SILENT HUNTER™

USER MANUAL

MINDSCAPE®

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WAR BENEATH THE WAVES

The December 7, 1941 attack on Pearl Harbour damaged or destroyed nineteen capital ships of the U.S. Navy's Pacific Fleet. This left the aged and outgunned forces of the Asiatic Fleet as the first line of defence against the oncoming might of the Japanese Navy. One force that emerged from the attacks on Pearl Harbour and Cavite, virtually unscathed and ready to carry the war to the enemy, were the submariners of the Fleet Scouting Force. The 51 submarines of the Asiatic and Pacific fleets were ordered to "...EXECUTE UNRESTRICTED AIR AND SUBMARINE WARFARE AGAINST JAPAN. YOU WILL SINK OR DESTROY ENEMY SHIPPING WHEREVER ENCOUNTERED."

Authorised to sink any vessel bearing the "Rising Sun" of Japan, the untried men of the Pacific submarine forces quickly became hunters of the largest prey around. Now, you too can stalk the tankers and freighters that carry the lifeblood of the empire, the destroyers, cruisers and carriers that are the weapons of war. You can become a Silent Hunter.

What Comes with This Game

The game box should contain this user's manual, a SILENT HUNTER CD-ROM, and a data card. This user's manual explains game controls and contains historical information about submarine warfare in the Pacific Theatre during World War II. To install the game, please refer to the data card.

This manual contains a description of how to use all of the controls that this simulation provides to realistically reproduce the feeling of hunting and being hunted by the ships of the Imperial Japanese Navy. It also contains several appendices which provide more insights into the reality of submarine warfare

by William P. "Bud" Gruner, who commanded SS 305, the U.S.S. *Skate* on her third, fourth and fifth war patrols. Appendix A is entitled "The U.S.S. *Skate* and the Fifth Fleet." Appendix B provides a brief overview of submarine tactics. Appendix C describes the formulas for calculating a manual firing solution.

Using the Mouse

In this manual, the term "click" means to move the mouse pointer over the desired area of the screen and press either the left or right mouse button. The mouse pointer changes shape depending on the type of action which can be taken. "Left-click" or "right-click" means to move the mouse pointer to the desired position and press the appropriate button.

Left-clicking is used to change stations aboard the submarine, set controls, fire weapons, and alter preferences. Left-clicking handles most of the controls in SILENT HUNTER. Right-clicking opens the Abort Mission box where the current mission can be ended.

STARTING THE GAME

After the opening animation, two choices are offered for playing SILENT HUNTER, a Single Mission or the Career Menu. In addition, there are options to view an interview with William P. "Bud" Gruner, who commanded the U.S.S. Skate; take a multimedia tour of the U.S.S. *Pampanito*; or Exit to DOS.

Single Missions

Choosing Single Mission presents an option to perform one of five different kinds of authentic missions that U.S. submarines undertook during WWII. In addition to seeking out and destroying enemy warships and cargo ships, U.S. submarines performed other valuable services such as rescuing downed pilots. All of the types of missions except for the Historic Mission selection are generated randomly, and can be customised prior to play.

These missions will begin with some form of contact notification regarding the enemy, either a radar contact, a hydrophone bearing, or a lookout report. The mission ends when the submarine is out of contact with all enemy ships. This might be because the submarine has sunk all the enemy ships, has disengaged or been outrun by the enemy, or has been destroyed. At this point a scoring screen appears which correlates the level of realism and the number of enemy vessels damaged or sunk and presents the score. Left-clicking on the Exit button returns you to the Single Mission menu.

Historic Mission

This option presents the opportunity to test your skills against those of historic submariners in encounters that defined what it meant to be a member of the Silent Service. The available missions are listed in the menu, with the appropriate briefing listed below the mission menu.

The Historical Mission menu automatically defaults to the top mission on the menu, so go ahead and make any realism changes prior to selecting the mission to be played.

Convoy Encounter

During WWII U.S. submarines sank nearly 5,000,000 tons of Japanese merchant shipping, accounting for over 1100 confirmed sinkings. This was the most likely type of encounter during the war.

Warship Encounter

This mission consists of intercepting and attacking an Imperial Japanese Navy task force. Aircraft carriers were the highest priority target for the submarine force, followed by battleships and escort carriers.

Patrol Encounter

Encounter a Japanese anti-submarine (ASW) patrol searching for U.S. submarines.

Lifeguard Duty

Over 500 aviators owe their lives to the men of the Silent Service. Submarines were frequently positioned to recover downed pilots at the scene of surface engagements, such as Midway, or during large air strikes. A downed aviator can only survive a limited time in the water, and the submarine's task is to effect a rescue before the sea claims him or the enemy captures him.

Mission Customisation

After a mission type has been selected, several mission variables may be chosen. Each type of mission has some of the following options available.

Date

The date affects the location of the encounter, the number and type of ships encountered, and the equipment available to both sides. For more information regarding the types of equipment available for any given month of the war, see the "SILENT HUNTER Weapons Data" table on page 50.

Crew Quality

Crew quality affects the ability of the crew to operate the submarine. Reload time, dive time, lookout sighting distances, and other factors are all determined by the crew quality setting. The crew can range from green to elite.

Convoy Size

The size of the encountered convoy, small, medium, or large.

Warship Type

Capital ships travelled in a main body of vessels, usually with an interior screen of cruisers and an exterior screen of destroyers. Select between carrier, battleship, cruiser, and light cruiser task forces.

Escort Size / Patrol Threat

These options determine the number and probability of encountering some form of patrol vessel or escort.

Enemy Quality

This setting determines how tough the enemy is. Gun and depth charge attack accuracy, lookout sighting distance, and overall coordination of attack are controlled by this setting. Enemy crews can be green, veteran, or elite.

Air Cover/Threat

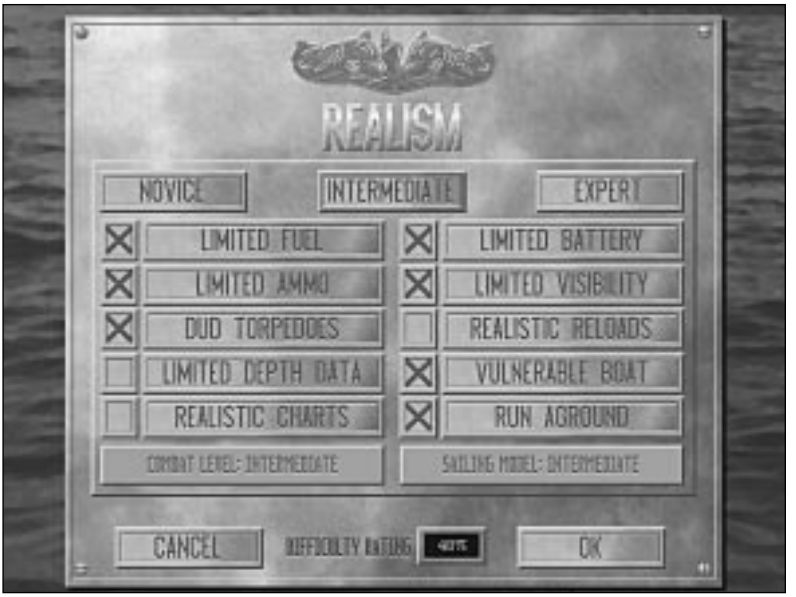
Task forces and occasionally convoys were supplied with air cover. Other missions run the risk of encountering an aerial patrol. These settings determine the number and probability of encountering some form of air cover.

Time of Day

Select whether to begin the mission at Dawn, during the Daytime, at Dusk or during the Night. Submarines equipped with radar could operate on the surface at night much more readily than could earlier submarines.

Weather

The weather affects the speed of ships and the amount of visibility. Heavy seas affect the submarine's stability near the surface, while fog can be a commander's best friend.



Realism

The level of realism experienced while playing SILENT HUNTER can be modified for both single missions and careers. This is done using the Realism screen, which is available from all Single Mission screens and when the submarine is in port during campaign games. With all Realism settings selected, the simulation is as close to real as is possible!

Overall settings

At the top of the Realism menu are three buttons: Novice, Intermediate, and Expert. These buttons are quick ways to select specific sets of play conditions.

Novice level lowers the combat and sailing model levels to novice, and turns off all realism settings except the vulnerability of the submarine.

Intermediate level lowers the combat level and sailing models to "Intermediate," and turns off the Dud Torpedo, Realistic Reloads, Limited Depth Data, and Realistic Charts settings.

Expert level implements every possible realism setting, duplicating live conditions during WWII as closely as possible. The combat level is set to "Advanced" and the submarine manoeuvers realistically.

Other Realism Settings

There are options other than the three preset levels. Ten settings can be toggled on or off and each of these settings has the effect of reducing the realism by a certain percentage when turned off. The Combat Level and Sailing Model settings have more than two levels and each of these levels also change the overall Difficulty Rating.

Limited Fuel

The Limited Fuel setting has a small effect on Single Mission games, but is a serious consideration for the Campaign Game. Refueling can only be performed by a submarine tender or at a base. Turning this setting off reduces the realism factor by 10%.

Limited Battery

With Limited Battery turned off, the submarine never needs to surface to recharge the batteries. Turning this setting off reduces the realism factor by 30%.

Limited Ammo

The submarines simulated by SILENT HUNTER normally carried one hundred rounds for the deck gun and twelve to twenty-eight torpedoes. When turned off, there is an unlimited supply of both types of munitions. Turning this setting off reduces the realism factor by 50%.

Limited Visibility

With this option on, only ships actually visible to the crew will appear on the map screen at the Charts station. If the submarine is submerged with the periscope lowered, only the most recent observed contact will be shown on the map. With this setting off, all ships will be shown on the map. Turning this setting off reduces the realism factor by 30%.

Dud Torpedoes
From the beginning of the war until late in 1943, a series of problems with the torpedoes caused a significant number of them to fail. With this setting off, torpedoes are always reliable, but realism drops by 15%. For more details of the torpedo problems, see the "Torpedoes" section on page 50.

Realistic Reloads
The Realistic Reloads setting toggles the torpedo tube reload time between two minutes and a more realistic time that is also affected by crew quality. Turning this setting off reduces the realism factor by 10%.

Limited Depth Data
With Limited Depth Data toggled on, the Depth Gauge indicates only how deep the submarine has gone. There is no information available other than the chart about how deep the waters are in that particular part of the ocean. When toggled off, an additional gauge appears at the Gauges station entitled "Depth Under Keel." This indicates how deep the local waters are. Turning this setting off reduces the realism factor by 5%.

Vulnerable Boat
Toggling Vulnerable Boat off eliminates the chance of the submarine taking damage, and correspondingly, reduces the Realism level by 80%.

Realistic Charts
The Realistic Charts setting controls the information that can be viewed at the Charts station. With this setting toggled on, the chart shows only the position of ships relative to the submarine, further modified by the Limited Visibility setting. With this setting off, the Charts station shows torpedo wakes and shell splashes as well. Turning this setting off reduces the realism factor by 10%.

Run Aground
With this setting turned off, the submarine can run aground without sustaining damage. This setting alters the Difficulty Rating by 5%.

Combat Level
Changing the Combat Level setting affects the accuracy and lethality of both side's weapons. The amount of information displayed on the map at the Charts station, such as torpedoes, sonar pings, and gun hits, also decreases at the advanced levels. The Realism rating is reduced 15% for each level below Expert; from Expert to Advanced, to Intermediate and finally Novice.

Sailing Model

The Sailing Model controls the manoeuverability of the submarine, affecting dive time, maximum speed in heavy seas, turn rate and the likelihood of the submarine running aground. Realism drops by 10% for each reduction in level; from Realistic to Intermediate and from Intermediate to Novice.

Difficulty Rating

The Difficulty Rating is based on the effects of changing the realism settings above. The mission score for completed missions is modified by the level of realism chosen. The higher the realism setting, the higher the potential score.

Realism and Japanese Anti-Submarine Warfare

The realism setting determines the effectiveness of Japanese anti-submarine warfare (ASW). Throughout most of WWII, the Japanese Navy believed that no submarine could dive below 200 feet and survive, so most of their ASW efforts were expended at depths between 50 and 150 feet. In deep water, U.S. fleet submarines could dive routinely below 200 feet and so were able to survive repeated depth charge attacks.

In SILENT HUNTER, the Combat Level setting can be used to increase realism beyond 100%. This reflects Japanese ASW efforts that take into account the full capabilities of U.S. submarines.

Submarine Class Selection

The type of submarine used can be selected for any of the single mission scenarios from a range of vessels available at that date. For Historic Missions, the type of submarine used in the actual encounter is preselected. Each type of submarine is displayed with statistical details by left-clicking on the list of classes. Left-clicking on the Description button toggles to a brief description. Confirm the choice of a particular class by left-clicking on the Select button. For more details about the submarine classes available in SILENT HUNTER see the "Submarines" section on page 40.

Victory or Defeat

The scenario continues until the submarine is destroyed or all enemy vessels are beyond contact range. This can be because they have been sunk, they have outrun the submarine, or the submarine has evaded all pursuit.

At this point a scoring screen appears which correlates the level or realism and the number of enemy vessels damaged or sunk and presents the score. Left-clicking on the Exit button returns you to the Single Mission menu.

THE CAREER MENU

The Career Menu is where the campaign game begins. Starting at any point in the war, a series of war patrols are performed that can then be compared to those of some of the greatest submariners ever.

Starting a Career

Enter the name of the submarine's commander and select a starting month and year for this career. Up to twenty different careers can be accommodated by the career roster; if all twenty positions have been used, a new career must be entered over an older career.

The date chosen determines what classes of equipment are available to the commander. This includes submarine classes, and features such as radar, improved torpedoes, and radar detectors.

Best Careers

This option displays the top careers to date.

Main Menu

This button returns to the Main Menu.

Continue a Career

This button opens a menu where a saved career may be continued, reviewed, or deleted. The Career Roster lists the names that have been entered for the careers in progress. To continue to play a particular career, left-click on it to highlight it and left-click on the Select button or double left-click to resume that career.

The View button displays the progress of a highlighted career. The Delete button deletes the highlighted career.

After selecting a career, the Base Menu appears.

Base Menu Options

The campaign aspects of SILENT HUNTER are managed from the Base Menu — campaigns are made up of a series of war patrols. While at base several activities are possible:

- Start a war patrol.
- View the top scores for commanders in that campaign.
- Examine the record of the active commander.
- Visit the Officer's Club for news and rumours.
- Save the active career.
- Return to the Main Menu.

Start War Patrol

This option begins a war patrol. The submarine will be assigned a patrol area in which to operate. Any changes to the realism settings must be done now, while still in port. See the "Realism" section on page 6 for more information.

Prior to departure initial instructions are issued for any particular missions the submarine is to undertake. While on the mission, occasional radio messages will update the commander of enemy activity in the area.

Ending a War Patrol

A war patrol continues until:

- The submarine is destroyed.
- The submarine is damaged beyond the ability of the crew to repair it.
- The submarine runs out of supplies (fuel and /or ammunition).
- The submarine is ordered back to base at the end of the patrol.

Depending on the success of the war patrol, the commander may be rewarded. Success is measured in a variety of ways, and reassignment is possible in cases of poor performance.

Tonnage

The primary yardstick of success for a submariner during WWII was ships sent to the bottom, whether merchant or military. The tonnage sunk figure does not include ships that were damaged but did not actually sink.

Score

The score takes into account ships damaged or sunk, the overall mission difficulty, and the difficulty based on realism level. The score for damaged ships is based on the amount of damage done. The higher the realism level, the higher the score.

Promotion, Medals, and Awards

While referred to on board as "Captain," officers commanding submarines were all Lieutenant Commanders or Commanders; all officers of higher rank either moved to a different command or were assigned shore duty. For this reason, submarine commanders in SILENT HUNTER will not be promoted in order to remain historically accurate. Reassignment for inadequate performance is always possible.

Medals are awarded based on the results of a particularly productive war patrol. The medals that are possible, in order of precedence are:

- Medal of Honour
- Distinguished Service Medal
- Navy Cross
- Silver Star
- Bronze Star

Submarine crews may also earn either a Presidential Unit Citation or a Unit Citation if the overall record of the submarine is good and it has an exemplary war patrol.

View Career

The career of the active submarine commander can be viewed using this option. In addition to the name of the commander's submarine and the base he is assigned to, useful information is shown including the number of ships sunk, the total tonnage sunk, and any medals or commendations the commander or submarine have been awarded.

CONTROLS

The Smart Mouse Pointer

The submarine is managed using controls and displays at several stations around the submarine which are accessed via the control room. Move the mouse pointer until it changes from an arrow to the name of the station and left-click to change the view. Each station is represented by one or more screens. Moving the mouse pointer over the controls and gauges at each station is the fastest way to determine which are controls and which are displays because the mouse pointer changes from an arrow to a reticule with a word above it, such as SET, SELECT, or FIRE.

- Settings on dials are changed by moving the reticule to the desired position on the dial and left-clicking.
- Buttons are pressed by moving the mouse pointer over the button and left-clicking.

Using the Function Keys (F1 - F10)

The stations listed below can also be reached using the corresponding function keys:

FUNCTION KEY	STATION
F1	Control Room
F2	Up Scope/Periscope
F3	Target Bearing Transmitter
F4	Bridge
F5	Charts
F6	Torpedo Data Computer
F7	Gauges
F8	Status
F9	Radar
F10	Logbook
Alt F4	Deckgun

Setting the Detail Level

Once a mission or war patrol has begun, pressing Alt-D opens the Detail Level box. Graphic features that enhance the appearance but may hinder play of SILENT HUNTER such as clouds, waves, land texture, ship and torpedo wakes can be toggled on or off using this box. In addition, visibility range can be increased in increments of one mile using this control. Left-clicking in the upper left corner returns to play.

Control Buttons

At each station there are buttons at the bottom of the screen for changing certain game settings, stations or accessing features.

The rate at which time passes can be changed by left-clicking this button, from 1x to 256x. At 1x time passes at the normal rate. This button appears on all stations. The + key increases compression, while the – key decreases time compression. The Enter key returns the time rate to 1x. Note: During encounters with enemy ships, the maximum rate of time compression is 16x. While torpedoes are active the maximum rate is 8x.

This common button is used to return to the Control Room from almost any station on the submarine. The control room button is available on the Gauges, Status, Captain's Quarters, Periscope, Charts and TDC station screens.

This button brings up the first of three parts of the Torpedo Data Computer (TDC) for use at the periscope or the Target Bearing Transmitter (TBT). This button appears on the periscope screen and the TBT screen. At the Status Station, the Torpedo button toggles the view to the Torpedo Room station where the torpedo tubes are reloaded displayed combat and the status of torpedo reloading can be found. The button is replaced with the Status button while the Torpedo room is visible. See the Status Station section on page 38 for more information.

The Wheel button changes the "controls" portion of any screen to the Manoeuver Controls subset. This button appears on the periscope, the TBT station, and the Chart station.

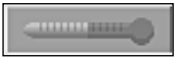
The Bridge button returns to the Bridge view from the TBT and Deck Gun stations.

Pressing this button opens the Ship Identification Manual which is normally stored in the Captain's Quarters. It contains views of the ships that Naval Intelligence has determined are likely to be encountered. This option is available at the TBT, Periscope stations, and the Captain's Cabin. For more information see the section on the Captain's Cabin starting on page 17.

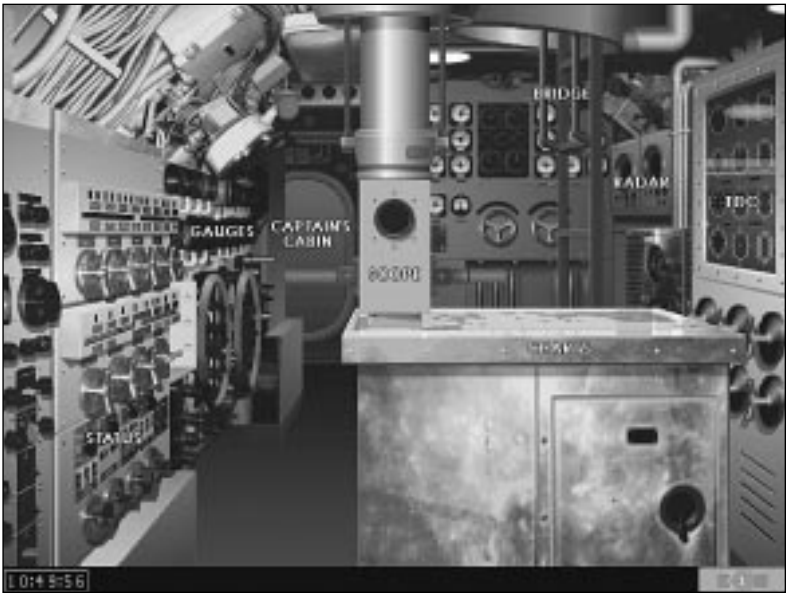
The Target Bearing Transmitter (TBT) button is located on the Bridge and contains the same components as the Torpedo Data Computer (TDC), divided into three sections to fit at the bottom of the screen. For more information see the section on the TBT

starting on page 35.

This button is found on the Bridge station and goes to the Deck Gun station. For more information see the "Deck Gun" section starting on page 36.



The Bathythermograph button is located at the Gauges station. It replaces the "Christmas tree" display, which indicates the usage of engines to charge batteries, with the bathythermograph. For more information see the "Thermal Layers and the Bathythermograph" section starting on page 26. When the bathythermograph is visible, the Bathythermograph button switches to a button marked "Engines" which restores the Bathythermograph button and the Christmas tree display.



COMMANDING THE SUBMARINE

The control room is the nerve centre of the submarine. All other stations necessary to fight and manoeuver the submarine are accessed from the control room. Other stations are reached from the Control Room by moving the pointer until it changes to a word, for example Charts or Gauges. Left-clicking changes the view to that particular station. Note: On actual U.S. submarines the periscope was accessible in the conning tower. It has

been placed in the Control Room in SILENT HUNTER for ease of use.

Captain's Cabin

Ship Identification Manual

The Ship Identification Manual on the captain's bookshelf is a valuable tool in prosecuting the war against the enemy and not our own shipping. The Ship Identification Manual contains views of thirteen classes of enemy vessels at various angles. The displacement, length and maximum speed in knots are also listed. A copy of this manual is available on the bridge to be used with the Target Bearing Transmitter (TBT) and at the periscope.

Logbook

The Logbook can be viewed in the Captain's Cabin or by pressing F10. This is where the crew's victories are recorded as enemy shipping is harried across the Pacific.

Calendar

Left-clicking here shows more than the current date. Weather information, the phase of the moon, and rising and setting times for the sun and moon are also listed here.

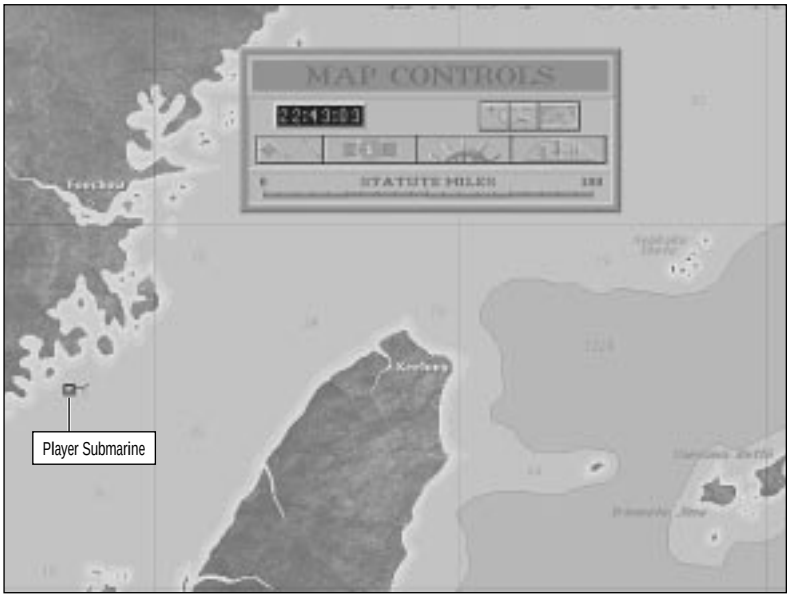
Charts

The Charts station is reached by pressing F5, or moving the pointer until it reads Charts. The Charts station contains charts of the current patrol area, showing important features such as depth information, enemy bases, shipping lanes, and ports of call. Visible enemy ships and reports of enemy vessels are indicated on the chart for tracking purposes depending on the realism level. Boxes that are available while viewing the charts allow for manoeuvering, setting way points along a course and general map controls. At high levels of zoom the submarine is represented by a blue box trailing a line away from its heading.

Sonar

At lower speeds the submarine's sonar can detect other vessels. This is indicated on the map by a line along the relative bearing of the target. The line is either gray, representing a set of low-speed screws, or orange, representing high-speed screws. High-speed screws are usually warships, while low-speed screws can be either a merchant ship of some sort, or a warship travelling at low speed.

Map Controls

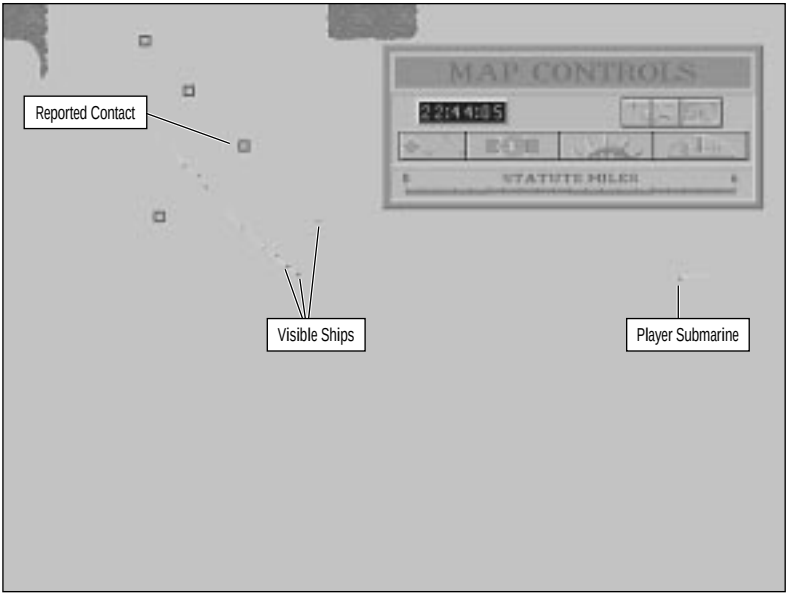


Time Controls

The local time is displayed above the Time Compression control button, and at the bottom left at most other stations. Activating Time Compression allows the rate time passes to be changed from 1x to 256x. At 1x time passes at the normal rate. The + key increases compression, while the – key decreases time compression. The Enter key returns the time rate to 1x. Note: Because of the complexity of this simulation, some features may not operate smoothly at high rates of time compression.

Zoom and Centreing Buttons

The Zoom controls allow a bird's-eye view of the submarine and other ships at the highest levels of magnification. Zoom in by left-clicking on the "+" button, which turns the pointer into a frame. Drag the frame over the section of the map to be viewed. At this point, pressing the "Z" key increases the level of zoom, represented by the size of the frame shrinking. Pressing the "X" key will increase the size of the frame, decreasing the amount of zoom. Left-clicking a second time engages the zoom and changes the view. At zoom levels below a certain point, some map features such as depth gradients are not visible.



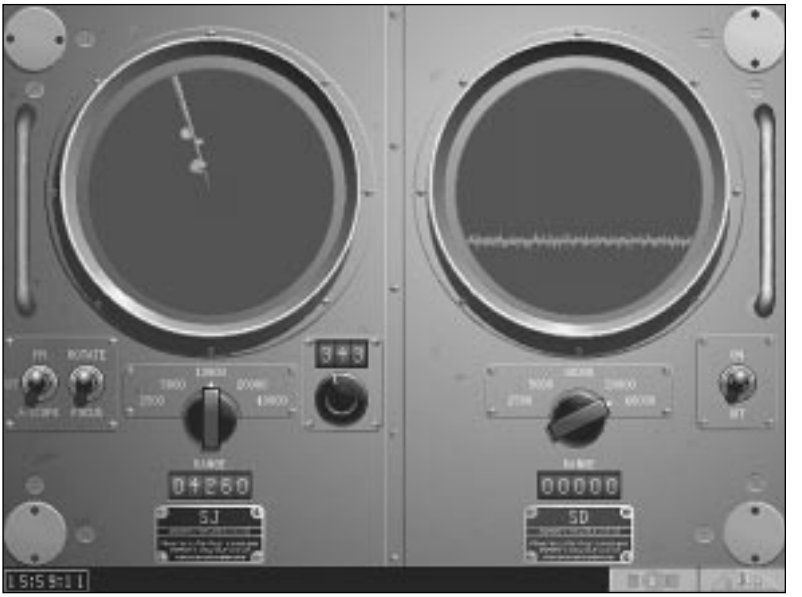
Moving the cursor to the edge of the screen allows the entire map screen to be shifted in any direction. The Centreing button returns the submarine to the centre of the screen.

Way Point Selection

The Way Point Selection button allows navigational way-points to be set or cleared. Left-clicking on the map establishes a course for the submarine which is followed until cleared from this panel by pressing the CLEAR button, when the course is completed, or if the manual helm is used to override it.

Navigation

The Navigation button opens a box showing the Engine Room Telegraph, the Manual Helm, the Speed Gauge, Course Indicator and the Depth Control. The two buttons at the bottom return to the Map Controls or the Control Room. For more information on these controls see the "Gauges Station" section on page 23.



Radar

The Radar station contains two radar range finding panels. On the left is the SJ surface radar, on the right is the SD aerial radar. Both types of radar can be tuned using the range knob; the scope will show an approximate representation of the distance to the target object, the digital readout below the knob gives more precise range information. Note: Neither will function if the submarine is below 45 feet.

SJ Radar

SJ surface search radar was installed on all submarines built after the war started, and six of the older S-class submarines were refitted in 1943. Radar made night surface-actions practical for submarines by generating accurate range information.

The SJ radar represented in SILENT HUNTER can operate in two modes: Plan-Position Indicator (PPI) and A-scope.

The PPI screen shows the direction the radar's antenna is pointing with a line that sweeps through 360 degrees. When a contact is made, the radar produces a blip on the screen. Distance to the contact is indicated on the digital readout below the central knob, and by the blip's relative position on the radar screen.

An A-scope contact doesn't show the direction on the radar screen the way the PPI does. The direction can be derived by the digital bearing readout on the right side of the SJ console. A contact is represented as a spike in the baseline reception, the size of the spike representing the size of the contact. Contact range is indicated on the digital readout and by where the spike appears on the screen. The farther to the left the spike appears, the closer to the submarine the contact is.

The antenna can be aimed by switching from Rotate mode to Focus. This allows the PPI scope to be aimed by left-clicking right on the scope screen or by left-clicking the bearing knob. The A-scope is aimed using the bearing knob on the SJ panel. The radar's aim can be fine tuned by left-clicking on the digital display above the knob to adjust the bearing of the antenna by hundreds, tens, or single degrees. The SJ radar can be toggled on or off using Alt-S. Left-clicking on the Range knob allows the radar coverage to be fine tuned by aiming the radar at the bearing chosen.

SD Radar

All submarines used in WWII were equipped with SD radar to prevent them from being attacked by aircraft. The SD radar in SILENT HUNTER is of the A-scope variety, which reveals distance but not direction of aircraft detected on the screen. A contact is represented as a spike in the baseline reception. The SD radar can be toggled on or off using Alt-A.

TDC (Torpedo Data Computer)

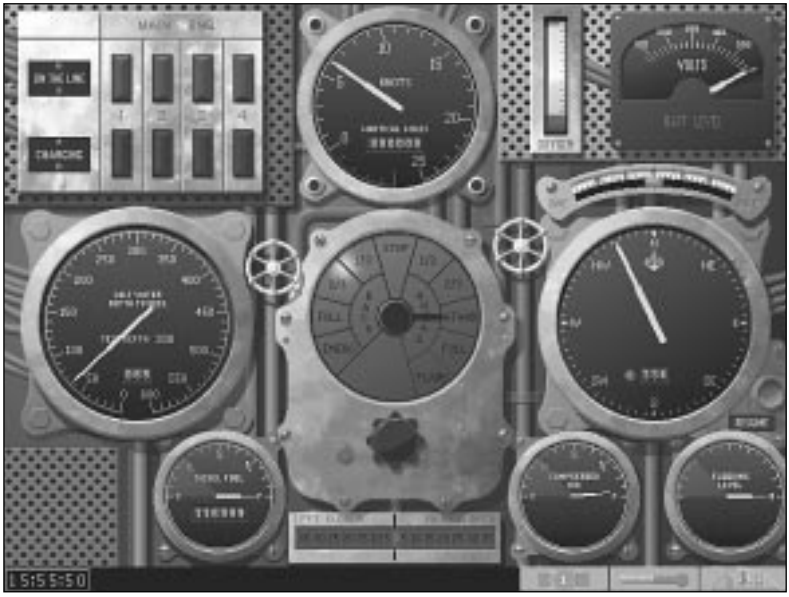
The controls on the Torpedo Data Computer (TDC) were remarkably sophisticated for the period. The firing officer input the estimated speed and course of the target ship, and the TDC compared this information with the sub's course and bearing and fed this information to the gyroscope in the torpedo. Once fired, the torpedo ran straight for roughly 20 yards, then altered course based on the gyro setting to intercept the target vessel.

There are three ways to access the TDC:

- At the main TDC station in the control room (or by pressing F6).
- Using the TBT binocular mount on the Bridge.
- Through the periscope.

The main TDC station has the complete set of controls and indicators for setting and firing torpedoes, however there is no way to take a bearing on the target from the TDC itself. The Target Bearing Transmitter (TBT) and periscope TDC controls are split into three partial screens which are accessed using a control knob. The launch buttons are arrayed on the right side of the TDC, forward tubes on top, aft tubes below.

Most torpedo attacks will be launched from the periscope in the control room or the Target Bearing Transmitter on the bridge. See the "Using the Local TDC" section on page 29 for information on using the TDC for making an attack.



Gauges Station

In SILENT HUNTER, the primary manoeuver controls are found at the Gauges station and consist of the depth gauge, the compass, the manual helm, the engine-room telegraph and the speed gauge. This station can also be reached from anywhere on the submarine by pressing F7. There are also displays for the electric motors, battery charge status, as well as gauges showing the amount of compressed air, the level of flooding, the amount of oxygen remaining, the remaining diesel fuel and the dive angle. The buttons in the lower right corner open the Time Compression box, toggle the Bathythermograph, or return to the Control Room.

Manoeuvering the submarine was the job of the diving officer, under the command of the captain or the executive officer. Most submerged manoeuvering was done by dead reckoning using navigational fixes taken while on the surface. The sub's speed and course were tracked on navigational charts, which were the only means of determining the submarine's

position. Strong ocean currents, inaccurate charts and long periods operating submerged without fixes created the possibility of running aground, particularly in the shallow seas of the Solomon, Marshall, and Philippine Islands.

Manual Helm

The submarine can be turned to port or starboard by left-clicking on the Manual Helm, or pressing the left- or right-arrow key on the keyboard. The 0 setting indicates a straight ahead course, barring wind and current. Turns of up to 35 degrees may be made to port or starboard by left-clicking over that number on the Helm. The submarine continues to turn until the Helm is returned to the 0 setting, either by left-clicking on the 0 or by pressing the arrow key which is opposite the current direction of turn until the Helm reads 0; in other words, if left rudder is being applied, press the right arrow key until the helm returns to 0. Pressing the "H" key establishes the current heading as the new course and returns the Manual Helm setting to 0. Pressing the "V" key restores the view to directly ahead of the submarine.

Compass

The course of the submarine can also be controlled using the compass. The white needle indicates current course while the red needle indicates the desired course. Left-clicking on the compass lays in a course, and the helm responds by gradually turning the ship onto that course. The manual helm should be used for radical course changes, such as evasive manoeuvers or attack manoeuvers. A course laid-in previously can be returned to by left-clicking on the Resume button or by left-clicking on the compass.

Diving Controls

In SILENT HUNTER diving and surfacing is handled simply by setting the dive depth on the depth-gauge or using a convenient keyboard command. The dive angle is displayed on the inclinometer. Below 65 feet, the periscope automatically retracts. Diving and surfacing are controlled by the diving officer at the captain's direction.

Diving involves the release of gas from the ballast tanks to reduce the submarine's buoyancy to a point where the weight of the vessel overcomes the displacement of water. As the submarine becomes less buoyant, the dive is controlled using the bow planes and the electric motors. Surfacing is the opposite of diving; compressed air is forced into the ballast tanks to replace water taken on when diving. This creates a positive buoyancy, causing the submarine to rise slowly. The bow planes and motors are used to control

the rate of change in depth. Once under water, with a neutral buoyancy, the submarine manoeuvers to different depths using the bow planes and motors exclusively unless an emergency occurs where depth must be gained or lost quickly. The diving planes can be controlled manually using the "down" arrow key to cause the submarine to dive, the "up" arrow key to cause a submerged submarine to climb, and the "5" key on the number keypad to resume a straight and level course

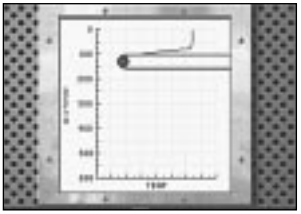
The following keyboard equivalents exist for certain standard manoeuvers to simplify the process of changing depth:

- B – Blow tanks; emergency surface at maximum speed using your compressed air reserves in an inefficient manner Note: Using this command leaves the submarine on the surface with few options since it takes time to restore the compressed air.
- C – Crash dive; the submarine heads for 200 feet at maximum speed and dive angle.
- P – Takes the submarine to periscope depth (65 feet).
- R – Takes the submarine to radar depth (45 feet).
- S – Surface normally.

Compressed Air Gauge

The number of times the submarine can change depth is dependent on the supply of compressed air used to force water out of the ballast tanks. This gauge indicates the amount of compressed air remaining. It is important to be aware of the status of the submarine's compressed air supply because without compressed air the only way to change depth is by using the diving planes and the electric motors. Once these tanks are empty, they can only be recharged by sailing on the surface. This process takes an hour or two depending on the amount of air required. If the submarine finds itself on the bottom with no compressed air, returning to the surface may be an impossible feat.

Thermal Layers and the Bathythermograph



In any large body of water, there are layers where the water is warmer or cooler. The bathythermograph plots water temperature against depth to identify the location of these thermal layers. The benefit of this is that these layers reflect sound waves, which travel very well through water, making it more difficult to locate a submarine using hydrophones or sonar. A submarine beneath the thermal layer becomes nearly undetectable.

As the submarine descends, the bathythermograph indicates the temperature at every depth. When the bathythermograph indicates that the temperature has dropped, this indicates that a thermal layer exists at that depth. Diving below one of these layers is a good way to escape an enemy ASW vessel.

Engine-Room Telegraph and Speed Gauge

Control of the submarine's diesel engines and electric motors is performed in the engine room. The Captain of the submarine forwards his orders by way of the engine-room telegraph. The telegraph's settings indicate the amount of thrust the engines and motors are set to provide, either forward or reverse. The speed of the submarine is indicated on the speed gauge and varies based on sea conditions, damage, and whether the submarine is running submerged or on the surface. Except at very low speeds, there is no way to come to a rapid stop. Inertia causes the submarine to continue moving until the drag of the water causes it to slow to a stop, unless reverse thrust is employed. The number keys across the top of the keyboard can also be used to control speed:

KEY	TELEGRAPH SETTING
0	All Stop
1	Ahead 1/3
2	Ahead 2/3
3	Ahead Standard
4	Ahead Full
5	Ahead Flank
6	Reverse 1/3
7	Reverse 2/3
8	Reverse Full
9	Emergency Reverse

Engine Status Indicator

The "Christmas tree," so named for the red and green lights it features, indicates which of the diesel engines are engaged in propelling the submarine or charging the batteries used to drive the electric motors. The panel contains one green light and one red light for each engine on the submarine. When a diesel engine is being used to charge batteries the red light is on, when the engine is being used to drive the submarine the corresponding green light is lit.

Voltage and Fuel Gauges

The state of battery charge is shown on the voltage gauge. When the electric motors are on line, the voltage level drops as batteries are discharged. When the batteries are being charged using the diesel engines, one or more of the red charging lights are lit and the needle climbs back to full charge. It can take several hours running on the surface to recharge batteries. Most of the submarines in SILENT HUNTER can run submerged for many hours at low speed, but running at flank speed while submerged will exhaust battery capacity quickly.

The fuel gauge shows the volume of diesel fuel remaining, with a digital counter for the number of miles available from the remaining fuel. Note: The amount of fuel carried by submarines was large enough to allow for extended missions, but was not inexhaustible. If the submarine runs out of fuel, the only margin of safety lies in the charge level on the batteries. If the submarine runs out of fuel in enemy waters, it is likely to be destroyed or captured.

Flooding Gauge

This gauge indicates the level of danger that flooding represents is in the event that the submarine takes damage which ruptures the pressure hull so that the submarine begins to take on water. The great danger of flooding is that the submarine may gain so much weight that the motors cannot lift it to the surface again.

Up Scope (or Periscope Station)

Left-clicking on the periscope shaft, or pressing F2, raises the periscope for viewing the surface, navigation, or fire control. The periscope cannot be employed at depths below 65 feet, and is automatically retracted when diving below that depth. The periscope also retracts automatically when destroyed or damaged.

Moving the pointer to the handles on either side of the periscope activates the Rotate Left or Rotate Right controls. Left-clicking when these commands are visible, turns the periscope in the appropriate direction, through 360 degrees. At the top of the screen is the Relative Bearing Indicator, which shows the bearing of any object viewed in the periscope relative to the submarine's heading.

The right handle of the periscope is also used to control the zoom factor of the periscope. When the pointer nears the right side of the periscope, it changes to the Zoom command. Left-clicking while this command is active increases the magnification through the settings 1x, 2x, 4x, and 8x. Pressing the "Z" key achieves the same result. The periscope can be lowered or raised from any station by pressing Alt-P.

When first activated, the periscope screen shows manoeuver controls to either side. These controls operate in the same manner as their counterparts at the Gauges station. The manual helm allows the submarine to be steered, the course can be set using the compass, and the submarine can be submerged or surfaced using the depth control. The Ship Identification Manual can be viewed at this station using the button at the bottom of the screen. Left-clicking on the Torpedo button or pressing the "T" key brings up the Position Keeper panel for the local TDC.

Using the Local TDC

The full TDC panel is not visible from the Periscope or the Target Bearing Transmitter (TBT) stations, but has been divided into three separate panels which appear to the right and left side of the Periscope and across the bottom of the TBT. Some components of the TDC which do not change are the Auto/Manual and Panel Selection switches and the firing buttons which are just above the right handle of the periscope and at the far right of the TBT. Pressing the “N” key restores the manoeuver controls panel.

The panel that is visible the first time that a local TDC station is seen, is the Position Keeper panel. It shows the Target Course and Relative Target Bearing dials as well as the Target Range, Target Speed and Solution indicators. The Solution dial indicates the quality of any firing solution as a percentage, from zero to one hundred percent. When a potential target is visible in the eyepiece, a red arrow will flash beneath the target indicating that the TDC is receiving information on that target. The longer a target is in view, the more accurate a firing solution the TDC will provide. Locking the target into the TDC allows the TBT or periscope to be used to view the rest of the horizon, while the TDC continues to calculate. This is done using the Mark button at the TBT station and the Spacebar at the Periscope. Leaving the TBT or periscope station resets the TDC.

Left-clicking on the panel selection knob changes to the Angle Solver panel which has the Gyro Angle Forward and Aft dials and Offset Angle dial. The Offset Angle dial is used to establish a "spread" of torpedoes by locking a course offset into each torpedo from the first torpedo fired. The Gyro Angle Forward and Aft dials are primarily indicators unless the TDC is set to manual, when they become active for setting the offset from the submarine's heading that the torpedo will need to intercept the target.

For example, if the target is dead ahead, the relative target bearing would be 0 degrees. The Relative Target Bearing dial shows an arrow pointing straight up, aligned along the centreline of the submarine.

Calculating a firing solution is a very complex process. For more information about the basic formulas of fire control, see Appendix C on page 73.

The Torpedo Depth setting dial and Torpedo Run Time dial are found on the Torpedo Data panel, as are the Torpedo Speed knob and Torpedo Type knob. The depth setting control is used to adjust the depth that torpedoes run. Different classes of ship have a different draft, and a torpedo set to hit an aircraft carrier will pass harmlessly beneath a destroyer.

There is also a Torpedo Speed knob where the speed can be changed for variable speed torpedoes. Common practice was to fire torpedoes at the highest speed available unless the target is motionless. A slow torpedo is more likely to be evaded by wary prey. The slow speed setting is useful when shooting at stationary targets at long range, such as inside a shallow harbour, where a close approach is too dangerous.

Making a Torpedo Attack

When using the TDC on automatic, the most important features to keep track of are the target's course, relative bearing, range, speed, and the firing solution quality. These are all located on the Position Keeper panel. All other factors can be left to the game's artificial intelligence (AI). The range indicator is particularly important because a torpedo only arms itself after travelling 500 yards. The ideal range for torpedo launch at a moving target is between 500 and 1000 yards. Only targets that are at anchor or damaged should be shot at from farther away than 1000 yards, particularly at higher levels of realism.

Once a target has been selected and locked into the TDC, the computer will continue to calculate a firing solution. Making a successful torpedo attack is a combination of having an accurate firing solution and being in range. While the torpedoes used in U.S. submarines had maximum ranges of between 3500 and 9000 yards, they were only used at ranges beyond 1500 yards in extreme situations.

Torpedoes can be fired by moving the mouse pointer over the illuminated number buttons, which correspond to the torpedo tubes, and left-clicking when the Fire reticule appears. When an appropriate range is reached, between 500 and 1500 yards, and the Solution dial is reading an acceptable level, preferably above 75%, fire away!

Torpedoes can also be fired by pressing the Alt key and the corresponding torpedo tube number on the keyboard, so that pressing Alt-1 fires torpedo tube one. The Alt-key combination is convenient because they can be used to fire torpedoes from any station.

The Torpedo Run Time dial found on the Torpedo Data panel can be used to monitor the time-to-target. Once torpedoes have been fired, escorts are likely to attack the position the attack came from. Good tactical doctrine suggests that keeping the periscope retracted until torpedo impact is imminent. Unlike the real world, submarines get credit for ships that sink, whether anyone witnesses it or not.

Automatic vs. Manual

The Automatic/Manual knob determines whether the TDC continuously feeds data into the torpedo gyroscopes or allows for manual correction of the gyro setting. When set on automatic, the TDC automatically calculates a firing solution for whichever ship is being viewed through the periscope or

Target Bearing Transmitter (TBT), as indicated by the flashing red arrow below the target. Left-clicking on the Mark button on the TBT (or the Space Bar when using the periscope) locks the current target into the TDC. At this point, the red arrow below the target stops flashing and the TDC continues to calculate a firing solution for that target even though it is not in view through the scope. This allows the TDC to continue improving its firing solution while the viewing device is aimed elsewhere. This simulates the continuous flow of information from periscope, radar, and hydrophones that the submariners used to locate and destroy the enemy with.

Attempting to create a manual firing solution for torpedoes requires several pieces of information about the target including the relative bearing, range, course, and the speed. Without the continuous feed of information provided by the TDC when on auto, the firing officer must make do with other sources.

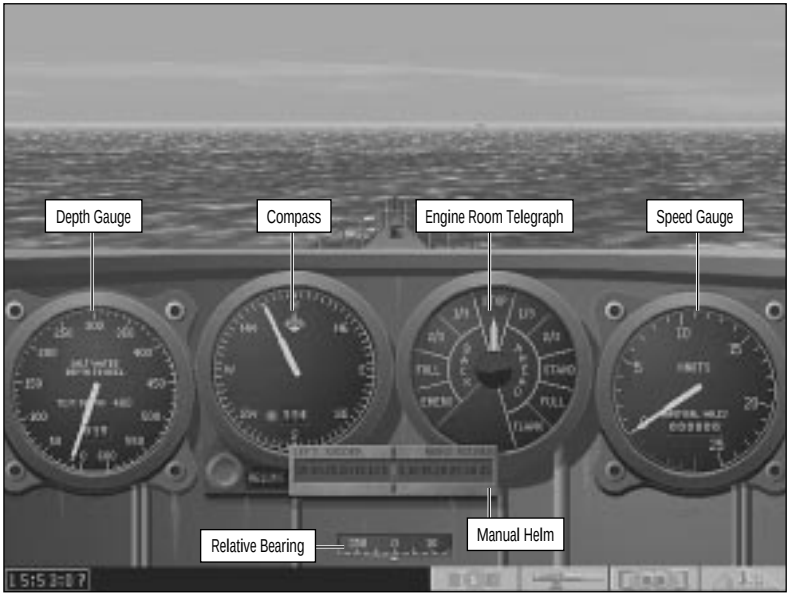
The relative bearing, or angle on the bow, can be determined using the periscope, TBT, or radar, if the submarine is equipped with it. The Officer of the Deck will also call out the approximate bearing when contact is first made. This information is programmed into the TDC using the Relative Target Bearing dial. The mouse pointer will change to a reticule and the word SET when moved over the dial. Simply left-click on the rim of the dial, each increment represents 10 degrees, until the digital readout at the bottom of the dial is close enough to the desired bearing. The bearing of targets can also be determined by the hydrophone operator when the submarine is travelling at low speed.

Determining range without the automatic setting will only be possible on submarines equipped with radar. As a commander becomes more experienced, however, making range "guesstimates" will become easier. The periscope has a set of graduated cross-hairs for that purpose. Once an estimated range is determined, move the mouse pointer over the Target Range digital counter until the pointer becomes an upward pointing arrow. Left-clicking on a particular column increments the Target Range counter.

The target's course should be entered in absolute terms; if the target is heading due south, its course would be 180 on the compass. The easiest way to calculate this is by using the Ship Identification Book. If the target ship is facing the submarine, start with a figure that is 180 degrees from the submarine's course, which can be found at any station with manoeuver controls. Alter that number to port or starboard based on the view angle as diagrammed in the Ship ID Book. If the target ship is facing away from the submarine, the base course starts similar to that of the submarine, which is then adjusted by the difference in view. Adjust the Target Course dial in the same manner that the Relative Target Bearing dial was adjusted, using the mouse pointer.

Speed is the most difficult to estimate. Once again, the Ship ID Book comes into play. The general class of ship provides a reasonable estimate for the target's maximum speed. This information can be programmed into the Target Speed counter in a similar manner to that of the Target Range. If all else fails, target course and speed can be easily determined by switching the TDC from manual to auto while the target is in view.

Once this information has been entered into the TDC, left-click on the red G button in the centre of the panel to generate a solution. When the G button is illuminated, a solution is locked into the torpedoes. The Forward and Aft Gyro Angle dials will present the gyro angle that is programmed into the torpedo. These steps may need to be repeated until the solutions seems sufficiently accurate. The Offset Angle dial is used at this point to establish a "spread" of torpedoes by locking a course offset into each torpedo from the first torpedo fired. Determining how wide a spread needs to be is a matter of experience, but at ranges between 500 and 1000 yards, the offset should be from 5 to 10 degrees in order to get a sufficient amount of spread. At that point, fire the torpedoes! A distant booming sound in the hydrophones and an entry in the submarine's log will indicate the sinking of the enemy.



Bridge

Climbing the ladder to the Bridge presents a 40-degree view of the surrounding waters. A set of manoeuver controls is here for commanding the

submarine while on the surface: the Depth Gauge, Compass, Manual Helm, Engine-Room Telegraph and Speed Gauge. For information about giving dive commands, see the "Diving Controls" section on page 24.

Compass

The course of the submarine can also be controlled using the compass. The white needle indicates current course while the red needle indicates the desired course. Left-clicking on the compass lays in a course, and the helm responds by gradually turning the ship onto that course. The manual helm should be used for radical course changes, such as evasive manoeuvers or attack manoeuvers. A previously laid-in course can be returned to by left-clicking on the Resume button or by left-clicking on the compass.

Manual Helm

The submarine can be turned to port or starboard by left-clicking on the Manual Helm, or pressing the left- or right-arrow key on the keyboard. The 0 setting indicates a straight ahead course, barring wind and current. Turns of up to 35 degrees may be made to port or starboard by left-clicking over that number on the Helm. The submarine continues to turn until the Helm is returned to the 0 setting, either by left-clicking on the 0 or by pressing the arrow key which is opposite the current direction of turn until the Helm reads 0. Pressing the "H" key establishes the current heading as the new course and returns the Manual Helm setting to 0. Pressing the "V" key restores the view to directly ahead of the submarine.

Engine-Room Telegraph and Speed Gauge

Control of the submarine's diesel engines is performed in the engine room. The commander of the submarine forwards his orders by way of the Engine-Room Telegraph. The Telegraph's settings indicate the amount of thrust the engines are set to provide, either forward or reverse. The speed of the submarine is indicated on the Speed Gauge and varies based on sea conditions, damage, and whether the submarine is running submerged or on the surface. Except at very low speeds, there is no way to come to a rapid stop. Inertia causes the submarine to continue moving until the drag of the water causes it to slow to a stop, unless reverse thrust is employed. The number strip across the top of the keyboard can also be used to control speed:

KEY	TELEGRAPH SETTING	KEY	TELEGRAPH SETTING
0	All Stop	5	Ahead Flank
1	Ahead 1/3	6	Reverse 1/3
2	Ahead 2/3	7	Reverse 2/3
3	Ahead Standard	8	Reverse Full
4	Ahead Full	9	Emergency Reverse

Moving the pointer to the far left or far right edges of the screen activates the Rotate Left or Rotate Right controls. Left-clicking when these commands are visible moves the view in the appropriate direction through 360 degrees. At the bottom of the screen, below the Manual Helm, is the Relative Bearing Indicator which shows the bearing of any object centred on the screen relative to the submarine's heading.

Two other stations besides the Control Room can be reached from the Bridge station, the Target Bearing Transmitter and the Deck Gun.

Target Bearing Transmitter (TBT)

Left-clicking on the button with the binoculars on it changes to the Target Bearing Transmitter (TBT) station. This station can also be reached from anywhere on the submarine by pressing F3. When first entered, the lower half of the TBT screen contains a set of helm controls: Depth Control, Compass, Engine Room Telegraph and Manual Helm. These controls operate exactly like their counterparts at the Periscope station and the Gauges station. The Ship Identification Manual can be viewed at this station using the button at the bottom of the screen. Left-clicking on the Torpedo button or pressing "T" brings up the Position Keeper panel for the local TDC. Pressing the "N" key restores the navigation controls.

Moving the pointer to the grips on either side of the TBT activates the Rotate Left or Rotate Right controls. Left-clicking when these commands are visible, turns the periscope in the appropriate direction, through 360 degrees. Above the eyepiece of the TBT is the Relative Bearing Indicator, which shows the bearing of any object viewed in the TBT relative to the submarine's heading. The Zoom can be increased by left-clicking on the lever to the upper-right of the zoom level readout on the right side of the TBT. On the top of the left handle is the Mark button which is used to lock targets into the TDC.

Other than the placement of dials on the three TDC panels, the use of the TDC from the TBT station is exactly the same as from the periscope. For more information about using the local TDC, see the "Using the Local TDC" section on page 29.

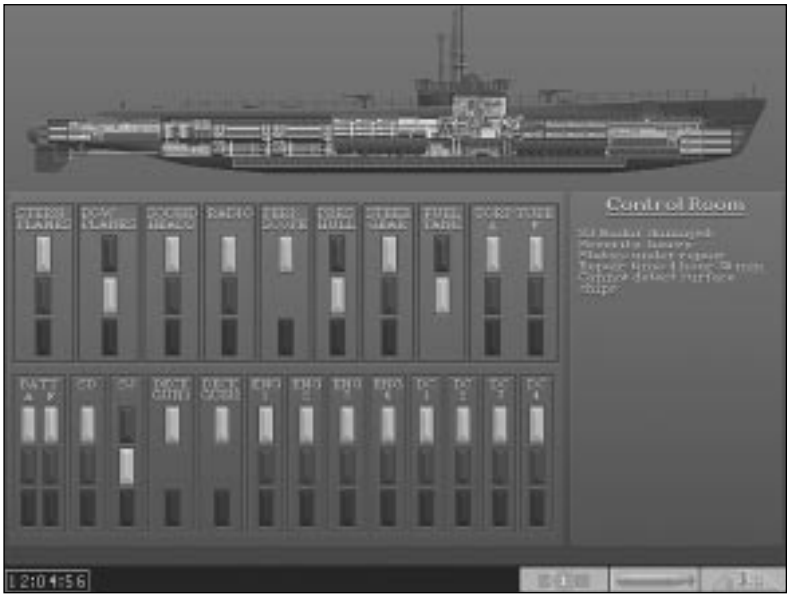
Deck Gun

Left-click on the Deck Gun button while on the Bridge to bring up the firing controls of the deck gun. Pressing Alt-F4 from any location while surfaced will also man the Deck Gun. Historically, deck guns were mainly used to finish off damaged ships rather than expend torpedoes. The odds of a submarine winning a surface battle with a patrol boat or destroyer are very small. Some classes of submarine carried two deck guns, such as the Tench class and the Narwhal class. On these submarines, there is an additional Deck Gun button with the letter 'F' for forward and 'A' for aft.

The knob on the right side of the sighting scope raises and lowers the gun, and the smaller knob on the left side of the sighting scope increases the zoom from 1x to 2x, 4x, and 8x then back to 1x. Moving the pointer to the handles on either side of the gun mount activates the Rotate Left or Rotate Right controls. Left-clicking when these commands are visible turns the gun mount in the appropriate direction, through 350 degrees. Note: the deck gun cannot be trained on anything directly in front of the submarine since that would force it to shoot through the conning tower. The same applies to two mount submarines for the forward gun.

At the top of the screen is the Relative Bearing Indicator, which shows the bearing of any object viewed in the sighting scope relative to the submarine's heading. Below the sighting scope is the control panel for the deck gun. The large black button on the left side of the panel fires the gun. The knob above the target range display toggles control of the gun between automatic and manual as does pressing Alt -G. When set on automatic, the deck gun will fire at the nearest target until the gun is taken off of automatic, the submarine submerges, all the ammunition is used up, the quality of aim drops below 80%, or the gun is damaged.

The closer to the target, the more effective the deck gun can be. A red triangle will appear in the sighting scope when the target has been acquired, and the solution dial shows the increasing solution quality. The solution dial indicates how accurate the firing solution is for the deck gun. Speed, weather, and crew quality all effect how accurate gunnery fire is. Press the fire button to fire the gun when the target is centred in the cross-hairs of the sighting scope. The ready light indicates the wait while the gun is reloaded and the shells counter shows the amount of ammunition remaining.

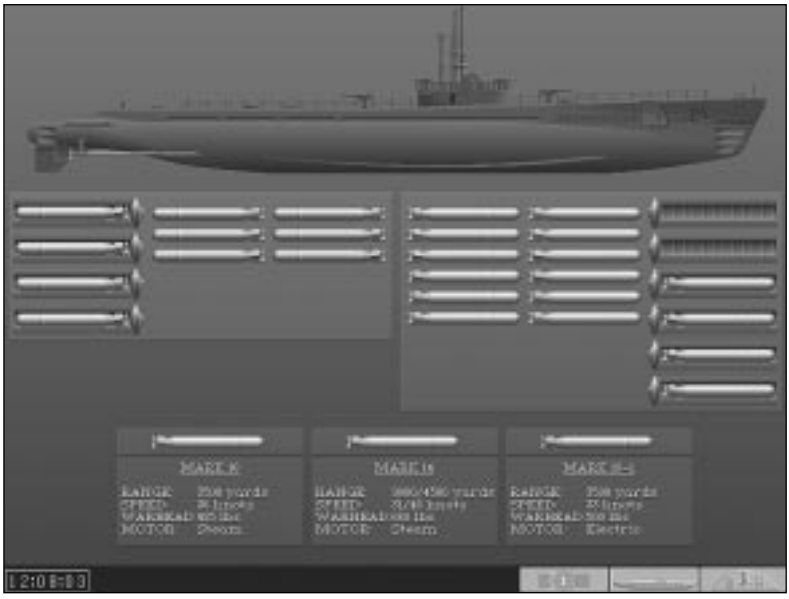


Status and Torpedo Room Stations

Pressing F8 from any station, or moving the pointer until it changes to the word Status while in the control room, shows the Damage Control and Status station. The cut-away view of the submarine at the top of the screen contains important areas of the submarine outlined in dark red. Damaged areas are outlined in a brighter colour red and may show some animation, for example, flooding. When the cursor is over an area for which a damage report is available, it changes from an arrow to a cross-hair. Left-clicking causes the status of that area to be shown on the Damage Control Report panel.

Below the cut-away are the display panels which show the status of important ship systems. Each system has "Christmas tree" lights which allow a quick status check of systems such as the torpedo tubes and specific engines.

If the submarine suffers damage, the Damage Control Report panel lists important information about the damage. The location of the damage, the severity of the damage, the repair status and time if repairs are possible, and any effects the damage may be having on submarine operations.

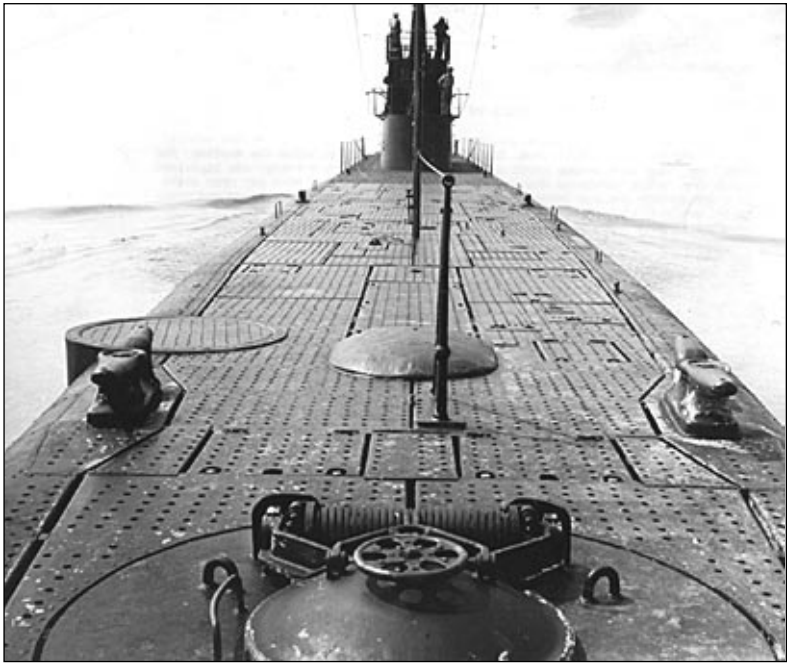


Torpedo Room

There were three types of torpedoes available during the course of the war, but not all submarines could carry all three types. Most of the submarines built before the war, including the S-, Barracuda, and Narwhal classes, were equipped to carry only the older Mark 10 torpedo. The later "fleet" submarines, including the P-, Salmon, T-, Gato, Balao, and Tench classes were equipped to carry the longer Mark 14 torpedoes. They could also accommodate the Mark 10 and the Mark 18 electric torpedo when it became available in 1944.

Left-clicking on the torpedo button on the Status Station screen shows the contents of the forward and aft torpedo rooms. The submarines in SILENT HUNTER carry between twelve and twenty-eight torpedoes including those loaded in the tubes. Once one or more torpedoes have been fired, the reload process is automatic and is affected by the Realism setting chosen, the crew quality level chosen, and any damage the submarine has sustained. Once the reloading process is under way, the time remaining until a tube is reloaded can be determined by left-clicking over that tube.

Note: Torpedoes from the forward torpedo room cannot be moved aft except while in port.



SUBMARINES

The submarines that were used in the desperate battles above and below the waves of the Pacific included some which were the epitome of modern technology and design. Others that saw duty were older, slower, more cramped but contained crews whose bravery and dedication could not have been overmatched by mere technology. Despite the brutal lessons taught during World War I by the Kaiser's U-boat wolfpacks, the development of submarine technology held a position of secondary importance to that of the battleship, aircraft carrier and cruiser. Changes were in progress at the war's beginning, but both the Pacific command, SubPac, and the Asiatic fleet, still had antiquated S-class submarines.

® *S-Class*

Displacement (in tons): . . . . 903 when surfaced; 1230 when submerged
Dimensions (in feet): . . . . . 265 x 21 x 13
Machinery: . . . . . 2 diesel engines; 2 electric motors
Max. Power (in hp): . . . . . 1800 surfaced; 1500 submerged
Max. Speed (in knots): . . . . . 14.5 surfaced, 11 submerged
Test Depth (in feet): 200
Range (in miles): . . . . . 8000 at 10 knots surfaced
Torpedo Tubes: . . . . . 4 forward; 1 aft; 12 torpedoes
Guns: . . . . . 1 – 4 inch

The oldest U.S. submarines to see combat in World War II were the S-class, some of which had been launched as early as 1918. Six "sugar boats" were stationed at Manila with the Asiatic Fleet and six with the Pacific Fleet at Pearl Harbour. These submarines accounted for fourteen Japanese ships including the destroyer *Natsushio* sunk by *S-37* in February 1942 and the cruiser *Kako* sunk by *S-44* in August 1942.

Designed and built during the first World War, S-class submarines were designed for a defensive role, to interdict other submarines along the Atlantic coastline. When compared with the later fleet-type submarines, they were more cramped, smaller, and had a shorter range. They featured double hull construction with the ballast tanks on the outside of the pressure hull. The hulls were rivetted together, as were most ships constructed prior to the war. Underwater speed was deemed an important feature at the time of their design, to enable the submarine to evade escorts. Speed was sacrificed later for more dependable surface performance and safety features such as an enclosed bridge.

® *Barracuda*

Displacement (in tons): . . . . 2000 when surfaced; 2620 when submerged
Dimensions (in feet): . . . . . 341 x 27 x 14
Machinery: . . . . . 2 diesel engines; 2 electric motors
Max. Power (in hp): . . . . . 6700 surfaced; 2400 submerged
Max. Speed (in knots): . . . . . 18 surfaced, 8 submerged
Test Depth (in feet): 200
Range (in miles): . . . . . 12000 at 11 knots surfaced
Torpedo Tubes: . . . . . 4 forward; 2 aft; 12 torpedoes
Guns: . . . . . 1 – 5 inch

The Barracuda class were an early attempt at what would later be called the fleet-class submarine. They were not as fast as the S-class when submerged, but were larger and capable of longer patrols. None of the B-class submarines, *Barracuda*, *Bass*, or *Bonita* saw service during the war, except as training vessels.

® *Narwhal*

Displacement (in tons): . . . . 2915 when surfaced; 4050 when submerged
Dimensions (in feet): . . . . . 371 x 33 x 15
Machinery: . . . . . 1 diesel engines; 2 electric motors
Max. Power (in hp): . . . . . 6000 surfaced; 2450 submerged
Max. Speed (in knots): . . . . . 17 surfaced, 8 submerged
Test Depth (in feet): 328
Range (in miles): . . . . . 18000 at 8 knots surfaced
Torpedo Tubes: . . . . . 4 forward; 2 aft; 26 torpedoes
Guns: . . . . . 2 – 6 inch

The *Narwhal* and *Nautilus* were submarine cruisers, large enough to accommodate two 6-inch deck guns and capable of higher surface speeds than the older S-class. They were derived from an earlier mine-laying design, the *Argonaut*. In practice, the greater size needed to accommodate the second deck gun made the submarine easier to detect and did not make up for poor handling characteristics. The original diesel engines never delivered horsepower adequate to the task of manoeuvering such a large vessel and were replaced in 1940. Both submarines were used to deliver supplies to guerrillas, transport commandos and coast watchers. Between them, they managed to sink eleven Japanese ships including the destroyer *Yamakaze*.

® *P-Class*

Displacement (in tons): . . . . 1330 when surfaced; 2005 when submerged
Dimensions (in feet): . . . . . 300 x 25 x 13
Machinery: . . . . . 2 diesel engines; 2 electric motors
Max. Power (in hp): . . . . . 4300 surfaced; 2336 submerged
Max. Speed (in knots): . . . . . 19 surfaced, 8 submerged
Test Depth (in feet): 250
Range (in miles): . . . . . 10000 at 10 knots surfaced
Torpedo Tubes: . . . . . 4 forward; 2 aft; 16 torpedoes
Guns: . . . . . 1 – 4 inch

P-class submarines, represented by the *Pike*, *Pickerel*, and *Permit*, were the earliest pre-cursor to the Gato class. They were innovative in that they were welded rather than rivetted, had air-conditioning, and used diesel engines to drive generators which powered electric motors. This allowed the submarine to cruise on the surface with one engine while using the other to charge the batteries used during submerged operation.

Welded construction permitted the submarines to dive deeper and withstand attacks from depth charges better. Most of the subs in this class were divided into nine watertight compartments. A few had additional external torpedo tubes added fore and aft to increase their firepower.

® *Salmon*

Displacement (in tons): .... 1449 when surfaced; 2198 when submerged
Dimensions (in feet): ..... 310 x 27 x 14
Machinery: ..... 2 diesel engines; 2 electric motors
Max. Power (in hp): ..... 5500 surfaced; 3300 submerged
Max. Speed (in knots): ..... 20 surfaced, 9 submerged
Test Depth (in feet): 256
Range (in miles): ..... 10000 at 10 knots surfaced
85 at 5 knots submerged
Torpedo Tubes: ..... 4 forward; 4 aft; 20 torpedoes
Guns: ..... 1 – 4 inch

The Salmon class consisted of six submarines which were nearly identical to the ten submarines of the Sargo class. Both types had been increased in length by ten feet and had their battery capacity substantially increased for a submerged cruising range of 80 miles or more. Two additional rear-firing tubes brought the total up to eight, and the overall torpedo capacity was increased to 20.

The vessels of these classes had one dangerous problem early in their history in the form of a faulty hatch covering the main diesel induction. This caused the loss of *Squalus* and twenty-three crew members in 1939, and both *Snapper* and *Sturgeon* experienced similar, though not fatal, failures of the induction hatch during the war.

® *T-Class*

Displacement (in tons): . . . . 1475 when surfaced; 2370 when submerged
Dimensions (in feet): . . . . . 307 x 27 x 14
Machinery: . . . . . 2 diesel engines; 2 electric motors
Max. Power (in hp): . . . . . 5400 surfaced; 2740 submerged
Max. Speed (in knots): . . . . . 20 surfaced, 8.75 submerged
Test Depth (in feet): 200
Range (in miles): . . . . . 8000 at 10 knots surfaced
60 at 5 knots submerged
Torpedo Tubes: . . . . . 6 forward; 4 aft; 24 torpedoes
Guns: . . . . . 1 – 5 inch

An increase in displacement of fifteen tons added two torpedoes in front and increased the total number of torpedoes carried to 24. The vessels in the T-class had the distinction of being the last peace-time submarines commissioned, and were thus forced to carry the load for the Navy during the opening months of the war until the Gato class submarines arrived later in 1942. The crew complement was 60.

The highest scoring submarine of the Pacific campaign in number of vessels sunk was the *Tautog*, a T-class submarine, with 26 confirmed sinkings.

® *Gato*

Displacement (in tons): . . . . 1825 when surfaced; 2410 when submerged
Dimensions (in feet): . . . . . 312 x 27 x 15
Machinery: . . . . . 4 diesel engines; 4 electric motors
Max. Power (in hp): . . . . . 5400 surfaced; 2740 submerged
Max. Speed (in knots): . . . . . 20.75 surfaced, 8.75 submerged
Test Depth (in feet): 300
Range (in miles): . . . . . 11800 at 10 knots surfaced
95 at 5 knots submerged
Torpedo Tubes: . . . . . 6 forward; 4 aft; 24 torpedoes
Guns: . . . . . 1 – 4 inch

The Gato, Balao (pronounced ba-ley'-o), and Tench classes were virtually identical and formed the backbone of the U.S. submarine force from late 1942 through the end of the war. The fundamental "fleet" submarine, they were all of welded construction and capable of operating at greater depths than their predecessors— they had crush depths of up to 750 feet which allowed operation at depths of between 300 and 400 feet. The displacement of these fleet class submarines was increased again to more than 1800 tons to accommodate even more batteries and improved diesel engines. The crew complement for a war patrol was 80 officers and crewmen.

One hundred and eighty five submarines of these three classes saw war service; 73 Gato, 101 Balao, and 11 Tench. Of the twenty highest scoring submarines in both tonnage and number of ships sunk, two thirds were either Gato or Balao class. The top three submarines in terms of tonnage sunk were all Gato class, the *Flasher*, the *Rasher* and the *Barb* with nearly 300,000 tons sunk between them. The *Skate*, which was commanded by Bud Gruner was a Balao class.

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® *Balao*

Displacement (in tons): . . . . 1826 when surfaced; 2391 when submerged
Dimensions (in feet): . . . . . 312 x 27 x 15
Machinery: . . . . . 4 diesel engines; 4 electric motors
Max. Power (in hp): . . . . . 5400 surfaced; 2740 submerged
Max. Speed (in knots): . . . . . 20.75 surfaced, 8.75 submerged
Test Depth (in feet): 400
Range (in miles): . . . . . 11800 at 10 knots surfaced
95 at 5 knots submerged
Torpedo Tubes: . . . . . 6 forward; 4 aft; 24 torpedoes
Guns: . . . . . 1 – 5 inch

See Gato, page 47.

® *Tench*

Displacement (in tons): . . . . 1860 when surfaced; 2428 when submerged
Dimensions (in feet): . . . . . 312 x 27 x 15
Machinery: . . . . . 4 diesel engines; 4 electric motors
Max. Power (in hp): . . . . . 5400 surfaced; 2740 submerged
Max. Speed (in knots): . . . . . 20.75 surfaced, 8.75 submerged
Test Depth (in feet): 400
Range (in miles): . . . . . 12000 at 10 knots surfaced
95 at 5 knots submerged
Torpedo Tubes: . . . . . 6 forward; 4 aft; 28 torpedoes
Guns: . . . . . 2 – 5 inch

See Gato, page 47.

SILENT HUNTER WEAPONS DATA

U.S. Torpedoes

MODEL	ENGINE	MAX. SPEED	MAX. RANGE	WARHEAD WT.	DATE
Mk 10	Turbine	36 Kts	13,500 yds	385 Lb.	1917-1943
Mk 14	Turbine	46 Kts	9,000 yds	507 Lb.	1939-1945
Mk 18-1	Electric	27 Kts	4,000 yds	500 Lb.	Oct. 1943
Mk 18-2	Electric	40 Kts	4,000 yds	500 Lb.	Aug. 1944

Radar and Bathythermograph

NAME	USE	RANGE	AVAILABLE
SD	Air	6-10 miles	Jan. 1942
SJ	Surface		Aug. 1942
Imp. SJ	Surface		Dec. 1942
A-Scope	Surface		Dec. 1941
PPI	Surface		Sept. 1943
APR-1 Radar Detector	Surface		May 1944
Bathythermograph	Submerged Thermal Layers		Mar. 1943

Deck Guns/AA Guns

TYPE	USE	AVAILABLE	
.50 Cal. MG	AA	1938	Some subs also had 2 or 3 .30 Cal. MG's as well
20mm	AA	11/42	
40mm	AA	4/44	Note: By late 1944 most subs mounted both 20mm & 40mm AA guns.
3in/50 Gun	Surface	1938	
5in/25 Gun	Surface	8/44	Smaller version of the 5in/51, some subs mounted 2 of these guns by 1945.
5in/51	Surface	7/42	Standard 5in gun for most sub classes.

TORPEDOES

Shortages

Many problems faced by the Pacific submariners had nothing to do with tropical storms, the sweltering heat of tropical waters, or the actions of hostile escorts and aircraft. Frequently, torpedoes were seen to explode near or heard to hit targets, but later investigation indicated that they had exploded prematurely or been duds. Shortages of torpedoes in the early months of the war meant that submarine commanders had to carefully hoard their torpedoes, and could not always fire on targets of opportunity.

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The primary torpedo storage facility at Pearl Harbour endured the bombing on 7 December 1941 largely unscathed. Unfortunately, 233 torpedoes were destroyed by the 10 December bombing of Cavite Navy Yard in the Philippines. Torpedo production at the war's start was roughly 60 per month from the torpedo manufacturing facilities at Newport, Rhode Island and Alexandria, Virginia and reserves were only in the hundreds. Transportation difficulties continued to make supply a problem even after production had overcome expenditure by early 1943.

Torpedo Types

Three primary types of torpedoes were carried by U.S. submarines: the Mark 10, the Mark 14, and the Mark 18. Both the Mark 10 and Mark 14 were steam powered, 21 inches in diameter and used T.N.T. at the war's beginning, but were converted to torpex by war's end. The Mark 10 was the standard torpedo on the earlier S-boats, while the Mark 14 was used on the later fleet submarines, which were designed to accommodate its length.

At the war's start, the Mark 10 had been in service on the older S-boats for a decade. The warhead of the Mark 10 carried 497 pounds of T.N.T. in 1941; later it was converted to carry 485 pounds of torpex. Fitted with the Mark 3 contact detonator, the Mark 10 had a range of 3500 yards at a speed of 36 knots.

The Mark 14 was the latest in U.S. torpedo technology in 1941. While still 21 inches in diameter, it had been designed to be superior in almost every way. The Mark 14's normal range had been increased to 4500 yards at a speed of 46 knots, but was also capable of a greater range of 9000 yards at a lower speed setting of 31.5 knots (although in practice this was rarely used). The warhead held 507 pounds of T.N.T. when first issued, but was later improved to carry a 668-pound torpex payload. The crucial difference between the Mark 14 and its predecessor was the Mark 6 detonator.

Between the World Wars, the Mark 6 detonator was developed to take advantage of the magnetic field that ships created in the water around them. Besides a contact detonator similar to that used in the Mark 3, the Mark 6 used a magnetic detonator. Designed to explode the warhead as the torpedo passed through the target's magnetic field, the magnetic detonator effectively increased the target area. Conventional wisdom of the pre-war era held that an explosion under the keel of the ship caused more damage because of the presence of armour plating at the waterline and internal compartmentalisation. In theory, the Mark 14 would be a difficult weapon to evade.

History proved differently. For the sake of secrecy and economy, test firings by submarines used a dummy warhead or were set to pass beneath the target vessel. This was to avoid damaging the ship or torpedo and accustom

the crew to relying on the magnetic detonator. This methodology disguised several very serious flaws in the Mark 14 torpedo and the Mark 6 detonator that were only revealed as each prior problem was solved. A 1943 Bureau of Ships report on the circumstances of shipping sunk by U-boats also disproved the keel damage theory. The report indicated that most damaged ships that sank foundered from loss of stability rather than actual flooding.

Problems Arise

Submarines went to sea in 1941 and 1942 with a largely untried weapon, and began reporting premature detonations and a number of missed shots. At first, these problems were explained by the Bureau of Ordinance as "human error." The newly promoted Rear Admiral, Charles Lockwood made a priority of getting to the bottom of the matter. After a number of reports of missed shots, Admiral Lockwood had the submarines *Skipjack* and *Saury* test fire Mark 14 torpedoes set for a depth of 10 feet at a net strung 850 yards away. The first test, made by *Skipjack* on June 20, 1942 showed that torpedoes set for 10 feet were punching through the net at depths between 18 and 25 feet. Torpedoes set for zero depth ran down to 11 feet too deep.

These first tests were rejected by the Bureau of Ordinance, so a second set of test shots were made by *Saury* on July 18. The results were the same. Both Mark 10 and Mark 14 torpedoes would actually run as much as 10 feet deeper than they were set. For the Mark 10 this was a serious problem, since it actually needed to contact the enemy vessel to detonate. Theoretically, this was less of a problem for the Mark 14, since the magnetic detonator should still cause an explosion when it entered the target's magnetic field. In practice this was not the case.

Detonator mechanisms were deactivated at the point of firing to prevent them from exploding early while the torpedo "found its bearings." The torpedo travelled for approximately 450 yards after firing before the safeties released and allowed the detonator, which was itself a small bomb, into contact with the normally inert explosive in the warhead. At this point, several mechanisms became active. Since a spread of torpedoes were fired sequentially, they were equipped with a device to prevent the explosion of one torpedo from triggering premature explosions in those nearby. This anti-counter-mining device actually locked the magnetic exploder on some deep-running torpedoes, preventing detonation.

Once the depth-setting problem was corrected, the next fault to appear was the tendency to detonate prematurely. In this case, it was the magnetic detonator that was found to be largely at fault. If the torpedo were running shallow, it would encounter the ship's magnetic field far enough away from

the target to cause a premature explosion. Several commanders also reported that torpedoes detonated shortly after arming. In July, 1943 Admiral Nimitz, Commander in Chief, Pacific (CinCPac) ordered that all submarines and destroyers under his command disable the magnetic component of the Mark 6 detonator. Other commands slowly followed suit, and by March of 1944, all of the Mark 14 torpedoes were set for contact detonation only.

On 24 July 1943 the Gato class submarine *Tinosa*, skippered by Lieutenant Commander L.R. Daspit had sixteen Mark 14 torpedoes aboard, when it found the 19,200 ton tanker *Tonan Maru No. 3.* Forced to make a long range shot at an oblique angle, the *Tinosa* nevertheless rendered the tanker immobile with four torpedo hits. Unable to surface because of the *Tonan Maru's* deck guns, the *Tinosa* lined up a perfect 90 degree shot at an optimal range of 875 yards. The first torpedo ran true, but failed to explode, as did a second. After careful checks and aiming, *Tinosa* fired two more — neither exploded. Lt. Commander Daspit fired seven of his remaining eight torpedoes at the helpless tanker, all of which struck home but failed to detonate.

After Lieutenant Commander Daspit's incredible report, Admiral Lockwood ordered tests performed at Pearl Harbour. These tests confirmed that the contact exploder's firing pin would release, but friction on guide pins within the mechanism would prevent the firing pin from striking the primer hard enough to go off. A simple correction was rapidly devised, and Mark 14 torpedoes went into service that could be expected to run at the depth set, not explode prematurely, but detonate on what they hit.

Perhaps the most peculiar thing about the various problems suffered by the U.S. Navy with the Mark 14 torpedo and the Mark 6 detonator is that the German Kriegsmarine had experienced a nearly identical series of problems. Problems with depth keeping, the magnetic detonator, and the contact detonator had plagued German U-boat commanders from 1939 well into 1942.

The New Hope

The Mark 18 electric torpedo was developed after examining a German torpedo captured in early 1942. The primary advantage of the electric torpedo was the lack of a visible wake. Steam torpedoes left a trail of bubbles behind them that could be seen by a sharp-eyed lookout in time for some vessels to take evasive manoeuvers. Initial testing of the Mark 18 revealed that it had superior depth control and didn't suffer from the steam torpedoes' tendency to dive after firing. The main deficiency of the new electric torpedo was its slower speed, between 28 and 30 knots. Some initial problems with the electric torpedo were hydrogen gas leaks from the batteries, slow running in cold waters, and erratic running caused by defective tail vanes.

These problems were quickly tracked and solved by the torpedo shop at Pearl Harbour under Commander M.P. Hottel. By the end of 1944, over 60% of the torpedoes fired were the "wakeless" Mark 18 electric torpedoes.

THE COMMANDERS

The men who successfully fought the war beneath the waves were a different breed than their peacetime counterparts. More than one submarine commander found himself relieved of command for being too cautious in their prosecution of the war. They were charged with taking the war to the enemy's doorstep using untested tactics and unpredictable weapons. These men saw themselves as an elite force and proved that fact again and again.

Vice Admiral Charles Lockwood

If any one man made a difference in the submarine war it was Charles Lockwood. The man who would rise to the post of Vice Admiral in command of the Pacific Submarine Fleet (ComSubPac) graduated from the Naval Academy and went into submarines. He commanded the submarines *A-2* and *B-1* between 1914 and 1918, *G-1*, *N-5*, and *R-25* in 1920. He also served as an assistant naval attaché in Tokyo then went on to command the *V-3*, otherwise known as the *Bonita*. Lockwood also instructed at the Academy and commanded Submarine Division 13 based out of San Diego. In 1941, Lockwood served as naval attaché in London.

Lockwood reported to Freemantle Australia as Rear Admiral commanding Division 51 and the South West Pacific Submarine Fleet (ComSubSoWesPac). His work was cut out for him, as the Japanese increased the dimensions of the "Greater Co-prosperity Sphere" through the Solomon Islands towards Australia. Admiral Lockwood proceeded to streamline the procedures for maintenance and supply of the submarines under his command. He also attended to reports from experienced submarine commanders of problems with the Mark 14 torpedo.

In December of 1942 Lockwood was promoted to Vice Admiral and placed in command of the Pacific Submarine Fleet (ComSubPac) when the plane carrying Admiral Robert English crashed outside of San Francisco killing all aboard. Lockwood's first accomplishment was to unravel the bizarre sequence of problems with the Mark 14 torpedo and Mark 6 detonator. Admiral Lockwood was also instrumental in the development and introduction of a larger calibre deck gun, the Mark 18 electric torpedo, the Mark 27 acoustical torpedo, and improved low-light periscopes.

Dudley W. "Mush" Morton and the *Wahoo*

The first submarine Mush Morton commanded was almost the last. Assigned to the *Dolphin* in 1942, he found the submarine to be in terrible condition and resolved not to sail her. This almost cost him his posting in submarines, but for the intervention of squadron commander John H. Brown.

Given the *Wahoo*, another submarine whose reputation was less than sterling, Morton proceeded to turn the crew into a devastating fighting machine. He let it be known in no uncertain terms that no foolish risks would be taken, but that the *Wahoo's* job was to attack Japanese shipping. This they did with a fervour that had not yet been seen in the Silent Service.

On their first war patrol, the *Wahoo* penetrated the harbour at Wewak, New Guinea to reconnoiter. Nine miles into the shallow waters of the harbour, Richard O'Kane, the submarine's executive officer, saw an anchored destroyer through the periscope. While the crew was preparing a firing solution, the destroyer got under weigh. When the periscope was raised, the destroyer was attempting to leave the harbour. Three torpedoes were fired, all of which missed but they attracted the destroyer's attention to the *Wahoo*. As the warship charged the submarine, the remaining three torpedoes were fired at her one by one. The last one struck home as the submarine headed for the bottom, expecting to be depth-charged.

The rest of that first patrol continued in the same manner. On the way to their assigned patrol area, Morton's *Wahoo* encountered a four ship convoy. Two freighters, a troop transport and a tanker went down before the *Wahoo's* torpedoes. Morton returned to Pearl Harbour with a broom attached to the periscope shear, signifying a "clean sweep," — every target fired at had been sunk.

The *Wahoo's* next war patrol was equally productive, with nine enemy ships sunk. Lieutenant O'Kane and Lieutenant George Grider were reassigned to their own submarines, while the *Wahoo* went on. In October 1943, after sinking 19 ships, the *Wahoo* was lost off the coast of Honshu, Japan.

Lawson P. "Red" Ramage and the *Parche*

The biggest advantage that U.S. submarines had was their ability to track Japanese convoys on the surface from beyond the spotting distance of Japanese escort ships. The submarines would then close under cover of darkness, or pass on a parallel course, and attack. One such instance led to the attack on a Japanese convoy by the *Steelhead* and the *Parche* under the command of Lawson P. "Red" Ramage. The two submarines had been on patrol for two weeks with nothing to show for it. On July 30, 1943 however, that changed when they picked up a convoy with heavy air cover. The convoy was pursued and an attack was planned for early the next morning

when the air craft would be absent.

At 0300 hours on July 31st, the *Steelhead* lead off by torpedoing a tanker and a freighter. While attention was directed toward the *Steelhead*, Ramage sailed the *Parche* around the escorts and into the midst of the convoy, who, unaware of her presence had steered toward her. Evading a near collision with a freighter, Ramage fired two forward tubes which missed followed by a shot from the aft tubes which damaged the ship. Meanwhile, two tankers loomed out of the darkness. Ramage fired four torpedoes at the first ship, and then, after some quick reloading, three more at the second. One ship went down and the other remained, burning on the surface.

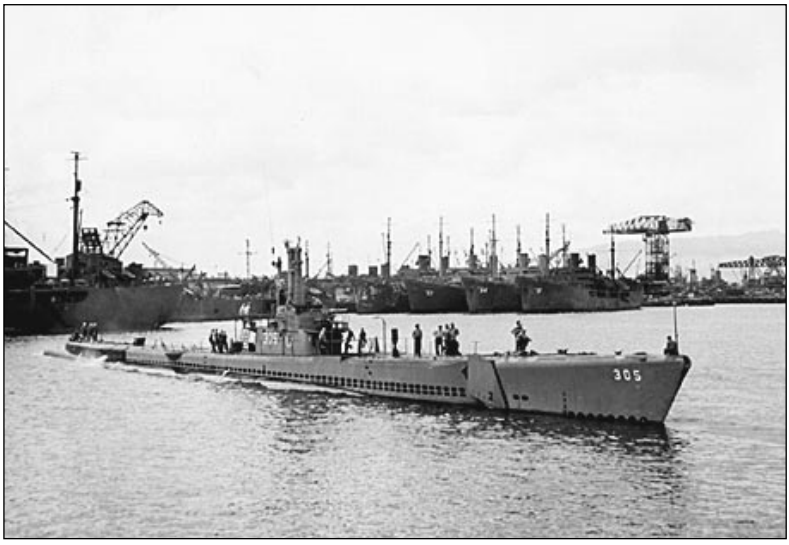
Pursued by escorts and taking fire from all quarters, Ramage remained on the surface and fired five other torpedoes at targets illuminated by burning ships. *Parche* found her way being blocked by a cargo ship. Three torpedoes from the forward tubes resulted in two hits near the bow. As Ramage sailed past, a final shot from the aft tubes tore into the stern of the motionless ship. As the *Parche* cruised off into the night, the merchant's bow dove beneath the surface. Ramage was the first living submariner to receive the Medal of Honour.

Richard H. O'Kane and the *Tang*

Transferred from the *Wahoo*, Dick O'Kane was given command of the *Tang*. A new *Balao* class submarine, the *Tang* would rise to fame as one of the highest scoring submarines for the number of ships sunk: 24.

One of *Tang's* first missions was lifeguard duty off of Truk island in April 1944. While U.S. bombers pounded the island, O'Kane's crew picked up 22 aviators in groups of one and two, daring near approaches to the shore on one occasion. *Tang's* deck gun got plenty of use that day suppressing fire from nearby Japanese positions, and sadly, being used to destroy a damaged Kingfisher float plane that had been assisting in rescue duty.

The *Tang's* finest hour was also her downfall. On her fifth patrol in the Formosa Straits in October 1944, O'Kane encountered a convoy of tankers and freighters. Seven ships were sunk including two that collided while both tried to ram the *Tang*. O'Kane had fired all but two of his torpedoes. Stern tubes loaded, O'Kane was attempting to put away a transport damaged earlier, when disaster struck. One of the torpedoes went off course and swung in a great circle to strike the *Tang* in the aft torpedo room. O'Kane and the others on the bridge were thrown clear. Thirteen of the crew escaped the *Tang* when she settled on the bottom at 180 feet, but only five of those made it to the surface alive. O'Kane and his eight surviving crewmen were picked up by a patrol boat the next morning. All nine men survived the war and O'Kane was awarded the Medal of Honour.



APPENDIX A: U.S.S. *SKATE* AND THE FIFTH FLEET

by William P. Gruner

The year was 1943 and U. S. fortunes of war were improving. On September 5th, the new fleet submarine U.S.S. *Skate* (SS305) arrived in Pearl Harbour for training, deperming and a sound survey to make her less detectable by Japanese MAD and sonar gear. She had been built at Navy Yard Mare Island, California, and placed in commission on April 15 under the command of Commander Eugene B. McKinney. McKinney was a veteran submarine skipper. He had commanded the fleet submarine *Salmon* for five war patrols in the South China Sea. In *Salmon* he had skirmished inconclusively with two Japanese destroyers and sent a large repair ship, a passenger-cargo ship and a converted salvage vessel to the bottom.

The new arrival found that the Pacific Fleet had undergone many changes since the Japanese attack on December 7,1941. Early in the morning of that day, over 350 fighters, bombers and torpedo planes from six Japanese carriers had done their jobs and departed. Rendered hors de combat were eight of the nine battleships of the Pacific fleet. Added to this loss were most of the military aircraft on the island. Fortunately, our three Pacific Fleet carriers were not in port that day. *Lexington* and *Enterprise* were at sea and *Saratoga* was at San Diego for repairs.

Two days later Japanese land-based aircraft sent HMS *Prince of Wales* and *Repulse* to the bottom off the coast of Malaya, 6,000 miles away. Suddenly, both military and armchair strategists throughout the world were convinced that even large well armed surface ships were vulnerable to air attacks launched from hundreds of miles away. Until the attack on Pearl Harbour, the keystone of U.S. naval strategy

for over 100 years had been based on "control of the seas," and in the early twentieth century it was the job of our battleships to exercise that control. Now, the time had come for a drastic revision of U.S. naval strategy. The new strategy was patterned after that first employed by Admiral Isoruku Yamamoto, CinC of the Japanese Combined Fleet. Almost a year before the attack, Yamamoto had ordered his staff to develop plans for a carrier air strike on Pearl Harbour. His instructions were clear. The operation was to depart from the generally accepted doctrine of employing carriers as a protective force for battleships and instead use them as an offensive air weapon.[1] With no battleships to form a new battle line, our naval command now had to look to aircraft carriers to carry the war to the enemy.

The attack on Pearl Harbour had other important effects. President Roosevelt had quickly appointed Admiral Ernest J. King to the post of Commander-in-Chief, U.S. Fleet, with headquarters in Washington. In turn, Vice Admiral Chester W. Nimitz became Commander-in-Chief of the Pacific Fleet. Significantly, both King and Nimitz were ex-submarine officers with an appreciation of how submarines could best be used. Prior to the attack, our submarines had been attached to the Scouting Force, Pacific Fleet to be deployed as advanced scouts for the battle force. Now, without a battle force to scout for, and without the speed to keep up with a fast carrier task force, the Submarine Force, Pacific Fleet, was formed. Its commander, Rear Admiral Charles A. Lockwood, Jr. reported directly to Commander, Pacific Fleet. Fortuitously, the long range, long endurance, speed, and large torpedo load design requirements for the scouting mission were nearly ideal for new submarine missions in the vast Pacific. Actions had been rapidly implemented after Pearl Harbour to rebuild the Pacific Fleet. By mid 1942 repairs had been made to most of the damaged and sunken ships. In addition, new ships, planes and men began to join the fleet at an accelerating pace. Of particular importance to Pacific Fleet power was the addition of both large fleet carriers and smaller carriers converted from other hulls. By mid 1943 war production held promise of being able to provide sufficient resources to continue the offensive already underway in the South Pacific, and to open a new offensive in the Central Pacific. Toward that end, CinCPac staff was busy creating plans to dislodge the Japanese from their mid-Pacific island outposts. By being at the right spot at the right time, *Skate* had the opportunity to conduct her first three war patrols concurrently with Fifth Fleet attacks on Japanese held island groups from Wake to Truk.

It had so happened in the late summer of 1943 that Rear Admiral Charles A. Pownall, Commander Carrier Task Force Fifteen, had requested ComSubPac to assign submarines to patrol off the Japanese held islands of Wake, Marcus and the Gilberts during planned air strikes. They would be used to search for and rescue U.S. airmen forced or shot down at sea, and to provide navigational information to the airmen. Although such usage would divert submarines from their primary task of sinking enemy ships, ComSubPac agreed. Accordingly, *Skate* and two other submarines were assigned to perform what became known as "Lifeguard Duty."

Fleet operations to regain the Central Pacific began with an attack on Wake Island in early October 1943, and then rolled relentlessly westward. The strike on Wake had three objectives: to test new strategic concepts and tactics using the strengthened Pacific Fleet; to neutralise Japanese air power at Wake; and to regain an offensive posture. Before the war, the Japanese had viewed Wake as a stepping stone between the Japanese mainland and Midway, Hawaii and the U.S. west coast. Accordingly, like Pearl Harbour, it had been attacked on December 7, 1941, and occupied two weeks later.

At midday on September 25th, *Skate* departed Pearl with orders to patrol off Wake. Upon arrival on station on the morning of October 4th she closed the atoll and submerged to conduct photo-reconnaissance. Two days later Task Force 14 under the command of Rear Admiral A. E. Montgomery arrived off Wake to carry out a carrier air/cruiser bombardment. *Skate* was on the surface west of the atoll ready to perform life- guard duties. The strike commenced at early dawn. Quoting from *Skate's* patrol report[2] , "0448 (local time) - Sighted much flak and anti-aircraft fire from Wake. Many planes were in the air over Wake dropping bombs and there were several dog fights. Eight or ten planes were seen to fall and our planes were seen to form up." The report continued with a sad note. "We were attempting to close on the surface toward the nearest crash when at 0545 what appeared to be a Japanese Zero suddenly dove out of a nearby cloud and started strafing us. Plane was coming in low from the starboard beam. Made a quick dive. After getting below it was discovered that Lieutenant (jg) Willis Edward Maxson, III, U. S. Navy, junior Officer-of- the-deck, had been hit by a bullet. He was very seriously wounded."

Skate surfaced a half hour later to resume the search. Several U.S. and enemy planes were noted in the air, as was a trail of 25 calibre bullet holes through the STS armour plate protecting the bridge and conning tower. At 0808 *Skate* was again forced to dive by two Japanese planes making strafing runs from a distance of about two miles. Seconds later the planes flew over the disappearing periscope but loosed no bombs as *Skate* passed 50 feet on her way down. At 0900 she surfaced to resume her rescue mission, but was again forced down. It appeared that our aviators had failed to gain control of the air that day.

It was squally and overcast the next morning, October 7th. Several squadrons of friendly aircraft were soon sighted, and at 0601 *Skate* "Exchanged visual signals with a squadron of friendly dive bombers. Four of them circled us several times and.....asked the bearing and distance to the target. We informed them and they headed in the proper direction. Anti-aircraft fire and bombings started shortly thereafter." At 1043 "when about 6 miles from shore searching for downed aviators a heavy shell hit about 400 yards on the port bow. Another whistled over the bridge and hit about 800 yards astern and as we were diving the third hit about 200 yards on the starboard quarter." The Japanese were getting closer, but no cigar that time.

Upon surfacing at 1128 word was received that three aviators were down. They were soon sighted about 2 miles off the beach. Trimmed low in the water, *Skate* headed toward the beach with Ensign Francis Kay, gunner's mate William Shelton, and torpedoman Arthur G. Smith on the bow to make the rescue. Despite the fact that, "They were firing at us from the beach and small and heavy shells were hitting all around us," Lieutenant Harold J. Kicker, USNR was snatched from the sea forty-five minutes later. Minutes after that Smith went over the side with a life ring and towed Ensign Murray H. Tyler, USNR to the submarine where torpedoman Frederick J. Lambert assisted in bringing the exhausted flier aboard. Further rescue efforts were interrupted by a Japanese dive bomber. While submerging, a near miss damaged the bow buoyancy tank vent-operating mechanism but repairs were quickly made and *Skate* soon surfaced.

At 1242 another aviator was reported down off Peacock Point. While closing the reported position "a heavy shell hit 500 yards on our port beam and ricocheted with a scream over the bridge, followed by two more close overs. Made a quick dive and heard three more shells strike the water and they sounded very close." *Skate* surfaced forty minutes later to again resume searching. More Japanese planes were sighted and at 1459 *Skate* was bombed while passing 60 feet on her way under. Two bombs exploded about a minute apart, but did only minor damage. Plane contacts continued to be observed through the periscope until the ship surfaced at 1822. Although Japanese planes continued to be present during darkness, they made no further attacks that night.

By early morning of the 8th, Lieut. Maxson's condition had worsened and in accordance with instructions, *Skate* headed for Midway where medical help was available. Her return was interrupted by orders to return to Wake to rescue nine airmen adrift in the open sea. Unfortunately, Lieut. Maxson succumbed to his wounds during the morning. He was buried at sea the next night.

The search for downed airmen was resumed during the early morning hours of October 9th, and at 1033 a life raft was sighted. However, another Japanese plane forced *Skate* to dive. She surfaced at 1119 and twenty minutes later Lieut.(jg) Richard G. Johnson, USNR, was brought aboard.

The search continued on October 10th, and early in the morning a red flare was sighted at what appeared to be about 5 miles distant. *Skate* headed directly for it, but nothing was sighted until she had gone over 15 miles. Then a raft was sighted and soon *Skate* rescued Lieut.(jg) William E. McCarthy, USNR, and Paul T. Bonilla, AOM, USNR. Later the same afternoon Commander Mark A. Grant, USN, an Air Group Commander was rescued.

Skate remained in the area until October 14th and continued to observe enemy air activity. As a parting gesture a VAL dive bomber made a bombing run that afternoon from a distance of 3 miles. Although the bomb detonated as *Skate*

passed 110 feet she escaped damage. Early on the night of the 14th, *Skate* departed for a newly assigned patrol station. She encountered no significant action there and left for refit at Midway on the evening of the 23rd, and arrived five days later.

Altogether, *Skate* had plucked six aviators from the sea during the strike on Wake. She also vectored one of our dive bomber squadrons to its target. In the process she was bombed three times, fired on by shore batteries three times, strafed twice, and lost one very fine young officer to the initial strafing. *Skate's* persistence in searching for downed airmen in the midst of bombs, shells and bullets required great courage, coolness and determination on the part of the entire crew. In acknowledging *Skate's* accomplishments, the Commanding Officer of *Lexington* radioed, "Anything on *Lexington* is yours for the asking. If it is too big to carry away, we will cut it up in small parts."

Although other submarines had previously stood by to rescue airmen during strikes, it was *Skate's* successful performance that opened a new chapter in submarine operations. From that day until the end of the war, no important carrier strike was made without one or more lifeguard submarines on station. By the end of the war our submarines had rescued 504 airmen from the sea.

On to the Gilberts

While *Skate* was engaged in performing life-guard duties, the Pacific Fleet staff was busy preparing plans and assembling resources for the next step across the Pacific. In planning an offensive to drive the Japanese from their islands, two major problems confronted the planners. First, was the fact that over the years the Japanese had taken or fallen heir to island groups which gave them control of the Central Pacific. The keystone to that control was Truk, their fleet's main base. Providing a defence in depth were strategically located bases on island groups throughout the Central Pacific. A related problem was the manner in which land was distributed throughout the vast expanse of the Central Pacific. Approximate distances between some of these bases are: Pearl Harbour to Midway Islands 1150 nm; to Wake 2050 nm; to Johnston Island 780 nm; to Kwajalein and Tarawa 2050 nm,; and to Truk 3050 nm. The distance from Wake to Truk is about 1100 nm and from Kwajalein to Truk about the same. It was clear to the planners that if the Japanese bases were to be taken, attacks would have to be made by carrier based aircraft and surface ship bombardment, followed by amphibious landings.

By the time *Skate* returned to Midway for refit in late October 1943, the fleet had been reorganised. Vice Admiral Raymond A. Spruance had been given command of Fifth Fleet. It was composed of 118 warships, including 13 battleships, 19 carriers, a large number of lesser combatants, plus transports, supply ships and auxiliaries. Its first major operation was *Operation Galvanic*. The objective was

seizure of the Gilbert Islands, a group of coral atolls lying about 2,000 miles west-southwest of Pearl, and far to the east of Truk. Of the numerous bits of coral reef protruding above the ocean in the Gilberts, Tarawa, Makin, and Apamama were the main atolls to be taken. Of these, the primary objective was Tarawa. Fifth Fleet struck all three atolls on D-day, November 20, 1943. By that time Japanese defence forces in the Central Pacific had been greatly weakened by both ship and aircraft losses in the South Pacific. Consequently, reinforcement from there and from Truk were unavailable. Makin, the northernmost atoll was taken in two days by the Army's 27th Division following air attacks and bombardment by battleships of the invading force. Similar attacks were made on the islets of Tarawa, and that atoll was taken after bitter fighting by our marines on Betio islet. Within ten days all *Galvanic* objectives had been achieved.

Ten submarines participated in *Galvanic*. Of these, nine were placed along the route east of Truk to intercept reinforcements proceeding to the attack area. *Nautilus,* however, was more directly involved. She performed reconnaissance and lifeguard duties off Tarawa immediately prior to the attack, and then transported eight officers and 70 marines to assist in the taking of Apamama. In a case of mistaken identity during darkness while enroute with her marine detachment, her conning tower plating was holed by a five inch shell from a less-than-friendly destroyer. Nevertheless, she was able to dive to escape and carry out her mission.

An assessment of *Galvanic*'s complete and rapid success proved the validity of the new coordinated carrier and land based air, surface ship, amphibious and support team strategy. With success in hand and a force in being, plans were made to accelerate the planned capture of the chain of Marshall Islands extending some 350 to 750 miles to the north-northwest, and closer to Truk. The date set for the new operation, *Flintlock*, was late January of the new year. While major segments of the fleet were being readied, minor harassing strikes were made against the Marshalls and as far west as Nauru, 350 miles beyond the Gilberts.

With activity heating up in the Central Pacific, more submarine operations were planned for that area. *Skate* departed Midway November 15, 1943 to conduct her second patrol in the area to the north of Truk. She arrived on station a week later and commenced reconnaissance and a search for targets. It was during this patrol that *Skate* began to earn her reputation as the "Big Game Hunter of World War II." A number of distant ship contacts were made off the north entrance to the atoll, but could not be approached close enough to permit an attack until mid-morning of the 30th. While patrolling on the surface, a task group was detected. Course was changed to intercept what was soon identified as a converted aircraft carrier escorted by two destroyers with heavy air cover. Two additional destroyers and two large carriers were soon seen to be following the first carrier. When the range to the large carriers had closed to about 9,000 yards, *Skate* submerged and headed in for a bow shot. Coming to periscope depth at 1106, it was observed that

the targets had zigged and that it would be necessary to fire from the stern tubes. Six minutes later when a look through the periscope showed the two large carriers to be overlapping, three torpedoes were fired at a range of about 1,500 yards. The patrol report read, "One minute and fifty seconds after firing a large geyser of water arose just forward of the centre of the nearest carrier and the entire ship heeled to port. The explosion was heard but no smoke. The near carrier appeared to hold course and speed while the overlapping carrier turned sharply about 90º to port."[3] The escorts rushed in to drop a pattern of depth charges and then returned to their escort positions for no apparent reason.

Suffering no damage, *Skate* resumed her patrol. A number of air and ship contacts were subsequently made, and although twice depth-charged, she was unable to get in any further attacks until the night of December 20th. At 2123 a single large ship with two escorts came within radar range. Running on the surface to gain position ahead of the group she submerged to attack at dawn. At 0620 four torpedoes were fired at the large ship. A mishap during the firing caused the submarine to broach in plain sight of the escorts and as the escorts closed for the kill the Captain ordered the Diving Officer to "take her deep." The torpedoes were still on their way as *Skate* passed below periscope depth and no further visual observation could be made. However, the sonar operator soon reported three hits. Thirty-eight depth charges shook the ship during the next five hours. Specks of dirt were loosened in the periscope optics and the deck mounted JP sound head was knocked out, but no major damage was inflicted. When *Skate* surfaced shortly after noon a glow of burning oil was reflected in the sky, and later that night a tremendous explosion was heard and flames shot high into the air. The 6,400 ton freighter of the *Terukawa Maru* class had carried her last cargo.

The patrol continued without undue excitement until early in the morning of Christmas Day. Contact with a small group of ships was made while patrolling on the surface. Unidentified at the time was a very large ship escorted by two destroyers. *Skate* submerged to close the target and fired a spread of four torpedoes. Quoting from the patrol report, "After a (torpedo) run of about two minutes there was one definite explosion followed by another muffled explosion." A brief depth charging discouraged further observations and shortly thereafter the target group disappeared over the horizon.

Post-war disclosures by Japanese sources confirmed the identity of the target as the battleship *HIJMS Yamato*. As she sped away her Commanding Officer reported by despatch, "On 25 December 1943 at 180 nautical miles north of Truk, at latitude 10º 5' N. and longitude 150º 32' E., one torpedo hit was received from a single enemy submarine. A hole about 5 meters depth, extending downward from the top of the bulge connection (at the armour) and 25 meters in length, between frames 151 and 173, was produced. Water flowed into the No. 3 (turret) upper magazine from a small hole in the longitudinal bulkhead caused by caving in of water-line armour."[4]

Yamato was 863 feet long with beam 127 feet, draft 35.6 feet and displacement 73,000 tons. She mounted nine 18.1" guns in three turrets and had a top speed of 27 knots. Yamato and her sister ship, Musashi, were the largest and most powerful warships built by any nation. Extensive design analyses and tests conducted prior to and during construction made them as unsinkable as the state of the art would permit. To that end the designers provided multiple longitudinal bulkheads which incorporated one armoured bulkhead in addition to the normal heavy armour belt protecting vital engineering and ordnance spaces. Because of her defensive capability, Yamato barely hesitated after being hit by Skate's torpedo.

The torpedo that did the damage was the infamous Mk.14-3A steam torpedo armed with a Mk.16 warhead loaded with 600 pounds of Torpex. Although depth was set for 10 feet, the torpedo apparently ran at half that depth. The reason for failure of the other three torpedoes is unknown. However, in view of the size of the target and the position of the single hit along the hull, it is likely that the blame rests on the unreliable Mk.14-3A torpedoes and their faulty Mk. 6 exploders.

Skate returned to Pearl on January 7, 1944 to receive congratulations from ComSubPac for putting one Japanese carrier and one battleship on the injured list and sinking one maru.

Operations Flintlock and Hailstone

After the Gilberts had been taken, CinCPac established *Flintlock* as the next major step in the Central Pacific. *Flintlock* entailed the capture of the Japanese held Marshall Islands including their major base at Kwajalein atoll. The Marshalls differed from the Gilberts in that there were many more coral atolls and islets occupied by military installations, and they were spread over a much larger area.

CinCPac's plans called for gathering forces from California, Hawaii, Samoa, the Ellice Islands and other bases, and set D-day as January 31, 1944. The three major bases to be seized were Roi-Namur, Majuro and Kwajalein. Seizure of Eniwetok was planned for later. In accordance with the plan, a massive armada descended on the Marshalls. Fifth Fleet's Task Force 58 advanced with 6 large carriers, 8 battleships, 6 cruisers and 36 destroyers. The landing force of 297 ships and 53,000 assault troops followed. Bombardment of enemy air bases commenced on D-3 day in the area between Roi-Namur in the north, Majuro in the south and Eniwetok in the west. Kwajalein was quickly occupied after a "Spruance haircut" had obliterated all the palm trees and buildings on the atoll. Majuro offered no resistance, and by D-1 all bases were neutralised. By late February 2 the main objectives had been occupied, eight weeks ahead of schedule.

The following day a Marine Liberator flew from the Solomons to Truk and took the first photo-coverage of the great base since the Japanese had taken it over from the Germans after World War I. Perhaps more important than the photos was the warning given Admiral Koga that the Americans would soon attack major

elements of the Combined Japanese Imperial Fleet at Truk. Faced with depleted resources, Koga decided not to risk a decisive engagement until his carriers could be replenished with planes and pilots, and wisely began a withdrawal to the west. His move was timely for Admiral Spruance's staff had planned *Operation Hailstone* for a carrier strike on Truk. D-day had been set as April 15.

In late January, Lieutenant Commander William P. Gruner relieved Commander E. B. McKinney in command of *Skate*. He inherited an outstanding crew and a great ship. Gruner's seven war patrols as Executive Officer of *Pike*, *Sunfish* and *Apogon* made him well qualified for command. D-day for the Marshall operation, *Flintlock*, was just a week away when *Skate* left Pearl to proceed once again to the Truk area. The date for Fifth Fleet's strike on Truk was still in the offing. When *Flintlock* went off like clockwork, CinCPac advanced D-Day for *Hailstone* to February 17 while *Skate* was still enroute. ComSubPac had participated in the planning for *Hailstone* and had assigned nine submarines to the operation. Near Truk were *Sea Raven* and *Darter*, *Seal* was off Ponape, and six other subs were placed along escape routes from Truk. Their objectives were reconnaissance and the sinking of Japanese ships attempting to flee Truk when Fifth Fleet struck. When the date for the strike was advanced, ComSubPac sent despatch orders to *Skate* to take station about 150 miles northwest of Truk. *Skate's* orders carried the proviso that she had to be west of Longitude 152º E. by midnight of the 16th. At that time the area to the east of 152º E. would become a "blind bombing zone" where *Skate* would be fair game for any aircraft - Japanese or U.S. That posed a problem. Stormy weather with heavy seas had set in, but it was necessary to maintain speed as best possible to avoid the blind bombing zone. That meant running on the surface with no opportunity to dive to "check the trim" (i.e. compensate for fuel used and other weight changes). To quote from the Patrol report[5] of February 12, "1000 - Wind has shifted during the night from east to southwest, through the south. Sea is rough, wind about 25 knots, increasing." An attempt was made to hold to two engine speed, initially about 13 knots, but green water was coming over the open bridge. At "1048 - A large wave coming over the port side almost knocked the starboard lookout out of his platform high on the periscope shears." The lookout was William A. Shelton, the gunner's mate who had helped rescue the airmen during the first patrol. Shelton's fingers clung to the platform supports while the green water strove to wrest him from the ship. When the water momentarily subsided, the deck watch helped him down to the bridge level and lowered him into the conning tower. His back had been badly wrenched in the ordeal and he spent the rest of the patrol in his bunk. Despite the casualty it was necessary for *Skate* to keep plowing through the seas. "The control room is very wet from water pouring down the conning tower hatch. Speed has been gradually reduced until at 1100 - we are able to make only 8 knots. The conversion of (ballast tanks) 4A and 4B to fuel ballast tanks has greatly reduced the sea keeping qualities of the ship. Seas from ahead sweep right over the deck although they are not unusually high. Safety and negative (tanks) have been blown dry with no appreciable improvement."

On the morning of the 15th the report noted, "Seas have shifted to the northwest and we have increased speed. If the wind stays where it belongs we should be able to make our schedule." Two radar contacts were made that day on planes that did not close. The next afternoon a plane contact at 13 miles forced *Skate* to dive. Confident that she could now cross the critical longitude before midnight, the opportunity was taken to get a trim. Then with a good trim, *Skate* descended to over 400 feet and unhappily found the water temperature in the area to be constant to at least that depth. That meant that no layer existed to hide under from enemy sonar should she get attacked.

Luck plays an important role in war as in life. Within minutes after surfacing at 1635 a lookout sighted the superstructure of a large ship, bow on, at a range of 12 miles. At the same time, a plane contact at 13 miles dictated immediate submergence. Due to the low height of the periscope lens above the surface, the target could no longer be seen. Meanwhile, somehow alerted, sporadic Japanese depth bomb or charge explosions could be heard. None were close enough, however, to do any damage. At 1722 the foremast of a Japanese cruiser came into periscope view. She was accompanied by destroyers on either beam and had possible air cover overhead. It appeared that the group would pass beyond torpedo range, but thirteen minutes later the cruiser's luck ran out. She zigged toward *Skate* to present a 30º angle on the bow at a range of 5,000 yards. She appeared to be a Kako class heavy cruiser with single stack, two turrets forward, one turret aft, and a scout plane at rest on the catapult between them. The starboard destroyer was well positioned for protecting her as it was headed directly for *Skate* when she fired four torpedoes from the bow tubes at a range to the cruiser of 2,300 yards. Actions then accelerated. *Skate* sought greater safety at depth as she rigged for depth charge. Three torpedo explosions were heard as she started down. A last look through the periscope showed the cruiser to be in a direct line with the setting sun so that only a smoke pall could be seen which extended from bridge to stern. Sonar reported a fourth hit as the starboard escort put on speed to attack. Seconds later the escorts started a heavy and continuous depth charging which lasted for the next 45 minutes. Their attack then slackened, but continued off and on for another hour as the submarine withdrew to the east.

It was important for *Skate* to confirm the results of this attack on an important Japanese combatant so she surfaced at 2115 to return to the scene. Flames and explosions were sighted in the distance, so a course was taken to circle the target group to attain a down-moon position for a second attack should it be required. At 0240 the wounded cruiser, later identified as *Agano*, gasped her last breath and sank beneath the waves. Midnight had now passed and the area had changed to a blind bombing zone. As *Skate* sped west toward safe operating territory she transmitted a report of the sinking. A few hours later Task Force 58 finished the job by sinking the escort destroyer *Maikazi* with her load of cruiser survivors.

This attack became the finale of *Skate* operations directly involved with the Fifth Fleet. However, she did make several more attacks on Japanese shipping during the balance of this patrol, but none resulted in confirmed sunk or damaged ships. In one night surface attack on a small escorted convoy off Palau she instilled the fear of the Lord into the enemy when another faulty Mk.14-3A torpedo exploded prematurely shortly after being fired. Thereupon, every ship in the convoy participated in a fireworks display rivalling an Independence Day celebration. Colourful tracers and starshells flew in all directions to illuminate the area.

To further her reputation as a big game hunter, *Skate*, on her fifth patrol, sank the large *Fubuki* class destroyer *Usugumo* in the Okhotsk Sea. Then on her last patrol under the command of Commander Richard B. Lynch she penetrated the mine field protecting the Sea of Japan to sink the large submarine *I-122*. Finally, to end her career, this famous ship became a target for both air and underwater nuclear weapon tests at Bikini in July 1946. Although surviving with extensive damage, this fine warship was later intentionally sunk off the California coast.

[1] "The Simon and Schuster Encyclopedia of World War II."

[2] ComSubPac Patrol Report No. 298 of 11/6/43, USS SKATE - First War Patrol.

[3] ComSubPac Patrol Report No. 345 of 1/13/44. USS SKATE Second War Patrol.

[4] Extract from a post-war report prepared by the Naval Technical Mission to Japan on the loss of major units of the Japanese Fleet.

[5] ComSubPac Patrol Report No. 393 of 3/26/44. USS SKATE Third War Patrol.

APPENDIX B: TACTICS

by William P. Gruner

Torpedo Attack

Tactics employed, whether making a surface or submerged torpedo attack, were governed by a number of different factors. These were:

1 Torpedo range and speed capabilities
2 Target group size and disposition, including escorts
3 Target group course, speed and zigzag pattern
4 Target group air cover
5 Choice of the primary target(s) and its (their) types and sizes)
6 Ranges to the target(s) and escorts throughout the approach
7 Submarine speed and submerged endurance capabilities
8 Sea conditions
9 Visibility conditions
10 Number of torpedoes available and their location (forward or aft); and
11 Single submarine or wolfpack coordinated attack.

Basic Approach Objective

Try to launch torpedoes at a distance of 500 to 1,500 yards off the target track to achieve a 90º torpedo track angle, in order to hit the target broadside (this assumes that torpedoes run as set and that exploders function properly, which they did not always do). Set torpedo depth depending upon the type of target :

® 6 to 8 feet for merchant ships and destroyers
® 0 feet for a cruiser
® 12 to 15 feet for a carrier or battleship.

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Torpedo Range and Speed

When available I chose to go on patrol with all (24 = 14 forward and 10 aft) 45 knot, 4,500 yard Mark 14 or 23 steam torpedoes. When a full load of steam torpedoes was not available I took out a mix which included some 30 knot Mark 18 electric torpedoes. Although wakeless, I preferred the higher speed Mark 14s because the time to impact was less. Steam torpedo wakes were not very visible in sea states less than absolutely calm.

Target Group Size and Disposition

Japanese merchant and naval ships normally travelled in groups or convoys with escorts, although single ships often travelled alone with and without escort(s). Important ships and important convoys (e.g. tankers) were normally accompanied by two or more escorts. Convoys of three freighters, tankers and personnel carriers usually travelled in a single column about 500 to 800 yards apart (foremast to foremast). One escort was often positioned about 1,000 yards bearing 060º relative on the starboard bow of the lead ship, and a second bearing 300º relative on the port bow of the lead ship. A roving escort was often place astern of the last ship in column. On occasion convoys were organised into two column abreast. Such was the case when *Jack* encountered a convoy of five tankers in the South China Sea in mid February 1944. Four tankers were in the main column and a 5th leading a group of three escorts, including one destroyer, was in a parallel column probably about 500 to 1,000 yards abeam. It is not known why that particular formation was used.

Large formations of battleships and/or aircraft carriers were frequently protected by an inner screen of cruisers and an outer screen of destroyers. Such formations often travelled at speeds up to 25 knots. At higher speeds destroyers had trouble keeping position in moderate to high seas and would tend to fall behind. On occasion, one or two large carriers or battleships would proceed independently at speeds up to 30 knots in light seas.

Target Group Course, Speed and Zigzag Pattern

Merchant ship convoys frequently travelled at speeds of eight to ten knots, although one, two or three personnel transports with or without escorts might make twelve to fifteen knots. Although zigzagging was often used by Japanese forces to confuse submarines, a zigzag at an inopportune time could generate an attack opportunity that would otherwise not have occurred such as when the *Skate* sank the *Agano*. Individual legs of a zigzag pattern were usually of eight to twelve minute duration.

Target Group Air Cover

The Japanese frequently provided anti-submarine (ASW) air cover from shore bases, aircraft carriers and scout plane equipped major combatant ships. ASW aircraft were normally encountered during daylight. However, *Apogon* was bombed

on a pitch black night in late November 1943 when about 75 miles north of Truk. I do not know how the pilot detected us.

The SD air search radar was installed in the first U.S. fleet type submarine just prior to the war. It often detected aircraft out to ranges of twelve to fifteen miles, although in *Skate* we were bombed by a plane first detected at a range of about three miles. The SD did not provide a bearing of the aircraft, only its distance. SD probability of detection depended upon the type, altitude and attitude of the aircraft, the alertness of the operator watching the scope, and the method of employing the radar. Some C.O.s worried that if the SD was used continually its signal would be homed-in on by aircraft. They therefore used it intermittently, if at all, as for 30 seconds every few minutes. My policy as C.O. was to use it continually when on the surface because I had no positive knowledge that the Japanese had radar intercept gear installed in their ASW aircraft, and I wanted all the advance warning I could get to submerge as soon as possible. Upon diving, my policy was go to 200 feet at full speed while turning with full rudder to a new course about 90º from the previous course in order to open out from the track indicated by our surface wake.

Choice of Target

When encountering a convoy or group of ships the choice of target was usually obvious. With limited submerged manoeuverability the target was normally the ship which presented the best firing conditions in terms of torpedo run and track angle, and firing position permitted by ASW escorts. Of course, if a major combatant was in the group every effort would be made to shoot at it first, and another afterward if possible.

In making a night surface attack on a group of ships it was not always possible to pick out the choice target. The SJ surface search radar was relied on extensively, augmented by what could be seen through binoculars. An indication of target size could sometimes be gathered from the strength of the blip on the SJ radar scope, plus "side-lobes" of the main blip. In some cases blips and side-lobes overlapped into a broad "smear". Visual bearings transmitted by the Target Bearing Transmitters (TBTs) on the bridge level could provide accurate firing bearings.

Monitoring Ranges to Targets and Escorts

In making an attack on a group of ships it was necessary to continually monitor the range and bearing of the target so that it did not "get by" (i.e. exceed favourable range and bearing before torpedoes could be fired). Submerged attacks are almost always made from a position ahead of the target or target group because target are usually detected coming toward the submarine; i.e. one rarely accidentally overtook a potential target. Monitoring target range was most important when attacking targets making speeds greater than about 15 knots. The "picture" changes rapidly, especially when approaching a target(s) from ahead, and the target range and bearing generated by the TDC were most useful to the C.O. and Fire Control Officer.

It was also critical that the position of threatening escorts be continually monitored. When making a night surface approach from ahead of the convoy, the range to nearest escort was of particularly concern because the closing speed was approximately the sum of own ship's and escort's speeds. Unlike an automobile, a submarine cannot stop or turn on a dime if necessary to avoid collision.

Submarine Submerged Speed and Endurance

At target speeds of 15 knots and greater submerged submarines often had difficulty getting into attack position because of low speed and limited battery capacity. In such circumstances it was often necessary to surface and do an "end-around" at full speed. This could take the better part of a day depending upon target speed. Upon getting ahead of the convoy or target the submarine could submerge for another attack if position was gained during daylight, or await darkness and deliver a night surface attack.

Sea Conditions

Waves and swells do not always travel in the same direction. Submarine depth control at periscope depth is difficult in heavy seas, particularly when running into them or when they come up from astern. Use of the SJ surface search radar during the first few years of the war was hindered when submerged in heavy seas because the antenna was mounted atop the periscope shears, requiring the submarine to run at relatively shallow depths (e.g. 40 to 45 feet). Near the end of the war an extendible mast was installed so that the antenna could be raised and lowered much like a periscope.

The speed of submarines on the surface with a full fuel load, as during the early days of a patrol, is limited when running into heavy seas by "green water" (waves) coming over the bridge and often up to the lookouts in the periscope shears. It is sometimes necessary under such conditions to slow to as little as five knots. Submarines are much less affected by waves and swells when submerged than ships on the surface. At a keel depth of 100 feet they are relatively stable. Unfortunately, below periscope depth (about 68 feet) they are totally dependent upon passive (listening) sonar for search and target information.

Visibility Conditions

Submarines have a much smaller silhouette than any surface ship. Thus, they can often approach within one to five miles or less of a target or escort at night without being detected, depending upon moonlight, starlight, and clarity of the air. Because the Japanese did not normally have surface search radar, visibility conditions were important in attaining attack position for night surface attacks. The Japanese did have 20 power binoculars with excellent light gathering capability for night vision, but that did not seem to affect us significantly.

Periscopes were useless at night. However, in clear weather it was advantageous when running on the surface to post a "high periscope watch" in other words, to have a lookout man a raised periscope. The increased "height of eye" provided a significant increase in the distance to the horizon and the range at which a target could be detected.

Vision is important in searching for targets. It was customary when on the surface to post three lookouts on the bridge in addition to the Officer of the Deck (OOD) and the Junior OOD. Vision capabilities of individuals vary considerably, and that is particularly true of "night" vision. Submarines "rigged for red" in the conning tower and elsewhere below decks as darkness approached so that the night vision of those going to the bridge would not be adversely affected by the normal white lighting. In addition ambient atmospheric conditions, of course, affect vision performance.

Number of Torpedoes Available

There were normally 14 torpedoes carried in the forward torpedo room at the start of a patrol; 6 in the tubes and 8 in the racks. In the after torpedo room, 10 torpedoes were carried; 4 in the tubes and 6 in the racks. As a patrol progressed the numbers decreased as torpedoes were expended. Most attacks were made using torpedoes from the forward room. Although stern shots were possible to augment the number fired from the bow, and vice versa, the gyro angles of torpedoes fired from the secondary set of tubes would usually be large. In my opinion that decreased their accuracy. If it is necessary to fire torpedoes from the stern tubes it was better to plan the attack with this in mind

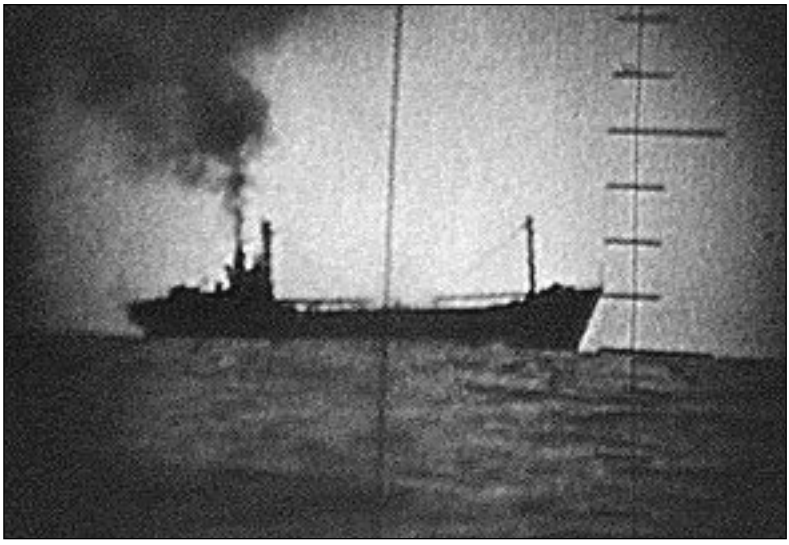
Torpedoes could not normally be transferred between torpedo rooms at sea, although it was done on the surface on at least one occasion. I would not recommend it.

Single Submarine or Wolfpack Attack

A torpedo attack consists of two phases, the approach to attain firing position, and the firing of torpedoes. Approach manoeuvers depend largely upon the disposition of the target(s) relative to own ship.

Coordinated operation of groups of submarines in wolfpacks has a number of advantages including a large increase in the area being searched, the ability to conduct simultaneous attacks, principally on convoys, from several directions, and saturation of escort defenses. Coordination was achieved through adherence to a prescribed set of tactics, codes, and inter-communications by means of voice radio. Many wolfpack operations were conducted by Pacific Fleet submarine in the period between October 1943 and Mid 1945.

When a coordinated attack is delivered each member of the wolfpack conducts its attack on a designated target, or target of opportunity, in essentially the same manner as a single submarine.



APPENDIX C: THE FIRE CONTROL PROBLEM

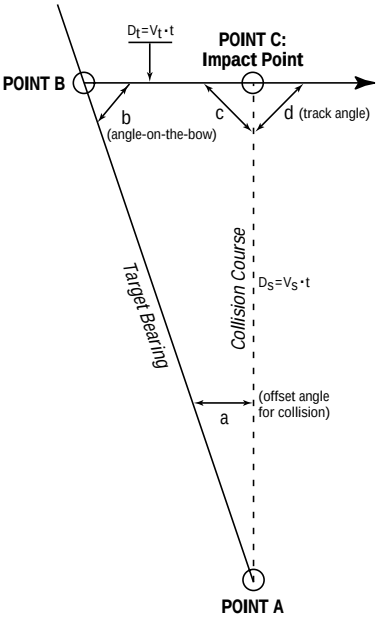
by William P. Gruner

A major problem faced by the C.O.'s is to determine when and from what position to launch the first torpedo to achieve a hit (or hits). The C.O. has a number of objectives after determining the nature of the primary target. These primarily include getting into a favourable launch position within a torpedo run of something between 500 and 2,000 yards; preferably between 500 and 1,500 yards — the shorter the distance the run to the target, the higher the probability that it will hit. The solution of the torpedo fire control problem requires that a gyro angle be entered into a torpedo such that after it completes its turn (if any) toward the target it will be on a collision course with the target. The following will clarify the collision course aspects of the problem.

A primary objective of the TDC is to generate the torpedo gyro angle which will cause a torpedo of given speed to settle on a straight course such that it collides with a target running on a straight course at a fixed speed. A collision (hit) will occur when the target and the torpedo arrive at the same point at the same time.

Step 1 - The General Case (See Figure 1) An observer at point A sees a target at point B moving at constant speed, Vt, on a steady course. The angle between the line-of-sight, AB, and the target's heading (angle-on-the-bow) is observed to be "b". The observer at A is moving at constant speed, Vs,

Fig. 1. Collision Course Geometry



QUESTION: What angular offset, a, from the line-of-sight, AB, should an observer on a ship, or a torpedo, take to collide with the target?

SOLUTION: A moving object at Point A will collide with the target if it proceeds on a course such that the time it takes to travel from A to C, (the point of impact) is equal to the time it takes the target to travel from B to C. That is, a collision will result if:

$$\triangle t = \frac{D_t}{V_t} = \frac{D_S}{V_S} \quad \textbf{or} \quad \frac{D_t}{D_S} = \frac{V_t}{V_S}$$

In accordance with the trigonometric sine law :

$$\frac{\sin a}{D_t} = \frac{\sin b}{D_S} \quad \textbf{or} \quad \sin a = \sin b * \frac{D_t}{D_S}, \text{ or } \sin a = \sin b * \frac{V_t}{V_S}$$

EXAMPLE

$V_t = 15_{Kts}$, $V_S = 45_{Kts}$, observed angle on the bow, $b = 70°$

$$\sin a = \sin 70° * \frac{15}{45} = Ø.93969 * \frac{1}{3} = Ø.31323$$

$$a = \sin^{-1} = Ø.31323 = 18.254°$$

Step 2 - Step 1 produces an approximation of the correct torpedo gyro angle, but it is just the first step in the solution because the course geometry of the torpedo at firing time is not located at the periscope, it is some 40 yards forward of it. The TDC must correct for this linear displacement of the torpedo. That geometry is illustrated in Figure 2 (which is not to scale).

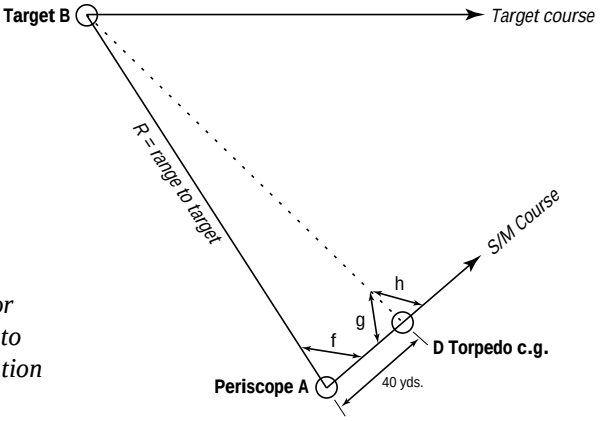


Fig 2. Step 2, Accounting for Parallax Due to Torpedo Location

In Figure 2 the distance BD is calculated by means of the equation where R = the observed range to the target, and the angle f is bearing of the target relative to the heading of the ship.

$$BD = \sqrt{R^1 + 40^2 - (2R * 40 * \cos f)}$$

The angle g may then be determined by the equation

$$g = \sin^{-1}\left(\frac{r * \sin f}{BD}\right) \text{ and the angle } h = 180° - g$$

Step 3 - In addition, I have assumed that because of the torpedo's need to clear the launch tube and its inertia, the torpedo course geometry advances 10 yards straight ahead upon being launched before it begins to turn on a circular arc of 20 yard radius in response to the gyro angle input. (See Figure 3) Thus, step 3 is to determine the geometry at the time the torpedo starts to turn toward the target. To do this I have assumed an average torpedo speed of 40 knots (22.522 yards/sec) during the 10 yards it travels before commencing its turn. It covers this distance in approximately 0.45 seconds (10 yards ÷ 22.522 yards/sec). In that time a target making 15 knots will advance about 4 yards along its course. A slower target will advance a shorter distance, and a faster target more, during this time interval. In any case, the distance advanced by the target is relatively small compared to inaccuracies in estimating target speed and course, plus small bearing inaccuracies input to the TDC caused by the ship's master gyro "hunting" for true north. This can amount to as much as +1/2º. This difference becomes more significant the farther the torpedo has to travel.

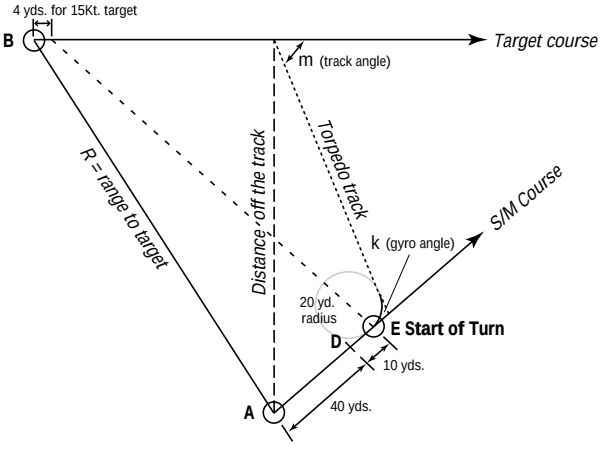


Fig. 3. Step 3, Accounting For Target Motion Before the Torpedo Turns

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Finally, to Bud Gruner and the men of the Silent Service for dedicated service in both peacetime and war. Bravo Zulu.

CONTENTS

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