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TNC and Tunago Electronic Monitoring Transshipment Vessel Research Project

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Executive Summary

This working paper provides background information and preliminary results from a cooperative multi-phase electronic monitoring (EM) research project on a tuna transshipment vessel. Phases 1 & 2 of the project have been completed and planning is underway to carry out a final Phase 3 component. The Nature Conservancy (TNC) has been working closely with various partners including the Pacific Islands Forum Fisheries Agency (FFA) and the Pacific Community (SPC), to design the project to collect information on previously identified data gaps and proposed monitoring elements to inform the use of EM as a complementary and reliable monitoring tool onboard tuna transshipment vessels.

Of note in this working paper is the installation and testing of an integrated motion-compensated crane scale (Figure 3) during the Phase 2 trial. The in-line crane scale successfully transmitted and electronically recorded, via Wi-Fi signal, the weights from over 3,200 full nets of frozen purse seine caught tuna to the EM system located in the wheelhouse of the transshipment vessel. This transmission was done automatically without need for human intervention which is the first time this type of data transmission has been accomplished in the Pacific. The ingested weights, coupled with the 24/7 EM video footage and supporting meta-data documenting the transshipment activities, provide a powerful monitoring, control, and surveillance (MCS) data set and tool to meet various science and compliance needs.

After completion of the Phase 2 field work, TNC has been working closely with the EM vendor Satlink based in Madrid, Spain to acquire and bench test a new motion-compensated crane scale that we believe will be a demonstrable improvement over the prototype scale used in the Phase 2 cruise. The improvements include a lighter overall scale weight (3 kg vs 25 kg), enhanced digital integration and automation features, longer battery life, a hand-held remote to monitor weights from various locales on the ship, and a new automatic data transmission protocol that relies on radio frequency technology versus Wi-Fi technology offering a longer range data transmission signal. One of the main objectives of the proposed Phase 3 research component would be to test this new fit-for-purpose scale during at-sea longline transshipment activity. TNC and project partners would value any comments and suggestions on additional data elements to collect and test during the Phase 3 component of the proposed project. An industry partner with a suitable transshipment vessel is currently being sought to sponsor the Phase 3 work.

Introduction

The Nature Conservancy (TNC) and the Tunago Fishing and Shipping companies (Tunago), along with a host of collaborative project partners, initiated a multi-phase tuna transshipment vessel electronic monitoring (EM) research project (the 'Project') in 2018. The Tunago owned and operated T/V Shin Ho Chun 102 (SHC102) served as the transshipment vessel platform for both Phase 1 and 2 of the Project. Phase 1 of the Project was completed in July 2020 and a comprehensive trip report was drafted and shared with Project Partners[3]. The Phase 1 Report outlined the Goals and Objectives and a Field Work Plan for the Phase 2 component of the Project. With supplementary funding received from the PEW Foundation, the Pacific Islands Forum Fisheries Agency (FFA), and other Project Partners, the Phase 2 field work was carried out in the waters and ports of the Western Central Pacific Ocean region from June through

[3] *Electronic Monitoring on Transshipment Vessels Operating in the Western and Central Pacific Ocean Longline Tuna Fishery, July 20, 2020*. *Prepared by Craig Heberer & David Itano.*

September 2022. This Phase 2 Report lays out, among other items, Data Outputs and Key Takeaways along with potential objectives for a Phase 3 component.

Figure 1. The Tunago Transshipment Carrier Vessel Shin Ho Chun 102 (SHC102) dockside in Bangkok, Thailand.

Phase 1 Overview

- A 4-camera Satlink EM System was installed on the SHC102 in June 2018 at Bangkok, Thailand.
- Per contract, the Satlink affiliated company, Digital Observer Services (DOS), conducted analysis of the EM video review and estimated a total of 59 individual longline vessel transshipments occurring between November 2018 and January 2019.
- After receipt of the analyzed video footage, a Final Phase 1 Report was submitted to the Project Partners in June 2020.
- The overall Proof of Concept for utilizing EM to monitor various key aspects of the tuna transshipment operation was achieved, including:
    - The existing camera placements and angles were sufficient to monitor the majority of transshipment activities taking place.
    - The EMS durability and 24/7 automated monitoring capabilities were confirmed.
    - All vessels that transshipped were confirmed to be good standing per FFA requirements and authorization to transship.
- The video reviews confirmed that full catch accounting is achievable, but that definitive tropical tuna species identification was challenging due to lack of critical meristic and common identifying characteristics obscured by the white coloring of the frozen condition of the fish.
- Albacore, skipjack, sharks, and billfish (generic, not to species level) were identifiable in the video imagery even with ultra-low temperature (ULT) white frost completely covering the carcasses being transshipped.
- Yellowfin and bigeye identification was challenging given the fins were cut off and this is a critical diagnostic character for these two species. Additionally, no skin coloration or markings were apparent to further define to species level given ULT frost.
- For future work, Pacific Community (SPC) scientists (pers. comm., Peter Williams) requested that the number of fish transferred by longline vessels be enumerated so potential match with logbook count estimates can be undertaken.

Figure 2. A Tunago longline vessel conducting an at-sea transshipment with SHC102 during Phase 1 research activities. *Note clear recording of longline vessel identification/call sign numbering.*

Objectives for Phase 2 Project

Funding was secured to carry out Phase 2 of the Project including contributions from:

- FFA to cover the costs of having a consultant (Ms. Deirdre Brogan) oversee the at-sea components of the sampling plan.
- Additional funds were brought to the table by PEW, Thai Union, Satlink/DOS to cost share on in-house development of the software package for the integrated crane scale operation.
- TNC covering Craig Heberer and Dave Itano expenses and contributions.
- Additional Project support was provided by SPC through personnel resource, Peter Williams and Tim Park, to assist with sampling design and field work logistics.

The following elements for the Phase 2 Project included:

- Upgrade the EMS onboard the SHC102 (from a 4-camera system to a 7-camera system) and field test a motion compensated crane scale with integrated digital outputs ingested directly into EMS server in the wheelhouse via WiFi transmission protocol.
- Conduct a comparative analysis of the various data sets collected (EM, offloading/cannery receipts, at-sea consultant data).
- Compose a draft set of EM Transshipment Performance and Data Standards to help guide the adoption and scaling up of EM (at-sea consultant deliverable under her FFA contract).
- Focus on longline tuna transshipments as a priority, if possible.

Phase 2 Field Work Timeline

COVID-19 restrictions and lack of port access led to significant delays with initial equipment installation and boarding of the at-sea consultant. Efforts were made to carry out the installations in Fiji (August 2021) and in Taiwan (December 2021) but continued Covid concerns and port closures led to cancellation of both efforts. The new 7 camera Satlink EMS was finally installed and tested in Bangkok, Thailand in June 2022 along with the WiFi enable integrated crane scale. TNC (C. Heberer) and Satlink (I. Costas-Trillo) personnel, along with TNC Contractor David Itano and FFA at-sea consultant Deirdre Brogan, carried out the dockside installation and testing of the EMS and crane scale in Bangkok prior to SHC102 departure.

The integration of the motion compensated crane scale into the Sea Tube Nano EMS was initially developed and tested at the Satlink Madrid Spain facility and then installed in two other cargo vessels operating in the Indian Ocean. According to Satlink (pers. comm., Tomas Galan, Satlink) the preliminary results from these vessels indicated accurate data collecting and reporting[4]. Satlink noted that the integration of the crane scale would not demonstrably modify the general EMS installation plan, if no significant transmission impediments were present. If impediments were present, the installation of an additional WiFi antenna/repeater to secure data transmission to the central system might be needed (i.e., the crane scale uses WiFi as a link layer to transmit motion-stabilized weight readings to the Seatube Server in the wheelhouse).

The owner of Tunago, Stephen Lo, made a last-minute operational switch from the SHC102 receiving tuna longline deliveries on the post-installation trip to the SHC102 receiving tuna purse seine deliveries given continuing COVID-related operational challenges and longline vessel owners opting not to transship as planned. The Project leads made the decision, in consultation and agreement with Ms. Brogan, to continue with the trip as planned given the opportunity to test the crane scale regardless of gear type of vessels transshipping.

- The FFA at-sea consultant, Deirdre Brogan, boarded the vessel in Bangkok and the SHC102 set sail on June 22, 2022.

- After receiving deliveries from three Taiwanese flag purse seine vessels (two in PNG, one in FSM), the SHC102 returned to Bangkok on September 9, 2022, completing the Phase 2 field work component.

- During the at-sea trials, the crane scale reported to the system consistently as designed and the Sea Tube EMS transmitted the information per the software protocols in place. After post-installation feedback was received from the at-sea consultant and TNC staff on site in Bangkok, a new version of Sea Tube's software was developed and installed allowing the crew to check the scale readings in the bridge. It was noted by Ms. Brogan that the readings had a significant amount of lag time which DOS noted they would address in future upgrades to the system.

- Since the device is relatively heavy (~25kg) which could pose a potential safety risk, Satlink is working on the integration of a new, lighter (~3kg) motion-compensated crane scale. This new crane scale is designed to transmit scale weights to the EMS in the wheelhouse via a radio frequency link providing increased bandwidth and more consistent

[4] TNC has not viewed any of the data or reports from these other trials so confirmation on actual level of accuracy could not be validated.

transmissions compared to the existing WiFi links. The range of distances is expected to be greater and less affected by impediments (e.g., metallic structures).

- The new scale comes with a hand-held device so an observer can track near real-time measurements. The new scale has an algorithm for detecting stability in the measurements and its post filtering has been previously tested in other fisheries showing more accuracy than the WiFi linked scale (pers. comm., Tomas Galan, Satlink).
- The SHC102 hard drives were extracted by Satlink personnel in Bangkok shortly after the vessel docked and they were mailed to DOS in Bilbao, Spain for review. DOS received the hard drives on September 29, 2022, commenced their review and analysis of the video footage on October 6, and submitted their Final Report to TNC including annotated data on November 3, 2022. After some discrepancies noted and clarifications requested, an updated analysis and amended data outputs were made by DOS and a revised Final Report was submitted on February 6, 2023.
- The SHC102 commenced offloading dockside in Bangkok on September 12, 2022 and completed the operation on September 21, 2022.
- The official receipt/invoice with total weight offloaded by the SHC102 (see Fig.10) was sent to TNC by the Tunago Agent Jason Lin on October 9, 2022.

Figure 3. The Italian made DINI ARGEO MCW 09T6-1[5] motion-compensated digital crane scaled used for Phase 2 field work. Specs include a 6 mt capacity, 24-48 hr. rechargeable battery life, and waterproof design (1.5m, 30 min submersion).

[5] http://www.diniargeo.com/prd/scales/mobile-weighing/crane-scales-en/mcw-scale.aspx

Figure 4. The Phase 2 integrated crane scale undergoing dock side certification/verification testing during offloading activities of the F/V SHC102, Bangkok, Thailand.

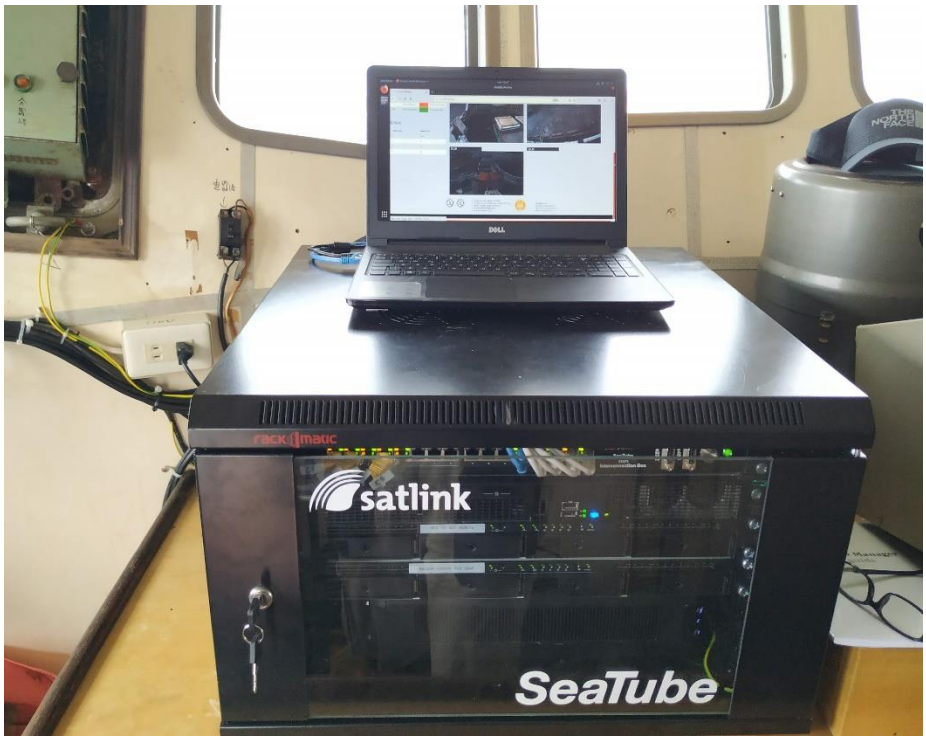


Figure 5. The Satlink Seatube Nano Integrated EM system server and cam repeater components in the wheelhouse of the SHC102.

Phase 2 Field Work

The field work component for the Phase 2 Project ended on September 9, 2022, with the arrival of the SHC102 back to Bangkok, Thailand, for offloading. The Project at-sea consultant Deirdre Brogan completed an FFA-required report of her field work, which was submitted on October 6, 2022[6].

Figure 6. F/V Shin Ho Chun 102 vessel track plot for the Phase 2 field work. Red bars indicate periods of drift/in-port activity.

[6] *Tender CP15-2021 Report - FINAL - INTERNAL- Potential for EM for LL Transhipment*. FFA Phase 2 Report prepared by Deirdre Brogan with assistance from Craig Heberer and David Itano.

Results/Data Outputs

The Final DOS report covers the visual counts of the net swings and the crane scale integrated weigh estimates from the three purse seine vessels that delivered tuna during Phase 2 field work. In total, 3,205 net swings (some swings contained two nets linked together) were observed and loaded onto the SHC102 for an aggregate total crane scale estimated weight of 2,122.8 mt. This compares to the aggregate estimated cannery weights of 2,315.7 mt. (see table 2 for breakdown by PS vessel).

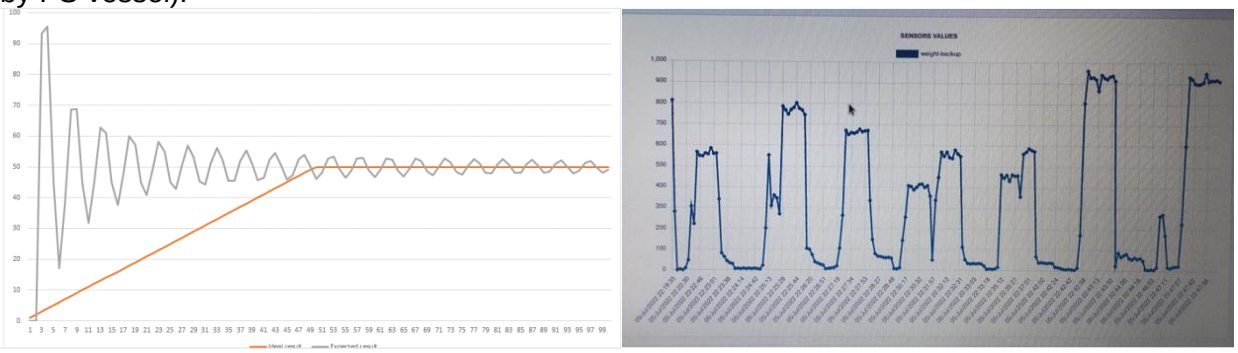


Figure 7. The harmonic stabilizing of the net swings prior to obtaining crane scale weight estimates in theory (left) and in practice onboard the SHC102 (right).

Table 1. Example of net swing information summarized by DOS EM analysts with corresponding weight estimates (kg) for each swing on 5th July 2022.

Exchange #	Time	Longitude	Latitude	Content	Species code	Hatch #	Weight
83	10:18:24	152,167	-4,2316	Fish	TUN	1	867
84	10:20:13	152,167	-4,2316	Fish	TUN	1	1507
85	10:20:16	152,167	-4,2316	Fish	TUN	1	1507
86	10:22:34	152,167	-4,2316	Fish	TUN	1	1404
87	10:22:37	152,167	-4,2316	Fish	TUN	1	1385
88	10:24:57	152,167	-4,2316	Fish	TUN	1	1502
89	10:25:02	152,167	-4,2316	Fish	TUN	1	1493

Table 2. Total net swings and corresponding aggregate crane scale and cannery weight estimates (mt) for the 3 purse seine vessels that transshipped to the SHC102 during Phase 2 field operations.

Vessel	Transship Dates	Total Net Swings	Crane Scale Weights (mt)	Cannery Weights (mt)	% Difference Cannery vs Crane
Vessel 1	July 5-10 (PNG)	1,488	950.97	1,051.3	+9%
Vessel 2	July 21-26 (PNG)	1,322	852.02	942.70	+10%
Vessel 3	August 21-22 (FSM)	395	319.82	321.70	+1%
Totals		**3,205**	**2,122.83**	**2,315.73**	**+8%**

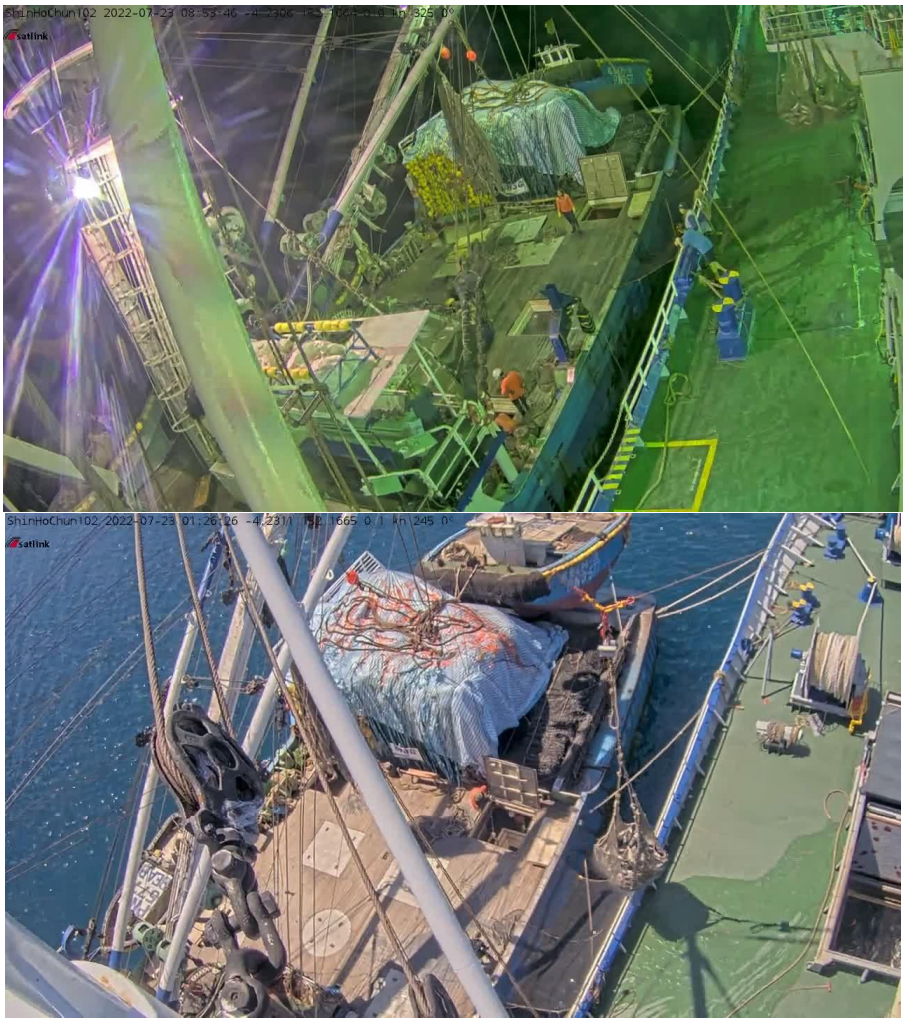
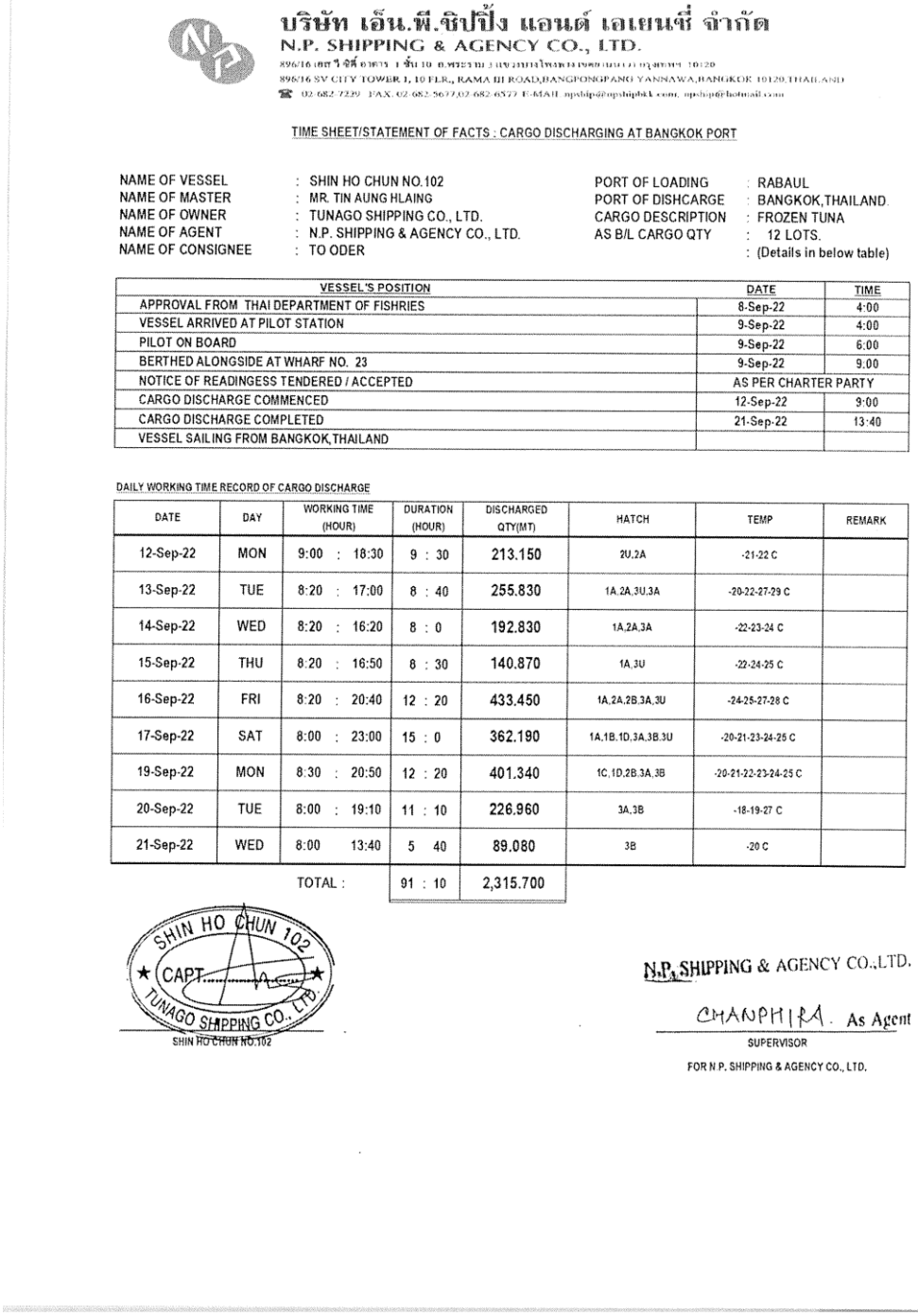


Figure 9. Night and Day images of tuna transshipment from vessel #2 (transshipping in Rabaul, PNG) from the high aspect camera (C4) located on super structure high above the wheelhouse.

Figure 10. Daytime image of tuna transshipment activity from vessel #3 (transshipping in Pohnpei, FSM) from the medium high aspect camera (C1) located on port side railing in front of the wheelhouse.



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TIME SHEET/STATEMENT OF FACTS : CARGO DISCHARGING AT BANGKOK PORT

NAME OF VESSEL	: SHIN HO CHUN NO.102	PORT OF LOADING	: RABAUL
NAME OF MASTER	: MR. TIN AUNG HLAING	PORT OF DISHCARGE	: BANGKOK,THAILAND
NAME OF OWNER	: TUNAGO SHIPPING CO., LTD.	CARGO DESCRIPTION	: FROZEN TUNA
NAME OF AGENT	: N.P. SHIPPING & AGENCY CO., LTD.	AS B/L CARGO QTY	: 12 LOTS.
NAME OF CONSIGNEE	: TO ODER		: (Details in below table)

VESSEL'S POSITION	DATE	TIME
APPROVAL FROM THAI DEPARTMENT OF FISHRIES	8-Sep-22	4:00
VESSEL ARRIVED AT PILOT STATION	9-Sep-22	4:00
PILOT ON BOARD	9-Sep-22	6:00
BERTHED ALONGSIDE AT WHARF NO. 23	9-Sep-22	9:00
NOTICE OF READINGESS TENDERED / ACCEPTED	AS PER CHARTER PARTY	
CARGO DISCHARGE COMMENCED	12-Sep-22	9:00
CARGO DISCHARGE COMPLETED	21-Sep-22	13:40
VESSEL SAILING FROM BANGKOK,THAILAND		

DAILY WORKING TIME RECORD OF CARGO DISCHARGE

DATE	DAY	WORKING TIME (HOUR)	DURATION (HOUR)	DISCHARGED QTY(MT)	HATCH	TEMP	REMARK
12-Sep-22	MON	9:00 : 18:30	9 : 30	213.150	2U,2A	-21-22 C	
13-Sep-22	TUE	8:20 : 17:00	8 : 40	255.830	1A,2A,3U,3A	-20-22-27-29 C	
14-Sep-22	WED	8:20 : 16:20	8 : 0	192.830	1A,2A,3A	-22-23-24 C	
15-Sep-22	THU	8:20 : 16:50	8 : 30	140.870	1A,3U	-22-24-25 C	
16-Sep-22	FRI	8:20 : 20:40	12 : 20	433.450	1A,2A,2B,3A,3U	-24-25-27-28 C	
17-Sep-22	SAT	8:00 : 23:00	15 : 0	362.190	1A,1B,1D,3A,3B,3U	-20-21-23-24-25 C	
19-Sep-22	MON	8:30 : 20:50	12 : 20	401.340	1C,1D,2B,3A,3B	-20-21-22-23-24-25 C	
20-Sep-22	TUE	8:00 : 19:10	11 : 10	226.960	3A,3B	-18-19-27 C	
21-Sep-22	WED	8:00 13:40	5 40	89.080	3B	-20 C	
		TOTAL :	91 : 10	2,315.700			

SHIN HO CHUN 102 ★ CAPT. ★ TUNAGO SHIPPING CO., LTD.
SHIN HO CHUN NO.102

N.P. SHIPPING & AGENCY CO.,LTD.
CHANPHIRA. As Agent
SUPERVISOR
FOR N.P. SHIPPING & AGENCY CO., LTD.

Figure 10. The SHC102 cannery offloading invoice for the 3 purse seine vessel transshipments transferred during Phase 2 operations. Total weight received was 2,315.7 metric tons.

Key Takeaways from Phase 2 of the Project

- The crane scale trials were conducted on three separate purse seine vessel transshipments, two in Rabaul Port, Papua, New Guinea, and one in Pohnpei, Federated States of Micronesia.
- The results of Phase 2 demonstrate that, under ideal calm conditions of a sheltered port, the EMS with integrated crane scale can capture and transmit the weight of fish transferred between the catcher vessels and the transshipment vessel with some limitations. These limitations included several null weight estimates from bow net swings (furthest from the receiving equipment on the bridge), due in part to weak WiFi signals coming from the bow hatch of the SHC102. The weak signal transmissions may explain in part the discrepancy of the crane scale weights compared to the cannery weights (~8% for the full three loads).
- The SHC102 captain and chief engineer were very cooperative and welcomed the opportunity to use the crane scales and to record reliable weight data for their own use.
- The preliminary results suggest future alignment may be possible using this integrated crane scale-EMS application with the objectives of both science and compliance.
- “Based on these Phase 2 results, further collaborative projects on the electronic collection of weight (and count) data seems warranted” - Deirdre Brogan.
- Further field work is needed to:
    - Ascertain why the scale was providing under-estimations (e.g., net swing imbalances, net tare accuracy issues, cannery offload accuracy issues) and whether the system will work for the more challenging at-sea longline transshipment environment. Satlink/DOS have several ongoing EM projects that will continue to test and refine the scale being used.
    - Test a different crane scale to either improve the WiFi signal or integrate a different transmission technology/protocol (e.g., the Israeli 3 kg. scale with radio frequency transmission technology).
    - Update the crane scale battery capacity/life and adding a handheld screen read out device.

Next Steps

- Use a consultant and/or a Regional Observer Program observer to field test the existing integrated crane scale with suggested modifications (or the Israeli 3 kg scale) during at-sea longline transshipments as was originally planned.
- If we continue using the SHC102 and the same crane, no additional equipment needed save for:
    - Boosting WiFi signal from bow hatch area and/or integrating a different scale and transmission technology/protocol.
- Other potential Phase 3 options include finding a different transshipment vessel to carry out the proposed research (we are running to ground a promising lead with a cooperative

partner for utilizing an Eastern Pacific Ocean-based tuna transshipment carrier receiving longline deliveries).

- As envisioned in the original Phase 2 Research Plan, document the onboard procedures for longline transshipment including:
    - numerical counts of fish being transshipped and how species are mixed or separated in the cargo holds (e.g., strapped or cargo netted over).
    - where possible, how they are sorted pre-offloading on the longline vessels.
    - what information is recorded on the bridge including how each vessel is credited for its catch; and,
    - the weights by species or species group per vessel offloaded at the final cannery or processing destination.
- Continue adding to a Phase 1 & 2 labeled image library of target tunas and non-target fish (sharks, billfish) from the Project EMS video clips.
    - This library would be used in the development of machine learning/artificial intelligence algorithms to automate selected elements of the video review
- Reduce future review times, increase efficiencies, improve data quality and accuracy, and enhance observer and EM analyst training materials.
- Develop and incorporate relevant sensor outputs for ingestion in the EMS server to aid in the data review and annotation process.

Looking to the Future: On the Edge EM Capabilities

- In an ongoing TNC French Polynesia EM Project, we are using a Satlink-developed algorithm to randomly select 20% of full sets from participating Tahitian longline vessels and transmitting that via internet/cloud (no inefficient mailing of hard drives), we could do something similar onboard the transshipment vessels (on-the-edge) given increasing number of longline vessels carrying EM systems and the more sophisticated satellite transmission capabilities on these larger carrier vessels.
- Also explore potential to transfer EM files from the offloading longline vessels (walk hard drives to the transshipment vessel bridge or transfer via WiFi or some other delivery system) while the vessels are transshipping.
- Use transshipment vessels as Data Transmission Hubs to send via satellite a sub-set of images and text data.

Ths could become feasible at some point in future with decreasing costs of low earth orbit satellite transmission (e.g., Starlink) and new AI/ML advances. Worth testing if funding and cooperation can be secured?

Acknowledgements

This multi-phase and logistically challenging research project would not have come to fruition without the collaborative efforts of the Project Partners listed below. In particular, the authors would like to recognize the dedicated efforts and contributions of Thai Union representatives Tony Lazazzara and Francisco Leotte; Tunago agent Jason Lin; Key Traceability liaison Tom Evans; SPC scientists Peter Williams, Siosifa Fukofuka, Malo Hosken, and Tim Park; FFA representatives Ferral Lasi and Ana Taholo; PEW representative Jamie Gibbons; Satlink Chief Engineer Tomas Galan, DOS Director Gonzalo Legorburu, and DOS EM Analyst Asier Ruiz; SHC102 Captain Tin Aung Hlaing and SHC102 Chief Engineer V Aung Htun Winn; and last but not least Tunago owner Stephen Lo.