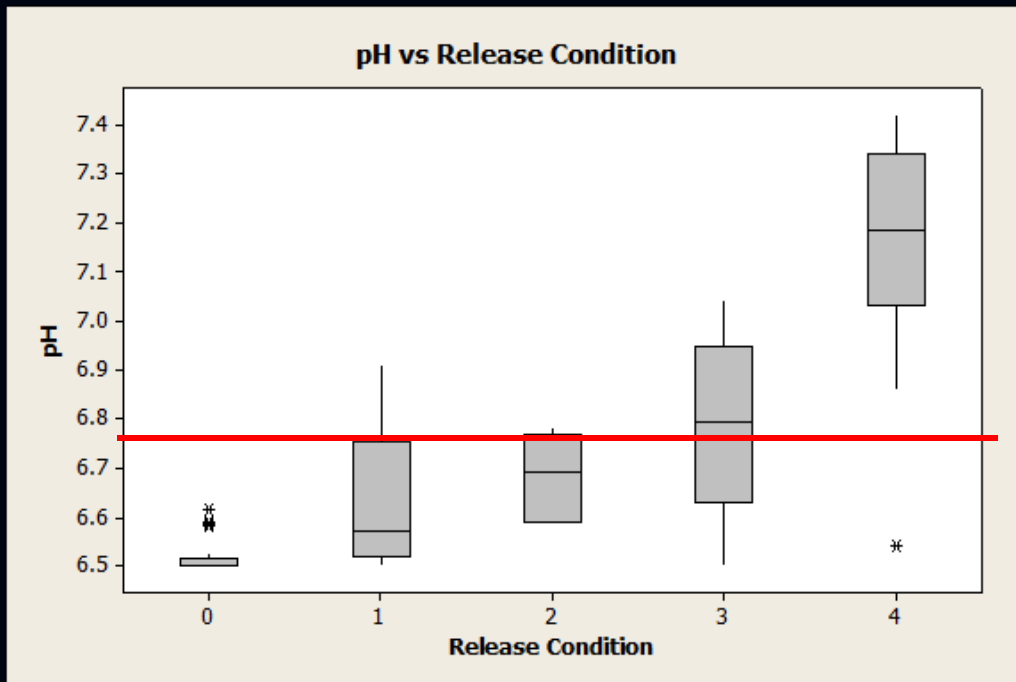
pH and Lactate levels by Release Condition



Release condition: 0 = Dead, 4 = Excellent

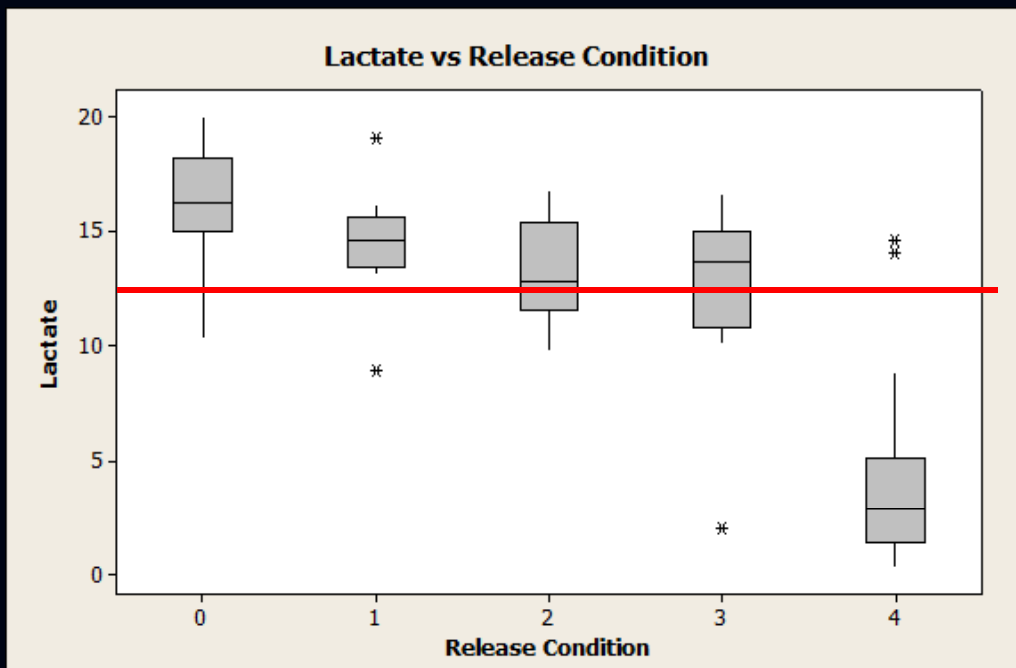


pH_(m) and Lactate levels by Release Condition

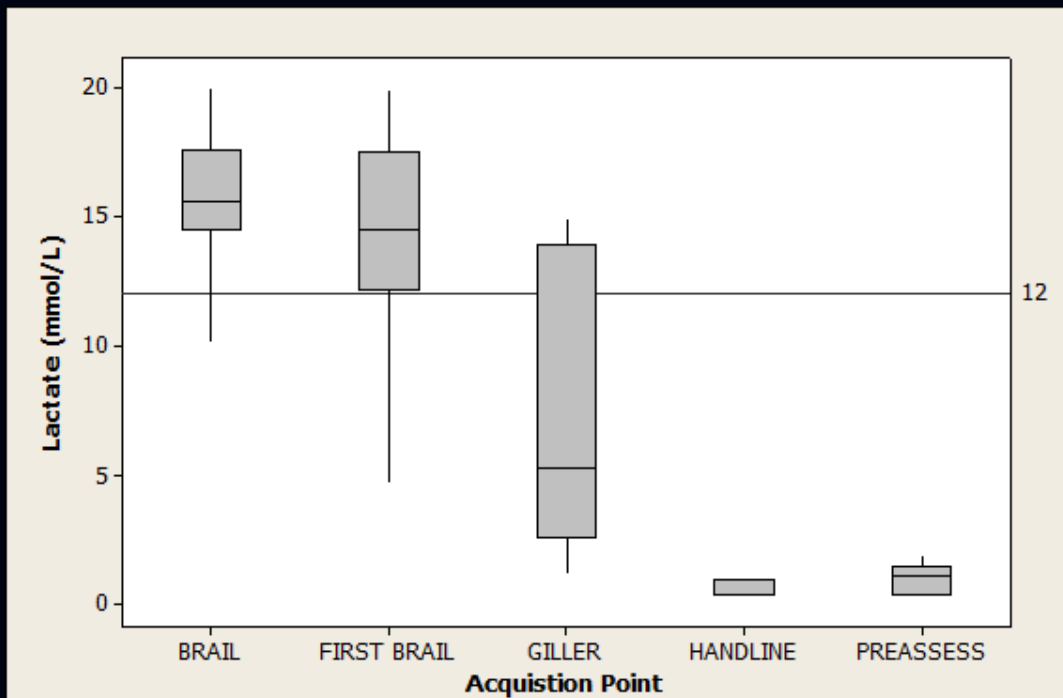
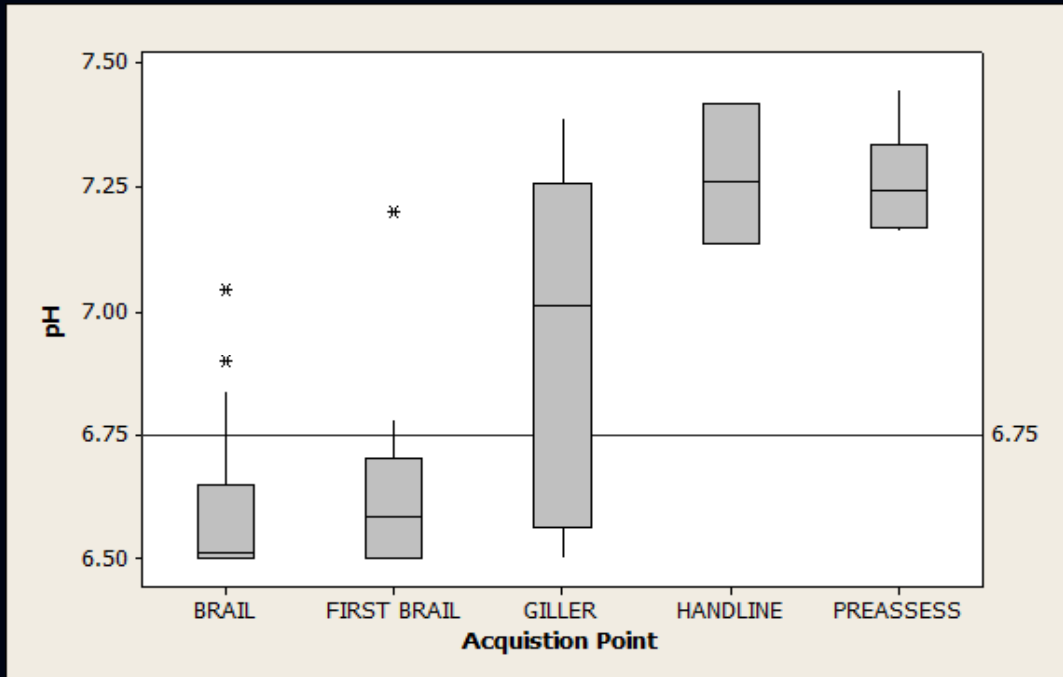


Release condition: 0 = Dead, 4 = Excellent

Release Condition	n	Predicted Survival	Survivors
0	165	2.94%	5
1	55	0	0
2	21	16.7%	3
3	16	25%	4
4	39	91.3%	36
Total	296	16.2%	48

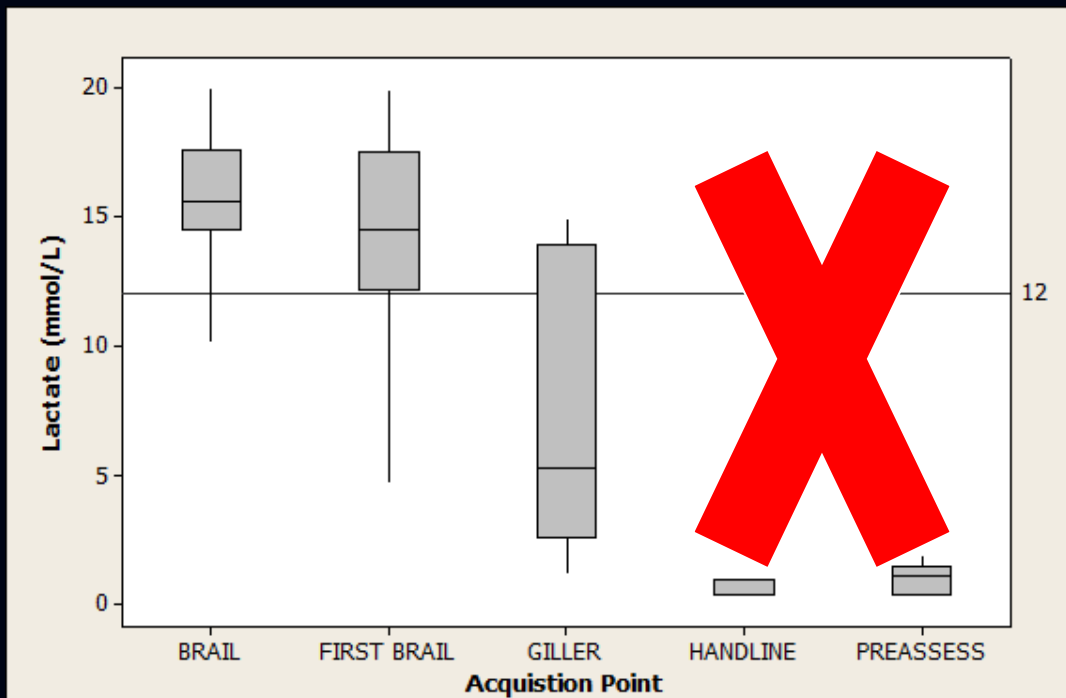
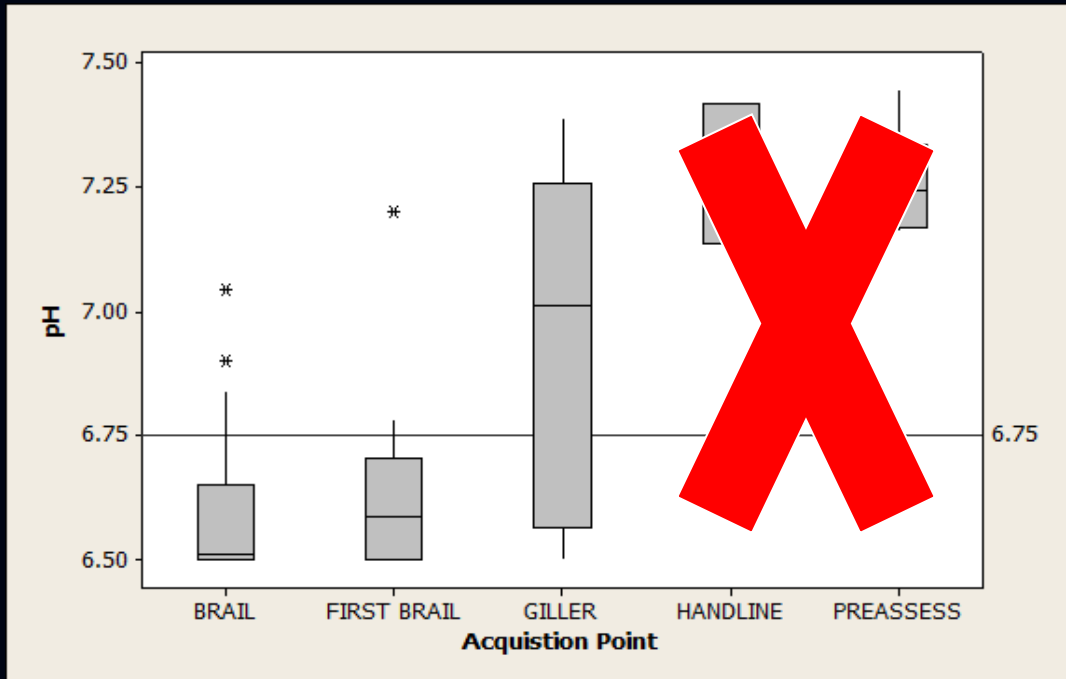


Predicted Survival by Landing Stage



Landing Stage	n	Predicted Survival (lactate)	Survivors
Brail	212	4.55%	10
1 st Brail	30	18.2%	5
Entangled	37	64.7%	24
Handline	7	100%	7
PreAssess	10	100%	10
Total	296	16.2%	47

Predicted Survival by Landing Stage



Landing Stage	n	Predicted Survival (lactate)	Survivors
Brail	212	4.55%	10
1 st Brail	30	18.2%	5
Entangled	37	64.7%	24
Total	249	15.7%	39

84.3% Mortality Rate

WCPFC Silky Shark Catch Rates

Table 2. Estimated catch (1000's of sharks) of silky shark and oceanic whitetip shark in the WCPFC by fishery.

Year	Silky Shark				Oceanic Whitetip Shark			
	Longline		Purse Seine		Longline		Purse Seine	
	Bycatch	Target	Associated	Unassociated	Bycatch	Target	Associated	Unassociated
1995	255.37	16.60	29.40	5.08	71.05	5.61	1.40	0.98
1996	92.26	277.08	37.22	4.74	57.30	5.23	1.69	0.86
1997	96.46	22.05	69.35	3.81	52.23	4.60	2.74	0.65
1998	79.68	24.84	48.66	5.81	59.67	4.76	1.82	0.74
1999	214.95	22.21	56.16	3.36	76.59	6.34	2.23	0.64
2000	174.19	17.66	60.78	6.51	74.28	5.69	2.39	1.09
2001	219.92	22.00	44.36	6.51	83.42	7.66	1.67	0.89
2002	160.74	39.84	57.46	5.29	92.02	10.60	2.17	0.75
2003	138.00	45.57	90.11	5.99	83.34	8.66	3.67	1.78
2004	150.51	31.37	131.04	4.63	78.99	6.91	5.33	0.75
2005	105.04	29.34	76.49	7.35	73.36	7.80	3.08	1.10
2006	175.80	33.77	83.26	6.49	74.67	7.08	3.25	0.85
2007	291.57	46.83	80.52	8.47	101.86	8.22	3.23	1.05
2008	304.31	22.00	86.63	10.22	102.23	7.03	3.40	1.06
2009	189.21	200.31	90.11	8.98	89.34	9.00	3.41	1.17

Alternate catch estimates for silky and oceanic whitetip sharks in
Western and Central Pacific Ocean

Joel Rice

WCPFC – SC8 – 2012/ SA – IP - 12 Korea

WCPFC Silky Shark Catch Rates

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1996	174.34	22.00	37.22	4.74	57.30	0.00	0.86	
1997	219.07	22.00	69.35	3.81	52.23	0.00	0.65	
1998	174.34	22.00	48.66	5.81	59.67	4.00	0.74	
1999	219.07	22.00	56.16	3.36	76.59	6.00	0.64	
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2008	304.31	22.00	86.63	10.22	102.23	0.00	1.06	
2009	189.21	200.31	90.11	8.98	89.34	0.00	1.17	

Alternate catch estimates for silky and oceanic whitetip sharks in Western and Central Pacific Ocean

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WCPFC – SC8 – 2012/ SA – IP - 12 Korea

Predicted Mortality: WCPO Purse Seine Fishery

Year	Associated	Unassociated	Total	Predicted Mortality
1995	29.4	5.08	34.48	29067
1996	37.22	4.74	41.96	35372
1997	69.35	3.81	73.16	61674
1998	48.66	5.81	54.47	45918
1999	56.16	3.36	59.52	50175
2000	60.78	6.51	67.29	56725
2001	44.36	6.51	50.87	42883
2002	57.46	5.29	62.75	52898
2003	90.11	5.99	96.1	81012
2004	131.04	4.63	135.67	114369
2005	76.49	7.35	83.84	70677
2006	83.26	6.49	89.75	75659
2007	80.52	8.47	88.99	75019
2008	86.63	10.22	96.85	81645
2009	90.11	8.98	99.09	83533

Mean: 63,775 ± 22,370 SD

Sum: 956,628

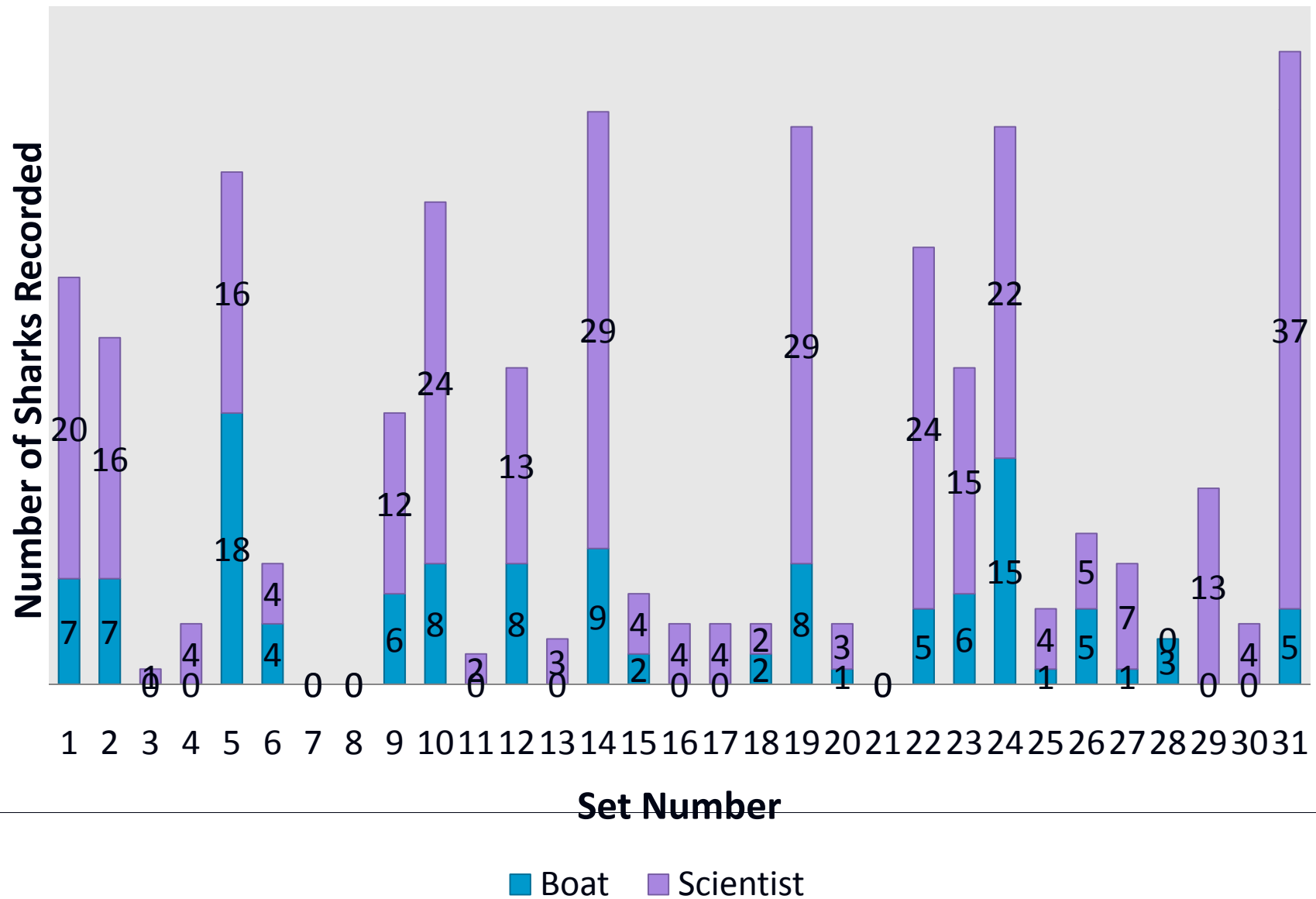


Thank you!



- ISSF – Susan Jackson, Victor Restrepo, Shira Worley, Mike Crispino
- Captain John Crisci & crew of the Cape Finisterre
- Trimarine
- WCPFMC, SPC, PIFSC - NOAA
- WPRFMC
- Wildlife Computers – Melinda Holland, Todd Lindstrom, Heather Baer
- Dr. Andy Taylor – University of Hawaii

Recorded Shark Interactions



(Wilcoxon signed rank test; $n = 31$, $V = 10.5$, p -value < 0.001)