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Source: *The Journal of Military History*, Vol. 69, No. 4 (Oct., 2005), pp. 987-1012

Published by: Society for Military History

Stable URL: <http://www.jstor.org/stable/3397177>

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Give Credit Where Credit Is Due: The Dutch Role in the Development and Deployment of the Submarine Schnorkel



Mark C. Jones¹

Abstract

The Germans' attempt during World War II to use an air mast (schnorkel) on submerged submarines to reduce their heavy losses is reasonably well known to naval historians. What is not well known, especially to those historians using English-language sources, is how the Germans came to deploy such a novel approach to operating diesel-powered submarines. This article explains the Dutch contribution to the development of the schnorkel. The article discusses the Italian version of the schnorkel, the Dutch invention and use of the schnorkel, the German adaptation of the Dutch technology, and the British experimentation with a schnorkel.

OVER half a century after the last Axis submarine threatened Allied shipping during World War II, naval historians remain interested in the German submarine fleet. A large number of books have described the

1. I would like to thank a number of people and organizations who made the completion of this article possible. Dr. A. P. van Vliet, director of the Royal Netherlands Navy's Institute of Maritime History, provided documents about Commander J. J. Wichers's service career, Dutch-language magazine articles on the schnorkel, and photographs of Dutch submarines equipped with the schnorkel. Leon Homburg, deputy curator of the naval museum at Den Helder, the Netherlands, provided drawings of the ventilation system on the Dutch submarine O-2. Keith Birtwhistle of the

Mark C. Jones lives in Manchester, Connecticut, and writes on the armed forces of the smaller European Allied countries of World War II that were integrated into the British armed forces after being driven from the continent (Czechoslovakia, Poland, Denmark, Norway, Netherlands, Belgium, France, Yugoslavia, and Greece).

German attempt to sever the trans-Atlantic supply lines.² Students of naval history who are particularly well acquainted with the literature on the Atlantic submarine war know that the *Kriegsmarine* (the German Navy) made an unsuccessful attempt in 1943 to improve the survivability of German submarines with the introduction of technological advances including acoustic torpedoes, electronic monitors to detect the use of radar, rubberized hull coverings to absorb sonar impulses, and most importantly, a ventilation mast that would permit a submarine to remain submerged while still using its diesel engines for propulsion or to recharge its batteries.³

Early in the war, German submarines could surface to charge their batteries and reposition themselves via rapid surface transits for attacks on convoys without great risk of detection. As the Allies deployed more escorts and long-range patrol aircraft, U-boats found it increasingly difficult to surface without being quickly forced back under. Even more important to the antisubmarine campaign than the increased quantity of escort ships and aircraft was the installation of radar, which removed the submarine's ability to travel undetected on the surface under cover of darkness. Allied control of the sea and the air over the open ocean meant that each time a submarine surfaced to recharge its batteries, the submarine risked detection by radar and possible destruction. The number of U-boats destroyed by Allied ships and aircraft rose dramatically and threatened the German strategy of interdicting Allied convoys.⁴

The solution to this surface and aerial threat was not to surface, but submarine propulsion technology at the time (1943) did not yet permit

Royal Naval Submarine Museum at Gosport provided copies of documents describing the Royal Navy's experimentation with the schnorkel. Pierre Besnard, Rear Admiral RNeN (retired), Professor Eduard van den Pol, Captain (Engineer) RNeN (retired), and Frank Duffy, Captain USN (retired) and a career submariner, plus three anonymous reviewers all read the manuscript and offered many useful suggestions. Jan Visser translated several of the Dutch-language sources into English. The Manchester (Connecticut) Public Library's Interlibrary Loan department assisted with locating sources. All errors of fact or interpretation remain the author's responsibility.

2. For example, John Terraine, *The U-Boat Wars, 1916–1945* (New York: G. P. Putnam's Sons, 1989); David Syrett, *The Defeat of the German U-Boats: The Battle of the Atlantic* (Columbia: University of South Carolina Press, 1994); Peter Padfield, *War Beneath the Sea: Submarine Conflict During World War II* (New York: John Wiley and Sons, 1995); Stephen Howarth and Derek G. Laws, eds., *The Battle of the Atlantic, 1939–1945* (Annapolis, Md.: Naval Institute Press, 1994); Clay Blair, *Hitler's U-Boat War*, 2 vols. (New York: Random House, 1998).

3. Eberhard Rössler, *The U-Boat: The Evolution and Technical History of German Submarines* (London: Cassell, 2001). See also Axel Niestlé's chapter "German Technical and Electronic Development" in Howarth and Law, eds. *The Battle of the Atlantic*, 430–51.

4. Paul J. Kemp, *U-Boats Destroyed: German Submarine Losses in the World Wars* (London: Arms and Armour Press, 1997).

this. What was possible was to minimize the amount of the submarine that broke the surface and thus exposed it to detection. The *schnorchel* was a metal ventilation tube that was raised to allow the submarine to draw in air for use in the submarine's diesel engines.⁵ The submarine could thereby remain submerged with just a few feet of the mast above the water. It was hoped that Allied radar could not detect a target as small as a few feet in height, and that a lookout on a surface ship would not be able to see the thin mast or the wake it created, especially at night. The Germans first tested the schnorkel in summer 1943 on the *U-58* and installed it on increasing numbers of submarines beginning in spring 1944.⁶

The Germans' attempt to use this technology to reduce their heavy losses is reasonably well known. What is not well known to naval historians, especially those using English-language sources, is how the Germans came to deploy such a novel approach to operating diesel-powered submarines. This article's purpose is to explain the Dutch contribution to the development of the schnorkel. The article includes sections on the literature concerning the origin of the schnorkel, the mission and forces of the Royal Netherlands Navy (RNeN) between the world wars, the early Dutch attempts at creating a ventilation mast, the Italian version of the schnorkel, the Dutch invention of the schnorkel, the predicted advantages and disadvantages of the schnorkel as theorized by the Dutch, the Dutch schnorkel in service, a summary of the wartime careers of the Dutch schnorkel-equipped submarines, the German adaptation of the Dutch technology, and British experimentation with a schnorkel.

The Literature on the Origin of the Schnorkel

The invention of the schnorkel is commonly associated with the German *Kriegsmarine* because of that navy's effective use of schnorkel-equipped submarines during the later stages of the Battle of the Atlantic. Even the word commonly used to describe the air mast, *schnorkel*, indicates its German origin. This misperception exists because the vast majority of sources in English on the Battle of the Atlantic and/or German submarines say little or nothing about the design history of the schnorkel. An example of omitting any reference to the origin of the

5. The proper German spelling is "schnorchel," while the Anglicized spelling commonly used is "schnorkel." This article uses the more common Anglicized spelling. After the war the Dutch referred to the schnorkel as the "snuiver" so as to not have to use the German word "schnorkel." "Snuiven" is the Dutch verb "to sniff," in the sense of inhaling. Some English-language works also use the term "snort" (British) or "snorkel" (American).

6. Antony Preston, *U-Boats* (London: Bison Books, 1978), 154.

schnorkel is Peter Padfield's *War Beneath the Sea: Submarine Conflict During World War II*.⁷ Padfield frequently mentions the operation of schnorkel-equipped submarines but gives no explanation for the development of the technology.

When a source does indicate that the schnorkel was invented by the Dutch, the explanation generally does not go further than a few sentences stating that the Germans acquired the technology as a result of capturing several incomplete Dutch submarines. A good example of this level of explanation appears on the website of the Icelandic naval historian Gudmundur Helgason: "In 1940 when the German army defeated the Netherlands a stroke of luck landed upon the German Navy, namely the Dutch invention the Germans called somewhat rudely the Schnorchel. The Dutch navy had been experimenting as early as 1938 (on the submarines *O-19* and *O-20*) with a simple pipe system which enabled a periscoping submarine to operate its diesels and thus have almost unlimited underwater range."⁸ One of the best-known naval histories of World War II is S. W. Roskill's official study of the British Royal Navy, *The War at Sea*. Roskill goes farther than most English-language sources in identifying the Dutch origin of the schnorkel, but still does not explain how the Dutch developed the equipment or how the Germans modified it for their use:

The Schnorkel equipment had been invented by a Dutch naval officer as long ago as 1927 [sic] and four new submarines which escaped to England in an incomplete state in 1940 had it installed. The British authorities, however, saw no use for it at that time, and as it had certain disadvantages it was removed from the Dutch submarines before they operated under British control. Not until the arrival of ten-centimetre radar had so greatly increased the danger to a surfaced submarine did the Schnorkel come into its own.⁹

The most complete explanation in English of the Dutch origins of the schnorkel appears in Eberhard Rössler's *The U-Boat: The Evolution and Technical History of German Submarines*.¹⁰ However, this 384-page specialist publication was originally written in German and first appeared in English translation in 1981.

While English-language sources generally fail to mention the Dutch role or refer to it in the briefest possible manner, Dutch sources regularly state that the schnorkel was developed by an officer of the Royal Nether-

7. Padfield, *War Beneath the Sea*.

8. Gudmundur Helgason, Uboat.net The U-boat War 1939–1945, <http://www.uboa.net/technical/schnorchel.htm>, last accessed 8 August 2003.

9. Stephen W. Roskill, *The War at Sea*, vol. 3, pt. 1 (London: H.M.S.O., 1960), 18 n. 1.

10. Rössler, *The U-Boat*.

lands Navy. The most thorough accounting of the Dutch role appears in an article from the Dutch naval professional magazine *Marineblad*.¹¹ While Dutch-language sources regularly mention the Dutch role in developing the schnorkel, the fact that these sources are generally not translated into English has prevented this information from finding its way into the English-language naval history literature.

Whether the Dutch role in creating the schnorkel is acknowledged, and the depth of explanation offered, depend largely on the nationality of the author. Sources written in Dutch (and to an extent German) are likely to attribute the schnorkel to the Dutch. Sources written in English generally omit mention of this point or cover it in a few sentences, most likely due to ignorance of the Dutch-language literature on the topic. This article makes available to the English-language naval history community additional information about the Dutch role in the development of the submarine schnorkel.

Necessity is the Mother of Invention

The Royal Netherlands Navy between the world wars was a small but professional force. The Netherlands had avoided involvement in World War I by maintaining a policy of strict neutrality. While the Dutch hoped to remain neutral in future conflicts, the country needed to maintain a military force capable of deterring aggression.¹² For the RNeN, the challenge was great. The RNeN needed to station its limited forces in home waters, at the six Dutch islands in the Caribbean Sea, in Dutch Guiana (Suriname), and in the Netherlands East Indies (NEI). These four theaters were widely separated from each other, and in the case of the NEI, the theater itself covered many thousands of square miles. Approximately 75 percent of the RNeN was stationed in the NEI during this period.

Further complicating the situation was the minimal amount of financial resources allocated by the Netherlands to its military services. Early in the twentieth century the RNeN had considered building battleships as the major naval powers of the time were doing.¹³ However, the RNeN received meager funding and so could not afford to build a surface fleet with many ships or especially large ships such as battleships or battle-

11. Eduard van den Pol, "De geboorte en de vroege ontwikkeling van de hedendaagse snuiver," *Marineblad* (The Hague), April 1995, 110–23.

12. Robert Gardiner, ed., *Conway's All the World's Fighting Ships, 1906–1921* (London: Conway Maritime Press, 1985), 363–64.

13. Anthonie van Dijk, "The drawingboard battleships for the Royal Netherlands Navy," *Warship International*, 1988, 353–61. The article is continued in the 1989 volume, pages 30–35 and 395–403.

cruisers.¹⁴ The solution was to emphasize weapon systems that could cover large amounts of territory, such as naval aircraft; could remain hidden from enemy forces but deliver a telling blow, such as submarines; and were relatively inexpensive and well suited to shallow waters, such as mines.¹⁵ By the mid-1930s the RNeN had begun a modernization and expansion program.¹⁶

The Dutch began to build a submarine fleet that formed a substantial portion of their total naval force.¹⁷ Dutch submarines would necessarily operate in shallow coastal waters where they could expect to frequently encounter enemy aircraft and surface ships and thus need to submerge. Frequent submerging would make it hard to ventilate the submarine. The shallow waters of the North Sea off the Dutch coast are known for their rough weather, so even when the submarine was on the surface, it might be hard to ventilate it without water crashing over the conning tower and thus coming down into the vessel.

Early Dutch Experiments in Submarine Ventilation

During World War I, the Dutch experimented with battery ventilation tubes to provide air to submarines running on the surface or barely submerged.¹⁸ The early submarines *O-2* to *O-7*, plus the *K-II* and *K-V* to

14. Siegfried Breyer, *Battleships and Battle Cruisers, 1905–1970* (Garden City, N.Y.: Doubleday), 451–56; and Jurrien S. Noot, “Battlecruiser design studies for the Royal Netherlands Navy 1939–1940,” *Warship International*, 1980, 242–67. The Dutch attempted to build battleships before World War I and battlecruisers before World War II, but in both cases hostilities prevented the ships from being built. For an English-language source that includes sections on ships, weapons, bases, and many other aspects (except the submarine service) of the RNeN during World War II, see the web site created by Jan Visser, “Royal Netherlands Navy Warships of World War II,” <http://www.netherlandsnavy.nl>.

15. Tom Womack, *The Dutch Naval Air Force against Japan: The Defense of the Netherlands East Indies, 1941–1942* (Jefferson, N.C.: McFarland, 2005).

16. John D. Spek, “The Dutch naval shipbuilding program of 1939,” *Warship International*, 1988, 68–83.

17. G. Teitler, “Colonial Defence and the Challenge of Naval Technology: The Case of the Dutch Submarine,” *Militärhistorisk Tidskrift* (Stockholm) 5 (1983): 85–100. The best English-language source about the submarine service (Onderzeedienst or OZD) of the Royal Netherlands Navy is the web site by Bram M. Otto, “Dutch Submarines” <http://www.dutchsubmarines.com>. Dutch-language sources include J. F. van Dulm, ed., *Veertig Jaren Onderzeedienst 1906–1946* (Amsterdam: Scheltens and Giltay, 1947); C. J. W. van Waning and J. J. Leeftang, eds., *De Nederlandse Onderzeedienst van 1906–1966* (The Hague: Zuid-Hollandsche Uitgevers Maatschappij, 1967); P. C. Jalhay and J. J. A. Wijn, eds., *Ik Nader Ongezien! De onderzeeboten van de Koninklijke Marine 1906–1996* (Amsterdam: De Bataafsche Leeuw, 1997).

18. *GB-110 Mededelingen van de Marinestaf, Appendix 1* (1957), 116, Institute of Maritime History, Royal Netherlands Navy, The Hague, Netherlands.

K-VII, were fitted with a pair of retractable tubes, initially one to ventilate the battery compartment from the buildup of noxious gasses and the other to bring fresh air into the entire submarine, including the engine room. On the *O-2*, a tube was located both forward and aft of the conning tower (Figure 1—next page). These pipes allowed the diesels to run, but the procedure was dangerous, as the valve on the tubes did not work well, risking seepage of water into the battery compartment where it could produce hazardous gas. The Dutch referred to this semisubmerged operation of the diesels as *getrimd dieselen*, or literally “trimmed (down) dieseling.” This procedure was used on the “O”-series boats in home waters as early as 1916 and on the “K”-series boats in the NEI after 1922.¹⁹ After these early experiments, the Dutch did not make any additional improvements in the early schnorkel. Submarines completed after *O-7* and *K-VII* did not have any ventilation pipes but instead would conduct *getrimd dieselen* by opening the conning tower hatch (Figure 2).²⁰

The Italian Invention of the Schnorkel

Though the Dutch had been using ventilation masts since World War I, they employed these masts while the conning tower was still visible above the surface. Therefore, the Dutch were not yet using a true schnorkel. The invention of a modern schnorkel is credited to an Italian naval engineer, Major Pericle Ferretti, in 1923.²¹ By November 1925, trials with a functional schnorkel were conducted on the submarine *H-3* at the major Italian naval bases at Naples and Taranto. An existing ventilation pipe between the two periscopes was used as the air intake while the exhaust was located on the deck. The system worked well, but there was concern about the visibility of a schnorkeling submarine. The following

19. Van Waning and Leeftang, *De Nederlandse Onderzee dienst 1906–1966*, 176. Given the long distances between the NEI and home waters and the different physical environments in the two theaters, ships were designed for and stationed in a particular theater. This included submarines which were designated with an “O” for “Onderzeeboot” in home waters or “K” for “Kolonien” in Asian waters. “O”-series submarines were followed by Arabic numerals (1, 2, 3), while “K”-series submarines were followed by Roman numerals (I, II, III). The distinction between vessels intended for home and colonial waters was ended in the late 1930s with *K-XVIII* being the last “K”-series. *O-19* and *O-20* were originally designated *K-XIX* and *K-XX* but were renamed before launching. British-built submarines transferred to the RNeN during the war were given names of sea creatures (e.g., *Zwaardvisch* = Swordfish), as were all Dutch-built submarines commissioned after the war.

20. Van den Pol, “Snuiver,” 122.

21. Attempts to supply air to a submerged submarine first occurred not long after the invention of the submarine, and took place in a variety of navies. See “Snorkel: An Old Salt,” *All Hands*, January 1949, 2–5. This article considers only those navies that designed and deployed a working schnorkel system.

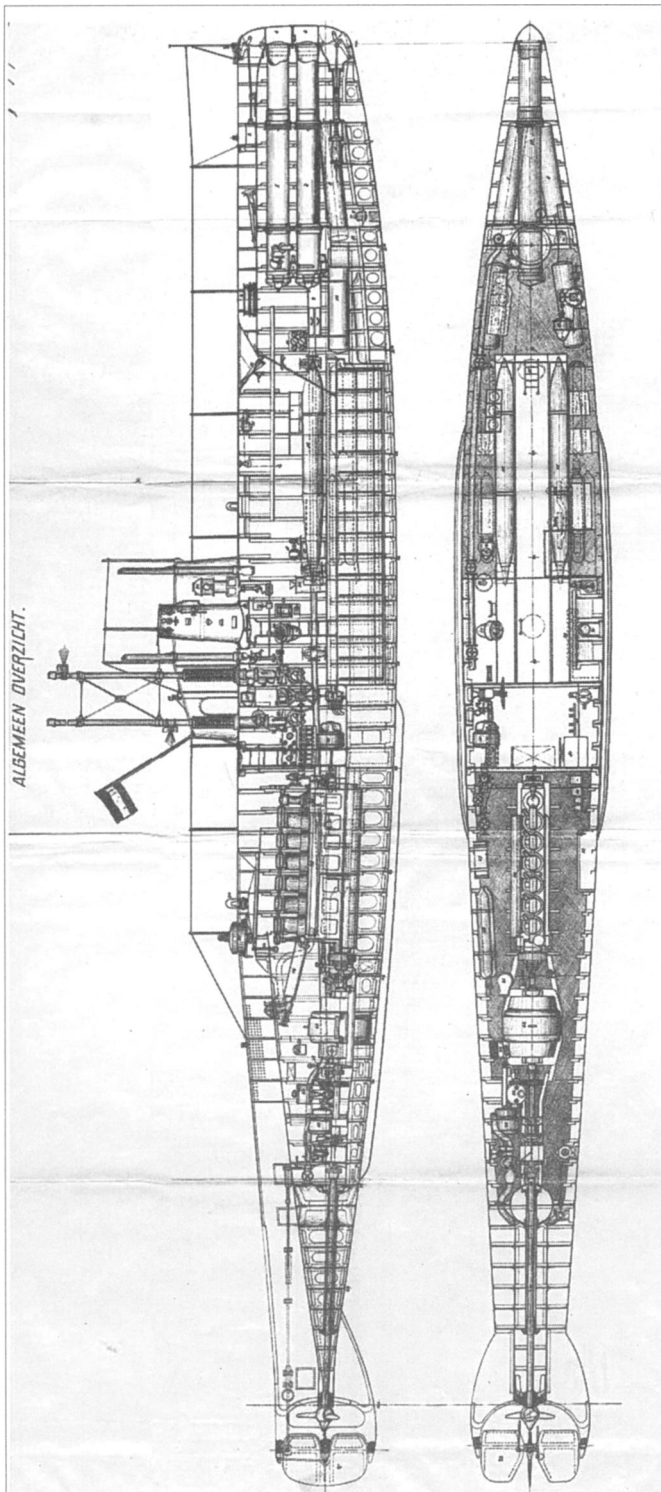


Figure 1. The early submarine O-2 used a pair of tubes to ventilate the submarine while operating the diesel engines with the deck awash. The tubes were located immediately forward and aft of the conning tower with the two periscopes at the rear of the bridge structure. Drawing used with permission of the Dutch Naval Museum at Den Helder, the Netherlands.

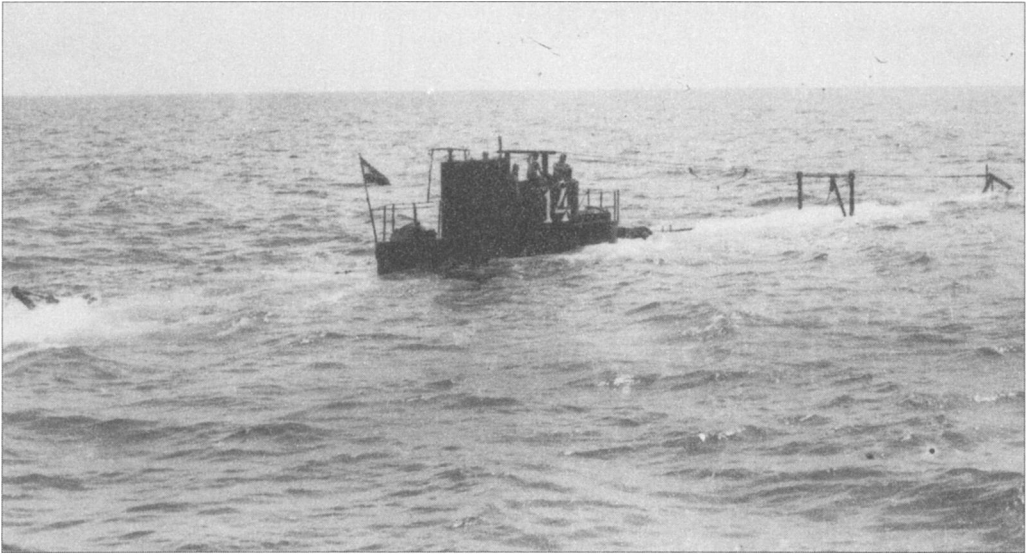


Figure 2. K-XIV conducting getrimd dieselen with the submarine trimmed down but the conning tower hatch open. Date and place of photograph are unknown, but it was presumably taken after 1933 in the Netherlands East Indies where all “K” series boats were stationed after conducting trials in home waters. Figures 2 through 6 are used with the permission of the Royal Netherlands Navy’s Institute of Maritime History, located in The Hague.

year a patent on the invention was applied for. At this time the Italian schnorkel was known as the “Ferretti instrument.”

Though Ferretti’s invention was considered a success, the Italian Navy waited seven years (1933–34) before it installed a schnorkel on the newly built *Argonauta*-class submarine *Jalea* as well as two submarines of the later *Sirena* class.²² On the *Sirena*-class vessels the schnorkel used two masts, the air intake mast being retractable and the exhaust mast being fixed and remaining submerged while in use. The schnorkel was now called the “ML instrument.” These submarines had the equipment removed before commissioning because there was no real operational need at the time for a schnorkel, and the Italian Navy was concerned about the visibility of the mast’s wake.²³

22. Van den Pol, “Snuiver,” 110.

23. Most of the details concerning the Italian schnorkel are drawn from Gino Galuppini, “Lo schnorchel è una invenzione italiana,” *Rivista Marittima* (Italy) 108 (December 1975): 19–31. Also available is a much longer and more technically oriented version of the Italian schnorkel story by the same author, *Lo schnorchel italiano* (Rome: Ufficio Storico della Marina Militare, 1986).

In mid-1937 the Italian experiment with the schnorkel came to an end when the new commander of the submarine force, Rear Admiral Antonio Legnani, ordered all schnorkel equipment removed from various submarines and destroyed. No reason was given at the time for this order. Erminio Bagnasco confirms this account: “[T]he schnorkel was never fitted in Italian boats, though a device designed for the same purpose and functioning on the same principle had been tested with modest success in the submarine *H.3*, as early as 1926, but was suddenly abandoned without explanation.”²⁴ So while the Italian Navy was the first to develop a fully functional schnorkel for submerged use, it did not actually deploy submarines with this innovation once it entered World War II in June 1940. This remained the case even after tremendous losses of Italian submarines to Allied aircraft and surface vessels.

The Dutch and Italian navies were thus more or less simultaneously working on the problem of supplying air to a submarine while the submarine was either submerged or submerged up to its conning tower. Eduard van den Pol argues that there is no reason to believe that either of the two navies had any specific knowledge of schnorkel development in the other navy.²⁵ While Dutch ships transferring between home waters and the NEI via the Mediterranean Sea and the Suez Canal might have made a port call at one of the major Italian naval bases, it is unlikely that Dutch naval personnel would have been allowed to learn of such an important naval technology. In addition, the fact that the Dutch system was deployed more than a decade after the Italian system suggests that the Dutch did not benefit from knowledge of the Italian invention.²⁶ The Dutch can be considered to have independently invented the technology, though more than a decade after the Italians.

Given that the Italian Navy did not deploy submarines equipped with a schnorkel, that the Dutch independently developed a schnorkel and actually deployed schnorkel-equipped submarines, and that the Germans developed their version of the schnorkel from the Dutch model, it seems accurate to describe the Dutch as the developers of the schnorkel.

While the Dutch schnorkel is not well known in English-language naval history literature, the Italian schnorkel is even less well known. Gino Galuppini explains that the Italian Navy’s security procedures required that certain classes of documents be destroyed after a set period of time.²⁷ The vast majority of documents relating to the Italian

24. Erminio Bagnasco, *Submarines of World War Two* (Annapolis, Md.: Naval Institute Press, 1977), 136.

25. Van den Pol, “Snuiver,” 120.

26. Letter of 14 January 2003 from Rear Admiral (Engineer) Gino Galuppini to the author, forwarded by the Italian Navy History Office, director Captain Alessandro Valentini.

27. Galuppini, “Una invenzione italiana.”

schnorkel were destroyed either by periodic purges of confidential documents or as a result of damage to archives and headquarters during World War II. The only documents remaining were Ferretti's personal copies, a few articles in Italian-language professional journals, and several sets of architectural drawings held by the shipyard that built *Sirena*-class submarines for Italy.

From *Getrimd Dieselen* to the Schnorkel

Lieutenant Commander J. J. Wichers, RNeN, had been the captain of four different "K"-series submarines in the NEI between 1925 and 1928.²⁸ He thus knew firsthand the possibilities of a fully functional schnorkel. Wichers shared his initially simplistic ideas with two engineering branch officers stationed at the submarine base at Soerabaja, Java, Lieutenant Commanders H. Riemers and J. C. van Pappelendam. After receiving constructive criticism from these engineering officers, on 27 May 1933 Wichers submitted plans for a schnorkel to Vice Admiral J. F. Osten, commander in chief of the RNeN in the NEI. While the navy considered Wichers's modified proposal to be technically possible, the cost to install an experimental system on the old submarine *K-III* was judged to be too high. As a result, the plans remained in storage.

The Wichers system remained on the drawing board until the captain of a *Gouvernementsmarine* (similar to a coast guard) ship in the NEI reported sighting a mysterious object that moved on the surface, created a wake, and emitted smoke. Because the Dutch were concerned about Japanese intelligence-gathering activities, they interpreted this report as a sign that the Japanese had equipped their own submarines with schnorkels. The RNeN consequently re-examined the Wichers plan and proceeded to install schnorkels on the submarines *O-19* and *O-20* that were under design in 1936.²⁹

Several engineers assigned to the design and construction of new submarines were involved with implementation of the new schnorkel system on *O-19* class submarines. Commander (Engineering) J. C. van Pappelendam, who as a Lieutenant Commander (Engineering) in the NEI had been consulted by Wichers before the design was submitted in 1933, as we have seen, was now working on new submarines in the Netherlands. The other important contributors to the project were the chief engineer

28. Ministerie van Defensie, Marine, *Curriculum vitae van Kapitein-luitenant ter zee titulair Jan Jacob Wichers*, 1977. Document held by the Institute of Maritime History.

29. K. W. L. Bezemer, *Verdreven doch niet verslagen: verdere verrichtingen der Koninklijke Marine in de tweede wereldoorlog* (Hilversum: De Boer Maritiem, 1967), 520.

of the RNeN, G. de Rooij (later K. de Munter); the head of design for the Netherlands United Shipbuilding Bureau, F. Guhrauer; and the first chief engineer of the *O-19*, Lieutenant Commander (Engineering) J. Maats.³⁰

Predicted Advantages and Disadvantages of the Schnorkel

Proponents of the schnorkel argued that installation of a ventilation mast would have three main benefits. First and foremost was the ability to remain submerged to avoid detection. Dutch naval strategy between the wars assumed that a country attacking the NEI (most likely Japan) would have a stronger navy than the RNeN and would also control the air. Submarines were to be used as a means of attacking the enemy fleet. Surface ships would make contact with the enemy ships and then deliberately withdraw across a patrol line of Dutch submarines, luring them within range of the submarines.³¹ For this patrol line to remain undetected by enemy ships or aircraft, the submarines would need to remain submerged for long periods of time. To operate submerged for any length of time while using the batteries would mean that the submarine would engage the enemy with partly depleted batteries, a circumstance to be avoided. Therefore, the schnorkel was needed for the submarine to remain submerged and to possess fully charged batteries.

The second benefit of the schnorkel was the ability to move faster while submerged, using the main engines, than was possible while on battery power.³² A submarine would often need to approach its target

30. In addition to the question of whether the schnorkel was first invented by the Italians or the Dutch, there is the matter of who in the RNeN deserves credit for the idea. Van den Pol, "Snuiver," attempts to answer this complicated question. The answer seems to be that Lieutenant Commander J. J. Wichers proposed a technically unfeasible plan involving a flexible air intake hose and, as we have seen, sought advice from two engineering branch officers in the NEI, including Lieutenant Commander (Engineer) J. C. Pappelendam. Though the Wichers plan seemed stalled in the NEI in 1933, Wichers inquired several times about the status of his idea. His perseverance in seeking credit for the invention seems likely to have brought the concept to the attention of the director of naval equipment, Rear Admiral A. Vos, and the minister of the navy. Although Wichers was not aware of it at the time, the operational schnorkel in Dutch service came into existence with the approval of these two officials and bearing the subsequent engineering modifications contributed by several engineers from the RNeN, especially van Pappelendam, the RNeN's design office, and the commissioning head engineer of the first submarine to have a schnorkel, *O-19*. Wichers thus seems responsible for bringing forth the idea and keeping the idea alive long enough for it to be implemented. Two years after Wichers retired from the navy in 1946 as a lieutenant commander, the RNeN belatedly recognized him as the inventor of the schnorkel by promoting him to honorary Commander.

31. Van den Pol, "Snuiver," 111.

32. Bezemer, *Verdreven*, 519.

while submerged, but ran the risk of being unable to catch the target due to the generally higher speed of surface vessels. Although submarine batteries at this time did not allow for very high speeds, the diesel engines would permit a submarine to attain speeds high enough to reposition itself for an attack. The issue of relative speed between a surface ship and an attacking submarine was one of the primary reasons Lieutenant Commander Wichers argued so strenuously for the installation of a schnorkel.³³

The third advantage was being able to ventilate the boat on the surface without having water come down the conning tower. In heavy seas, occasional waves would crash onto the conning tower, resulting in a wet interior. With the boat fully surfaced, the top of the schnorkel would be high enough above sea level so that waves and/or spray would not enter the air mast in any substantial amount.

Opponents of the schnorkel identified numerous drawbacks, some quite serious, that can be grouped into three categories. The first category can be termed controlling water and air intake into the boat. First, there was a serious risk that depth charges would collapse the opening in the hull for the schnorkel, resulting in the boat taking on water while submerged. To maintain watertight integrity, the number and size of openings in the hull should be minimized. Second, boats equipped with a schnorkel would need to maintain a very precise depth. The mast of the schnorkel was not very long, necessitating a shallow operating depth. If the boat rose closer to the surface as a result of heavy seas or an inexperienced crew, the boat might break the surface and lose the advantage of surprise. If the boat sank deeper than the length of the mast, the valve on top of the mast would close, causing the engines to draw air from the interior of the boat. The accidental closing of the air mast in turn led to the third drawback. The diesel engines required great amounts of air to operate. If the valve closed, the engines would draw air from within the boat, causing sharp changes in air pressure that would affect the crewmembers' ears.

The second category of drawbacks concerns enemy detection of the schnorkel-equipped boat. The installation of the schnorkel apparatus required two masts, one for air intake and the other for exhaust. The height of the two masts and the larger bridge structure compared to non-schnorkel-equipped boats would increase the likelihood of the boat being spotted while on the surface.

The final category of drawbacks concerns design and construction. First, the installation of schnorkel equipment would involve more time and greater cost than required for the construction of a submarine without a schnorkel. Second, the schnorkel equipment would add weight and take up internal space, both of which affected performance.

33. "Snorkel: An Old Salt," and Van den Pol, "Snuiver," 111.

The Dutch Schnorkel System Enters Service

Since the advantages of schnorkel use appeared to outweigh its disadvantages, the RNeN incorporated the new technology in the next class of submarines it built. The improved ventilation mast was first installed on the minelaying submarines *O-19* and *O-20*, which were commissioned in July and September 1939 respectively.³⁴ The air intake was retractable and power-driven, while the exhaust mast was fixed in place. The air intake was located aft of the periscopes and forward of the exhaust mast (Figure 3). Because of the relatively short length of the air intake pipe, the boat was barely submerged while schnorkeling, so it was imperative that accurate depth-keeping be maintained. On the *O-19* class, the valve on the air intake mast was only 1.5 meters (roughly four feet) above the surface of the water.³⁵ The exhaust pipe remained below the water line while schnorkeling. Maximum speed while schnorkeling was five to seven knots.³⁶ If the valve on the air intake mast closed due to unexpected submergence, the engines shut off automatically.

Once the *O-19* class entered service, several difficulties emerged with the schnorkel system. First, use of the diesel engines while submerged caused problems for other parts of the vessel. Engine vibration was so great that the periscopes were unusable. Oil fumes from the engine room were drawn throughout the boat. When the valve on the air intake closed, the engines created an under-pressure.³⁷

Second, the air mast was large enough in diameter that it created a wake of considerable length, three hundred to six hundred meters, even in calm seas.³⁸ This wake was quite noticeable at night and particularly so in a tropical sea where the phosphorescence of sea creatures made a wake even more obvious. Since the schnorkel-equipped boats were intended for the tropical waters of the NEI, the size of the wake was a significant concern.³⁹

Third, the exhaust mast proved to be too short. Originally, the exhaust mast remained submerged while schnorkeling and emitted exhaust fumes when the exhaust pressure exceeded the water pressure. This, however, caused problems with the engines. The remedy was to install a longer exhaust mast so the exhaust was discharged above the surface (Figure 4).

34. Ph.M. Bosscher, *De Koninklijke Marine in de Tweede Wereldoorlog*, vol. 1 (Franker: T. Wever, 1984), 151.

35. Van den Pol, "Snuiver," 116.

36. GB-110, 117, Institute of Maritime History.

37. GB-110, 118, Institute of Maritime History.

38. Van den Pol, "Snuiver," 116.

39. The Dutch judged the waters in the North Sea to be too rough for schnorkel use, so the schnorkel would have been used only in the NEI.

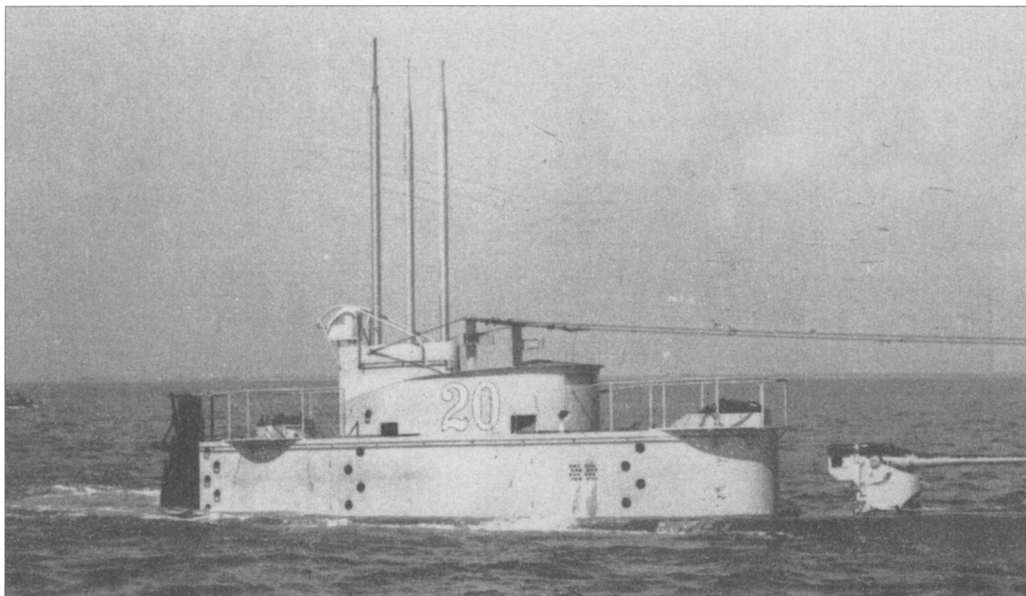


Figure 3. O-20 at sea, date and place of photograph unknown. The air intake mast is in the retracted position just aft of the periscopes. The exhaust mast is the dark protrusion at the rear of the bridge structure, and is the original length.

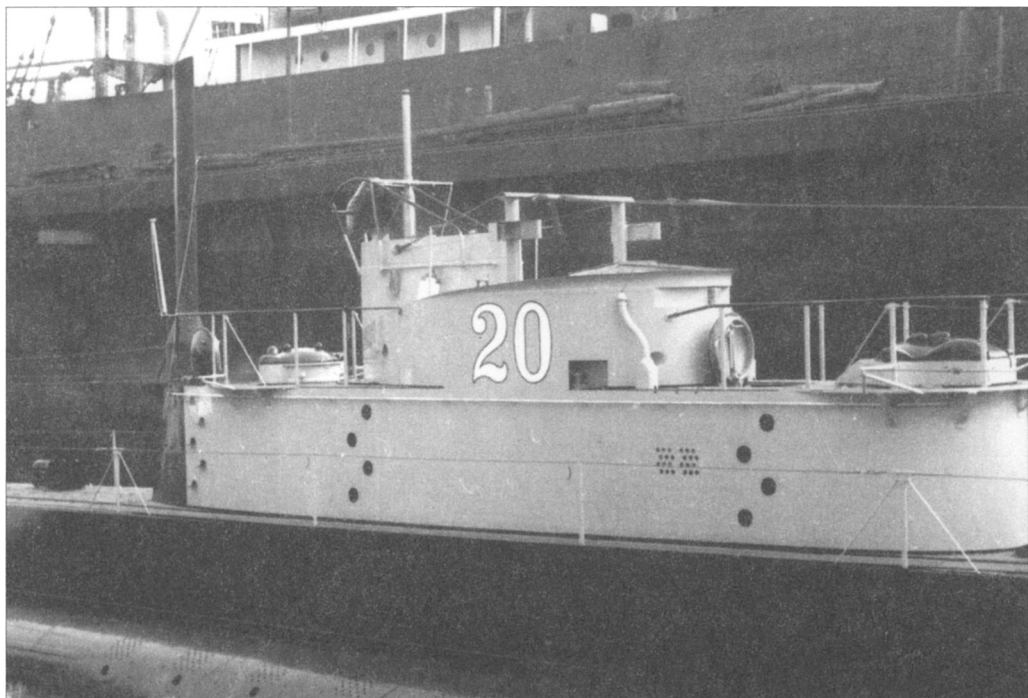


Figure 4. O-20 showing the longer version of the exhaust mast.

Fourth, a submarine using the schnorkel to cruise on its diesel engines could not simultaneously recharge its batteries.⁴⁰ On *O-19* and *O-20*, the minimum electrical current needed to charge the batteries required both engines to operate, one for propulsion and one to charge the batteries. However, the schnorkel mast was only large enough to provide sufficient air for one engine to operate at a time. Diesel engines that used less air were not available, and a larger-diameter air mast would increase the wake detection problem. The solution was to use the main electric motor for slow propulsion while using the one diesel engine for battery charging.

Finally, there was the issue of speed. A submarine using the schnorkel could make only five to seven knots. One of the main reasons for developing the schnorkel was to allow a submerged submarine to move fast enough so that it could maneuver to attack a surface ship when the target was not in a favorable position. A submarine using its schnorkel was still likely to be much slower than a surface ship and thus could attack only when circumstances presented a favorable opportunity.

Despite the problems detected with the schnorkel system in the *O-19* class, the schnorkel was incorporated into the design of the seven submarines of the *O-21* class. It was generally similar to the system in the *O-19* class, but featured several improvements.⁴¹ The exhaust mast was retractable instead of fixed, manually operated, and located at the aft end of the superstructure. The air intake mast was located aft of the periscopes toward the rear of the conning tower (Figures 5, 6). Improved ventilation arrangements prevented oil fumes from spreading throughout the submarine. Maximum speed using the schnorkel was now 8.5 knots. A further Dutch design under consideration in 1940 featured a combination intake and exhaust mast that was retractable and power-operated.⁴²

When the Germans invaded the Netherlands in May 1940, both *O-19* class submarines were in the NEI and the *O-21* class submarines being built in the Netherlands were in various stages of completion.⁴³ *O-21* and *O-22* were completed but had not finished their trials, *O-23* and *O-24* were almost complete and had not begun trials, *O-25* was launched but could not be evacuated, and *O-26* and *O-27* were not yet launched. The first four submarines of the class escaped to Britain, but the Germans captured the remainder in an incomplete and/or damaged condition.

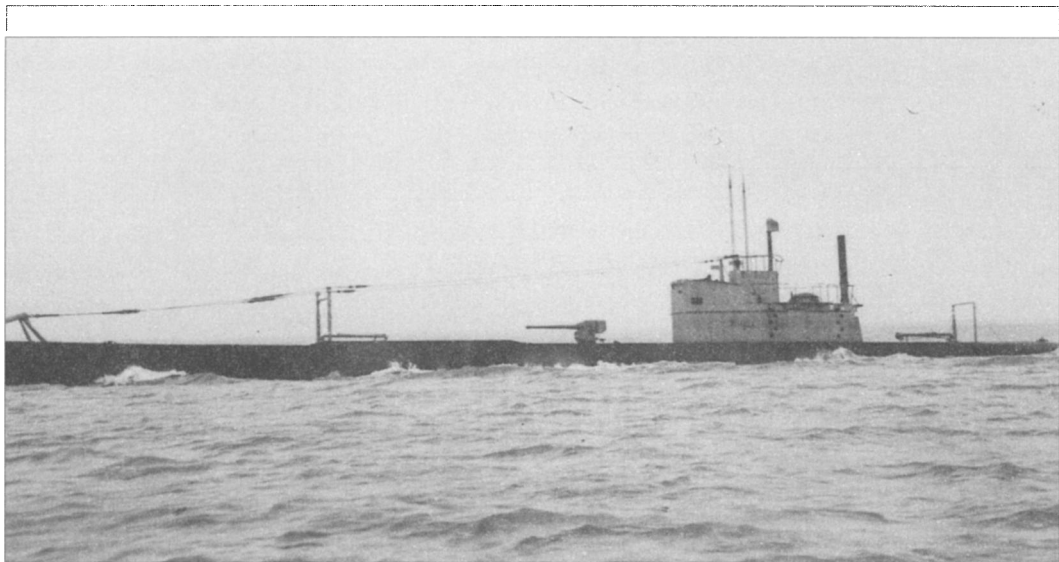
Although the RNeN equipped the submarines of the *O-19* and *O-21* classes with schnorkels as standard equipment, the drawbacks mentioned

40. GB-110, 118, Institute of Maritime History.

41. Eduard van den Pol, *Aspects of Submarines* (Den Helder: Koninklijke Instituut voor de Marine, 1992), 39.

42. Rössler, *The U-Boat*, 198.

43. Hubert V. Quispel, *The Job and the Tools* (Rotterdam: Wyt for Netherlands United Shipbuilding Bureau, 1960).



nent the schnorkel masts are in the ship's silhouette. Date and place of photograph are unknown, but it is likely to have been taken in 1940. The large numerals painted by the Dutch on the conning tower of each submarine before the war have been removed leaving just the much smaller letter/number combination on the bow, and both masts are still in place. The RN directed the RNeN to remove the schnorkel system once the O-21 and its three sisters were integrated into RN submarine flotillas.

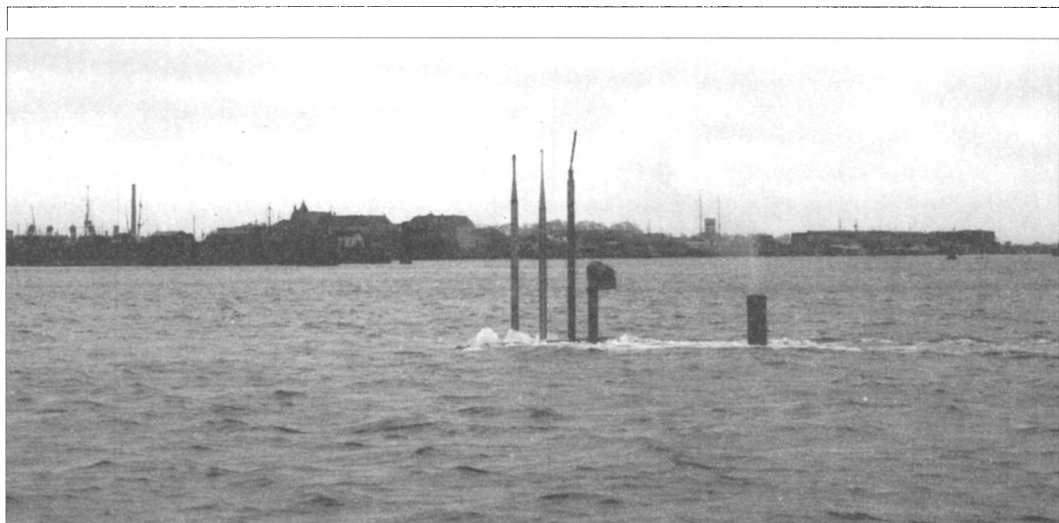


Figure 01. O-21 remaining in the Scheldt river, early 1940. The ventilation and exhaust masts are visible just aft of the periscopes. Note how just a few feet of each mast extends above the water.

above were serious enough that submarine unit commanders chose either to not use the schnorkel or to have it removed as at that time there was no operational need for a schnorkel. When the four submarines of the *O-21* class escaped to Great Britain in May 1940, the British Royal Navy (RN) wished to have the schnorkels removed. Why? According to Hubert V. Quispel, “[t]he way in which Allied submarines operated during the war did not present much opportunity for the use of this effective system of air supply; it was accordingly dismantled on the Netherlands boats to save weight.”⁴⁴ The British apparently felt that there was no tactical advantage to be gained by having the schnorkel since the Germans did not yet possess radar. If there was no advantage to be gained, then the extra risks to the submarine from the additional openings in the hull were not warranted. The commander of the Dutch submarine service in Britain, Commander C. Hellingman, concurred with the Royal Navy request as he considered the schnorkel to be “dangerous.”⁴⁵ The valve head atop the intake was removed in June 1940 to reduce the vessel’s silhouette. The mast was still used for ventilation when running on the surface in heavy weather until January 1942 when it was removed altogether.⁴⁶ The captain of the *O-21*, Lieutenant Commander J. F. van Dulm, regretted losing the air mast when the *O-21* was integrated into the Royal Navy because it had allowed the submarine to stay dry while running on the surface.⁴⁷

Wartime Careers of Dutch Schnorkel-Equipped Submarines

All of the six submarines from the two schnorkel-equipped classes that served in the RNeN during the war were actively deployed. *O-19* and *O-20* were stationed in the NEI from the time of their commissioning in 1939 and conducted frequent neutrality patrols between September 1939 and December 1941. This active service limited the opportunities for further experimentation with the schnorkel system, and the *O-20*’s crew did not train with the schnorkel. After consultation with the senior officer of the submarine flotilla to which both submarines belonged, Lieutenant Commander J. A. de Gelder, the schnorkel system was no longer used.⁴⁸

The *O-20* was lost on 19 December 1941 when a severe depth charging from the Japanese destroyer *Uranami* forced her to the surface off

44. *Ibid.*, 64.

45. Bezemer, *Verdreven*, 521.

46. GB-110, 119, Institute of Maritime History.

47. Jak P. Mallmann Showell, *The German Navy in World War Two* (Annapolis, Md.: Naval Institute Press, 1979), 49.

48. GB-110, 118, Institute of Maritime History.

the east coast of Malaya. All but seven of the crew escaped from the sinking ship and were picked up the next day by another Japanese destroyer. The wreck of the *O-20* was found in June 2002 by a group of Dutch and local divers approximately thirty-five miles northeast of Kota Bharu, Malaysia.⁴⁹

The *O-19* escaped the fall of the NEI in March 1942 and, except for refits, remained in the Far East for the duration of her career. The submarine used its schnorkel at least once during the war, to escape from Java to Ceylon via the Sapé Strait in March 1942.⁵⁰ At some point during her subsequent service, most likely during a 1943 refit in Britain, *O-19*'s schnorkel was removed in keeping with RN directives.⁵¹ She conducted numerous patrols from Ceylon into the NEI to lay mines and attack targets of opportunity afterwards. In late 1944 many of the British and Dutch submarines operating from Ceylon were transferred to Australia due to the shortage of targets in the Indian Ocean and the western portion of the NEI. While on a routine transport mission to the Philippines from Australia, the *O-19* grounded on Ladd's Reef in the South China Sea on 8 July 1945. The ship could not be freed so it was destroyed and the crew rescued by the submarine *USS Cod*.⁵²

The *O-21* class formed the backbone of the Dutch submarine force after the loss of many "K"-series submarines in the NEI and the rapid retirement of others that escaped to Australia or Ceylon. As mentioned above, the four schnorkel-equipped submarines that escaped from the Netherlands to Great Britain in May 1940 lost their schnorkels during the summer of 1940. The *O-22* was lost shortly thereafter in November 1940 in the North Sea off Norway, most likely to a mine.⁵³ The other three submarines survived the war after numerous combat patrols in the North Sea, Mediterranean Sea, and Indian Ocean. Beginning in mid-1940, they operated from Dundee, Scotland, as part of the Royal Navy's 9th Submarine Flotilla. This unit was unusual in that it contained British, Dutch, Free French, Polish, and Norwegian submarines, necessitating that daily orders be issued in five languages. The large size of these submarines made them somewhat unsuitable for the shallow North Sea, so in March 1941 the three remaining boats moved to Gibraltar and joined the 8th Submarine Flotilla that covered the eastern Atlantic Ocean and western Mediterranean Sea. In 1942 the boats eventually transferred to the 4th Submarine Flotilla at Colombo, Ceylon. By mid-1945, the trio had moved

49. Bram M. Otto, "Dutch Submarines," <http://www.dutchsubmarines.com>.

50. Bezemer, *Verdreven*, 267.

51. Eduard van den Pol, e-mail message to the author, 25 April 2003.

52. Otto, "Dutch Submarines."

53. H. M. Ort, *Hr. Ms. O-22: de onderzeeboot die in 1940 verloren ging en in 1993 werd teruggevonden* (Amsterdam: Van Soeren, 1995).

yet again, this time to the 8th Submarine Flotilla that was now at Fremantle in western Australia. All three ships achieved great success during the war, the most notable of which was *O-21*'s sinking of the German submarine *U-95* while returning to Gibraltar on 29 November 1941.⁵⁴

Because the RNeN was obliged to remove schnorkels from submarines operating with the RN, and because of the early loss of *O-20*, it appears that the only Dutch submarine to use the schnorkel on a combat patrol would have been *O-19*. Even this submarine was likely to have seldom used the schnorkel due to the lack of opportunity to train with it before the war, the submarine's assignment to antisubmarine training duties and refit periods during most of 1942, and subsequent removal of the schnorkel in early 1943. Thus, the *Kriegsmarine* would become the first navy to actually use the schnorkel on a sustained basis beginning with the Type VIIC submarine *U-264* in February 1944.

German Adaptation of Dutch Technology

When the German conquest of the Netherlands was completed, the *Kriegsmarine* began to assess the naval equipment captured from the RNeN. This included several damaged and/or incomplete vessels such as the destroyer *Gerard Callenburgh* and the submarines *O-25*, *O-26*, and *O-27*. These vessels were finished for later commission in the *Kriegsmarine* as the *ZH-1*, *UD-3*, *UD-4*, and *UD-5* respectively. A German naval engineer, Ulrich Gabler, inspected the *UD-4* (the former *O-26*) in 1941. After some tests of the schnorkel system, the *Kriegsmarine* in late 1941 ordered the schnorkel removed from all three ex-Dutch boats despite the objection of a senior naval construction official, Christoph Ashmoneit. Like the Dutch, the Germans considered the schnorkel to be unsuitable for submerged use in the rough weather in European waters. Its only benefit would be to ventilate the submarine on the surface, but as German submarines already possessed a suitable surface ventilation system, there was no need for the schnorkel.⁵⁵

In early 1943, rapidly rising submarine losses compelled the *Kriegsmarine* to reconsider the schnorkel.⁵⁶ Propulsion engineer Hellmuth

54. John D. Spek, "Hr. Ms. O-21," *Warship International*, 1966, 302-6, 316-17. For a detailed career of each Dutch submarine, see Otto, "Dutch Submarines." In addition, a three-volume operational history of the British submarine force during World War II includes descriptions of the patrols of the various Allied submarines that served with the RN. This rare document, *Naval Staff History Second World War. Submarines*, vols. 1-3, is held under the file number BR1736/52 by the Royal Naval Submarine Museum at Gosport, England (RNSM Gosport).

55. Rössler, *The U-Boat*, 198.

56. Kemp, *U-Boats Destroyed*.

Walter, who in October 1933 had proposed the use of ventilation tubes for submerged use of the main engines, wrote to Admiral Karl Dönitz in March 1943. Walter suggested the schnorkel be developed, an idea that Dönitz approved. Two members of Walter's staff, Ulrich Gabler and Heinrich Heep, then redesigned the Dutch schnorkel to adapt it to the rough waters of the Atlantic Ocean. They made use of the Dutch feature of a ball float that automatically closed when a rising wave threatened to introduce water into the air mast, but used the atmosphere of the entire submarine as a buffer to supply the engines when the air mast was closed.⁵⁷ The Germans also sought to interview the developer of the Italian schnorkel, Pericle Ferretti, in 1943. However, Ferretti had long ago retired from the Italian Navy to become a professor of engineering. He was warned that the Germans wanted to contact him so he assumed a new identity and went into hiding.⁵⁸

A successful test of the German version was conducted on the Type IIC submarine *U-58* just four months later in August 1943. Since the schnorkel was being added to submarines that were not designed for such equipment, retrofitting Type VII and IX submarines required that the schnorkel be a folding rather than a fixed or telescopic mechanism. The German schnorkel-equipped submarines still experienced some of the problems the Dutch encountered, such as a slow submerged speed of only six knots, vibrations that prevented the periscopes from being used, and the sudden under-pressure caused by the diesel engines running after the air intake valve had closed due to a wave.⁵⁹ Thus, a submarine using its schnorkel was both blind and deaf. Extended periods without fully surfacing also created a sanitation problem as food waste and other garbage could not be disposed of. While the schnorkel sometimes allowed a U-boat to escape destruction, it was not a popular device with U-boat personnel.⁶⁰

The deployment of schnorkel-equipped submarines beginning in February 1944 allowed the Kriegsmarine to introduce a new tactic in the Battle of the Atlantic. U-boats now had a reasonable chance to evade air patrols and survive long enough to inflict losses on Allied shipping, especially once (October 1944) the Germans invented a radar-absorbent covering for schnorkel heads that drastically reduced the reflection of the

57. Rössler, *The U-Boat*, 198.

58. Galuppini, "Una invenzione italiana," 31.

59. Robert C. Stern, *U-Boats in Action* (Carrollton, Texas: Squadron/Signal, 1977), 33. For clear drawings of both German wartime and generic postwar schnorkel systems, see Ulrich Gabler, *Submarine Design* (Koblenz: Bernard and Graefe, 1986), 72–76.

60. Herbert A. Werner, *Iron Coffins: A Personal Account of the German U-Boat Battles of World War II* (New York: Holt, Rinehart and Winston, 1969), 260–62, 265, 289.

schnorkel.⁶¹ The author of the official history of the Royal Navy during World War II, in writing about the schnorkel-equipped U-boat, states that:

As long as the U-boats were on the surface Coastal Command aircraft were able to strike against them with deadly effect; but once the "Schnorkel" had arrived, and the U-boats were able to remain submerged for much longer periods, the air patrols lost a good deal of their effectiveness; for the "Schnorkel" funnel was far more difficult to pick up by eye or by radar than the hull of a surfaced U-boat. The dangerous significance of this development, which threatened to restore to the enemy the initiative which he had been forced to surrender in the early spring of 1943, was not lost on the British authorities.⁶²

The deployment of schnorkel-equipped submarines was by itself not nearly enough to turn the tide of the war at sea, but it made the Royal Navy change its antisubmarine tactics and continue to develop its own schnorkel.

British Experimentation with Schnorkels

While the British required the Dutch to disable the schnorkel equipment on boats that reached Britain in May 1940, the British did not forget about the innovative system. By June 1942, the RN was considering the merits of the schnorkel and in July requested drawings and photographs of the schnorkel system from the RNeN.⁶³ The impetus for this investigation appears to be that if the Allies could develop radar capable of finding surfaced submarines, then it was likely that the Germans would eventually be able to do the same. German operation of radar from shore stations would prevent British submarines from operating in coastal waters. Thus British submarines needed a means to charge their batteries without surfacing.

A schnorkel that supplied air to either the main engines or to auxiliary engines for battery charging was needed. Initially, the RN considered experimenting with a "U"-class submarine due to the small engine size of that class.⁶⁴ Presumably the "U" class was selected over a class with larger engines because the volume of air required by its small engine could be satisfied by the size of the ventilation pipes being considered. By October 1942 the RN concluded that the success of the

61. Niestlé, "German Technical and Electronic Development," 445–46.

62. Roskill, *The War at Sea*, vol. 3, pt. 2, 68.

63. Assorted correspondence among high-ranking line and engineering officers during the period June–October 1942 concerning RN interest in fitting a schnorkel system to British submarines, file number A1942/066, RNSM Gosport.

64. A1942/066, RNSM Gosport.

schnorkel depended on how calm the sea was. Even moderate wave action would create three problems. First, the submarine would need to submerge deeper and sail faster in order to maintain proper depth. Second, the air intake pipe would need to be taller to prevent water from coming down into the boat. Third, all components of the schnorkel system would need to be stronger to withstand the force of the seas.

Even in calm seas, using a schnorkel had disadvantages.⁶⁵ A memo from the office of the Engineer-in-Chief lists several drawbacks including increased noise generated by a submerged submarine using its main engines. Presumably, enemy ships using hydrophones would detect the noise, and any sparks from the exhaust tube would be visible to lookouts. The schnorkel system would also weigh more, take up more space, and make submarines equipped with it more complicated to operate than conventional submarines. Running the main engines while submerged would increase the temperature and introduce pollutants into the air within the submarine. The risk of fire was also greater since the battery compartment could not be ventilated. These disadvantages were acknowledged by Admiral (Submarines) G. E. Creasy, but the need to evade enemy radar was seen as a greater priority.

Rear Admiral Creasy circulated a memo of 1 November 1944 explaining the apparent advantages and disadvantages of the schnorkel system to various RN units and offices, seeking their input and reaction.⁶⁶ By this time, the Germans had deployed schnorkel-equipped submarines with success, which the RN was aware of. In addition to the disadvantages mentioned in the previous paragraph, the memo listed several more. While using the main engines, the submarine's own sonar would be of reduced effectiveness. To prevent the schnorkeling submarine from being surprised at periscope depth, the RN would need to develop and field a radar/search receiver that could be used while all of the submarine but the radar and air intake was under water. The sense of safety that the schnorkel would provide might encourage commanding officers to remain submerged more often, thus limiting the offensive potential of the submarine. The Admiral (Submarines) concluded the memo with a plan for testing the schnorkel on one vessel from each of the most modern submarine classes ("S," "T," "U," and the soon-to-be-delivered "A"). He also proposed changing the name of the apparatus from "submerged dieseling," a term that reflects the Dutch term *getrimd dieselen*, to "snorting."

The first British submarine to be equipped with a schnorkel was the "T"-class submarine HMS *Truant*, which was modified between 2 March

65. A1942/066, RNSM Gosport.

66. Memo of 1 November 1944 from Admiral (Submarines) to the Secretary of the Admiralty concerning the RN's policy on using a schnorkel system on British submarines, file number A1945/45/003, RNSM Gosport.

and 5 May 1945.⁶⁷ The RN design differed from the Dutch version, necessarily so since the schnorkel was being fitted to a ship not originally designed for that equipment. The “snort” fitted to *Truant* combined both the air intake and exhaust tubes into a single mast with the exhaust tube venting several feet below the top of the air intake. The hydraulic mast was hinged and when not in use, was stowed on the deck on the port side of the submarine aft of the conning tower. After successful trials with *Truant*, the schnorkel was installed on the rest of the “T” class and also on the later units of the most recent “A” class.⁶⁸

Conclusion

The Royal Netherlands Navy faced a challenging strategic situation during the 1930s and early 1940s. As a minor power with a relatively small defense budget, the RNeN was obliged to defend the home country, scattered islands in the Caribbean Sea, Dutch Guiana, and the NEI. The submarine seemed like an affordable weapon that could inflict severe damage on an enemy fleet. To increase its combat effectiveness, a necessity given the importance of submarines in Dutch naval strategy for the NEI, a means had to be found to allow the submarine to remain submerged for a longer period of time. The Dutch initially tried simple ventilation masts that were raised while the submarine was submerged up to the conning tower, a procedure termed *getrimd dieselen*. In the mid-1930s, thanks to the ideas of Lieutenant Commander J. J. Wichers and the technical expertise of several designers and engineering officers, the RNeN created a working schnorkel that was installed in two classes of submarines comprising six vessels. Because of the German invasion of the Netherlands, the RNeN did not have the opportunity to further develop or deploy the schnorkel-equipped boats in combat situations. Three of the *O-21* class submarines under construction were captured, while the other four, which had escaped to Britain, had their schnorkels removed at the request of the RN. Of the two *O-19* class submarines stationed in the NEI, neither trained extensively with the schnorkel due to the operational demands placed upon them by neutrality patrols. *O-20* was lost just two weeks after the war in the Pacific began.

The Dutch schnorkel system stimulated advances in submarine technology in both the British Royal Navy and the German *Kriegsma-*

67. Paul J. Kemp, *The T-class Submarine: The Classic British Design* (Annapolis, Md.: Naval Institute Press, 1990), 121.

68. Kemp, *The T-class Submarine*, chapter 9, includes several photographs of “T”-class boats with a schnorkel, and gives the details of postwar trials and accidents involving the schnorkel on various British submarines during the late 1940s and early 1950s.

rine.⁶⁹ The *Kriegsmarine* was experiencing serious losses in submarines due to the Allies' use of radar to detect surfaced submarines. The Dutch schnorkel system captured in May 1940 was used as the basis for an improved German version that used the entire submarine's interior as a reserve air supply for occasions when the valve on top of the air intake mast closed. Would the Germans have eventually developed the schnorkel, even without obtaining a working system from the Dutch? This is certainly possible given that Hellmuth Walter had proposed the idea in 1933, and that Germany's ally Italy had already developed a working system. The acquisition of the Dutch system certainly speeded up the production of the German system so that the schnorkel, unlike so many other innovative German submarine technologies, was brought into active service before the end of the war. The Dutch system also prompted the Royal Navy to consider developing a schnorkel for British submarines; otherwise, the RN would have had to begin from scratch, which might have delayed its deployment well beyond the end of the war. In the Italian Navy, no submarines were equipped with a schnorkel in spite of the device being first invented by Pericle Ferretti in 1923.

While the RNeN was small compared to the major navies of the era, it had built several modern and capable ships just prior to the war.⁷⁰ It also had demonstrated technical capability with the development of not just the schnorkel but also a tri-axially stabilized twin 40mm antiaircraft gun made by Hazemeyer that was superior to anything of its kind in the world at the time.⁷¹ The Dutch had also developed a prototype fire-

69. Two other navies may have also been indirect beneficiaries of the Dutch schnorkel technology. The U.S. Navy installed a prototype schnorkel on an obsolete "R"-class submarine during World War II. See John D. Alden, *The Fleet Submarine in the United States Navy: A Design and Construction History* (Annapolis, Md.: Naval Institute Press, 1979), 91. Presumably, the U.S. Navy learned of the technology from its British allies. However, the U.S. Navy did not develop the technology until after the war because American submarines were so successful in the war against Japanese shipping that a schnorkel was not needed. The first submarine to be equipped with a schnorkel after the war was the *Tench*-class USS *Irex* (SS-482), which received the equipment in 1947 (Alden, *The Fleet Submarine*, 152). The Imperial Japanese Navy learned of the schnorkel in 1944 when a German submarine fitted with that equipment arrived at Singapore. The Japanese fitted schnorkels to the remainder of their submarine fleet by the end of the war and the *I-201* class boats were designed with a schnorkel. On this class, of which only three were completed before the end of the war, the schnorkel was connected to an auxiliary engine for battery charging and not to the main engines. See Norman Friedman, *Submarine Design and Development* (Annapolis, Md.: Naval Institute Press, 1984), 42.

70. Quispel, *The Job and the Tools*; and H. T. Lenton, *Royal Netherlands Navy* (Garden City, N.Y.: Doubleday, 1968).

71. Robert Gardiner, ed., *Conway's All the World's Fighting Ships, 1922-1946* (London: Conway Maritime Press, 1980), 386.

control radar system, had equipped their submarines with air conditioning before the U.S. Navy deployed the same technology, and commonly operated small floatplanes off a variety of warships including destroyers beginning in the 1920s.⁷² The schnorkel was one of several important naval technologies developed by the Dutch but it is most strongly associated with the Germans because of that country's widespread deployment of schnorkel-equipped U-boats during the later stages of the Battle of the Atlantic. This article seeks to give credit where credit is due, clarifying the important role of the Royal Netherlands Navy in developing and deploying the submarine schnorkel.

72. For the fire-control system, see Bezemer, *Verdreven*, 514–19. For air conditioning on submarines, see Pieter L. van Ewijk, "History of the Dutch Submarine Force," *Submarine Review*, July 1992, 78–85. For floatplanes on surface ships, see R. D. Layman, "Sparrows among the Hawks: Shipboard Aviation of the Smaller Navies, 1919–1939," *Warship International*, 1984, 138–57.