REPUBLIC OF THE MARSHALL ISLANDS

Office of the Maritime Administrator

F/V KOO'S 101 CASUALTY INVESTIGATION REPORT

Main Boom Structural Failure with Loss of Life

18 June 2011

Official Number: 60007

IMO Number: 9348120

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AUTHORITY

A marine safety investigation was conducted under the authority of Republic of the Marshall Islands laws and regulations, including all international instruments to which the Republic of the Marshall Islands is a Party.

Office of the
Maritime Administrator

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INTRODUCTION

On the morning of 18 June 2011, the main boom upper topping lift's swivel pin on KOO'S 101 failed while the vessel's crew was securing the skiff boat prior to entering port on the vessel's stern ramp. As a result, the main boom fell onto the skiff and the power block struck the person in charge of the skiff boat, or chief of the skiff boat, on the head. The chief of the skiff boat died as a result of the injuries he sustained.

The Maritime Administrator's investigation determined that the swivel pin failed as a result of fatigue cracking over an unknown period of time after it became frozen in the block body due to a lack of regular maintenance.

FINDINGS OF FACT

The following Findings of Fact are based on information available to the Maritime Administrator:

1. Please see chart to the right for Vessel Particulars.

2. KOO'S 101 is an 1152 gross ton (GT) purse seiner built in 2005 by Ching Fu Shipbuilding Co., Ltd, based in Kaohsiung, Taiwan, fitted with a single main boom and two auxiliary booms and is a Japanese-style purse seiner design. *See Figure 1*. Since delivery, KOO'S 101 has been owned and operated by Koo's Fishing Company Limited and registered in the Republic of the Marshall Islands.

Figure 1: KOO'S 101

3. KOO'S 101 crew consisted of 29 crewmembers. This included five (5) Taiwanese, three (3) Marshallese, and 21 Chinese.

MAIN BOOM FAILURE

4. At 0810 (+12 UTC) on 18 June 2011, KOO'S 101 was underway on a south, southeasterly course at a speed of approximately 10 knots en route to Majuro, Republic of the Marshall Islands, with approximately 320 metric tons (MT) of fish onboard and had entered the Republic of the Marshall Islands territorial waters at location 04° 44.896'N, 171° 04.251'E, ETA Majuro 19 June 2011. The weather was reported as: overcast; winds, Beaufort 3 to 4; with 2 to 3 meter swell.

VESSEL PARTICULARS

Vessel Name
KOO'S 101

Registered Owner
Koo's Fishing Company Limited

Operator
Koo's Fishing Company Limited

Flag State
Republic of the Marshall Islands

IMO No.	Official No.
9348120	60007

Vessel Type
Purse Seiner Fishing Vessel

Call Sign	Length
V7HB9	61.85 meters

Date of Build	Deadweight
2005	950

Classification Society
Not applicable

Number of Crew
29

Cargo
Not applicable

5. In preparation for entering port, the fishing net had been stowed in the net storage space, which is on the main deck immediately forward of the stern ramp, and the skiff boat was in the process of being secured on

the stern ramp. It was reported that there were three (3) crewmembers inside the skiff boat: the chief of the skiff boat was stationed forward near the quick release hook, and two (2) others were aft, for securing the wire and lashings on the port and starboard sides, respectively. The Navigation Master was operating the main boom from the Control Station on the Bridge Deck, portside. The Fishing Master was inside the Bridge. The rest of the crew were reported to be clear of the area.

6. To secure the skiff boat, it must be pulled up the stern ramp by the main boom to its regular stowed position on the stern ramp. *See Figure 1*. The main boom was raised to a position of around 70° from the horizontal, using the topping winch and secured in place. The runner wire from the double winch was connected to the forward end of the skiff boat which was then pulled up the ramp. The Navigation Master was just "inching" the skiff boat into position using the double winch, and it was reported to have hardly moved 5 centimeters when suddenly the main boom crashed down and landed on the skiff boat. *See Figure 2*. The chief of the skiff boat, who was in the forward position of the skiff boat standing-by the quick release hook, was hit by the power block, which is located at the end of the main boom.

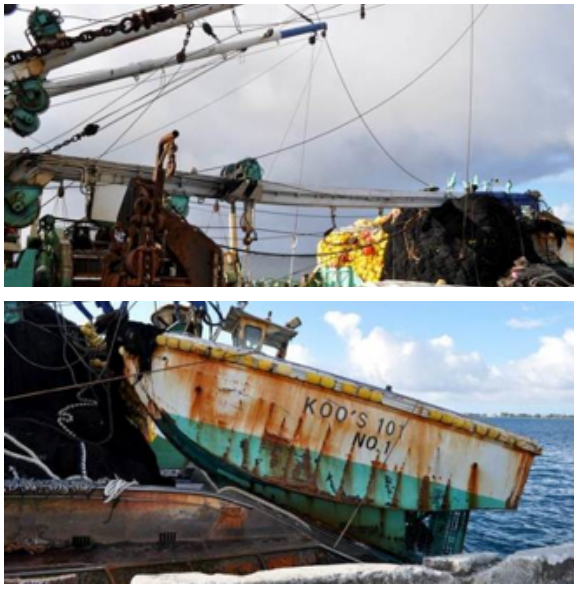


Figure 2: Main boom in collapsed position (top); the power block can be seen laying on the forward end of the skiff boat (bottom).

7. The chief of the skiff boat suffered head trauma; he was reported to have died instantly. The other two (2) crewmembers who were in the skiff did not receive any injuries.

8. The crew raised the general alarm and the Fishing Master was informed, who then notified a Koo's Fishing Company Limited's representative located in Majuro. The port and starboard auxiliary booms were used to lift the main boom so that the deceased crewmember's body could be moved.[1]

9. Following the collapse of the main boom, the crew observed that the main boom upper topping lift swivel pin had sheared off. *See Figures 2 and 3*. The topping lift is a three (3) sheave block; the diameter of the swivel pin is 58 millimeters. The lower third of the main boom

Figure 3: Upper topping lift, swivel pin remains attached to the joining shackle (left); fallen topping lift laying on fish net on the main deck (right).

1 The body was removed to a refrigerated hold for transport to Majuro. After the vessel's arrival in Majuro on 19 June 2011 an investigation was conducted by the Republic of the Marshall Islands Criminal Investigation Division, Department of Public Safety (DPS). The DPS investigation eliminated any criminal acts as a potential cause of the loss of life. Republic of the Marshall Islands, Department of Public Safety, Criminal Investigation Division, Report dated 19 June 2011.

nearest the mast was bent and the power block was cracked. No other damage was reported.

MAIN BOOM DETAILS AND POST CASUALTY INSPECTION AND TESTING

10. There was a Rig Plan depicting the sizes and dimensions for all three (3) booms and their fittings. *See Figure 4*.

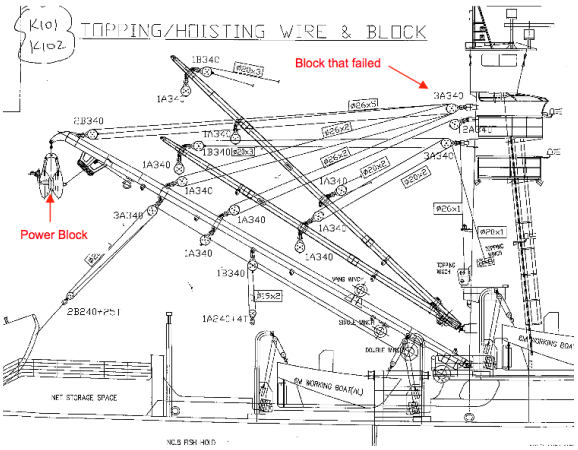


Figure 4: Rig Plan for KOO'S 101.

11. Based on information provided by representatives of Ching Fu Shipbuilding Co., Ltd., a record of the safe working load (SWL) calculations for the main and auxiliary booms was not established when KOO'S 101 was built. In addition, no load tests were reportedly conducted for the main and auxiliary booms. According to the shipyard representatives SWL calculations are not required for fishing vessels, regardless of registry.

12. A Load Chart for the main and auxiliary booms was developed by the shipyard. For the main boom, the Load Chart included minimum and maximum allowable angles for single-point loads at three (3) points on the boom. *See Figure 5*. The crew reported that they only operated the three (3) booms with single-point loads. None of the booms were fitted with limit switches.

13. Based on the Load Chart for the main boom, the minimum angle for pulling the skiff boat was 50°; the maximum angle was 70°. The potential maximum allowed load when pulling the skiff boat varied based on the angle of the boom: it was 23.5 tons (T) at 50° and 27 T between 60° and 70°.

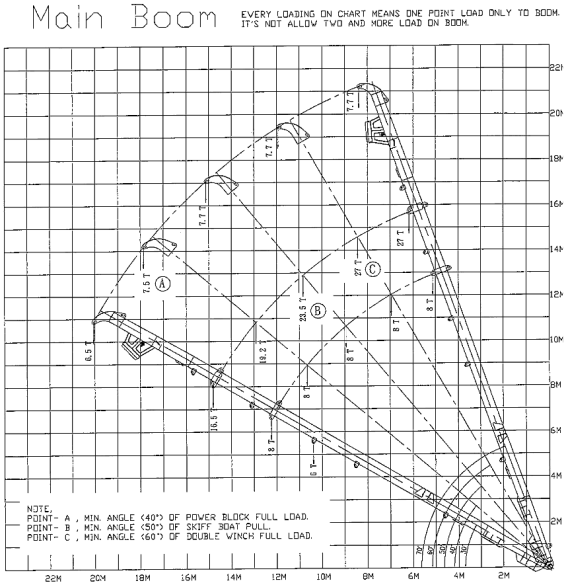


Figure 5: Main Boom Load Chart.

14. Load tests of the lifting equipment on KOO'S 101 were not routinely conducted.

15. The KOO'S 101 main and auxiliary booms were load tested when the vessel was dry docked in March 2008, and SWL test certificates were issued. The main boom was tested to 7.0 T, and its SWL was set at 6.0 T. Based on the Load Chart, these loads would be for the outer end of the main boom. The auxiliary booms were tested to 3.5 T and their SWL set at 3.5 T. A load test was not conducted for the other load points shown on the Load Chart.

16. The following pre-existing cast or punched SWL markings were noted when the main boom topping lift and shackles were inspected after the casualty:

- Topping lift: SWL 18 T / total load (TL) 36 T (based on punch marks).
- Shackles: SWL 18 T (cast on the shackle).

There were no certificates available documenting the SWL and material standards for this gear.

17. Reportedly, the weight (empty) of the KOO'S 101 fishing net is approximately 73 T. This type of fishing net is heavier than those previously used (70 T). Reportedly, the new fishing net was introduced during August 2010. The dimensions of the new fishing net remained as previous but used a heavier wire. The weight of the skiff is reportedly between approximately 19 and 23 T.

18. The crew of the vessel reported that the auxiliary and main boom wires were renewed at or about every six (6) months. It was also reported that the wires and blocks were greased once a month. However, as there were no maintenance records kept on board, it was not possible to verify the frequency of the boom wire renewals or when the wires and blocks were greased. When examined after the casualty, the wires were observed to be satisfactorily greased; however, the blocks did not appear to have been regularly greased. Access to some of the blocks was difficult due to their location on the mast. *See Figures 4 and 6*.

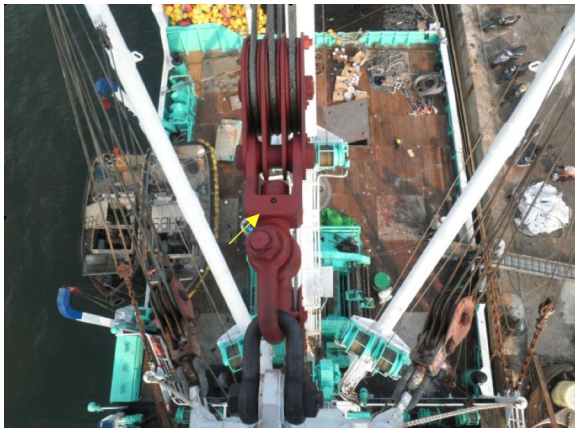


Figure 6: Location of grease fittings on swivel of main boom topping lift (replacement after casualty). Note the location and height above the deck.

19. The manufacturer of the swivel blocks recommend they be properly greased in order for the swivel to work normally and thus reduce the bending forces that would otherwise occur.

20. According to representatives of Koo's Fishing Company Limited, their operational guidelines require that lifting gear operations be stopped when the sea current exceeds 1.5 to 2.0 knots and the wind force is greater than Force 3. However, the vessel's crew could not provide a document onboard the vessel with this restriction.

POST CASUALTY TESTING OF THE SWIVEL

21. Post casualty laboratory testing and analysis of the failed swivel for the main boom topping lift was conducted.[2] Tests that were conducted included a macroscopic examination, metallographic examination, micro-hardness testing, a components

Figure 7: Cross section of main boom topping lift swivel pin showing final fracture zone in the center (Source: UITL Report, page 4).

2 The testing was done at the Universal Inspection Technology Laboratory in Kaohsiung, Taiwan between 15 and 25 July 2011. A copy of the report, which was issued on 25 July 2011, was provided to the Maritime Administrator for review and will hereinafter be referred to as the UITL Report.

analysis, scanning electron microscope (SEM) observation and energy dispersive spectroscopy (EDS) microanalysis.

22. The visual examination of the swivel pin determined that the fracture was in the center of the pin. *See Figure 7*.

23. The macroscopic examination identified micro cracks and beach marks[3] on the swivel that initiated from the right and left sides of the fracture, growing towards the core. *See Figure 8*. This was confirmed by the SEM and EDS analysis.[4] The breaking pattern is indicative of a fatigue fracture caused by alternating stress.[5]

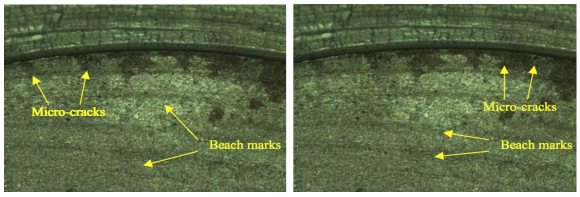


Figure 8: Macroscopic images of the topping lift swivel pin on the left (left image) and right (right image) sides of the fracture zone (Source: UITL Report, page 5).

Figure 9: Threads on lower (left) and upper (right) pieces of the main boom topping lift (Source: UITL Report, page 6).

24. The macroscopic examination and magnetic particle testing also identified numerous cracks on both the threads and the thread roots.

25. The metallographic examination determined that the swivel contained "a lot of non-metallic inclusions" at the initiation sites of the cracks and the core, but that overall the microstructure was normal.[6] The component analysis determined that the material met the requirements of Japanese Industrial Standard (JIS) G4051 for S25C class steels.[7] Lastly, the EDS microanalysis did not identify any external corrosion at the crack initiation sites.

REGULATORY REQUIREMENTS

26. As a commercial fishing vessel, the construction, operation and maintenance of the KOO'S 101 are not subject to the requirements of the International Convention for the Safety of Life at Sea (SOLAS), and the operator, Koo's Fishing Company Limited, is not subject to the International Safety Management Code. KOO'S 101 is required to comply with all other applicable Republic of the Marshall Islands maritime law and regulations. Republic of the Marshall Islands national regulations for commercial fishing vessels are addressed by Marine Notice 2-011-8, "National Safety Requirements for Miscellaneous Vessels."

27. Lifting gear on Republic of the Marshall Islands registered vessels, including commercial fishing vessels, is addressed by Technical Circular No. 3 (Tech Circ 3). In accordance with Tech Circ 3, operators of Republic of the Marshall Islands flagged vessels are encouraged to voluntary comply with Articles 21-32 in Part III of International Labour Organization (ILO) Convention No. 152 (ILO 152)–Occupational Safety and Health (Dock Work). Article 25(2) contains the following four 'General Instructions' for lifting gear:

- initial examination and certification;
- periodic examinations and re-testing;
- inspections; and
- certificates.

3 "Beach marks" are macroscopic characteristics of fatigue fracture and result from multiple stress cycles. Harry Chandler, Metallurgy for the Non-Metallurgist, ASM International (1998), page 171.

4 UITL Report, page 18.

5 UITL Report, page 21.

6 UITL Report, pages 8 and 21.

7 UITL Report, page 17. JIS G4051 establishes requirements for carbon steels for machine structural use and is published by the JIS Committee.

28. The International Maritime Organization (IMO) Code of Safety for Fishermen and Fishing Vessels (2005) (the "Code"), which is accepted as an international reference for good marine practice on the safe operation of commercial fishing vessels, is not referenced by Republic of the Marshall Islands' national regulations. Part B, Chapter VI of this Code requires routine load testing of lifting gear.

29. KOO'S 101 is required to be inspected annually by a flag State inspector. Part N, Number 16 of the Republic of the Marshall Islands Annual Safety Inspection (ASI) Report (MSD-252F) addresses cargo gear, which includes references to masts, booms and associated gear. During the two (2) ASIs conducted prior to this marine casualty (15 March 2010 and 26 April 2011) the attending inspector noted that the maintenance of the masts, cranes and rigging was satisfactory.

ANALYSIS

The purpose of the analysis is to identify the causes of this very serious marine casualty.

DECK OPERATIONS

It was noted during the investigation that members of the crew not directly involved in securing the skiff boat were out of the general area. Based on the information available, it was not possible to determine whether they had been directed to move away from the vicinity of the skiff boat or if they had been engaged in other work elsewhere on deck. It was a standard practice onboard for the chief of the skiff boat to stand in the forward part of the skiff boat while it was being pulled up the stern ramp. This indicates that the Navigation Master, the Fishing Master and chief of the skiff boat inadequately assessed the risk associated with standing directly under the main boom during this operation. In general there was a lack of procedure and possible lack of overall situational awareness of the potential risks associated with this operation by all of those directly involved.

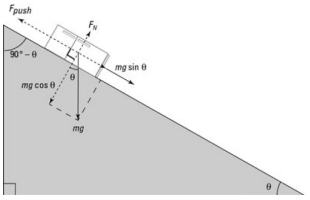
LIFTING GEAR MAINTENANCE

There was no documented planned maintenance system in place for the lifting gear of this vessel. Similarly, the lifting gear was not subject to regular testing or third party inspections. Although the cables did appear to have been greased at regular intervals, as reported by the crew when inspected by the flag State after the failure of the main boom topping lift, the blocks did not appear to have been greased or subject to regular maintenance. In addition, there were no records available to document whether the main boom topping lift had been subject to detailed inspection since being fitted when KOO'S 101 was built in 2005.

It is noted that when the booms were load tested while KOO'S 101 was dry docked in March 2008, the test weight for the main boom was based on the maximum loads for the end of the boom. It is also noted that additional load tests were not conducted for the other load points shown on the Load Chart.

FORCES IMPOSED ON THE MAIN BOOM AND TOPPING LIFT

The force necessary to pull the skiff boat up the stern ramp is a function of the skiff boat's weight, the angle of the stern ramp from the horizontal and the coefficient due to friction. *See Figure 10*.



$F_n = mg \sin \theta$
$F_f = \mu\, mg \cos \theta$
mg = weight
μ = coefficient due to friction
$F_p = F_n + F_f$

Figure 10: Forces of an object on a ramp.

The coefficient of friction will also vary based on whether the skiff boat is at rest, i.e., static friction, or moving, i.e., kinetic friction. The coefficient of friction is also sensitive to whether there is an oxide film on one or both of the surfaces. The effect of oxide is to reduce the coefficient of friction.[8]

The calculated force necessary to start pulling the skiff boat and then keep it moving up the ramp of KOO'S 101 is between approximately 20 and 27 T. *See Table 1*.

Weight of Skiff Boat	Static Force ($\mu = 0.74$)	Kinetic Force ($\mu = 0.57$)
19 T	22.4 T	19.8 T
23 T	27.1 T	23.9 T

Table 1: Calculated Force to Move Skiff Boat. Note: The angle of the stern ramp from the horizontal was estimated to be 35°.

Based on the information available, the actual force needed to move the skiff boat up the ramp of KOO'S 101 when the main boom upper topping lift failed cannot be determined. However, it is likely that it was lower than the calculated force since the bottom of the skiff boat and stern ramp had some surface rust, i.e., iron oxide.

The main boom topping lift consists of eight (8) parts. Six (6) of these parts are either connected to or reeved through the upper topping lift, and two (2) are reeved through the lower topping lift. *See Figure 4*. Although the actual force imposed on each of these blocks will depend on a number of different factors,[9] in general 75% of the total force will be imposed on the upper topping lift and 25% will be imposed on the lower topping lift.[10]

8 Mark's Standard Handbook for Mechanical Engineer's, 10th Edition, (New York: McGraw Hill, 1996), pages 3-21.

9 Factors include whether the main boom is being raised, lowered or held in position as well as if the sheaves are turning freely and if the block is aligned with the blocks on the main boom.

10 This is because the force of the load is distributed between each part of the parts of the tackle. Therefore, in an eight (8) part system, each part will bear an eighth of the TL.

The force imposed on these blocks is a function of the load on the boom, which in this case was the force needed to move the skiff boat up the stern ramp, as well as the weight of the main boom and its tackle, including the power block. Without accounting for the weight of the main boom and tackle, based on the calculated forces in *Table 1*, the force imposed on the upper topping lift from the skiff boat while it was being moved into position is estimated to have been between approximately 15 and 20.25 T, whereas the force on the lower topping lift is estimated by have been between approximately 5 and 6.75 T.

As noted above the actual force needed to pull the skiff boat up the stern ramp was likely less than the calculated force, which would reduce the force on the topping lifts. However, taking into account the fact that the force on these blocks would also include the weight of the main boom and tackle, it is possible that the force on the upper topping lift was approaching or may have exceeded the block's 18 T SWL while the skiff boat was being moved into position. It is noted that the 18 T SWL is based on the structural integrity of the swivel pin being intact. It is further noted that a 27 T load, which is the maximum allowed by the Load Chart, results in a force of approximately 20.25 T plus the weight of the main boom and tackle being imposed on the upper topping lift.

MAIN BOOM UPPER TOPPING LIFT FAILURE

The inspection of the main boom topping lift after it failed and the laboratory testing both determined that the swivel pin was frozen. This would have prevented the block from aligning with the blocks on the main boom and would have imposed a lateral load on the pin, with the maximum stress on the edge where the pin came out of the nut. The laboratory testing identified multiple cracks that started at the threads and roots of the threads. These cracks propagated toward the center where it ultimately fractured. The presence of beach marks across the surface of the pin indicate that the cracks propagated over time as the pin was effectively bent back and forth when in service.[11]

Although the material did contain non-metallic inclusions, the material was within established industry standards.

The results of the laboratory testing and analysis indicate that the main boom topping lift swivel pin failed due to fatigue resultant from multiple stress cycles over time. As the cracks propagated from the root of the thread toward the center of the swivel pin, the strength of the pin was reduced below the main boom topping lift's 18 T SWL / 36 T TL due to effective reduction of the cross section of the pin. Based on the available information it is not known how long the stress cracks on the swivel pin for the main boom topping lift were propagating, and the resulting risk of failure increasing.

REGULATORY REQUIREMENTS

There are no mandatory international or national requirements applicable to the design, construction or inspection of the lifting gear onboard KOO'S 101. However, there is national guidance recommending voluntary compliance with ILO 152, Articles 21 – 32. Implementation of the requirements of these Articles by the operator of KOO'S 101 would have required the development of a system

11 UITL Report, p. 21,

of planned, documented maintenance as well as inspections and testing of the vessel's lifting gear by a competent authority.[12]

The operator of KOO'S 101 had not voluntarily complied with ILO 152, Articles 21−32 as recommended by the Maritime Administrator. However, there is some potential for confusion regarding whether the requirements of ILO 152 are applicable to the lifting gear onboard KOO'S 101. This is because ILO 152 is commonly understood to apply to lifting gear used for dock related work, i.e., cargo operations, whereas the lifting gear onboard KOO'S 101 is used primarily for operations related to fishing, i.e., hauling the net, pulling the skiff boat from the water, etc.

12 Tech Circ 3, Paragraph 2.1.

CONCLUSIONS

The following Conclusions are based on the above Findings of Fact and Analysis:

1. The immediate cause of death of the chief of the skiff boat was injuries sustained as a result of being struck on the head by the power block following the material failure of the main boom upper topping lift swivel pin while the skiff boat was being moved into position on the stern ramp of KOO'S 101 in preparation for entering port.

2. A contributing cause of the power block striking the chief of the skiff boat's head was the lack of situational awareness by those directly involved. The Master and the Fishing Master of the vessel, as the senior officers on deck, were each responsible for ensuring that the skiff boat move in preparation for entry into port was conducted safely, and the safety of the crewmembers. Similarly, the chief of the skiff boat was

personally responsible for his own safety. If it was necessary to be under the main boom and power block at any time while the skiff boat was being secured, it should have been done with full awareness of the potential risks, and then only with the permission of the senior officer conducting the operation and for as short a time as necessary.

3. A contributing cause of the material failure of the main boom upper topping lift failure was the lack of regular maintenance. Because the swivel pin was not greased regularly, it became frozen in the block body, which prevented the block from pivoting to align with the angle of the blocks on the main boom. This increased the bending force on the pin and contributed to the initiation of the stress cracks at the thread roots. Ultimately the pin failed when the load on the block exceeded the reduced strength of the material. The load on the pin at the time of the failure is not known.

4. The basic, or root cause, of the material failure was that the operator did not have a system of planned maintenance and inspections for the lifting gear of the vessel.

5. A contributing cause was the lack of applicable international or national regulations establishing design requirements as well as requiring a system of regular, planned maintenance and regular third-party inspections to verify continued proper maintenance and identify potential material defects.

6. Based on the information available it cannot be concluded if the 18 T SWL for the main boom upper topping lift was in fact exceeded when the skiff boat was being moved into position on the stern ramp. However, it can be concluded that a 27 T load on the main boom would more than likely impose forces in excess of the block's 18 T SWL.

RECOMMENDATIONS

The following Recommendations are based on the above conclusions:

1. If not already done so, it is recommended that Koo's Fishing Company Limited make all of their seafarers aware of the dangers of standing underneath operating lifting gear; notably, the main and auxiliary booms during all vessel evolutions: fishing operations, skiff retrieval, fishing net retrieval, loading gear, etc. Additionally, it is recommended that the area underneath the lifting gear is marked with "Dangerous, Do Not Stand."

2. It is recommended that the operator develop, implement, and document a system of planned maintenance and inspections for their vessels' lifting gear. It is further recommended that the operator voluntarily comply with ILO 152 per the recommendations in Tech Circ 3.

3. It is recommended that the Rig Plan for KOO'S 101 and other vessels operated by Koo's Fishing Company Limited be reviewed and, as appropriate, revised by a competent person as defined in ILO 152 to verify it is appropriate for the loads imposed during all vessel evolutions. As appropriate, the lifting gear of the vessel should be modified at the earliest opportunity.

4. It is recommended that the Maritime Administrator review and, as appropriate, revise its regulatory requirements for lifting gear on fishing vessels based on the Code.

5. It is recommended that the Maritime Administrator review and, as appropriate, revise its policies and procedures for verifying that lifting gear is maintained in good working order during flag State inspections.

The Maritime Administrator's investigation is closed. It will be reopened if additional information is received that would warrant further review.