

**MEDICAL REPORT ON SNORKEL OPERATIONS  
OF  
USS AMBERJACK (SS-522)**

**Interim Report No. 1  
on  
Project NM-002-009  
(X-753, Sub.No.156)  
entitled  
"Field Study of the Effects of Snorkelling  
on Submarine Personnel"**

**The opinions and conclusions herein are those  
of the author, and do not necessarily reflect  
the official views of the U.S.Navy.**

**Reference may be made to this report in the  
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author, title, source, date and report number.**

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**RESTRICTED**

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## SUMMARY AND CONCLUSIONS

1. Medical observations were made aboard USS AMBERJACK during two periods of snorkelling, one lasting fifty-five and one-half hours and the other forty hours.

2. The fluctuation of pressure was usually one to two inches of mercury.

3. Sleep was undisturbed by snorkelling under these conditions. Wakening pain and redness of ear drums were caused during one period when, at the request of the medical officer, maximal pressure fluctuation was produced.

4. Aerotitis media was uncommon and the degree of inflammation was mild.

5. Ventilation of the boat during snorkelling was adequate.

6. Only limited predictions can be made concerning the effect of snorkelling on personnel. Some of the reasons are: (a) the period of snorkelling was short, (b) the seas were relatively calm, (c) snorkelling at all possible engine speeds was not done, (d) after engine shut-down the pressure was not rapidly returned to atmospheric, and (e) the patency of ear and sinus passages of AMBERJACK personnel may have been better or worse than in personnel of other submarines.

7. Adequate evaluation must be deferred until a time when the scope and duration of medical observations will not be limited by operational priorities, e.g. high speed submerged runs, operations with radar search planes.

## INTRODUCTION

In May 1945, German submarines with snorkels became available to the U. S. Navy for study. As a result the Bureau of Medicine and Surgery approved two projects which were formulated to study the effect on personnel of snorkelling. The title of the project assigned to the Naval Medical Research Institute was "Physiological Effect of Pressure Changes in Relation to Submarine Snorkel Operations", X-605 (Sub. No. 130); principal investigator Lt. Comdr. R. Hayter, (MC) USN. The title of the project assigned to the Naval Medical Research Laboratory was "Preliminary Study of the Effect of Snorkelling on Submarine Personnel", X-606 (Sub. No. 131); principal investigator Lt. Comdr. J. G. Bateman, (MC) USN.

### SIRAGO - SEPTEMBER 1945

In September 1945, at Portsmouth Naval Shipyard, a temporary snorkel was installed on SIRAGO (SS-485), a fleet type submarine. Dockside tests were conducted in which the snorkel valve was cycled manually. A vacuum which caused inefficient operation of the engines was not great enough to produce oxygen lack in personnel. When exhaust pressure was increased, there was slight inboard leakage of exhaust gas; analysis of compartment air revealed only a trace of carbon monoxide.

Manual cycling of the head valve produced greater fluctuation of pressure than would ordinarily have been encountered during snorkel operations at sea. As a result the incidence of aerotitis media was high; however, the inflammation was rarely severe.

In November 1945, Doctors Bateman and Hayter prepared a joint report titled "Observations made during Simulated Snorkel Operations carried out at Portsmouth Navy Yard aboard the USS SIRAGO (SS485) on 11, 12, and 13 September 1945".

**U-873 - FEBRUARY 1946**

In February 1946, sea trials were conducted on U-873, a German submarine with a float-type snorkel. The data were meager because the sea was calm and operational and maintenance difficulties prevented continuous snorkelling. Aerotitis media was common but it was usually mild. The highest incidence occurred among those who had colds or slept during snorkelling.

Smoke filled the engine room when the exhaust pressure was raised by increasing the depth of submergence of the submarine; the exhaust line and gaskets were in a poor state of repair. When the smoke became dense, the men in the engine room coughed violently and complained of sore eyes. The concentration of carbon monoxide in the engine room was so low that poisoning would have required an exposure of at least two to three hours. It was concluded that the limiting factor during simulated loss of depth control was the presence of irritating exhaust fumes in the engine room.

Since some of the men who had passed the 50-lb, recompression-chamber submarine selection test developed aerotitis media on the U-873, it appeared that the usual method of administration of the chamber test had been unsatisfactory for snorkelling selection. It was pointed out that better results might be obtained with a more rapid administration of pressure, in order that the rate might approach the rate encountered during snorkelling. Parenthetically, one might add that in order to obtain suitable men for snorkel boats, it may be necessary to adopt a chamber selection policy that would be stricter than the policy that was necessary during wartime when many men were needed for the rapidly expanding submarine fleet and fluctuation of pressure in the boats was insignificant.

In October 1946, Project No. X-606 (Sub. No. 131) was terminated and the Bureau of Medicine and Surgery approved Project No. X-753 (Sub. No. 156), subsequently numbered NM-002-009. Since the ENT specialist, Doctor H. L. Haines, had returned to civilian practice, he was employed under a Personal Service Contract to assist in the new project.



In January 1947, the final report on Project X-606 was published. It summarized the information obtained from interviews with German prisoners and from experiments on SIRAGO and presented in detail the data obtained on U-873.

In March 1947, Doctor Bateman was released from the Naval Service. Doctor Hayter was designated principal investigator of X-753 and was transferred from NMRI to the Staff of ComSubLant to study the medical aspects of snorkelling.

#### IREX - MAY 1947

In April and May 1947, dockside and underway tests were conducted on USS IREX (SS-482). During dockside tests the snorkel head-valve was cycled once a minute by means of a mechanism actuated with high-pressure air and controlled by a hand switch. An automatic vacuum cut-out safety device stopped the engines when the pressure in the boat was reduced to 23 in. Hg. This pressure was more or less arbitrarily chosen as one/harmful to personnel or engines. <sup>not</sup>

The time required to reach 23 in. depended on the number of engines in operation, the engine speed and the timing of the cycles. For example, when one engine ran at 550 RPM, one-minute cycles of head-valve open 10 seconds and shut 50 seconds caused the pressure in the boat to drop to 23 in. in five minutes; but when two engines ran at 720 RPM, cycles of 35 seconds open and 25 seconds shut caused the pressure to drop to 23 in. in two and one-half minutes.

The concentration of carbon monoxide and carbon dioxide in the engine room was measured during periods in which the exhaust pressure was increased by partly closing the snorkel exhaust valve. The concentration of carbon monoxide was always less than 0.001 percent. The highest concentration of carbon dioxide was 0.6 percent.

During underway tests, the lowest pressure (25.2 in.) was reached when two engines were running at 720 RPM and the sea was condition four. The tests were interrupted to permit alteration of the snorkel installation.



In August, IREX operated with search planes in the Key West area. The nature of the operations and materiel failures precluded satisfactory medical observations.

#### AMBERJACK OPERATIONAL DATA

USS AMBERJACK (SS-522) snorkelled fifty-five and one-half hours from 16 to 18 November and forty hours from 19 to 21 November 1947. During the latter period snorkelling was interrupted once for one and one-half hours and another time for four hours. Certain periods during which the engines obtained air from the snorkel were not included in the time given above, because for operational reasons the boat was held at a depth which kept the snorkel head-valve well above the reach of the waves. For example, during the night of 20 November, the depth was decreased in order to permit greater exposure of the radar mast; as a result the pressure did not vary, since the head-valve was constantly open.

During most of the operations, the snorkel induction mast was in the intermediate position. The keel depth was usually 57 to 59 feet. The sea condition was usually two and occasionally one to three. Propulsion was obtained from one engine at 550 RPM; when two engines were in operation, the speed was 700 RPM.

The pressure fluctuation was usually not more than 1 or 2 in. because (a) the seas were relatively calm; (b) only one engine was running during most of the operation; and (c) the planesmen being inexperienced, the diving officer tried to keep the boat at a depth that allowed only brief infrequent submergence of the head-valve.

The maximum vacuum occurred during loss of depth control (submergence of head valve). During phase one of the operation (16-18 Nov.), the maximum pressure reduction was 2.5 in. Hg., which is equivalent to an altitude of 2400 ft. During phase two (19-21 Nov.) the maximum reduction was 6.4 in. Hg., (6,400 ft). This was reached when the loss of depth control lasted long enough to cause stopping of the engines by the vacuum cut-out device, which was adjusted to be activated at 23.5 in. Hg.

## AEROTITIS MEDIA

The ears of the eighty persons aboard were examined with an otoscope on 18 November, at the end of the first period of snorkelling. Only five men had inflamed tympanic membranes and the inflammation was minimal. Of the five, two had colds and one had had ear pain during Escape Tank training and had not yet completed a course of radium therapy given to improve middle-ear ventilation. During the first period, everyone including the five men with aerotitis media, slept soundly.

During the last four hours of the second period of snorkelling, the depth was held at 59 to 61 feet in order to obtain the greater pressure fluctuation that occurs during frequent closing of the head valve. During two and one-half hours of the four-hour period, two engines ran at 700 RPM, and during one and one-half hours, one engine ran at 550 RPM. During the entire four-hour period, the fluctuations averaged 2 to 3 in. Hg. and the engine(s) shut down four times as a result of a drop of the boat pressure to approximately 24 in. Hg.

When the proper depth was regained after an engine shut-down, the pressure in the boat was gradually restored to atmospheric by manual cycling of the head-valve. The pressure returned to atmospheric in about three minutes instead of one minute, the time of return when the head-valve is left open.

Fourteen of twenty-two men sleeping during the four-hour period were awakened by discomfort in the ears but eight slept soundly. The pressure fluctuation did not affect sleep during the remainder of the second (40 hr.) period of snorkelling.

At the end of the second period, all the men were re-examined with the otoscope. Seven had ears whose drums were red. The redness was slightly greater than during the first period and, as might be expected, the degree of discomfort was correspondingly greater. Only two of the men had ear involvement during both periods of snorkelling and no one had sinus pain during either period. It is probable

that had the rate of increase of pressure after engine shut-down been uncontrolled, the incidence and severity of aerotitis media, particularly among those sleeping, would have been greater.

#### FATIGUE OF PLANESMEN AND PERISCOPE OFFICER.

Officers who stood diving and periscope watches were interviewed concerning the maximum period a watch could be efficiently stood on the periscope and planes during snorkelling. The consensus was that sixty minutes was the maximum and that probably thirty minutes would be the optimum.

#### VENTILATION

Ventilation of the ship during snorkelling was adequate. Results obtained by measurement of the dry and wet bulb temperatures with a psychrometer confirmed the feeling of comfort. A typical reading in the control room was: D.B. 76, W.B. 62, Rel. Humidity, 45. Another indication of the adequacy of the ventilation was the finding of only 0.3 percent carbon dioxide in the conning tower, a compartment in which there is little change of air.

There were no engine exhaust gases in the compartment of the AMBERJACK; its snorkel exhaust duct vented above the surface of the water.

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