

THE
UNKNOWN
BATTLE OF MIDWAY

**THE DESTRUCTION OF THE
AMERICAN TORPEDO SQUADRONS**

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ONE

The Destruction of the American Battle Line at Pearl Harbor

On the morning of December 7, 1941, the Imperial Japanese Navy made a surprise attack on the American Pacific Fleet tied up in Pearl Harbor at Ford Island, the pearl at the center of the deep inlet. Tied alone to a dock at the naval yard, just behind a dry dock containing the battleship *Pennsylvania*, was the minesweeper *Oglala*. This was where the Japanese expected the aircraft carrier *Enterprise* to be on the morning of December 7 and where four torpedoes were put into the hapless *Oglala* in its stead. But the *Enterprise* and the two other American carriers then in the Pacific, *Lexington* and *Saratoga*, were not in Pearl Harbor, where Japanese intelligence had predicted they would be. The attackers knew that the carriers' absence qualified their victory enormously, and they were dead right.

Little official information about the extent of the damage in Pearl was given to those of us on the *Enterprise*, just outside the harbor, but scuttlebutt, the navy rumor mill, piled it high. Even so, when the *Enterprise* entered the harbor to refuel, late in the

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afternoon of December 8, we were flabbergasted by the devastation we saw as we proceeded to our dock, moving slowly around the harbor from east to west. One battleship, the *Nevada*, was lying athwart the narrow entrance channel, beached bow first, allowing barely enough room for the carrier to squeeze by and move past the great battle fleet lying in ruins at its anchorages alongside Ford Island. The water was covered with oil, fires were burning still, ships were resting on the bottom mud, superstructures had broken and fallen. Great gaps loomed where magazines had exploded, and smoke was roiling up everywhere. For sailors who had considered these massive ships invincible, it was a sight to be seen but not comprehended, and as we made our way to a dock on the west side of Ford Island, just beyond the old target battleship *Utah*, turned turtle, we seemed to be mourners at a spectacular funeral.

The navy assumed that in the event of war our battle fleet, centered on its massive battleships, would sweep across the Pacific to relieve General Douglas MacArthur and the army in the Philippines, and then beat up on the Japanese navy and go on up to Tokyo. Something like this had actually been projected for years in a series of secret war plans brightly labeled Orange and Rainbow. But it was not to be. For the time being the navy fought a holding action.

The *Saratoga* was torpedoed in January near the Hawaiian coast, and after that America, with two oceans to fight in, had only three carriers in the Pacific, the *Enterprise*, the *Yorktown*, and the *Lexington*, while the Japanese had six fleet carriers and

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a number of smaller ones. It was risky to go anywhere west of Hawaii, and Vice Admiral Chester Nimitz, commander in chief of the Pacific Fleet (Cincpac), played his cards carefully even after the *Yorktown* and the brand-new *Hornet*, sister ships of the *Enterprise*, came around from the Atlantic. There was, too, it has to be admitted, something of a shell-shocked sluggishness in the American fleet after Pearl Harbor. We had thought the Japanese manufactured only cheap goods you bought in ten-cent stores, but now we became acquainted with their superb optics, the devastating Zero fighter, and what was later called the Long Lance torpedo. It took only a little while to learn that the Japanese were also first-rate in their courage and in their training, and that they were unsurpassed not only in gunnery and some actions like fighting their ships at night but, most significantly for our immediate futures, in their magnificent aerial torpedo system.

The crews chafed as the American aircraft carriers operating in task forces with fast cruisers and destroyers were sent to the South Pacific to block a Japanese invasion of Australia and were limited to a series of raids, quick in, quick out, against isolated Japanese bases far out in the Pacific: Marcus, Wake, Kwajalein. We were not at the beginning really ready for war, and these raids punctuating long days of cruising taught us the skills that would enable us to win, with the aid of some good luck, the Battle of Midway. It was amazing how long it took to get the hang of it and to react instantly in the right way. War, we gradually learned, is a state of mind before it can be anything else.

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The run in to an island would begin at high speed the night before a raid, and the crew sweated in their bunks all night long while the driveshafts turning at high speed rattled everything. Flight Quarters came before daylight, and soon afterward General Quarters was sounded. The ship turned into the wind to add near 30 knots plus the wind to the speed of the planes taking off. The first planes off were the fighters for the combat air patrol (CAP) overhead and then the scout planes of the anti-submarine patrol (ASP) to fly vectors looking for enemy ships or subs. The radar antenna — one thing we had, courtesy of the British, that the Japanese did not — like a double-bed spring rotated constantly on the mast top. Early radar was short-range and quirky, but it gave us a distinct advantage in knowing when unidentified planes were approaching.

Vice Admiral Chuichi Nagumo, leader of the Pearl Harbor strike and of *Kido Butai*, the Japanese fleet of aircraft carriers at Midway, and his commander in chief, Admiral Isoroku Yamamoto, were proud Japanese samurai, and while we were making small raids, they were ranging over half the world. After devastating the Pacific Fleet at Pearl Harbor, the Japanese empire went on in six months to destroy British naval power in the Far East by sinking the warships *Prince of Wales* and *Repulse* off Malaysia, capture Singapore, raid Ceylon, and obliterate a combined Australian, Dutch, and American fleet off Indonesia, bringing down the old colonial empires of Britain and the Netherlands. Japanese troops were halfway across China, had stalemated the Russians in Manchuria, and soon forced Bataan and the for-

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tress of Corregidor to surrender in the Philippines. And now, in early June 1942, the navy was preparing to bring its ships to Midway Island, the westernmost American outpost remaining in the Pacific, with the intention of extending Japan's conquest to within 1,200 miles of Hawaii and drawing out and sinking any opposing American fleet. It was also said that the Japanese navy was so deeply embarrassed by the Doolittle Raid on Tokyo, in sight of the emperor's palace, in mid-April 1942 that it was determined to make sure that the U.S. Navy could never approach Japan again.

The Japanese navy had begun to push in late April and May toward New Guinea and Australia to the south, and the Solomon Islands and Fiji to the east, with the aim of cutting off the United States from our allies down under, Australia and New Zealand. Task Force Seventeen, commanded by Rear Admiral Frank Jack Fletcher, built around the two carriers *Yorktown* and the old warhorse the *Lexington*, stopped the Japanese drive, sinking one small carrier and putting a larger one out of commission. But the *Lexington* was sunk in the exchange and the *Yorktown* was heavily damaged. When the *Enterprise* and *Hornet*, Task Force Sixteen, arrived too late to get into the fight, the three remaining carriers were ordered to make a fast run back to Pearl Harbor.

The *Enterprise* and *Hornet* arrived back in Pearl Harbor on May 26. On May 27, the *Yorktown* returned from the Coral Sea and soon went into dry dock. The navy yard worked miracles on it, repairing in three days enough of the damage to make it pos-

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sible for it to fight at Midway. All liberty was canceled, and re-provisioning and refueling of the ships began immediately. Our admiral on the “Big E,” William Halsey, had been tormented with a terrible allergic rash and was forced to go into the hospital. He was relieved as commander of Task Force Sixteen by Rear Admiral Raymond Spruance, a line officer, not an aviator, who had been in command of a cruiser force.

Rumors began to circulate that the Japanese were planning to invade little Midway Atoll and draw our ships out to fight the great sea battle their strategy had long anticipated. Our information, we heard, at the scuttlebutt, came from code breakers: “Like troglodytes, [the code breakers] inhabited a kind of underworld cellar, approached only by two locked doors and in a permanent state of shabby disorder amid which heaped files and the ejections of IBM machines struggled—as the occupants were indeed doing—for survival. [Commander Joseph] Rochefort presided, in his ancient red smoking jacket and carpet slippers: a man driving himself to the limit on two or three hours of sleep and a diet of coffee and sandwiches. He slept on a cot among the squalor and had to be expelled to take a bath. A perfectionist, he allowed no message to leave Hypo [Hawaiian Code Center] until he himself had checked the translation.”¹

Unbelievably, the Japanese never tumbled throughout the entire war to the fact that their codes had been broken, and the U.S. Navy, equally blindly, continued to believe that its ability to read one after another of the Japanese codes remained a deep, dark secret from its own sailors. But when the American car-

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riers sailed from Pearl Harbor to the Battle of Midway everyone aboard knew what was in the wind and how we knew it. Admiral Nagumo may have told his carrier sailors that “the enemy lacks the will to fight,” but the American navy had been making itself ready for years to fight this, its greatest sea battle.²

TWO

Trading Armor for Speed: The New Battle Line

There is something in a naval engagement which radically distinguishes it from one on the land. The ocean, at times, has what is called its sea and its trough of the sea; but it has neither rivers, woods, banks, towns, nor mountains. In mild weather, it is one hammered plain. Stratagems,—like those of disciplined armies, ambuscades—like those of Indians, are impossible. All is clear, open, fluent. The very element which sustains the combatants, yields at the stroke of a feather. One wind and one tide operate upon all who here engage. This simplicity renders a battle between two men-of-war, with their huge white wings, more akin to the Miltonic contests of archangels than to the comparatively squalid tussles of earth.

So our great American sailor-writer, Herman Melville, described in *Israel Potter* (1854) the nature of naval warfare as it was conceived and practiced until December 7, 1941, and the Japanese attack on Pearl Harbor. The American and Japanese

aircraft carriers that steamed to the Battle of Midway left behind them in the fires and wreckage of Pearl Harbor not just a fleet of devastated ironclads but an ancient mode of naval warfare in which for centuries battleship had thundered broadsides against battleship. Now aircraft carriers would be able to ambush unsuspecting enemies, and the crucial question for naval commanders from Pearl Harbor on had to be, "Where are the enemy carriers?"

Admiral Nimitz well understood the new strategy and tactics that December 7 enforced. Some of the Pearl Harbor battleships had been repaired by the time of Midway and were assembled in San Francisco harbor, raring to go, but Nimitz left them there, to their great chagrin. They were, he knew, too slow to keep up with 30-knot carrier task forces for one thing, but he also understood that their day had passed. They would serve in the long war to come for bombardment of assault beaches, and they slugged it out once in the Philippines in late October 1944 with equally obsolescent Japanese battleships. But the Pacific war featured fleet carrier task force against fleet carrier task force, and this type of warfare would first be displayed in its full dimensions at the Battle of the Coral Sea in May 1942, and then at Midway one month later.

Though he had designed the Pearl Harbor attack that initiated carrier war, Admiral Yamamoto, commander of the Imperial Japanese Combined Fleet, never entirely understood the lesson he had taught. At Midway, which was also very much his operation, he continued to treat his carriers as an advance

force for the big-gun fleet he commanded from his flagship, the largest battleship in the world, the *Yamato*, named for the ancient Japanese kingdom. It weighed 63,000 tons, had 18-inch guns, and displayed the royal chrysanthemum on the bow. He placed his carriers several hundred miles in front of what he designated his main fleet, confidently planning to use them to clear the beaches for the invasion force and to draw out the American fleet for him to finish off with his big guns. His leading pilot, Commander Mitsuo Fuchida, commented wryly after the war that at Midway, “The officers and men of the big battlewagons were still confident that their massive firepower would win the [war-ending] battle when it came.”¹ Yamamoto’s death after his defeat at Midway seemed almost designed finally to teach him the superior force of modern air power. In 1943, while on an aerial tour of his Solomon Island command, his plane was shot down by American fighters alerted to his schedule by the code breakers in their Pearl Harbor basement who had set up his fall at Midway.

In time nuclear submarines armed with atomic missiles would displace the aircraft carrier as the world’s first-line capital ship. But in the 1920s the aircraft carrier was still considered an auxiliary to the main line of battleships, and the champions of air power, the visionaries of the Japanese and American navies, had to fight to design and construct them. The two countries competed directly with each other under conditions imposed by the Washington Naval Treaty of 1922, which attempted to limit the major naval powers of the world by setting a 5-5-3 tonnage

ratio for the British, American, and Japanese navies. The Japanese, with growing imperial plans, were embittered by being treated as a lesser power and at once began to rearm for the “big battle” they anticipated with the Yankee enemy, building new battleships and big carriers like *Akagi* (Red Castle) and *Kaga* (Increased Joy).

At the outset the Japanese, though advised by the British, who were leaders in carrier construction, were as uncertain as the Americans about the best design for their carriers and modified them constantly as they learned what worked and didn’t work. As first built, for example, “*Akagi* had three separated, vertically arranged flight decks: an upper landing deck 190 meters (624 feet) in length, a middle takeoff deck for fighters 18 meters (960 feet) long, and a 49-meter (160 foot) deck beneath that for launching torpedo bombers.”²

Like the American carriers *Lexington* and *Saratoga*, *Akagi* and *Kaga* were built on unfinished hulls of battle cruisers that, had they been completed, would have exceeded allowed tonnage under the Washington Naval Treaty. Commissioned in 1927, *Akagi*, the Japanese carrier flagship, was loaded with features that suggested its origin as a battle cruiser. It was a big carrier, 36,000 tons to begin with, and later modifications brought its displacement up to just over 41,000 tons. It was 855 feet long, and 102 feet wide after modifications, and had that distinctive Japanese open look under the flight deck at either end. Its decks could carry 63 planes, while 131,000 horsepower drove its four shafts and moved the huge ship at 31.5 knots. A peace-

time crew of twelve hundred, plus eight hundred air personnel, manned the ship. Six guns of 8-inch caliber were in casemates below the flight deck, twelve 4.7-inch anti-aircraft and fourteen twin 25mm along the deck. The Japanese flight decks had 45mm wooden planks and 7mm steel plates. *Akagi* was armored with 10 inches of steel in a side belt, with a 3-inch armored deck above the machinery.

Kaga, commissioned in 1928, was patterned closely on *Akagi*. Originally it, too, had two hangar decks and a long, open bow plus turrets for 8-inch guns. The upper hangar deck was later closed in the same way as *Akagi*, and its guns were moved to stern casemates to allow extension of hangar and flight decks near the bow. It had a small island on the starboard side, and a trunk along the starboard side conveyed boiler gases aft.

Hiryu (Flying Dragon) and *Soryu* (Deep Blue Ocean Dragon), the other Japanese Midway carriers, were designed as carriers from the keel up and, though slightly smaller, resembled the *Yorktown* class of American carriers.

Commissioned between 1937 and 1941, *Yorktown* (CV-5—carrier/heavier than air/number 5), *Enterprise* (CV-6), and *Hornet* (CV-8) were the American carriers that would fight the Battle of Midway. They reflected the time in which they were built. When the naval budget in a time of deep depression could not pay for the new American carriers needed to stay even with the Japanese, and when many workers were unemployed, *Yorktown* and *Enterprise* were built with money provided by the National Industrial Recovery Act to provide jobs for those out of work.

Many of the sailors aboard the ships were also there, as I was, because there were few jobs in depression America. The ships belonged to their time in other ways as well. Together with their planes the carriers represented an ongoing development of the Industrial Revolution from massive machinery and brute applications of energy to more sophisticated technology. From coal to oil, from steam to electricity and hydraulics, from mechanics to electronics, from two operational dimensions to three. The *Lexington*, the oldest of the first-line American carriers, with its huge General Electric turbo-electric drive was able to provide power needed by Tacoma, Washington, for a month in 1929 when that city's electric plant went down.

Within the American navy this technological shift was fought out in a running war beginning in the 1920s that did not end even with Pearl Harbor over the design of the new aircraft carriers. The old battleship "gun club" and the younger air-power enthusiasts, the "Airedales," known respectively, for their foot-gear, as the "Black Shoe" and the "Brown Shoe" navies, slugged it out. The first American carriers built after the Great War, *Lexington* (CV-2) and *Saratoga* (CV-3), were huge ships built on top of the hulls of heavy surface warships. They retained many gun-club features such as heavy armor and 8-inch surface gun turrets on the flight deck. They were designed to fight it out with any cruisers that might attack them when they formed part of a battle line or provided scouting for the main force of warships, which the old-line admirals considered their primary function.

The *Yorktown* carriers were, however, designed from the keel

up as carriers and embodied many of the ideas of naval aviators who saw aircraft and their carriers as an attack force in their own right, capable of operating independently of surface battleships. They were smaller than the earlier carriers, making it possible to build more under the Washington Treaty limits. Tremendous fights in the Bureau of Ships marked the design phase of these new-style carriers. Arguments raged about the thickness of the armor belt below the waterline, of whether the carriers should carry heavy guns to defend themselves, of whether the flight deck should be steel or wood. At one point in the design phase the *Yorktown* had a flight deck that ended short of the bow to allow room for a forward gun deck with 8-inch turrets. Underwater torpedo tubes appeared in one carrier design but never got to the construction stage.

What the aviators wanted above all was speed in their ships and enough deck space to fly off their planes and land them safely and quickly. Speed to go into attacks and to get out again, speed to help launch planes by running into the wind, speedy movement of the planes on deck to get maximum strikes into the air quickly. Speed was the desideratum, and the aviators got it in the *Yorktown* class, that varied in details but roughly conformed to a pattern. The flight deck was 800 feet long and 83 feet wide, broadened slightly opposite the island to make for easier plane handling when the amidships elevator, one of three, was operating. Not fully loaded they weighed about 20,000 tons and drew 26 feet of water. Nine boiler rooms fed geared steam turbines driving four shafts and moving the ships in trials at 32 or

33 knots. They were a few knots slower when loaded for combat and their bottoms were fouled. Running at an economical speed of 15 knots they had a range of 12,000 miles, but at high speed they burned fuel at a far faster rate and in combat conditions needed to refuel every few days. A crew of twelve hundred was needed to run them in peacetime, considerably more, up to three thousand, in war when all battle stations had to be manned.

Mostly the Brown Shoes got their design right, but at times they bungled. Early designs had arresting wires forward as well as aft so that planes could be landed while the ship was reversing, since it was first thought that, depending on the wind, the carriers were as likely to launch and land planes while going backward as forward. Good idea, but it didn't work that way in practice. They also at first had transverse catapults forward on the hangar deck so that planes could be launched through the open side curtains while air operations were proceeding independently on the flight deck. Both these features were removed in later refits.

Guns? On this the Brown Shoes were definite. Guns weighed a lot, and so those aboard the *Yorktowns* were all for protection against air attacks, nothing really for surface defense. They were right; only once during the war, at Leyte Gulf, did Japanese gunners get several escort carriers in their sights, and aircraft soon drove them off. Eight 5"/38 anti-aircraft guns were located in four sponsons at the corners of the flight deck; four quads of 1.1s (later Bofors 40mm) were fore and aft of the island on

Fig. 1 USS *Hornet* launches a B-25 bomber during the Doolittle Raid, official U.S. Navy photograph 80-G-41197, National Archives, reprinted with thanks

the flight deck; and twenty-four machine guns lined the flight-deck catwalks, .50-caliber Brownings at first but later upgraded to 20mm Oerlikons. The number of guns and their placement were improved throughout the war, but they were never as effective against air attack as the fighter planes of the Combat Air Patrol directed by radar.

The main armament of the *Yorktown* carriers consisted of the seventy-two planes of an air group, though it was found that in the pressure of wartime operations eighty or more could be handled efficiently. The mix was constantly changing, but at the

time of Pearl Harbor an American carrier air group was made up of four squadrons: a torpedo squadron, a fighter squadron, and two dive-bomber squadrons, one designated scouting and the other bombing. The bombing and scouting squadrons used the same plane, the Douglas SBD Dauntless, and both squadrons became dive-bombers for offensive purposes. That one squadron was designated for scouting, however, indicates the navy's continuing emphasis on the importance of scouting. In contrast, the Japanese concentrated on attacking aboard their carriers and left scouting to the floatplanes on their escort vessels. At Midway the destruction of the Japanese carriers can be traced to a scouting failure, while the Americans depended on land-based planes from Midway for the critical scouting reports.³

Optimally there were eighteen planes in each squadron, with a number of spares secured in the overhead of the hangar deck. After the war began it was clear that more fighters were required to provide both the combat air patrols needed to protect the ships from enemy planes and the escorts needed to accompany the dive and torpedo bombers on their attack. So the fighter squadrons got bigger. But the mix was considered critical, and the all-out coordinated strike on enemy ships that the navy aimed for was designed to distract the target with dive-bombers protected by fighters above while the torpedo planes, also protected by fighters, came in on the surface to deliver the knock-out blow. In view of what would happen at Midway it is worthwhile to note that pilots recognized early on how difficult it was to coordinate such an attack, calling it a "Group Grope."

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The art of handling the aircraft efficiently was developed by long practice and experience starting on the decks of the old *Langley*. The flight deck looked like a big war dance of different colors. The ordnance gang wore red cloth helmets strapped tight under the chin and a red T-shirt when they went about their work of loading machine guns, fusing bombs, and hoisting torpedoes on cables to secure them to the bomb racks. Other specialties wore different colors. Brown for the plane captains — one attached to each plane and responsible for its safety at all times that it was not airborne — green for the hydraulic men who manned the arresting gear and the catapults, yellow for the landing signal officer (LSO) and deck control people, purple for the oil and gas kings: it was all very colorful as we swirled around, moving smartly, getting the planes in the right places, ready to go. Everything was “on the double” and took place with whirling propellers everywhere, waiting to mangle the unwary. Crews of plane pushers in blue helmets and T-shirts, ran, not walked, back and forth, in the days before there were deck tractors, pushing the planes on deck forward to allow those in the air to land. And when the landing was complete, the planes forward were pushed back at a dead run to the stern so that they could be refueled and rearmed, readied to take off again. Planes needing work, engine repairs for example, were pushed onto one of the three huge elevators located forward, amidships, and aft. The elevator warning horn would blow, sounding like the automobile horns of the 1930s, GA-OOGAH, and a huge hole would open

in the flight deck, lowering a plane to the hangar deck below, where metal curtains could be lowered at night and work go on under the lights while maintaining the blackout that the ship operated under from dusk to dawn.

Deck spotting was if not a science then a fine art on an American carrier, making sure that the planes were in the right place to take off quickly, that planes returning could land before their gas was exhausted, all without having to clear the flight deck. Timing and speed were crucial, and the Japanese would lose at Midway in part because of failure to manage their flight decks efficiently. They had opted early along to keep flight decks clear for landing and takeoff, stowing all other planes on hangar decks. This limited the number of aircraft, sixty-three on the *Akagi*, to the number that could be parked on the hangar decks, twenty-one Zero fighters, twenty-one dive-bombers, and twenty-one Kate torpedo planes. They were caught by our planes at the critical moment when they were unable to launch a strike against the American fleet, whose presence they had just discovered, because their flight decks were tied up launching and landing fighters to defend against attacking American torpedo planes.

By the time war came at Pearl Harbor, the Brown Shoe navy had the ships it wanted and had worked out ways to manage them and their aircraft effectively. When the ironclads could no longer provide the battle line, the aircraft carriers were there and ready to take their place. But the fate of these proud and

seemingly invulnerable ships was built into them, not to become apparent until the Battle of Midway and the loss of the *Yorktown*. Armor and the location of the boilers were to be the critical matters.

Much of the weight of a warship, and its protection, are in its armor plating. The Washington treaty limited the weight of warships, which meant less armor or fewer ships. The Brown Shoes wanted as little armor as possible on their carriers in order to maximize the number built and increase their speed and range. They would have liked to do without armor altogether, but in the end they were forced to accept a compromise. The *Yorktowns* had light 2.5-to-4-inch armor belts below the waterline and an armored deck of 1.5 inches just above the vital machinery spaces and the magazines, considerably less than the thickness of armor built into a warship designed for gunfighting. Wooden flight decks weighed less than steel, and the supports rising from the hangar deck could be lighter as well, so wood it was, though the British had showed its value in the Mediterranean. Lighter armor made the *Yorktowns* fast, above 30 knots in trials, but it also made them, it turned out, vulnerable to damage by torpedoes. In the first year of the war, two of the three *Yorktown* class carriers were sunk by torpedoes. The USS *Yorktown* took two aerial torpedo hits and was abandoned, dead in the water, after a second attack on it at Midway. Reboarded, it was sunk a few days later by submarine torpedoes while under tow. The *Wasp*, similar in many ways to the *Yorktowns*, but smaller and

even more vulnerable, was sunk by submarine torpedoes near Guadalcanal. The *Hornet* canted sharply to starboard, water on its hangar deck, from aerial torpedo hits at Santa Cruz in October 26, 1942. It was later sunk by Japanese destroyer torpedoes after it refused to go down under a barrage of 5-inch gunfire from American destroyers. *Enterprise* alone of this class of ship survived to become the most famous warship of World War II. It was hit many times by bombs but never by a torpedo. The official report on the sinking of the *Hornet* makes clear that the light armor plating in these ships had made them vulnerable to torpedoes:

At the time of the design of this class of aircraft carrier, naval treaties imposed a limitation on size which forced some sacrifices in torpedo protection, as compared with battleships, in order to gain other characteristics desired by the Department. The transverse depth of the torpedo protection system was considerably less than is now considered necessary for protection against modern torpedoes. Exact evaluation of the protection afforded by any given system is only possible by means of full scale tests in which the weight of the charge is accurately known. In the absence of such tests, extrapolations from 1/2 scale or smaller model tests is necessary, with considerable doubt, in our present state of knowledge as to the scale factor. All of the information available to the Bureau, however, indi-

cates that this system should have withstood a charge of about 500 pounds of T.N.T. The indication, therefore, is that the particular Jap torpedo used in this case carried a larger charge, or a more powerful explosive, or both. Torpedo "E" is believed to have struck and detonated on the 4-inch special treatment steel side armor about two feet above the bottom of the plate. This conclusion is based on the location of the rupture in the holding bulkhead as reported by an eyewitness. If this location is correct, the armor belt apparently did not have any very great effect in reducing the damage from the explosion.⁴

The thinness of the armor plating in this class of ships was, with unforeseen consequences, linked to another design flaw. The ideal flight deck would have had no obstructions on it anywhere so that planes could be moved, landed, and launched without impediment. But a ship needed a bridge, as elevated as possible, and a flight control location, so there was always a need for some kind of an island structure on the flight deck. But what should be its size and location, port or starboard, fore or aft? The Japanese designers had the same problem and never settled on a pattern, building small island structures of different sizes in various locations. At one point in their design one carrier's bridge was even in the bow, just below the level of the flight deck. The American navy, however, settled on large starboard-amidships island structures, containing the bridge,

the mast, and a single huge stack aft. With a large single stack available directly above, all nine boiler rooms were then collected amidships, venting directly upward through the island stack, thus avoiding space-devouring trunks running through the ship, heating up hard-to-cool areas below deck. On some Japanese carriers boiler gases were vented through a trunk flared downward, just below the flight deck, starboard amidships, on other ships through a long horizontal stack running from amidships to the stern, just outside and below the flight deck.

The *Yorktown* design seemed practical, but it violated the usual navy arrangement of alternating boilers and machinery rooms to prevent all or most of the boilers and the steam power from being knocked out by a single torpedo or bomb hit. The *Yorktown* carriers, it emerged at Midway, with all boilers concentrated in one area, could go dead in the water with a hit, from either bombs or torpedoes, while the rest of the propulsion machinery might be still functional. This is exactly what happened to the *Yorktown* at Midway: "Aside from personnel casualties, the most serious effect of this bomb hit was that it ruptured the uptakes from boilers 1, 2, and 3, completely disabled boilers 2 and 3, and extinguished fires in boilers 2, 3, 4, 5, and 6. The fire rooms containing all saturated boilers (1, 2, 3, 4, 5, and 6) were filled with smoke and gases from the bomb hit and from the boilers themselves."⁵

A carrier that cannot move at high speeds while under air attack is a sitting duck, and this is exactly what happened in all

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Yorktown class losses.⁶ Captain Charles Perry Mason of the *Hornet* in his action report after his ship was sunk later in the year was brief and explicit about what a single torpedo could do to these big ships: “The key ship of a task force must not be completely disabled by one torpedo.”⁷