Silky shark (*Carcharhinus falciformis*) post release survival in tropical tuna purse seiners.

Update report:

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1. Background

This study was carried out during a trip on board the Seychelles flagged purse seine vessel, Jai Alai (Figure 1) in the Indian Ocean. The trip lasted from the 22nd of October to the 23rd of November 2020. The dimensions of the purse seine net used were 1.647 meters cork line length and 280 meters deep, with stretched mesh.

Figure 1: F/V Jai Alai during a fishing operation. Photo: Iñigo Onandia

The survey area comprises the waters north of Seychelles up to degree 9^{o}N of latitude and between degrees 57^{o}E and 63^{o}E of longitude in the Western Indian Ocean (Figure 2).

Figure 2: Survey area in the Indian Ocean.

2. Preliminary results

278 silky sharks (*Carcharhinus falciformis*) were caught incidentally during 41 FAD-fishing set operations, and 10%(n=28) of them were tagged with satellite tags and released following recommended best practice release methods. The sharks were tagged during two different stages: i) when releasing the shark before going down to the fish processing lower deck and ii) when releasing the shark using the bycatch release conveyor belt installed in the lower deck. Tagged specimens were also measured, sexed, and a blood sample was collected to measure lactate (a blood parameter closely related to anoxia levels). Vitality categories were assigned to all individuals ranging between 4 (excellent), 3 (good), 2 (fair), 1 (poor) and 0 (death).

2.1. Satellite tagging

28 silky sharks ranging between 101 to 188 cm fork length were successfully tagged with satellite tags (24 sPATs and 4 MiniPATs). Tables 1 and 2 show the release and pop-off information, respectively.

Table 1: Tagged silky sharks release information. Immediate mortality is highlighted in red.

Serial	Date	type	Lat	Long	Catch (tn)	mode	brail	position	Release	length	sex	vitality	Lactate
20P1366	2020-10-23	MiniPAT	-2.22	59.48	20	entang	NA	NA	strecher	110	Female	3	5.0
20P1398	2020-10-24	sPAT	-1.17	63.48	40	brail	1	Medium	strecher	166	Female	2	7.3
20P1400	2020-10-24	sPAT	-1.17	63.48	40	brail	2	Bottom	conveyor belt	149	Male	1	8.2
20P1399	2020-10-24	sPAT	-1.17	63.48	40	brail	3	Medium	conveyor belt	148	Female	1	12.6
20P1411	2020-10-25	sPAT	0.98	59.48	5	entang	NA	NA	strecher	117	Female	4	2.6
20P1412	2020-10-25	sPAT	0.98	59.48	5	entang	NA	NA	strecher	120	Female	3	1.3
20P1414	2020-10-25	sPAT	0.98	59.48	5	brail	1	Bottom	conveyor belt	119	Female	2	8.5
20P1420	2020-10-26	sPAT	3.33	59.10	40	brail	1	Up	strecher	150	Male	1	7.9
20P1416	2020-10-26	sPAT	2.57	58.27	15	entang	NA	NA	strecher	139	Female	2	2.8
20P1436	2020-10-27	sPAT	2.63	58.17	35	brail	1	Medium	conveyor belt	128	Male	2	7.9
20P1407	2020-10-27	sPAT	2.63	58.17	35	brail	2	Up	strecher	139	Female	2	8.6
20P1434	2020-10-29	sPAT	6.37	61.73	20	brail	1	Medium	strecher	142	Male	4	9.2
20P0061	2020-10-29	sPAT	6.13	61.58	17	entang	NA	NA	strecher	127	Male	2	8.0
20P0893	2020-10-29	MiniPAT	6.13	61.58	17	entang	NA	NA	strecher	147	Female	2	5.4
20P1370	2020-10-30	MiniPAT	4.83	63.77	8	entang	NA	NA	strecher	124	Male	3	9.4
20P0866	2020-11-02	sPAT	5.25	56.98	42	brail	1	Medium	conveyor belt	164	Female	2	NA
20P0077	2020-11-02	sPAT	5.25	56.98	42	brail	3	Medium	conveyor belt	144	Female	1	7.6
20P0867	2020-11-03	sPAT	6.52	59.62	28	brail	4	Medium	conveyor belt	101	Male	1	10.1
20P0868	2020-11-05	sPAT	7.22	61.33	22	brail	1	Up	conveyor belt	140	Male	2	NA
20P1001	2020-11-07	sPAT	7.27	59.10	33	brail	2	Bottom	conveyor belt	140	Female	2	NA
20P0916	2020-11-11	MiniPAT	6.17	58.62	35	entang	NA	NA	strecher	134	Male	4	3.2
20P1172	2020-11-11	sPAT	6.17	58.62	35	brail	2	Medium	conveyor belt	144	Female	2	7.2
20P1439	2020-11-11	sPAT	6.82	58.50	12	brail	2	Up	strecher	153	Male	3	6.0
20P1422	2020-11-12	sPAT	7.80	59.28	20	brail	3	Medium	conveyor belt	167	Male	2	NA
20P1437	2020-11-13	sPAT	7.43	59.63	28	brail	2	Bottom	conveyor belt	134	Male	1	9.1
20P1469	2020-11-14	sPAT	5.75	54.72	47	brail	1	Medium	strecher	157	Female	2	7.8
20P1433	2020-11-14	sPAT	5.75	54.72	47	brail	2	Bottom	conveyor belt	188	Female	1	NA
20P1468	2020-11-14	sPAT	5.75	54.72	47	brail	3	Medium	strecher	181	Male	2	9.2

Table 2: tags pop-off information. Immediate mortality is highlighted in red.

Serial	PTT ID		Type	Latitude	Longitude	Depth	Days at liberty	Release reason
20P1366	205512	2021-02-15	1.66	81.66	0	115.40	Premature.	Pin was intact at the time of release
20P1398	205441	2020-12-07	-0.10	83.25	0	43.87	Premature.	Pin was intact at the time of release
20P1400	205443	2020-11-26	0.12	82.85	0	32.82	Premature.	Pin was intact at the time of release
20P1399	205442	2020-10-24	-1.17	63.48	1400	0.05	Too Deep.	Pin was intact at the time of release
20P1411	205445	2020-12-24	3.21	89.02	8	60.52	Interval.	Pin was intact at the time of release
20P1412	205446	2020-12-24	1.51	87.46	24	60.51	Interval.	Pin was intact at the time of release
20P1414	205447	2020-12-24	1.56	91.78	40	60.49	Interval.	Pin was intact at the time of release
20P1420	205450	2020-10-26	3.30	59.19	1400	0.16	Too Deep.	Pin was intact at the time of release
20P1416	205448	2020-12-26	-0.31	86.21	56	60.68	Interval.	Pin was intact at the time of release
20P1436	205455	2020-10-27	2.63	58.21	1448	0.07	Too Deep.	Pin was intact at the time of release
20P1407	205444	2020-12-26	3.95	73.69	0	60.48	Interval.	Pin was intact at the time of release
20P1434	205454	2020-11-30	6.54	57.20	0	32.34	Premature.	Pin was intact at the time of release
20P0061	204896	2020-12-28	1.14	44.43	0	60.35	Interval.	Pin was intact at the time of release
20P0893	204856	2020-10-29	6.18	58.70	1688	0.05	Too Deep.	Pin was intact at the time of release
20P1370	205513	2020-11-08	4.11	65.06	0	9.17	Premature.	Pin was intact at the time of release
20P0866	204898	2021-01-01	4.74	53.85	8	56.83	Interval.	Pin was intact at the time of release
20P0077	204897	2020-11-25	4.09	53.80	0	23.64	Floater.	Pin was intact at the time of release
20P0867	204899	2020-11-03	6.52	59.62	1496	0.06	Too Deep.	Pin was intact at the time of release
20P0868	204900	2021-01-04	8.30	55.02	40	52.80	Interval.	Pin was intact at the time of release
20P1001	204902	2021-01-06	4.71	51.59	8	56.83	Interval.	Pin was intact at the time of release
20P0916	204858	2021-02-06	5.03	53.46	0	87.00	Premature.	Pin was intact at the time of release
20P1172	196530	2020-12-11	5.58	57.75	24	30.67	Interval.	Pin was intact at the time of release
20P1439	205457	2021-01-11	-1.95	45.53	24	60.42	Interval.	Pin was intact at the time of release
20P1422	205451	2021-01-12	0.92	54.98	8	56.83	Interval.	Pin was intact at the time of release
20P1437	205456	2021-01-13	-1.46	42.40	8	60.54	Interval.	Pin was intact at the time of release
20P1469	205459	2020-11-14	5.67	54.54	1528	0.28	Too Deep.	Pin was intact at the time of release
20P1433	205453	2021-01-13	5.16	49.99	24	56.84	Interval.	Pin was intact at the time of release
20P1468	205458	2020-11-14	5.73	54.58	1496	0.06	Too Deep.	Pin was intact at the time of release

A total of 7 sharks showed immediate mortality within the first 24 hours after release (highlighted in red in Tables 1 and 2). One of the tags popped off prematurely after 9 days at sea with no apparent clear reason, and 20 tags remained attached for more than 20 days, which was considered to represent surviving sharks. Figure 3 shows the initial release position of tagged sharks (white dots) and the final pop-off position (red dots). Two different movement patterns were clearly observed. The individuals tagged in the north-west of the survey area tended to move towards the African coast while the ones tagged in southern region tended to move rapidly towards the Indian ocean eastern area.

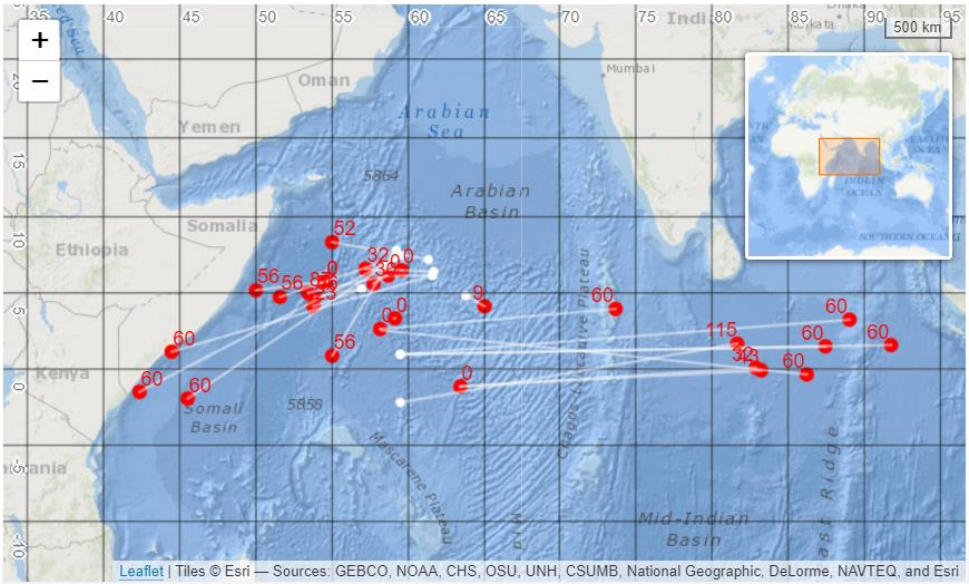

Figure 3: Release (white dots) and pop-off (red dots) positions of the satellite tags. Numbers indicate the days between tagging and pop off.

2.2 Vitality assessment

The vitality index at time of release was recorded for every captured individual. Conditions were recorded from 0 to 4, where (4), or “excellent”, was recorded for sharks that swam away rapidly without any apparent physical trauma. (3) “good” condition was recorded for sharks that swam away slower or disoriented. (2) “fair” was recorded for sharks whose swimming appeared laborious and/or signs of physical trauma. (1) “poor“ was recorded for sharks that were able to right themselves and made efforts to swim, while sharks who scored (0), or “dead”, sank upside down.

According to the survey results, vitality decreased with increasing releasing time during the fishing operation (Table 3). Individuals entangled in the net released during the hauling operation showed the best vitality score while the ones embarked after the second brail showed a high immediate mortality. Combining the survival rates obtained from tagged individuals with the vitality scores determined by the observer, we predicted an overall survival rate of silky sharks for this trip of 37.4%.

Table 3: Vitality assessment and predicted survival

	Dead (0)	Poor (1)	Fair (2)	Good (3)	Excellent (4)	Total	Survivors	Pred. survival (%)
Tangled	0	2	8	16	16	42	34	80.95
1st_brail	12	12	27	11	0	62	31	50
2nd_brail	31	26	17	4	0	78	25	32.05
3rd_brail	66	21	9	0	0	96	14	14.58
(all)	109	61	61	31	16	278	104	37.41
Pred. survival (%)	0	40	66.67	75	100			
Survivors	0	24	41	23	16			

2.3. Lactate

Blood samples were taken from the caudal peduncle of tagged silky sharks and measured "in situ" using a lactate meter. With survival rates obtained from tagged individual and lactate levels we calculated the survival probability curve shown in Figure 4. The point of inflection estimated a lactate concentration of 8.6 mmol l^{-1} Therefore those silky sharks with lactate values lower than 8.6 mmol l^{-1} were considered survivors.

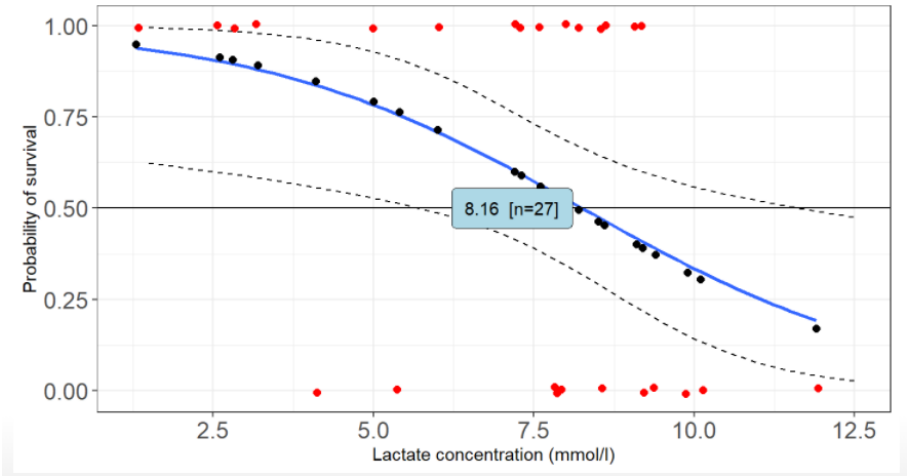

fig 4: Survival probability curve using lactate.

Based on the lactate prediction curve the overall survival estimation would be 43.8% of the total captured individuals.

Table 4: Vitality assessment and predicted survival

	Lactate<8.16	N measured	Pred. survival (%)	Total	Survivors
Tangled	12	15	80.00	42	34
1st_brail	8	14	57.14	62	35
2nd_brail	3	8	37.50	78	29
3rd_brail	2	8	25.00	96	24
(all)	25	45	43.88	278	122

In summary, this study provides two estimates of survival rates of silky shark during a purse seine fishing trip applying good handling and releasing practices: 37.4% and 43.88% using vitality index and lactate concentration as predictors, respectively. These survival rates are significantly higher than those estimated in previous studies: 19% in the Indian Ocean (Poisson, F. et al, 2014) and 15.8% in the Western Pacific (Hutchinson, M.R. et al, 2015).

3. References

Hutchinson,M., Itano, D., Muir, J. and Holland, K.N. (2015). Post release survival of juvenile silky sharks captured in a tropical tuna purse seine fishery. Marine Ecology Progress Series 521, 143–154.

Poisson, F., Filmalter, J.D., Vernet, A.-L. and Dagorn, L. (2014). Mortality rate of silky sharks (Carcharhinus falciformis) caught in the tropical tuna purse seine fishery in the Indian Ocean. Canadian Journal of Fisheries and Aquatic Sciences 71,795–798.

