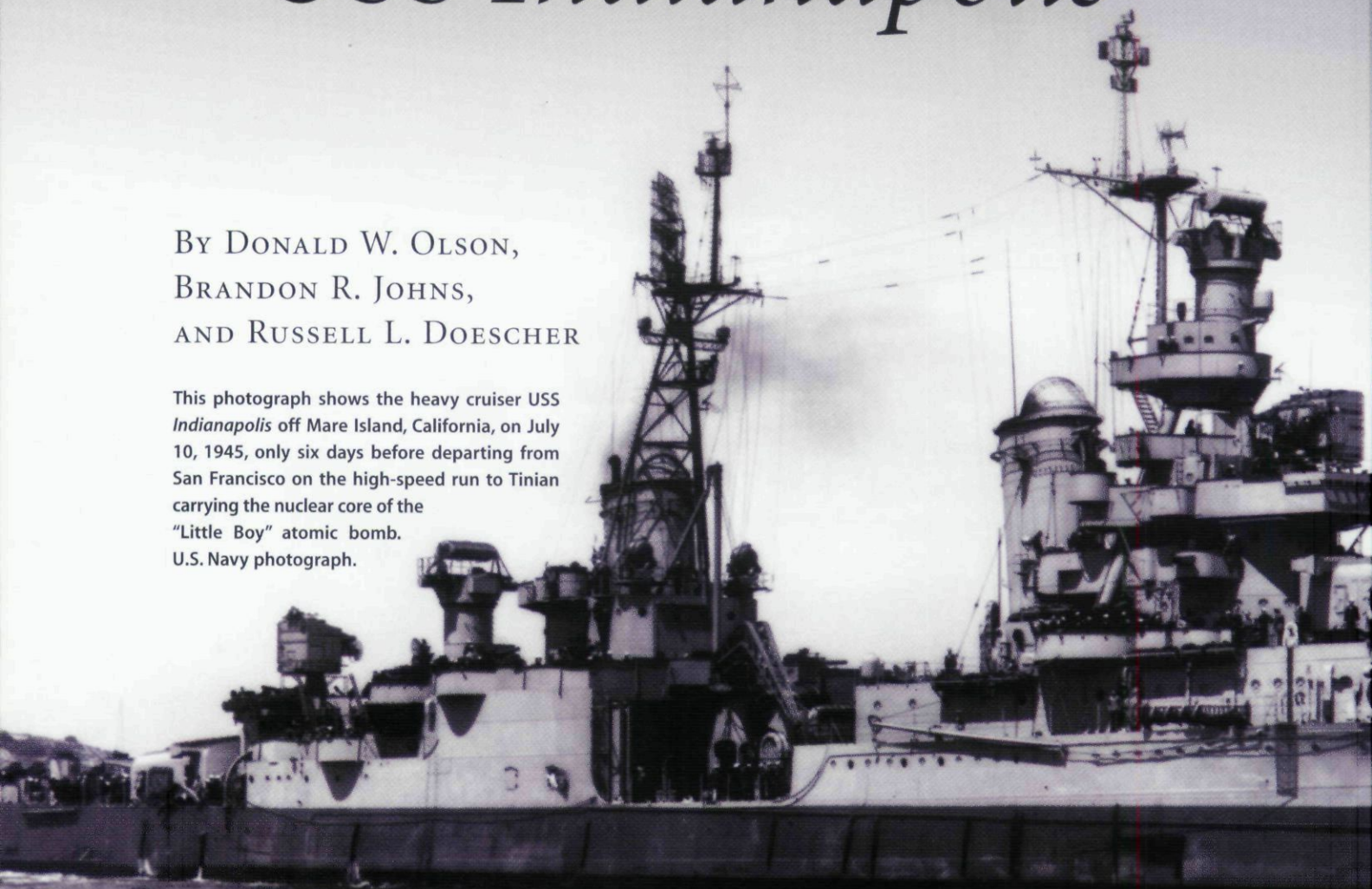


“Ill Met by Moonlight”*

The Sinking of the USS *Indianapolis*

BY DONALD W. OLSON,
BRANDON R. JOHNS,
AND RUSSELL L. DOESCHER

This photograph shows the heavy cruiser USS *Indianapolis* off Mare Island, California, on July 10, 1945, only six days before departing from San Francisco on the high-speed run to Tinian carrying the nuclear core of the “Little Boy” atomic bomb.
U.S. Navy photograph.



*William Shakespeare, *A Midsummer Night's Dream*, act 2, scene 1

During the final days of World War II, a Japanese submarine torpedoed the USS *Indianapolis*. Although some 900 of the nearly 1,200 sailors escaped the ship, only 317 survived the four days of exposure and shark attacks. The circumstances of the tragedy began with a binocular sighting in the moonlight. The celestial scene will repeat on July 29th.



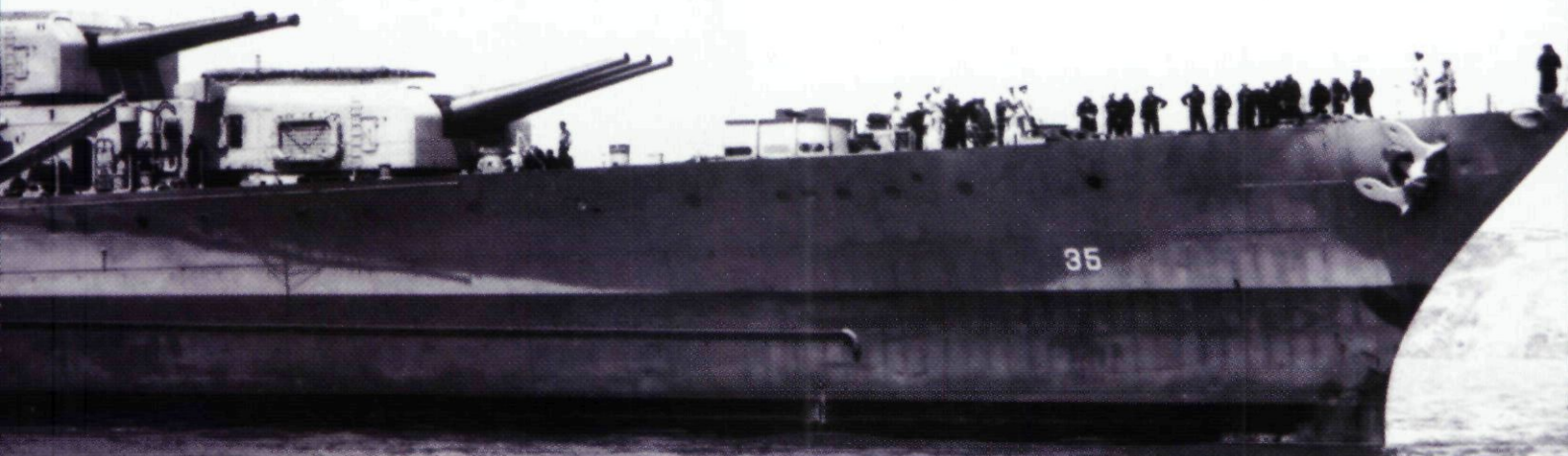
Water was still cascading down the sides of the surfacing Japanese submarine *I-58* as the navigator scrambled through the hatch and out onto the bridge to scan the night with his binoculars. Almost immediately he spotted a dark shape on the horizon under the Moon and called out: "Bearing red nine-zero degrees, a possible enemy ship!" Within three-quarters of an hour an American heavy cruiser was plummeting toward the bottom of the ocean. Many submarines fired torpedoes and many ships were lost on both sides during World War II in the Pacific Ocean, but the sinking of the USS *Indianapolis* stands out over all others for reasons that can be expressed in two words: Hiroshima and *Jaws*.

When the uranium-235 produced by the Manhattan Project was ready for shipment to the forward theater of war, the *Indianapolis* was selected to make a high-speed run departing from Hunters Point in San Francisco on July 16, 1945, pausing at Pearl Harbor in Hawaii on July 19th for refueling, and then continuing to Tinian in the Mariana Islands on July 26th. The *Indianapolis* carried the uranium "bullet" and the firing mechanism for "Little Boy," the first atomic bomb, which was dropped on Hiroshima by the B-29 *Enola Gay* on August 6th.

After delivering its cargo, the *Indianapolis* continued to Guam and there received orders to proceed to Leyte. The *Indianapolis* was about halfway across the Philippine Sea when, near midnight on the night of July 29–30, two torpedoes from the *I-58* exploded on the starboard side of the ship. Of the 1,197 men on the sailing list, about 300 were killed in the explosions or went down with the ship, leaving some 900 cast into the shark-infested waters. For more than four days, no personnel on shore bases realized that the cruiser had been sunk. When the pilot of a Lockheed Ventura spotted the sailors by chance on August 2nd, they were picked up and taken to hospitals. The U.S. Navy was horrified to learn that only 317 survivors remained.

Many people become aware of this disaster through a memorable scene in Steven Spielberg's 1975 film *Jaws*. While swapping stories with ichthyologist Matt Hooper (played by Richard Dreyfuss) about previous encounters with sharks, Quint (played by Robert Shaw) recounts harrowing details of the ordeal that he and his shipmates suffered from the ill-fated *Indianapolis*.

Considering the magnitude of the tragedy, authors of previous accounts have understandably focused on human stories. But there are many facets to the incident, including an astronomical element that is the focus of this article.



Numerous books and articles mention the moonlight of that night, but with details often frustratingly unclear, incomplete, or even contradictory. For example, one account places two officers on the bridge of the *Indianapolis* at 7:30 p.m., studying the heavy cloud cover and occasionally seeing a “half-moon shine through in bright flashes” (*Fatal Voyage*, by Dan Kurzman, 1990). Yet a pioneering study by Richard Newcomb states that the Moon did not rise until 10:30 p.m. (*Abandon Ship!*, 1958). To add to the confusion, a later chapter in Newcomb’s book contradicts his own earlier passage and informs the reader, “at 10:30 P.M. . . . the moon would have been in the east, about 23 degrees above the horizon.” Several authors describe a slender waning crescent Moon in the sky above the cruiser, while another book places a “full moon” over the survivors in the water. Faced with these conflicting versions, as astronomers we wondered: When *did* the Moon rise on July 29, 1945? What was the lunar phase? Did moonlight play a significant role in the sinking of the *Indianapolis*?

Confusing Dates and Times

We can explore these details thanks to today’s easy-to-use planetarium software. However, such programs require certain input: the date, the time, and the observer’s longitude, latitude, and time zone. For World War II events the dates and times can be surprisingly tricky. For example, the first bombs of the Pearl Harbor attack fell at about 7:55 a.m. in Hawaii, equivalent to 1:25 p.m. Eastern Standard Time (18:25 Universal Time) because in 1941 Hawaii used a noninteger time zone, 10½ hours behind Greenwich. Virtually every American knows the date of the Pearl Harbor attack as December 7, 1941, but many might be surprised to learn that Japanese histories give the date as December 8th. The Japanese strike force did not turn their calendars back a page upon crossing the International Date Line, but instead continued reckoning via the east longitude date used in Tokyo. The June 1942 Battle of Midway is probably the most confusing, since the opposing fleets fought literally back and forth across the International Date Line.

In the case of the *Indianapolis*, virtually all of the books and articles we consulted describe the high-speed bomb delivery as a 10-day run, allowing 3 days from San Francisco to Pearl Harbor, and then counting 7 days from Hawaii to Tinian — but such calculations ignore the International Date Line. By our reconstruction, the time at sea between the departure from Pearl Harbor at about 5 p.m. on July 19th (west longitude date, Hawaii war time, 9½ hours behind Greenwich) and arrival at Tinian by 8:30 a.m. on July 26th (east longitude date, 10 hours ahead of Greenwich) occupied less than 140 hours, or about 5.8 days.

To get accurate results for the lunar conditions on the night of the sinking, essential steps include sorting out the time zone, the time, and even the calendar-date system!

We consulted “tide and light” charts, radio messages, and routing instructions for the unfinished Guam-to-Leyte run of the *Indianapolis*, as well as official Japanese navy records for the last combat patrol of the *I-58* and transcripts for three interrogations of the submarine commander conducted shortly after the war’s end by U.S. Navy officers as part of the inquiry into the sinking.

The abundant evidence from primary sources allows us to conclude that on the evening of July 29, 1945, both the *Indianapolis* and the *I-58* were observing the east longitude date

convention, but with the submarine’s clocks set 9 hours ahead of Greenwich, and the ship’s clocks adjusted to a noninteger value 9½ hours ahead of Greenwich. The half-hour difference between the submarine and the ship is essential to understanding the event timeline and has an interesting consequence: the torpedoes struck late on July 29th (submarine’s time) or early on July 30th (ship’s time).

Events Aboard the *I-58*

In 1954 the commander of the *I-58*, Mochitsura Hashimoto, wrote a book about his wartime service titled *Sunk*. Regarding the sky on the evening of July 29, 1945, he recalled:

... toward nightfall the visibility deteriorated and by about 7 P.M. it was almost nil. We decided to wait for the visibility to improve and dived to await moonrise at 10 P.M. [submarine’s time].

Hashimoto brought the *I-58* to the surface 65 minutes after moonrise:

I ordered the night periscope to be raised just clear of the surface and quickly took a look round. The visibility was much better and one could almost see the horizon. The moon was already high in the eastern sky and there were few clouds in its vicinity. . . . I gave the order, “Surface,” and, “Blow main ballast.” . . . As soon as the upper deck was awash, the order was given to open the conning-tower hatch and the yeoman of signals who was standing by opened up and climbed onto the bridge. He was followed by the navigator. I myself was watching



On July 30, 1945, at 12:03 a.m. (ship’s time), two explosions ripped the starboard side of the *Indianapolis*. Marine artist Richard DeRosset (www.derosset.com) envisioned the scene of two torpedoes striking the cruiser’s hull. The ship sank within 15 minutes, sending some 900 seamen into the ocean. Only 317 survived.

The Japanese *I-58* was a type B-3 submarine, with an overall length of 108.9 meters (357 feet). Courtesy Tamiya America, Inc.

“At that moment the navigator shouted, ‘Bearing red nine-zero degrees, a possible enemy ship.’ I lowered the periscope, made for the bridge, and turned my binoculars in the direction indicated by the navigator. Without doubt there was a black spot which was clearly visible on the horizon on the rays of the moon.”

through the night periscope. . . . At that moment the navigator shouted, “Bearing red nine-zero degrees, a possible enemy ship.” I lowered the periscope, made for the bridge, and turned my binoculars in the direction indicated by the navigator. Without doubt there was a black spot which was clearly visible on the horizon on the rays of the moon. I ordered, “Dive.”

Because the submarine was cruising south, the relative bearing “red” 90°, measured from the submarine’s bow toward the left, or port, side, places the *Indianapolis* to the east of the *I-58*. Regarding the binoculars, Hashimoto noted that the “size 7 to 10 power was standard equipment. In addition they had 15 to 20 × 150 and 20 × 120.”

In another statement, recorded in the third person by a translator, Hashimoto was asked what happened at “2305” (11:05 p.m., submarine’s time):

A. On the supposition that at that time the visibility would have improved and the moon would be out, he brought his submarine to the surface. Thereupon, under the moon, he discerned a dark object and crash-dived immediately, and then swung his ship around to head in its direction. . . .

Q. And what — from his knowledge now — was the position of his ship relative to the dark object at that time?

A. His position was established still, roughly, at ten thousand meters . . . with the target bearing ninety degrees true . . . when the target had approached within a distance of . . . 1500 meters, he fired his torpedoes. . . .

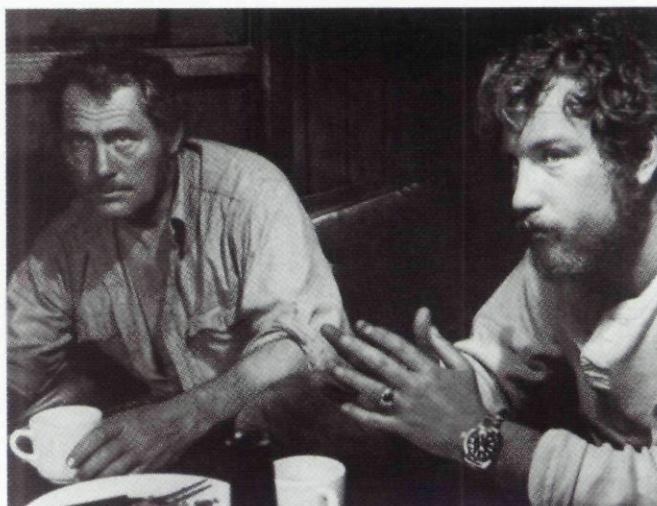
Q. How long after sighting this target did you fire this salvo?

A. About twenty-seven minutes.

Hashimoto was asked how he had been able to keep the *Indianapolis* in view:

Q. During this twenty-seven minutes, what was the visibility?

A. In the path of the moon I could see as far as the horizon. In areas other than that it was poorer; I could hardly discern the horizon.



PHOTOEST

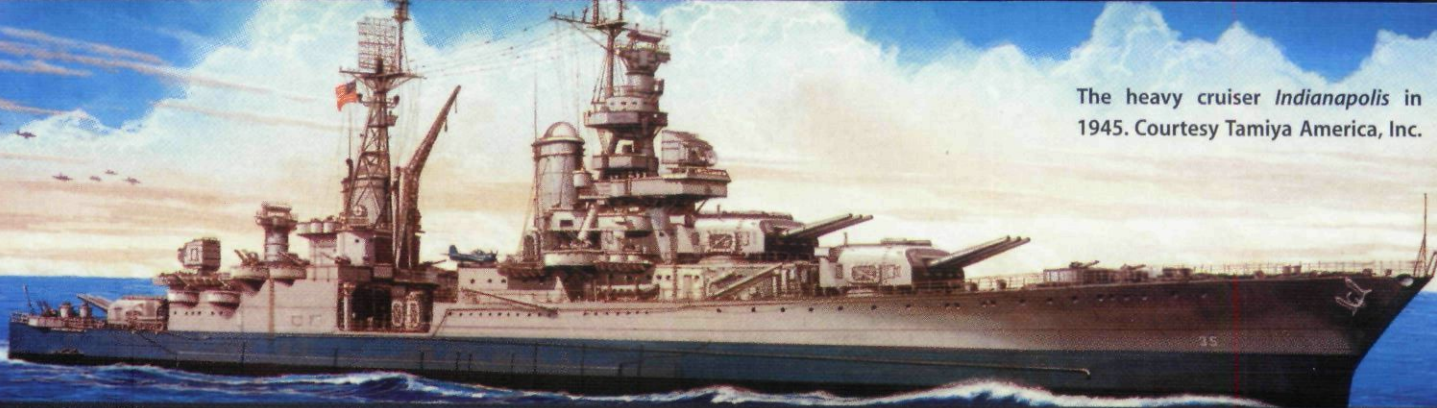
The saga of the *Indianapolis* was brought to a mass audience in the 1975 motion picture *Jaws*, in which Robert Shaw (at left, with Richard Dreyfuss) played a shark hunter named Quint. His character survived the sinking of the *Indianapolis* as well as the following days at sea when about 600 sailors died from exposure and shark attack.

Hashimoto’s official combat patrol report confirms that he fired a fan-shaped spread of six torpedoes at “2332” (11:32 p.m., submarine’s time). About one minute later, towering columns of water and red flame erupted on the starboard side of the *Indianapolis*.

Calculating the Moon

The exact location of the sinking may become known through the efforts of the Discovery Channel and undersea explorer Curt Newport. They have used side-scanning sonar and a remotely operated submersible in attempts, unsuccessful so far, to locate the *Indianapolis* on the ocean floor.* For now, the best estimate is an approximate position calculated in 1945 by

* See <http://dsc.discovery.com/convergence/indianapolis/indianapolis.html> for details.



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the Navy. Investigators started from the locations where the survivors were found and worked backward in time, allowing for more than four days of drift in the prevailing winds and currents. By this method, the sinking must have occurred near $134^{\circ} 48'$ east longitude, $12^{\circ} 02'$ north latitude.

The table on page 36 gives our calculations for that position and shows that the *I-58* lookouts first sighted the cruiser silhouetted against the bright moonlit sky under the waning gibbous Moon, which stood 15° above the eastern horizon at an azimuth only 6° south of due east. The Moon's illuminated fraction of 75 percent may come as a surprise to some historians. Although previous accounts mention almost every possible lunar phase, the majority describe the Moon as near "last quarter" and employ the colloquial term "half moon."

In the course of our research, we learned that we were not the first to make astronomical computations for the *Indianapolis* sinking. On December 4, 1945, the Navy took sworn statements about the moonlight from astronomer Gerald M.

Clemence, who was the director of the Nautical Almanac Office at the U.S. Naval Observatory. His distinguished career included contributions to such fields as radio navigation (LORAN), the definition of Ephemeris Time, and the orbit of Mars (*S&T*: April 1975, page 215). Readers may also know Clemence's name from his coauthorship of two classic works, *Methods of Celestial Mechanics* (1961) and *Spherical Astronomy* (1966).

Using the Navy's approximate position for the sinking, Clemence found that the Moon rose at "2230" (10:30 p.m., ship's time), described the evening as falling "about two days before the last quarter," and calculated that the Moon by midnight was in the azimuth 98° and at an altitude of 23° . Our calculations agree, except for the midnight altitude, for which we get $20^{\circ} 28'$.

Distance and Visibility

In the binoculars of the *I-58*'s lookouts, the *Indianapolis* first appeared as a dark silhouette against the moonlit part of the sky.



The Captain's Fate

The responsibility for the loss of the USS *Indianapolis* fell upon the captain, Charles B. McVay (left, in middle). At a court-martial in December 1945 he was convicted on the charge of hazarding his ship by failing to steer a zigzag course during "good visibility after moonrise." (According to Navy doctrine, frequently altering a ship's course makes it more difficult for a submarine to maintain a suitable firing orientation.) At the trial, Mochitsura Hashimoto (right), captain of the Japanese submarine, described sighting the ship "under the moon," and virtually every eyewitness was questioned about the Moon and the weather.

McVay committed suicide in 1968. *Indianapolis* survivors struggled for decades to clear their captain's name, resulting in the passage of legislation by the U.S. Congress in 2000 that "exonerated [McVay] for the loss of the USS *Indianapolis*." In July 2001 the Navy Secretary placed a copy of this resolution in McVay's file. Nevertheless, the questions of moonlight and visibility on the night of the sinking are still in dispute.

We wondered, what was the distance to the ship at that time?

Virtually all previous accounts give the same figure: 10 kilometers (5.4 nautical miles, or 6.2 statute miles). But the submarine commander's statements make it clear that this was just an estimate made "roughly" as a round-number value at the time when the ship appeared as a small "blob" or "black spot" on the horizon. For some time after the initial sighting Hashimoto "couldn't estimate the range since we didn't know the class of ship." As he continued watching through the night periscope the "black spot gradually became triangular in shape . . . the uppermost part of the triangular black spot had resolved itself into two portions. There was a large mast forward . . ." and he could then begin using the estimated height of the mast to calculate the distance.

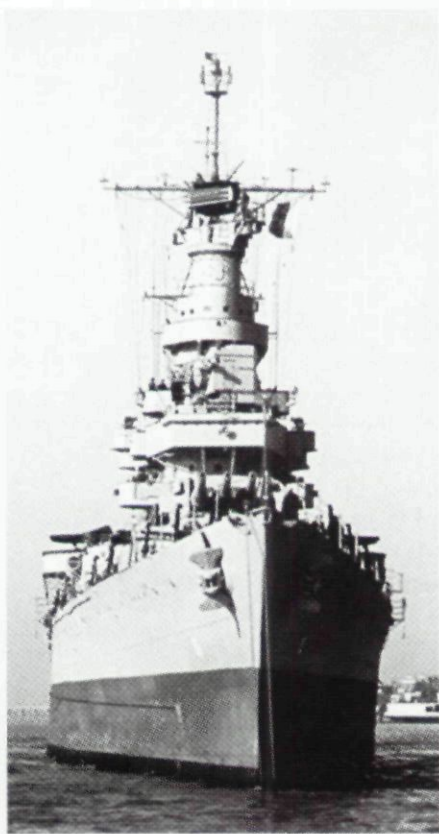
It might seem impossible to determine a more accurate value for the distance between the two vessels at the moment of the first sighting. But in fact this calculation is relatively easy, because the relevant speeds and times are known.

Documents from the Navy inquiry place the *Indianapolis*, just before the explosions, on a "steady course of 262° true [8° south of due west], speed 17 knots [31½ km per hour]." The Japanese records all agree that the *I-58* crept forward at 3 knots as Hashimoto watched the *Indianapolis* in the night periscope for 27 minutes before firing the torpedo salvo that found its mark a minute later. The range calculation then requires only a conversion of units (1 knot = 0.5144 meter per second) and among the simplest of all equations: distance = rate × time. During the 28-minute interval, the *Indianapolis* traveled 14.7 km, progressing westward by 14.5 km. The *I-58* wound along an S-curve path and then fired its torpedoes for a net eastward advance of about 2 km.

The range at sighting must have been near 16.5 km, equivalent to 8.9 nautical miles or 10.3 statute miles.

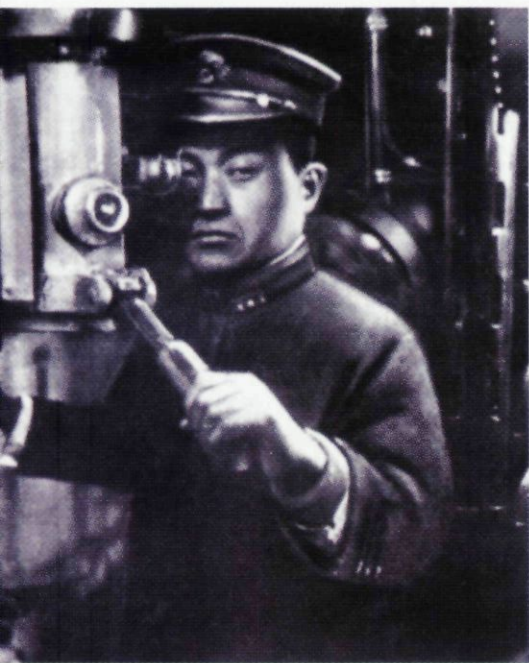
To check whether a sighting at such a great distance is possible, we consulted tables that give the distance of the horizon versus the height of the observer from the 1966 edition of Nathaniel Bowditch's *American Practical Navigator*. They allow for both the curvature of the Earth's surface and the refraction of the light near the horizon. From scale drawings of the *I-58*, we judge that an observer on the bridge would have his binoculars about 8 meters (25 feet) above the water line. The Bowditch tables confirm that even to an observer at a range of 16.5 km, most of the *Indianapolis*'s hull and its entire forecas-tle would have extended above the horizon.

Was the visibility on July 29–30, 1945, good or bad? Was the night bright or dark? The answers from witnesses vary considerably, depending on whom you ask, where they were stand-

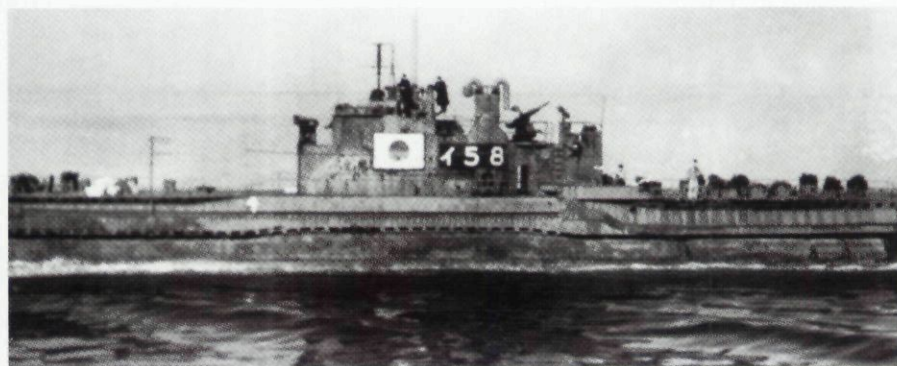


Above: This photograph, taken by the authors on September 8, 2001, at 5:30 Universal Time, shows a 75 percent waning gibbous Moon, exactly the same lunar phase that was visible during the torpedo attack on the *Indianapolis*.

Left: Taken at Mare Island, California, on December 9, 1944, this nearly bow-on photograph of the *Indianapolis* closely approximates the angle of view in the *I-58*'s night periscope shortly after the initial sighting on July 29, 1945, as the cruiser approached and the "black spot gradually became triangular in shape." U.S. Navy photograph.



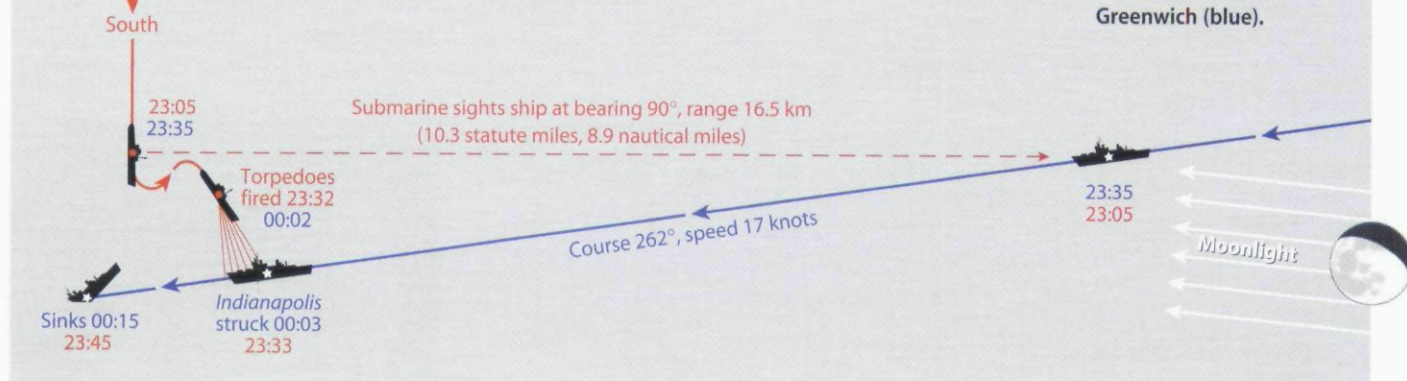
CAPT. WILLIAM J. TOTI



A lookout on the bridge of the *I-58* would have his binoculars nearly 8 meters (25 feet) above the water line, high enough to spot a cruiser at distances exceeding 16 kilometers. This photograph dates from April 1, 1946, shortly before the *I-58* was sunk by demolition charges into the waters off Sasebo, Japan. U.S. Navy photograph.

I-58 time	Indianapolis time		Moon's azimuth	Moon's altitude	
22:00	22:30	Moon rises	93°	0°	
23:05	23:35	I-58 surfaces and spots the <i>Indianapolis</i> as a "black spot" on the eastern horizon, under the 75 percent lit waning gibbous Moon	96°	15°	
23:30	00:00	Watch change on the <i>Indianapolis</i>	98°	20°	
23:32	00:02	Six torpedoes fired; two hits on the <i>Indianapolis</i> occur 1 minute later	98°	21°	
23:45	00:15	<i>Indianapolis</i> sinks	99°	24°	

When the Japanese submarine *I-58* came across the *USS Indianapolis*, the vessels were using two different time systems. The submarine's clocks were set 9 hours ahead of Greenwich (red); the ship's clocks were adjusted to a noninteger value $9\frac{1}{2}$ hours ahead of Greenwich (blue).



ing, what time they were there, and which way they were looking. Lt. Richard Redmayne described the period from 11 p.m. to midnight (ship's time) as "intermittent moonlight with the visibility good when the clouds weren't in front of the moon, and the visibility poor when the clouds were in front of the moon." The sky and ocean were darkest ahead of the ship, to the west, and brightest almost directly behind the ship, where the Moon was rising up into the eastern sky. As the map above shows, the *I-58* was positioned to view the dark ship silhouetted against a brighter moonlit sky.

Compared to previous studies that place a "half moon" in the sky and separate the two vessels by 10 km at the initial contact, both our astronomical and topographical calculations give significantly different results. We find that the Moon was actually three-quarters lit, and, though the cloud cover may have been thick at other times, the moonlight was bright enough at 65 minutes after moonrise to allow lookouts on the *I-58* to spot the backlit *Indianapolis* at the remarkable distance of 16½ km.

Different Eras, Same Moon

On July 29, 1945, at the position of the sinking, the Moon rose at 10:30 p.m. ($9\frac{1}{2}$ hours ahead of Greenwich). By 11:35 p.m. the waning gibbous Moon, 75 percent illuminated, was standing 15° above the eastern horizon, at azimuth 96°.

On July 29, 2002, at the same spot and time zone in the Philippine Sea, moonrise will again occur at 10:30 p.m. By 11:35 p.m. the waning gibbous Moon, 75 percent illuminated, will be 15° above the eastern horizon, at azimuth 96°.

North American observers, though on the wrong side of the International Date Line and too far north of the equator, can nevertheless see less-exact recreations of the lunar phase and position at about 90 minutes after moonrise on the nights of July 28–29 or July 29–30. Those near a body of water may gain



The *Indianapolis* prepares to depart Tinian harbor on July 26, 1945, just hours after delivering components of the first atomic bomb dropped on Hiroshima 11 days later. This may be the last picture taken of the *Indianapolis*. U.S. Navy photograph.

a better appreciation for how the *Indianapolis* was doomed from the moment the Moon came out from behind the clouds and the lookouts on the *I-58* used their binoculars to scan the glitter path stretching out to the eastern horizon and saw a silhouette.

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The authors are grateful for research assistance from the Naval Historical Center in Washington, D.C., the Indiana Historical Society Library in Indianapolis, and Margaret Vaverek of the Alkek Library at Southwest Texas State University.