Post-releases survival of Southern Bluefin Tuna released from longline vessels

延縄船から放流されたミナミマグロの放流後生残率

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Summary

This report describes the estimation of post-release survival of southern bluefin tuna (SBT) released from Japanese longline vessels. The survival rate in 48 hours after release were determined by pop up archival tag (PSAT) data (n=61; for 88-188cm FL fish). The data from 45 tags were available to estimate the post release survival. Among them, 4 tags showed the time-depth pattern indicating mortality, and 41 tags showed the dive pattern of living SBT. These data showed that a post-release survival rate was roughly 91%. The GLM analysis suggested that the post-release survival was able to be explained well by the fork length of released SBT and the method of landing on the deck. When only the brunch line is used to pull the SBT hooked up on the deck, high survival rate (> 90%) was expected for small fish (<105 cm FL). If the fish were scooped by the spoon-net using human power, more than 90% survival rate was expected even for 165 cm FL. In addition, if the system which lifts up the fish with the steel basket using electro-hydraulic power — called “scooper” — was used, almost 100% of survival rate was expected regardless of the size of fish. These results suggested that the post release survival rate could be kept high level if the proper landing method on the deck was used. These survival rate estimated by this study should be considered underestimate because the PSAT tagging probably has negative effect for the post release survival in itself.

要約

本文書は日本延縄漁船から放流されたミナミマグロの放流後生残率の推定について示す。本研究では、放流から 48 時間以内の生残率をポップアップアーカイバルタグ（PSAT）放流調査により検討した（61 個体分； 尾叉長 88-188cm の個体を対象）。放流した PSAT のうち、45 個のタグのデータが放流後生残率の推定に使用できた。そのうちの 4 個体には魚体の死亡を示す深度記録がみられ、残り 41 個体のタグのデータには放流後も生残したと考えられる遊泳行動が確認された。この結果は、おおまかに放流後生残率が 91%であることを示している。一般化線形モデル（GLM）による分析の結果、放流後生残率は放流個体の尾叉長とデッキへの引き上げ方法で良く説明できることが明らかになった。すなわち、枝縄のみを手繰って魚をデッキに引っぱり揚げる方法では、小型個体（<105cmFL）であれば高い生残率（>90%）が期待できること、大型個体であれば大型タモ網でデッキにすくい揚げることで 165cmFL でも 90%以上の生残率を、スクーパと呼ばれる取り込み装置ですくい揚げることでは魚体サイズに関わらず 100%の生残率を期待できることが明らかとなった。これらの結果は、魚体のサイズに応じて適切なデッキへの引き上げ方法を用いれば、放流後の生残率を高く保つことが出来ることを示す。本研究では PSAT を生残率の検討に用いているが、PSAT の装着そのものが生残率に負の影響を及ぼし得ることを考慮すると、今回推定された放流後生残率の結果は過小推定だと考えるべきである。

1. Introduction

Japan has implemented the individual quota (IQ) system for Japanese Southern Bluefin Tuna (SBT) longline fishery to improve the management scheme since 2006 (CCSBT-ESC/1309/SBT Fisheries-Japan). Since around the same time, small sized SBT has been remarkably caught possibly due to the increased abundance of small SBT. As the results of this situation, the number of live-released SBT, especially for small individuals, from Japanese longline vessels has increased. The aim of this "live-release" was not only to prevent exceeding their individual quota, but also to protect the small-sized fish in the context of the effective utilization of SBT stock. Post release survival is important information to evaluate the influence of the live-releases on the SBT stock.

Pop-up satellite archival tag (PSAT) technology is one of useful tool for evaluating post release survival due to its data logging and transfer function. PSAT can record the depth and temperature for predefined intervals, detach from the fish at a previously designated time, float to the surface, and transmit stored data via a satellite. To prevent from exceeding of pressure limitation, PSAT were arranged to disconnect their tether with automatic release mechanism. The data from PSAT allow researchers to determine if the fish died or not after release.

The purpose of this study was to determine the short-term (< 48 h) fate of SBT that were caught by longline and then released using the PSAT technology. Specifically, it was focused that some physical and environmental situation (e.g. the fish size, temperature, landing method on the deck etc.) would have influence on the post-release survival or not.

2. Materials and methods

Deployment of PSATs on SBT occurred in the fishing grounds of SBT (CCSBT statistical area 1, 2, 4, 8, and 9) in 2001-2012. PSATs were deployed on various size of SBT (n=61; 88-188cm FL) from 8 longline vessels (Table 1). 22 of all PSATs were the products of Microwave Telemetry Inc. (PTT100 and X-tag), and 39 of them were the products of Wildlife Computers Inc. (PAT2, Mk10PAT, and miniPAT). These PSATs were divided into 2 groups according to their size; larger (length 166-175mm, n=30; PTT100, PAT2, and Mk10PAT) and smaller (length 115-120mm, n=31; X-tag and miniPAT). All SBT released in this study were caught by the longline gear. The landing methods on the deck for the hooked SBT were divided into 3 types; 25 of them were pulled up on the deck using only the brunch line, 31 of them were scooped by the spoon-net using human power, and 5 of them were lifted to the deck by the steel basket using electro-hydraulic system. PSATs were rigged with a tether and a nylon or metal dart head which was inserted in between pterygiophore at the base of the second dorsal fin of SBT. PSATs have three sensors (temperature, pressure (depth), and light level) and emergency release gimmick that automatically detached if the PSAT came to the depth of crush limit (about 2000 m) or PSAT remained at a constant depth for more 96 h, suggesting a mortality resting on the ocean floor. Normally, PSATs were detached from the SBT at a previously designated time (in maximum 1 year), although sometimes they were released prematurely. When the PSAT floated to the sea surface after the detachment, the data stored in the PSAT were transmitted through the Advanced Research and Global Observation Satellite (ARGOS) system.

In this analysis, the mortality status of SBT was determined using the time-depth pattern recorded in PSAT in first 48 hours. We assumed that the dead SBT would sink to the bottom of the ocean, and remained there and/or released by the emergency gimmick. On the other hand, the surviving SBT would continue the regular or irregular dives to various depths. Non-transmitting tags and immediately (< 48 h) released tags were excluded this analysis. After the estimation of the mortality status of tagged SBT, the factors which would have influence of the post-release survival were estimated using a binomial generalized linear model (Logistic regression analysis). The calculation was conducted through "glm" package of R (ver. 3.0.1). At first, we used the following formula as a full model:

Mortality status = Intercept + Vessel ID + Landing methods + PSAT size + SBT size + SST + Error,
where “vessel ID” was the ID number of 8 vessels which were used in PSAT tagging, “Landing methods” was 3 types of above mentioned methods, “PSAT size” was large or small size of PSAT, “SBT size” was fork length of tagged SBT, and “SST” was sea surface temperature of the released position. Relative goodness of fit was evaluated by comparing the corresponding Akaike’s Information Criterion (AIC) model comparison statistics. The R function “step AIC” was used to search stepwise.

3. Results

We received data from 45 tagged fish producing records from 4 days to one year; 12 tags failed to report and 4 tags were detached immediately after the deployment (Fig. 1). The time-depth pattern consistent with mortality was observed in the data from 4 tags, all of which showed the sinking to the crush-limit depth and the emergency release of the PSAT probably after death in first 48 h. The data from 41 of tags showed the dive pattern of living SBT. These data roughly indicate a post-release survival rate of 91%. Fig 2 shows the fork length distribution of the SBT which were survived or not. The typical examples of the time-depth pattern indicating both mortality and survival are shown in Fig. 3.

The logistic regression analysis was conducted to estimate the influence of the each factor toward the post-release survival, and the AIC of full model was 37.664. The final model chosen based on the lowest AIC in the stepwise result of the logistic regression analysis were the model as follows;

Mortality status = Intercept + Landing methods + SBT size + Error, (AIC=28.03).
Its summary statistics are in table 2, and these results showed that the post-release survival/mortality was able to be explained well by the factors which were chosen in the final mode. Fig. 4 shows the prediction based on the final model; the post-release survival was predicted by the fork length of released SBT and the method of landing on the deck. This prediction means that the high survival rate (> 90%) were expected for small fish (<105 cm FL), even if the SBT hooked the longline were pulled up on the deck only using the brunch line. However this landing method predicted lower survival rate for the larger SBT, the other landing methods can produce higher post-release survival for the larger sized SBT: If the fish were scooped by the spoon-net using human power, more than 90% survival rate was expected even for 165 cm FL. In addition, if the system which can lift up the fish by the steel basket using electro-hydraulic power was used, almost 100% of survival rate was expected for much larger fish.

4. Discussion

Recently, a lot of results of post-release survival study for various species have been available (e.g. Kerstetter and Graves 2007; Campana et al. 2009). Some of these studies focused on the influence of the handling stress before the release; e.g. fight time (Stokesbury et al. 2011), handling (Danylchuk et al. 2007). In these previous studies, the negative effect of handling stress was discussed for the post-release survival. Our result showed the influence of the landing method for the post-release survival in the same context: the handling stress from landing the hooked SBT on the deck would have the negative effect for the survival after release.

The present study demonstrated that the mortality rate after release could be kept low level if the proper landing method on the deck was used. For the small sized SBT, “pulling up by the brunch line” was considered sufficient to achieve high post-release survival as the landing method. This method was actually used on the commercial longline vessels to release the small sized SBT. However, this method is potentially dangerous for the deck crew during the landing; the hook and weights of brunch line may fly-back at the crew in the event of line breakage or fish dropping-off. Therefore fishermen tended not to use this method to release larger sized SBT. Our analysis showed that “scooping by the spoon-net” and “lifting up by the electro-hydraulic basket" is more efficient method for larger sized SBT; probably these methods can reduce the handling stress during the landing before release. But, there are only a few vessels which have "electro-hydraulic basket" in Japanese fleet.

According to the hearing from fishermen, the large sized SBT were released by cutting line without landing on the deck. The handling time and effort of cutting line is shorter and smaller than landing by scoop-net and basket, thus cutting line may be more effective method for release with less handling stress. This suggests that the larger SBT actually released by Japanese commercial longline vessels would have higher survival rate than that was expected by our analysis. Moreover, the tagging which was used in this study has negative effect for the post release survival in itself, because of the extra stress by tagging and handling. Therefore, the result of post release survival in this study should be considered underestimate.

The estimation of the post-release survival of SBT released from longline vessels was required by the extended scientific committee in 2012 (CCSBT 2012a). In addition, the CCSBT 7th meeting of the compliance committee also required to monitor all fishing-related mortality from all sources (CCSBT 2012b). Estimating the release mortality would be important to improve our understanding of SBT catch, and it is useful for stock assessment science and compliance. The other mortality for live-release under the other fishing activities should be estimated too.

Reference

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Table 1. Information of tag deployment and pop up of southern bluefin tuna that were tagged with pop-up archival tags in 2001-2012. Fork length was measured at the tagging using a caliper.

Tag info.	ArgosID	Vessel name	Landing method	Tagged date	Tagged position (lat.)	Tagged position (lon.)	Fork length (cm)	Pop-up date	Data received (days)	Pop-up position (lat.)	Pop-up position (lon.)	Post-release survival	Note
PTT100 (Microwave Telemetory Inc.)	29574	Mastuei 3	scooped by the spoon-net	5-Nov-01	-40.57	25.79	139					Unknown	Lost
PTT100 (Microwave Telemetory Inc.)	29577	Mastuei 3	scooped by the spoon-net	5-Nov-01	-40.57	25.78	132					Unknown	Lost
PTT100 (Microwave Telemetory Inc.)	29852	Mastuei 3	scooped by the spoon-net	12-Nov-01	-40.06	36.04	153	30-Nov-01	18	-38.48	42.36	Survived	
PTT100 (Microwave Telemetory Inc.)	29960	Mastuei 3	scooped by the spoon-net	12-Nov-01	-40.06	36.04	150	18-Nov-01	6	-40.89	42.63	Survived	
PTT100 (Microwave Telemetory Inc.)	30140	Mastuei 3	scooped by the spoon-net	12-Nov-01	-39.97	36.00	129	18-Nov-01	6	-38.40	42.97	Survived	
PTT100 (Microwave Telemetory Inc.)	30361	Mastuei 3	scooped by the spoon-net	21-Nov-01	-39.98	36.85	142	28-Nov-01	7	-37.68	41.86	Survived	
PTT100 (Microwave Telemetory Inc.)	30487	Mastuei 3	scooped by the spoon-net	1-Dec-01	-40.87	42.10	138	12-Dec-01	11	-40.20	43.77	Unknown	Lost
PTT100 (Microwave Telemetory Inc.)	26465	Shoyo	lifted by electro-hydraulic basket	17-Jan-02	-15.52	117.25	180	13-Feb-02	27	-24.23	108.44	Survived	
PTT100 (Microwave Telemetory Inc.)	26466	Shoyo	lifted by electro-hydraulic basket	20-Feb-02	-16.30	117.67	188	10-Apr-02	49	-38.22	82.53	Survived	
PTT100 (Microwave Telemetory Inc.)	26547	Shoyo	lifted by electro-hydraulic basket	13-Feb-02	-16.02	117.00	159					Unknown	Lost
PTT100 (Microwave Telemetory Inc.)	26550	Shoyo	lifted by electro-hydraulic basket	15-Jan-02	-15.48	116.78	157	20-Jan-02	5	-16.37	113.62	Survived	
PTT100 (Microwave Telemetory Inc.)	26551	Shoyo	lifted by electro-hydraulic basket	11-Feb-02	-15.00	116.23	160	10-Apr-02	58	-38.72	122.50	Survived	
PAT2 (Wildlife Computer Inc.)	4026	Fukuseki 33	scooped by the spoon-net	20-Oct-02	-37.27	35.08	158	10-Nov-02	21	-35.37	47.08	Survived	
PAT2 (Wildlife Computer Inc.)	4029	Fukuseki 33	scooped by the spoon-net	21-Oct-02	-37.37	33.17	151	23-Oct-02	2	-36.12	32.63	Unknown	Immediately released
PAT2 (Wildlife Computer Inc.)	4035	Fukuseki 33	scooped by the spoon-net	22-Oct-02	-38.28	35.20	142	30-Nov-02	39	-42.72	36.25	Survived	
PAT2 (Wildlife Computer Inc.)	4036	Fukuseki 33	scooped by the spoon-net	7-Dec-02	-40.03	36.87	133	17-Jan-03	41	-37.81	51.73	Survived	
PAT2 (Wildlife Computer Inc.)	4043	Fukuseki 33	scooped by the spoon-net	19-Dec-02	-39.18	34.30	141	24-Jan-03	36	-38.19	51.62	Survived	
PAT2 (Wildlife Computer Inc.)	4044	Fukuryu 21	scooped by the spoon-net	24-Oct-05	-35.05	95.25	168	3-Dec-05	40	-27.16	104.10	Survived	

Table 1 cont.

Tag info.	ArgosID	Vessel name	Landing method	Tagged date	Tagged position (lat.)	Tagged position (lon.)	Fork length (cm)	Pop-up date	Data received (days)	Pop-up position (lat.)	Pop-up position (lon.)	Post-release survival	Note
PAT2 (Wildlife Computer Inc.)	4050	Fukuryu 21	scooped by the spoon-net	22-Oct-05	-35.13	95.30	166	9-Dec-05	48	-32.92	88.71	Survived	
PAT2 (Wildlife Computer Inc.)	4054	Fukuryu 21	scooped by the spoon-net	21-Oct-05	-35.03	95.05	162					Unknown	Lost
Mk10PAT (Wildlife Computer Inc.)	48843	Fukuryu 21	scooped by the spoon-net	20-Aug-07	-38.07	101.55	162	10-Nov-07	82	-31.81	83.14	Survived	
Mk10PAT (Wildlife Computer Inc.)	48844	Fukuryu 21	scooped by the spoon-net	7-Sep-07	-37.82	102.62	158	8-Sep-07	1	-37.22	104.80	Unknown	Immediately released
Mk10PAT (Wildlife Computer Inc.)	48846	Fukuryu 21	scooped by the spoon-net	5-Oct-07	-31.73	102.32	165	2-Dec-07	58	-35.23	74.57	Survived	
Mk10PAT (Wildlife Computer Inc.)	48848	Fukuryu 21	scooped by the spoon-net	5-Oct-07	-31.73	102.32	159	28-Jan-08	115	-38.42	85.86	Survived	
Mk10PAT (Wildlife Computer Inc.)	48849	Fukuryu 21	scooped by the spoon-net	14-Sep-07	-38.13	102.63	160	16-Sep-07	2	-37.61	104.60	Unknown	Immediately released
Mk10PAT (Wildlife Computer Inc.)	48851	Fukuryu 21	scooped by the spoon-net	21-Aug-07	-38.07	101.50	159	31-Aug-07	10	-28.07	103.87	Dead	
Mk10PAT (Wildlife Computer Inc.)	48853	Fukuryu 21	scooped by the spoon-net	7-Oct-07	-32.02	104.03	166	30-Dec-07	84	-30.43	101.44	Survived	
Mk10PAT (Wildlife Computer Inc.)	48854	Fukuryu 21	scooped by the spoon-net	2-Oct-07	-41.17	100.97	176	4-Oct-07	2	-39.42	101.12	Unknown	Immediately released
Mk10PAT (Wildlife Computer Inc.)	48856	Fukuryu 21	scooped by the spoon-net	7-Oct-07	-32.02	104.03	171	15-Oct-07	8	-26.19	99.94	Survived	
Mk10PAT (Wildlife Computer Inc.)	48857	Fukuryu 21	scooped by the spoon-net	7-Oct-07	-32.02	104.03	169	24-Oct-07	17	-24.73	99.93	Survived	
X-tag (Microwave Telemetory Inc.)	52165	Fukuichi 82	pulled up using brunch line	5-Jun-10	-38.98	154.31	115					Unknown	Lost
X-tag (Microwave Telemetory Inc.)	52166	Fukuichi 82	pulled up using brunch line	5-Jun-10	-38.98	154.31	109					Unknown	Lost
X-tag (Microwave Telemetory Inc.)	52167	Fukuichi 82	pulled up using brunch line	6-Jun-10	-38.93	155.06	107					Unknown	Lost
X-tag (Microwave Telemetory Inc.)	52168	Taiyo 28	scooped by the spoon-net	18-Jun-10	-32.85	81.58	103	18-Jun-11	365	-38.33	44.28	Survived	
X-tag (Microwave Telemetory Inc.)	52169	Taiyo 28	scooped by the spoon-net	18-Jun-10	-32.85	81.58	105	24-Dec-10	189	-40.34	74.63	Survived	
X-tag (Microwave Telemetory Inc.)	52170	Taiyo 28	scooped by the spoon-net	19-Jun-10	-32.78	81.87	121	13-Mar-11	267	-39.92	137.80	Survived	
X-tag (Microwave Telemetory Inc.)	52214	Fukuichi 82	pulled up using brunch line	7-Jun-10	-38.43	155.68	115					Unknown	Lost

Table 1 cont.

Tag info.	ArgosID	Vessel name	Landing method	Tagged date	Tagged position (lat.)	Tagged position (lon.)	Fork length (cm)	Pop-up date	Data received (days)	Pop-up position (lat.)	Pop-up position (lon.)	Post-release survival	Note
X-tag (Microwave Telemetory Inc.)	52215	Fukuichi 82	pulled up using brunch line	8-Jun-10	-39.03	155.13	123					Unknown	Lost
X-tag (Microwave Telemetory Inc.)	52216	Fukuichi 82	pulled up using brunch line	11-Jun-10	-39.19	154.71	105	29-Jun-10	18	-38.73	156.39	Survived	
X-tag (Microwave Telemetory Inc.)	52220	Taiyo 28	scooped by the spoon-net	17-Jun-10	-33.92	80.47	114					Unknown	Lost
miniPAT (Wildlife Computer Inc.)	52235	Taiyo 28	scooped by the spoon-net	14-Jun-10	-32.58	81.01	115	7-Oct-10	115	-33.92	84.16	Survived	
miniPAT (Wildlife Computer Inc.)	52260	Taiyo 28	scooped by the spoon-net	14-Jun-10	-32.58	80.87	110					Unknown	Lost
miniPAT (Wildlife Computer Inc.)	113761	Myojin 3	pulled up using brunch line	17-Aug-12	-39.51	103.44	127	25-Nov-12	100	-38.40	91.08	Survived	
miniPAT (Wildlife Computer Inc.)	113762	Myojin 3	pulled up using brunch line	21-Aug-12	-39.60	107.17	119	25-Aug-12	4	-39.50	107.65	Dead	
miniPAT (Wildlife Computer Inc.)	113763	Myojin 3	pulled up using brunch line	22-Aug-12	-39.59	107.17	114	26-Aug-12	4	-39.51	107.73	Dead	
miniPAT (Wildlife Computer Inc.)	113764	Myojin 3	pulled up using brunch line	25-Aug-12	-39.24	107.22	115	29-Nov-12	96			Survived	
miniPAT (Wildlife Computer Inc.)	113765	Myojin 3	pulled up using brunch line	10-Sep-12	-36.73	109.06	123	1-Dec-12	82	-36.50	121.74	Survived	
miniPAT (Wildlife Computer Inc.)	113766	Myojin 3	pulled up using brunch line	17-Sep-12	-36.23	109.35	112	21-Nov-12	65	-37.51	115.15	Survived	
miniPAT (Wildlife Computer Inc.)	113767	Myojin 3	pulled up using brunch line	27-Sep-12	-36.14	108.33	126	1-Oct-12	4	-35.99	108.19	Dead	
miniPAT (Wildlife Computer Inc.)	113768	Myojin 3	pulled up using brunch line	3-Oct-12	-36.49	107.95	114	15-Dec-12	73	-37.63	119.67	Survived	
miniPAT (Wildlife Computer Inc.)	113769	Myojin 3	pulled up using brunch line	23-Aug-12	-39.76	107.15	112	29-Oct-12	67	-31.70	138.83	Survived	
miniPAT (Wildlife Computer Inc.)	113883	Syofuku 8	pulled up using brunch line	24-Aug-12	-38.30	104.77	108	4-Jan-13	133	-39.05	126.62	Survived	
miniPAT (Wildlife Computer Inc.)	113884	Syofuku 8	pulled up using brunch line	27-Aug-12	-39.09	105.78	88	14-Sep-12	18	-35.26	109.00	Survived	
miniPAT (Wildlife Computer Inc.)	119456	Syofuku 8	pulled up using brunch line	29-Aug-12	-38.97	107.88	96	14-Sep-12	16	-34.40	110.76	Survived	
miniPAT (Wildlife Computer Inc.)	119457	Syofuku 8	pulled up using brunch line	29-Aug-12	-38.95	107.88	88	4-Sep-12	6	-37.56	109.17	Survived	
miniPAT (Wildlife Computer Inc.)	119458	Syofuku 8	pulled up using brunch line	31-Aug-12	-38.48	107.83	93	26-Oct-12	56	-32.68	112.39	Survived	

Table 1 cont.

Tag info.	ArgosID	Vessel name	Landing method	Tagged date	Tagged position (lat.)	Tagged position (lon.)	Fork length (cm)	Pop-up date	Data received (days)	Pop-up position (lat.)	Pop-up position (lon.)	Post-release survival	Note
miniPAT (Wildlife Computer Inc.)	119459	Syofuku 8	pulled up using brunch line	2-Sep-12	-38.03	107.87	90	1-Dec-12	90	-33.57	131.50	Survived	
miniPAT (Wildlife Computer Inc.)	119460	Syofuku 8	pulled up using brunch line	2-Sep-12	-37.82	107.92	92	11-Sep-12	9	-35.47	111.21	Survived	
miniPAT (Wildlife Computer Inc.)	119461	Syofuku 8	pulled up using brunch line	4-Sep-12	-37.43	108.03	91	7-Oct-12	33	-33.50	112.47	Survived	
miniPAT (Wildlife Computer Inc.)	119462	Syofuku 8	pulled up using brunch line	6-Sep-12	-37.07	107.90	89	11-Sep-12	5	-35.74	109.47	Survived	
miniPAT (Wildlife Computer Inc.)	119463	Syofuku 8	pulled up using brunch line	6-Sep-12	-37.02	107.93	96	7-Dec-12	92	-32.72	124.55	Survived	

Table 2. Result of final model for the logistic regression analysis to estimate the factors which would have influence of the post-release survival.

Analysis of Deviance Table (Type III test)			
	Chi-square	DF	P-value
Fork length of SBT	4.9204	1	0.02654
Landing methods	6.9650	2	0.03073

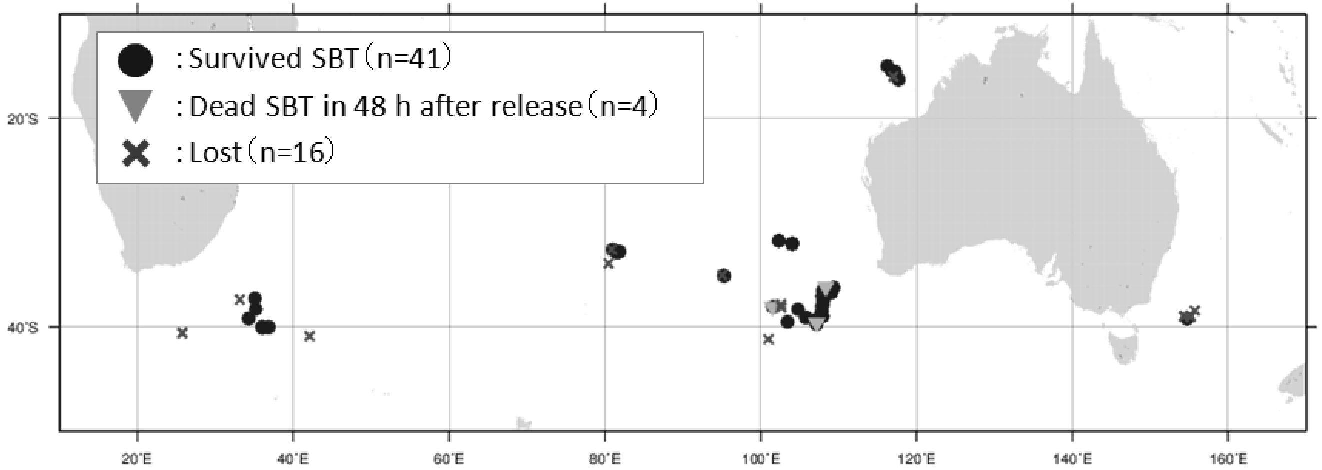

Fig. 1. Position of SBT release with pop-up satellite tags in 2001-2012.

Black circles = tags that were attached on survived SBT after release, Gray triangle = tags that were attached of dead SBT in first 48h after release, Black X = Non-transmitting or immediately released tags.

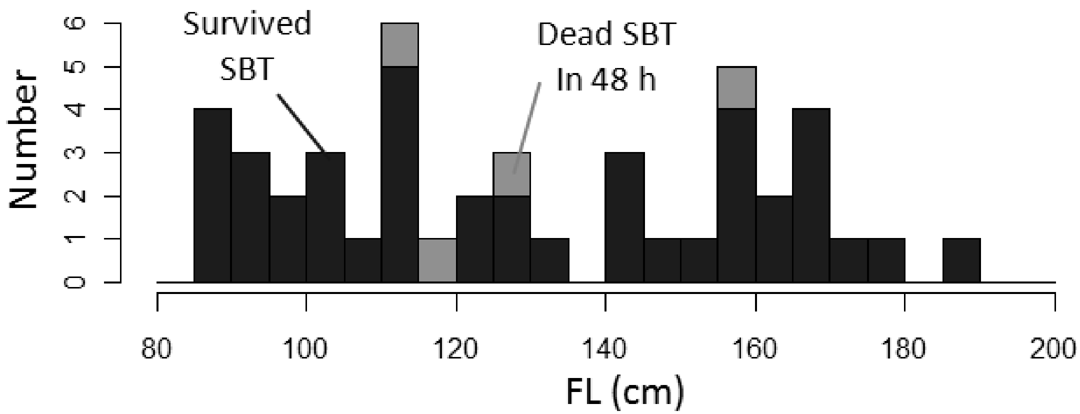

Fig. 2. Fork length of SBT release with pop-up satellite tags in 2001-2012.

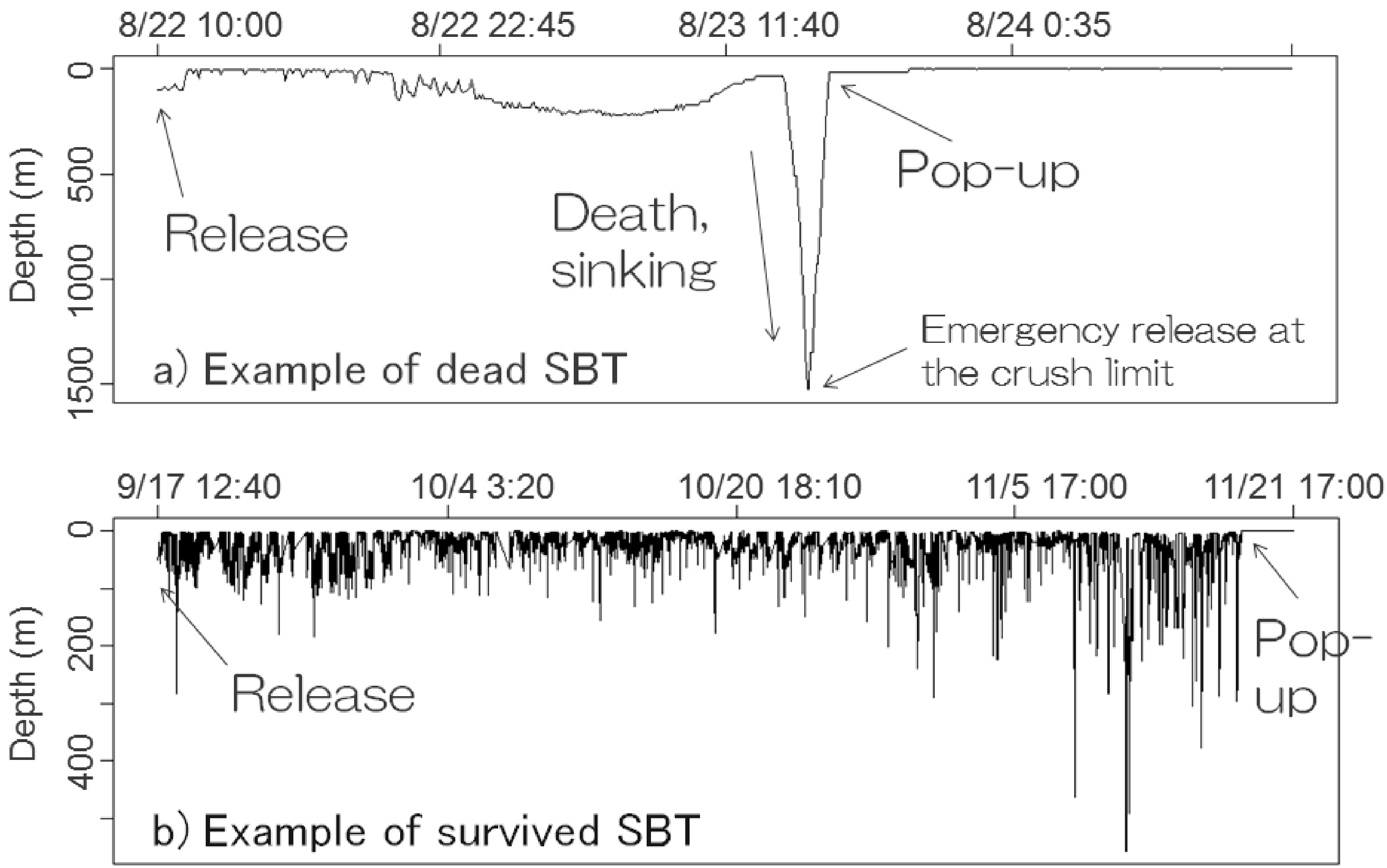

Fig. 3 The typical examples of the time-depth pattern indicating both (a) mortality and (b) survival.

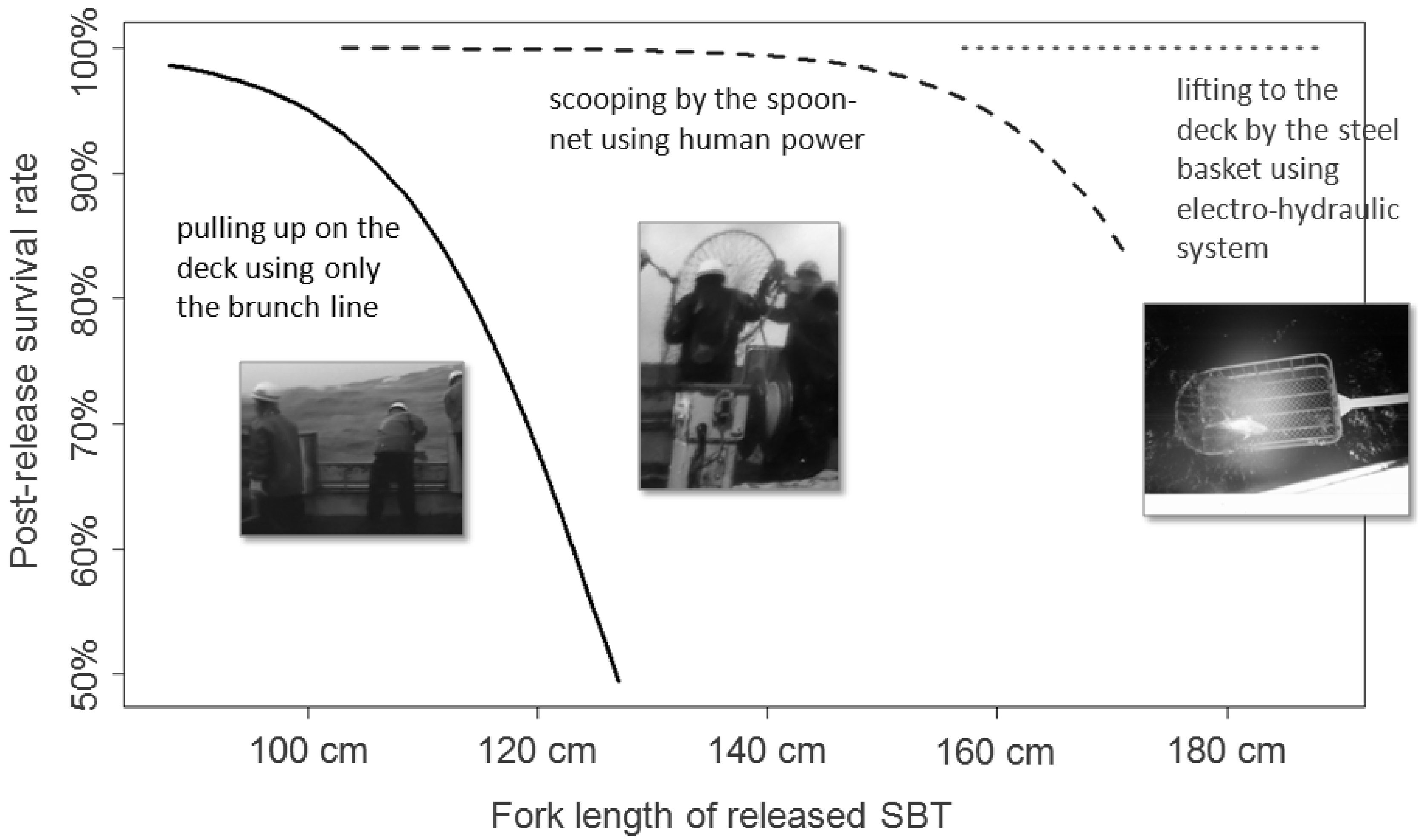

Fig. 4 The prediction based on the final model of the logistic regression analysis to estimate the factors which would have influence of the post-release survival; the post-release survival was well predicted by the fork length of released SBT and the method of landing on the deck.