Investigation of water stratification for the purpose of testing acoustic homing devices of torpedoes in the Puck Bay (Bay of Gdańsk) of the Baltic Sea for the German Navy (1935-1945)

Ingo Hennings

This contribution points out backgrounds of investigation of the fine structure of water stratification and the acoustic propagation within stratified sea-water from on board the research vessel of the Naval command (FdK) *Gauss*. In the Puck Bay, a part of the Bay of Gdańsk in the Baltic Sea, extensive water temperature measurements have been taken during the Second World War. By means of the national socialistic (NS) assumption of power in 1933 the Department of Navigation and Hydrography of the German Meteorological/Nautical Observatory (DSW) has been allocated to the Supreme Naval Command (OKM) in Berlin. Knowledge of acoustic propagation in the water column was important for the OKM for testing and application of acoustic homing devices of torpedoes. For that purpose the torpedo weapon place Hexengrund (Babie Doly) in the Puck Bay has been selected as testing area.

Erforschung der Wasserschichtung zum Zweck der Erprobung akustisch gelenkter Torpedos in der Putziger Wiek (Danziger Bucht) der Ostsee für die Kriegsmarine (1935-1945). Dieser Beitrag zeigt die Hintergründe der Erforschung des Feinaufbaus der Wasserschichtung und der Schallausbreitung im geschichteten Meerwasser mit dem Forschungsschiff der Kriegsmarine (FdK) *Gauss* auf. In der Putziger Wiek, einem Teil der Danziger Bucht in der Ostsee, wurden während des Zweiten Weltkrieges umfangreiche Wassertemperaturmessungen vorgenommen. Mit der nationalsozialistischen (NS) Machtübernahme im Jahr 1933 wurde die Abteilung Nautik und Hydrographie der Deutschen Seewarte (DSW) dem Oberkommando der Kriegsmarine (OKM) in Berlin zugeteilt. Dem OKM waren Kenntnisse der Schallausbreitung in der Wassersäule für die Erprobung und Anwendung von akustischen Zielsuchköpfen in Torpedos wichtig. Dazu diente als Erprobungsgebiet auch der Torpedowaffenplatz Hexengrund (Babie Doly) in der Putziger Wiek.

1. Introduction

After the Second World War a common collective silence has been developed in the new established and respectively re-founded marine research institutes in Germany if you are talking about National Socialism (NS). Often, a systematically work off of the state of affairs was blocked. A tendency of non-exposition with the recent political background predominated. Many of the involved re-engaged co-workers were not at all interested in being remembered on distinctly things. By all qualified appreciation for the works of involved physical, biological and chemical oceanographers the shadows in their biographies are to be impending often to fall into oblivion. Many of their so-called "quiet admirers" would prefer to keep silent about this time and their entanglements during the Third Reich. Hence it follows, that one takes it even not so exactly with the history. This condition still continued for decades after the end of the Second World War and in some cases also until today. The process of the exposition with the National Socialistic German epoch needs further clearing-up to confront the society with their political background. The critical examination of the "truthful reminiscent" must continue also in the future.

During the 28th session of the working group "History of Oceanography" of the German Society for Marine Research (DGM) e.V. on 9 October 2010 in Cuxhaven it was considered to be necessary to publish more about oceanographic research contents and its backgrounds under participation and leadership of the German Navy between 1935 and 1945. In particular, it also has been established during the meeting, that knowledge gaps and a lack of knowledge of work structures existing of this time (Lenz, personal communication 2010; Wegner, 2010). In this publication it will be reflected, how the Supreme Naval Command (OKM) has used oceanographic research for their purposes of underwater warfare.
First, a general citation of Spieß (1940, p. 199; English translation) stated:

> "Recently, the Meteorological/Nautical Observatory has been particularly turned towards the exploration of the Baltic Sea by investigation the physical and chemical condition of the water, the currents and water levels, and has been carried out different research explorations for this purpose."

The motivation for the oceanographic investigation activity which had been concealed behind the above cited statement will be presented in this article. Due to detailed hints in Krauß (2006), overlapping backgrounds and connections surrendered to this subject only after 61 years after the end of the Second World War. After publications, for example by Müller-Navarra (1993), Brosin (1995, 1999), Lenz (2002), Zarifi (2002), Lüdecke (2004), Krauß (2006) and Hennings (2010) concerning the subject "oceanography and navy", here a contribution about the reasons of the investigation of the fine structure of water stratification and the acoustic propagation within stratified sea-water in the Puck Bay (Putziger Wiek) for the navy will be presented. For the application of acoustic homing devices of torpedoes during underwater warfare the knowledge of acoustic propagation within the water column itself is necessary. Most of the oceanographic observation

material of the Puck Bay was annihilated at the destruction of the German Meteorological/Nautical Observatory in Hamburg during spring 1945 (Böhnecke et al., 1948).

What effects and consequences of such kind of underwater warfare could be result in for the "responsible persons" was obvious after the end of the Second World War. The First Lord of Admiralty Karl Dönitz (1891-1980), Commander-in-Chief of the German Navy and concurrently Commander-in-Chief of the submarines during the Second World War, was made the serious reproach of "scuttling of hostile merchant ships without warning" at the International Military Tribunal in Nürnberg, Germany, during October 1945. However, this reproach has been dropped afterwards over the course of the accusation, which has Dönitz certainly be kept from the death penalty (Der Spiegel, 1961; Sandhofer, 1967; Tayler, 1996). The scuttling of hostile warships and especially merchant ships predominantly took place by underwater shooting off of torpedoes from on board submarines of the German Navy.

2. Oceanographic observations in the Puck Bay

Hints of maritime defense studies in the representation of German oceanographic research contents and results between 1939 and 1946 published by Böhnecke et al. (1948) are missing extensively. A summary of observation results concerning the investigation of the sea bed of the Baltic Sea during seven research expeditions of the German Meteorological/Nautical Observatory (DSW) between 1937 and 1939 has been published by Pratje (1948). Already in summer 1939 the hydrographic and chemical condition of the Baltic Sea was investigated with the research vessel *Triton* (Wattenberg, 1940). From 1941 the DSW started systematically oceanographic investigations in the Baltic Sea and especially in the Puck Bay (Putziger Wiek), a part of the Bay of Gdańsk (Danziger Bucht), with the research vessel *Gauss* (*Gauss II* ex *Bacchus*). Böhnecke et al. (1948, p. 81; English translation) reported:

> "These works served for investigation of the fine structure of water stratification and the question of acoustic propagation in stratified sea water. In the German Bight and at the Norwegian coast also such special investigations have been carried out with the Naval Observatory."

Three ships have been used by the DSW at the first hydrographic investigation of the Puck Bay which result almost in a synoptically survey of this sea area. The measurements taken from on board the research vessel *Gauss* and the escorting vessels have been processed, but are mostly still unpublished (Böhnecke et al., 1948). Almost the total observation material was annihilated due to the bombing and the following burning of the building of the DSW in Hamburg during the night from 8th to 9th April 1945. In Wegner (1980, p. 14; English translation) it is said:

> "Besides the nautical-technical works (device tests, gyroscope experiments, position-finding tests) Prof. Kalle [1898-1975] carried out also acoustic propagation and thermocline investigations. With that activities „Gauss" covered the research part, which today is handled by the [Federal Armed Forces] Underwater Acoustics and Marine Geophysics Research Institute (FWG) in Kiel with the WFS [defense research ship] „Planet"."

For updating it should be mentioned that the FWG was integrated into the Bundeswehr (Federal Armed Forces) Technical Center for Ships and Naval Weapons (WTD 71) in Eckernförde on 1 February 2009 and is called today Bundeswehr (Federal Armed Forces) Technical Center for Ships and Naval Weapons, Maritime Technology and Research (WTD 71) (Eckernförde).

On 1 December 1930 Dr. Kurt Kalle started his marine chemical works as an assistant of the German Scientific Commission for Marine Research (Deutsche Wissenschaftliche Kommission für Meeresforschung (DWK)) at the DSW. In the biography of Kurt Kalle (Weichart & Weichart, 1975; Weichart, 1986) it is mentioned that during the Second World War he must to be occupied with physical oceanographic questions to a great extent. During summer 1943 the main building of the DSW in Hamburg was destroyed (Weichart, 2010). Therefore, first the marine chemical group has been transferred to the east of the Greater German Reich to Gdynia (Gotenhafen) which was relatively safety at this time and later on at the end of the Second World War to Ahrensburg nearby Hamburg (Weichart, 2010). It may be assumed that the outsourcing of the marine chemical group with K. Kalle took place to Gdynia not without a certain further intention (see section 3).

The physical behavior of the acoustic velocity in sea water with regard to density anomalies and acoustic thermoclines has been pointed out in Kalle (1942a), by taking corresponding values of the acoustic velocities from the so called "alignment tables" ("Fluchtentafeln") published by Kalle (1941). These investigations showed that density anomalies should not be necessarily identical with acoustic thermoclines, but both phenomena can developing totally independently in different deep water layers (Kalle, 1942a). Consequently, the determination of the horizontal acoustic velocity was of most importance for the OKM, because the acoustic refraction is effective in horizontally direction, which leads to unexpected propagation phenomena within the water. Due to the fine structure of water stratification and possibly developing of internal waves, variations of the refraction index by reflection arise (Brekhovskikh & Lysanov, 1991). Subsequently, the interferences caused by the different phases of the acoustic transmission paths will change and leading to acoustic transmission fluctuations. In dependence of stratification within the water column so called "acoustically dead zones" could occur.

The connection of these oceanographic works with the requirements and necessities of the Navy remains vague for the present even if results of oceanographic measurements in the Puck Bay have been published during the Second World War and later on (Kalle, 1942b; Neumann, 1944; Thorade, 1945; Neumann, 1949 & Kalle, 1953). In Kalle (1942b, p. 384; English translation) it is said solely:

> "Due to a special question just the proof and explanation of extreme short-periodic thermal fluctuations within the water mass, which we would like to denote as "thermal disturbance" ["thermische Unruhe"] of the ocean, was of an essential interest, therefore, a suitable instrumental aid must be looked for. By constructing the "streak measuring device" ["Schlieren-messer"] depending on thermo-electric basis, the author [Kalle] achieved this aim."

Also here, the meaning of the "special question" of the above citation is not clear. For investigation of near-surface thermal stratifications in the ocean the *"Dolphin"* has been developed after the Second World War in Germany (Joseph, 1962).

On 28 August 1942 the influence of a dived submarine on the thermocline has been measured from on board the *Gauss* in a water depth of 7.5 m in the Gdańsk Deep (54° 46,9' N, 18° 49,4' E). Kalle (1942b, p. 386; English translation) wrote:

> "During this condition [compensated character of the temperature variation], suddenly a submarine dives nearby the drifting observation ship [*Gauss*], abeam of 150 m. About 1 minute later the reaction is shown in 7.5 m depth in form of a sharp marked heat peak of some tenth degree and about 2 minutes duration, followed by a similar, already weaker marked heat increase 5 minutes later."

It is assumed that during these measurements the diving of a submarine close by the *Gauss* has not been an accidental and unwanted event.

The Bay of Gdańsk (Gulf of Gdańsk/Danziger Bucht/ Zatoka Gdańska) with the Puck Bay (Putziger Wiek/ Zatoka Puck) in the Baltic Sea is shown in Figure 1 (Hennings et al., 2003). The represented Hel Peninsula (Halbinsel Hela/ Mierzela Helska) is a spit with a length of 34 km and a width between 200 m and 3 km which separates the Puck Bay from the Baltic Sea. Southwesterly from the steep slope of Hel the bathymetry of the Puck Bay is characterized by a hollow with a water depth greater than 50 m. A Landsat satellite image of the Puck Bay acquired in the year 2000 is presented in Figure 2. The position of the ruin of the building of the torpedo test facility (shooting range) Hexengrund (Babie Doły) northerly of Gdynia (see section 3) is recognizable as a small bright point in the shallow coastal water of the satellite image. Also the shallow sea areas (blue) are distinctly visible in the satellite image caused by bottom reflection of the sea bed. A flat sand bank called gull reef (Möwenriff/Ryf Mew) has been arosen between Rewa Cape and Kuźnica (Neumann, 1944).

Later on, Kalle (1953) shows, how the measurements have been carried out from on board the *Gauss* during the years 1942-1944 to demonstrate the dynamical behavior of internal waves within the vertical water column. By means of an extensively distributed number of simultaneously temperature measurements the spatial dependence of these waves has been recorded. The research vessel of

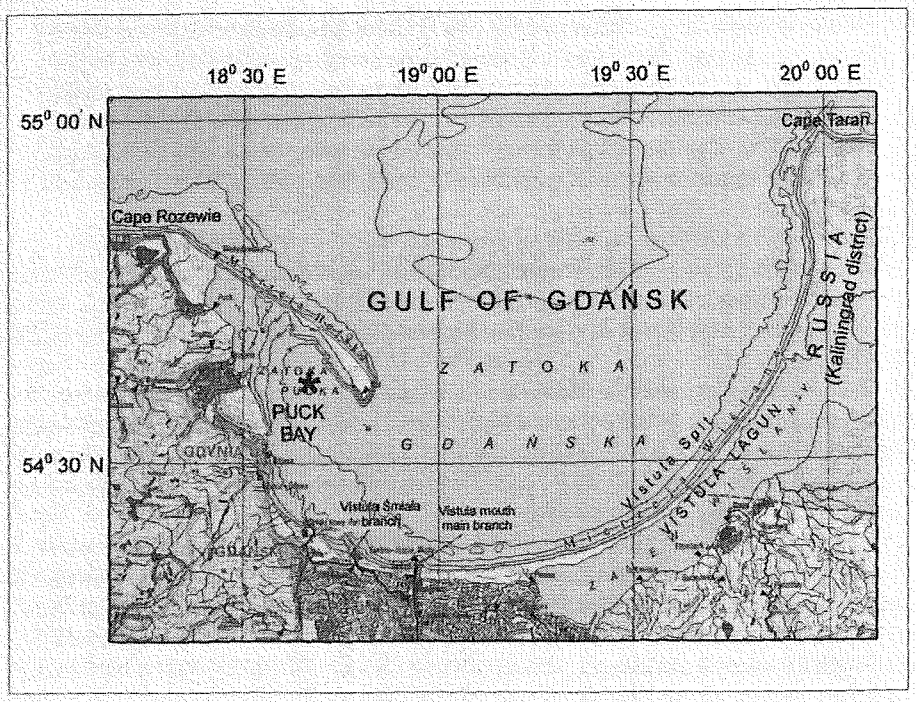


Figure 1: Bathymetric chart of the Bay of Gdańsk (Gulf of Gdansk/Danziger Bucht/ Zatoka Gdańska) with the Puck Bay (Putziger Wiek) in the Baltic Sea (Hennings et al., 2003). The star in the Puck Bay indicates the position of the FdK *Gauss* on 14 September 1943, where the measurements shown in Fig. 5 have been carried out.

the Naval Command (FdK) *Gauss*, where from on board such measurements have been carried out, is shown in Figure 3 (Wegner, 1980). The arrangement of the individual temperature sensors which are attached on board the *Gauss* by means of spreaders is presented in Figure 4. The distribution of the individual temperature sensors, numbered from No. 1 to No. 9, is indicated in Fig. 4 (Kalle, 1953). One example of a measurement series during pilot tests in the Puck Bay in summer 1943 is shown in Figures 5a-b. Kalle (1953, p. 168; English translation) analyzed this observation as follows:

> "According to this recording there is no doubt that this is a propagating wave. The individual peaks in the record make them belonging to one another so clearly that the present time difference between them can be only explained in that way. Due to double measurements in the depths of 26 [Fig. 5a] and 28 m [Fig. 5b] this state still has come out true. During this

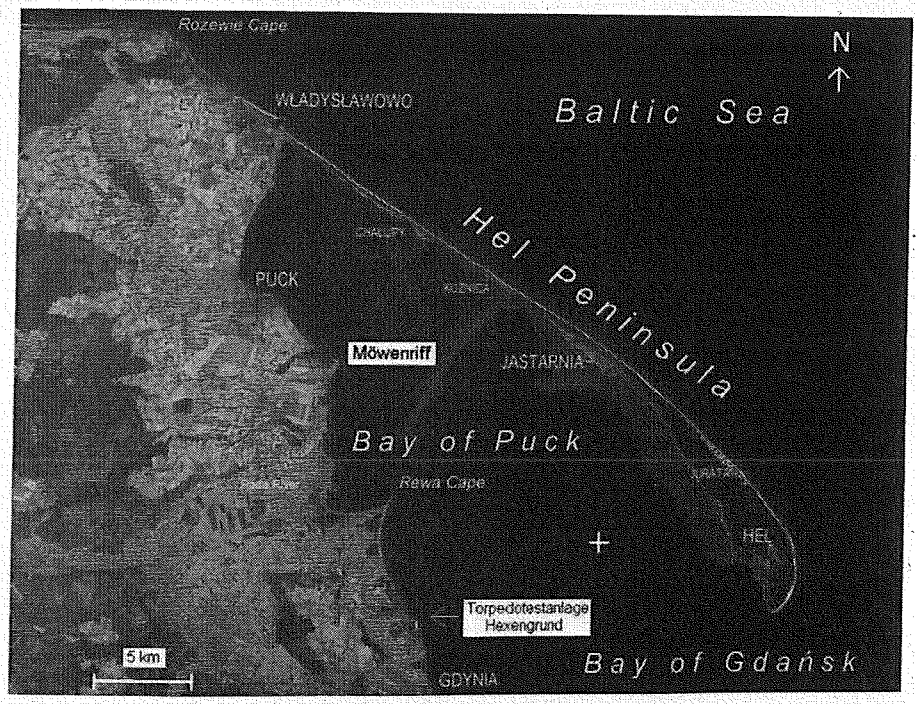


Figure 2: Landsat satellite image of the Puck Bay (Putziger Wiek) acquired in the year 2000 with the position of the ruin of the building of the torpedo test facility (shooting range) Hexengrund (Babie Doly) located northerly of Gdynia (Gotenhafen) (see also Fig. 7). The indicated cross in the Puck Bay denotes the position of the *Gauss* on 14 September 1943, where the measurements shown in Fig. 5 have been carried out.

> investigation the individual sensors are also placed as yet at the corners like an experimental ship circumscribed long extended square of 51 m length and 12 m width and that, four in each case, in the depth of 26 and 28 m within the thermocline. Comparing the recordings of the four behind with the four in front placed a corresponding time delay of 2.5 minutes has been observed. From this result the wave propagation velocity of 33 cm/sec has been calculated. At the same station a similar measurement some hours before has been obtained in the depth of 30 m and results in a pronounced wave with a period of 6 minutes (Fig. 37 [in Kalle, 1953]) with the same time delay, so that the related wave length should be determined to 125 m."

Simultaneously to the measurements from on board the *Gauss* variations of the sea level in the Puck Bay were investigated (Neumann, 1944). To separate period-

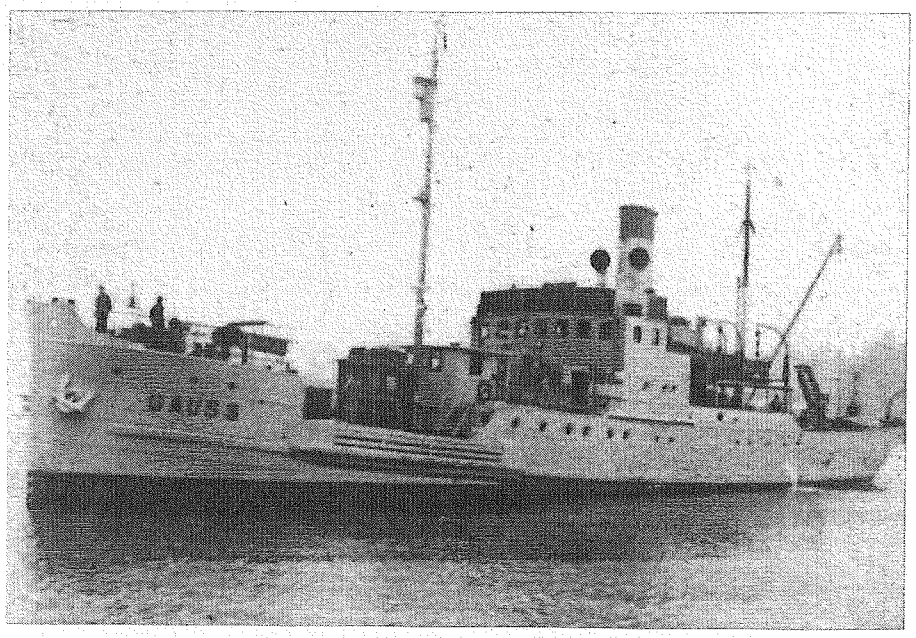
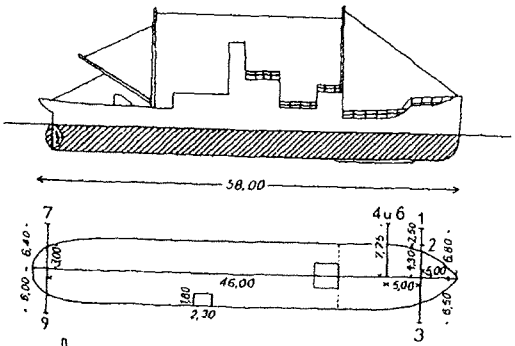


Figure 3: The research vessel of the Navy (FdK) *Gauss* (Wegner, 1980).

ical and none periodical parts of the variation and to explain their source the registrations of the water levels have been carried out at the three water level gauges Heisternest (Jastarnia), Hel (Hela) and Zoppot (Sopot), 5 km southerly of Gotenhafen (Gdynia) (see Fig. 2 and Figure in Neumann (1944)). Due to these measurements the basic oscillation of the Puck Bay has a period of T = 1.92 hours and sea level heights between 25 cm and 30 cm have been observed. According to the theory and verified by measurements of sea level variations one result was that the torpedo track from Hexengrund to Heisternest run parallel to the position of the node of oscillation of the first harmonic (see also section 3). Thus in direction of the node the first harmonic was quite not recognizable and consequently also no water level variations have been observed which was not unfavorably for the testing of torpedoes.

3. Torpedo test facility Hexengrund

When on 1 September 1939 the Greater German Reich which was governed by the National Socialism kindled the Second World War in Europe through the aggressive war towards Poland against international law the sudden attack of the



Nr. 1	5,00 m hinter dem Steven,	6,80 m backbord.	Schlierenmesser
Nr. 2	5,00 m hinter dem Steven,	4,30 m backbord.	Schlierenmesser
Nr. 3	5,00 m hinter dem Steven,	6,50 m steuerbord.	Schlierenmesser
Nr. 4	10,00 m hinter dem Steven,	7,75 m backbord.	Schlierenmesser
Nr. 6	mit Nr. 4 kombiniert,		Gradientmesser
Nr. 7	56,00 m hinter dem Steven,	6,40 m backbord.	Schlierenmesser
Nr. 9	56,00 m hinter dem Steven,	6,00 m steuerbord.	Schlierenmesser

Figure 4: Arrangement of the individual temperature sensors numbered from No. 1 to No. 9 which are attached on board the *Gauss* by means of spreaders (Kalle, 1953).

German Navy on Polish waters, ports and coasts ended on 7 October 1939. The torpedo test facility Hexengrund, northerly of the district Hexengrund (Babie Doly) of Gotenhafen (Gdynia) at the Puck Bay (see Fig. 2), has been newly established officially as a branch office by the German air force on 2 April 1942. Within this facility the testing and improving of aircraft torpedoes with its dropping equipment have been pursued. Nearly until the end of the war in April 1945 the facility was used. An undated air photo acquired in the 1940's of the torpedo test facility Hexengrund with the building of the shooting range and the torpedo recovery boat harbor is shown in Figure 6. The test torpedoes have been mostly launched or dropped in the direction to Heisternest (Jastarnia) of the peninsula Hela (Hel) (see Fig. 2). Also all new torpedoes for the German submarines, which sailed from Gotenhafen, have been checked before their final operation. After finishing their first testing of torpedoes in the Bay of Gdańsk some of the German Navy raiders sailed from Gotenhafen directly to their operational areas. An air photo acquired on 5 July 2007 of the ruin of the building of the torpedo test facility Hexengrund (shooting range) and remnants of the foundation of the torpedo recovery boat harbor is presented in Figure 7. The ruin of the building can be identified as a small bright point in Fig. 2. The facility was equipped with two torpedo shooting shafts of 1.5 m width and 4 m depth. Between two small buildings in the

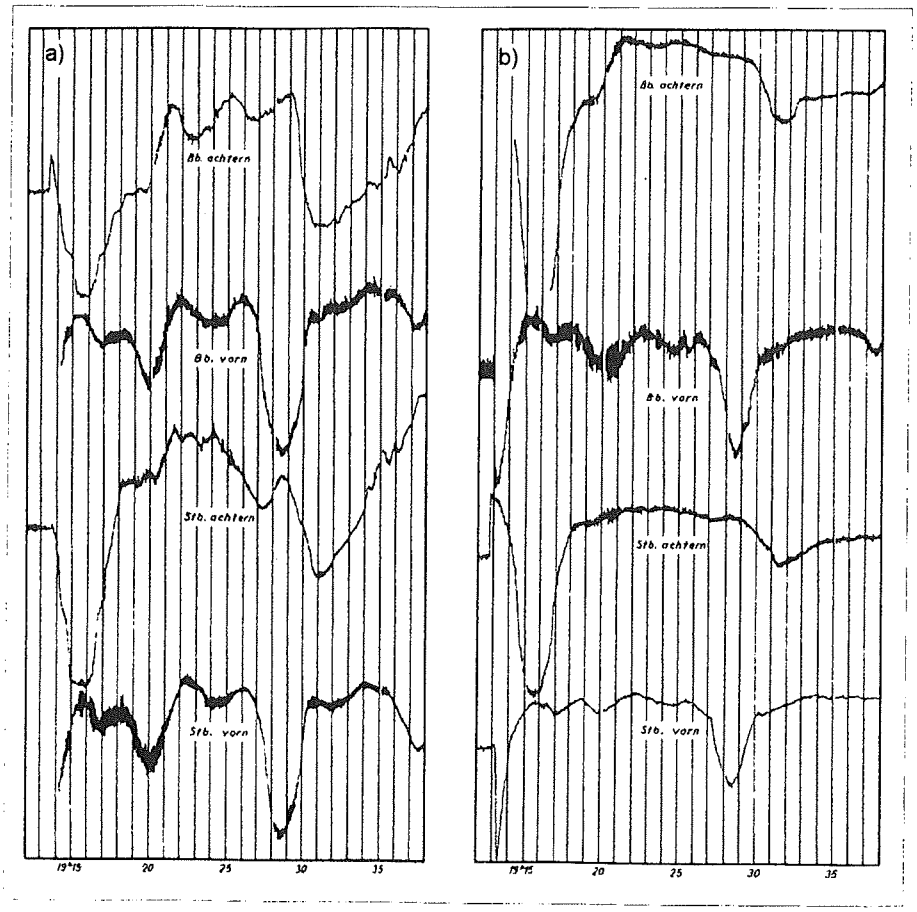


Figure 5: Temperature distribution in different water depths measured from on board FdK *Gauss* at different positions on the ship in the Puck Bay (Putziger Wiek) according to Kalle (1953); experiment 3, 14 September 1943, 19:12-19:38 local time, station 66, 54° 37.4' N, 18° 40.2' E, sea state 1-2, sensitivity inconsistent (tellurium-platinum-experimental-thermal elements), scale 1:2.3; a) water depth 26 m: port astern (Bb. achtern), port forward (Bb. vorn), starboard astern (Stb. achtern), and starboard forward (Stb. vorn); b) water depth 28 m: port astern (Bb. achtern), port forward (Bb. vorn), starboard astern (Stb. achtern), and starboard forward (Stb. vorn).

Puck Bay a net was stretched with which the launched torpedoes have been captured again.

For completion it is added here, that during 1941/42 a second branch office of the naval test facility (Marineversuchsanstalt) Eckernförde has been established at the Tollensesee nearby Neubrandenburg, Mecklenburg-Western Pomera-

nia. At the same time (1942) this department was also Industry Test Facility, Neubrandenburg (IVN) of the OKM, Office of Torpedo Weapon. Since October 1943 the branch office was called Torpedo Test Facility (Torpedoversuchsanstalt, TVA) Eckernförde, Department Neubrandenburg. The main field of attention in the development activities of this branch office covered general basic investigations, the torpedo steering, propulsion and ignition devices of the new acoustic torpedoes. In addition, general development tasks in the field of torpedo dynamics have been carried out.

In order to illustrate the requirements of the OKM concerning the torpedo sonar, it is necessary to give an inside into the state of the "defense technology" at this time to show distinctly the relation to the oceanographic research work at sea (see section 2). Concrete hints about backgrounds and connections of oceanographers for defense scientific research of the Navy in the Puck Bay can be derived from outlines published by Krauß (2006). He reported that the TVA Eckernförde was not suitable for investigations of torpedoes with acoustic homing devices like the type G7es due to physical reasons regarding the Bight of Eckernförde. Thereupon, the department Gotenhafen of the TVA has been exclusively dedicated to solve the problem of reducing the acoustic background noise. Acoustic background noise or ambient noise (Urick, 1975) is that part of transmitted waves by the active acoustic homing device of the torpedo, which is backscattered by the water body itself, from the sea surface and sea bottom, respectively. Disturbing factors from the sea surface to the sea bottom are: gas inclusions, fishes, water constituents, for example phytoplankton, pollution, salt streaks, sea state, air bubbles, different sea floor vegetation, different sediments, bed forms, stones, wrecks, and other objects. As a final result the torpedo G7es *"Falcon"* (T IV) has been available for operation against merchant vessels during late autumn 1942. A larger power of the torpedo implies generally also enhanced sound. But self-generated sound must be avoided because the acoustic signature ("akustische Verratsreichweite") has not to be growing up and the function of the homing device has not to be hampered.

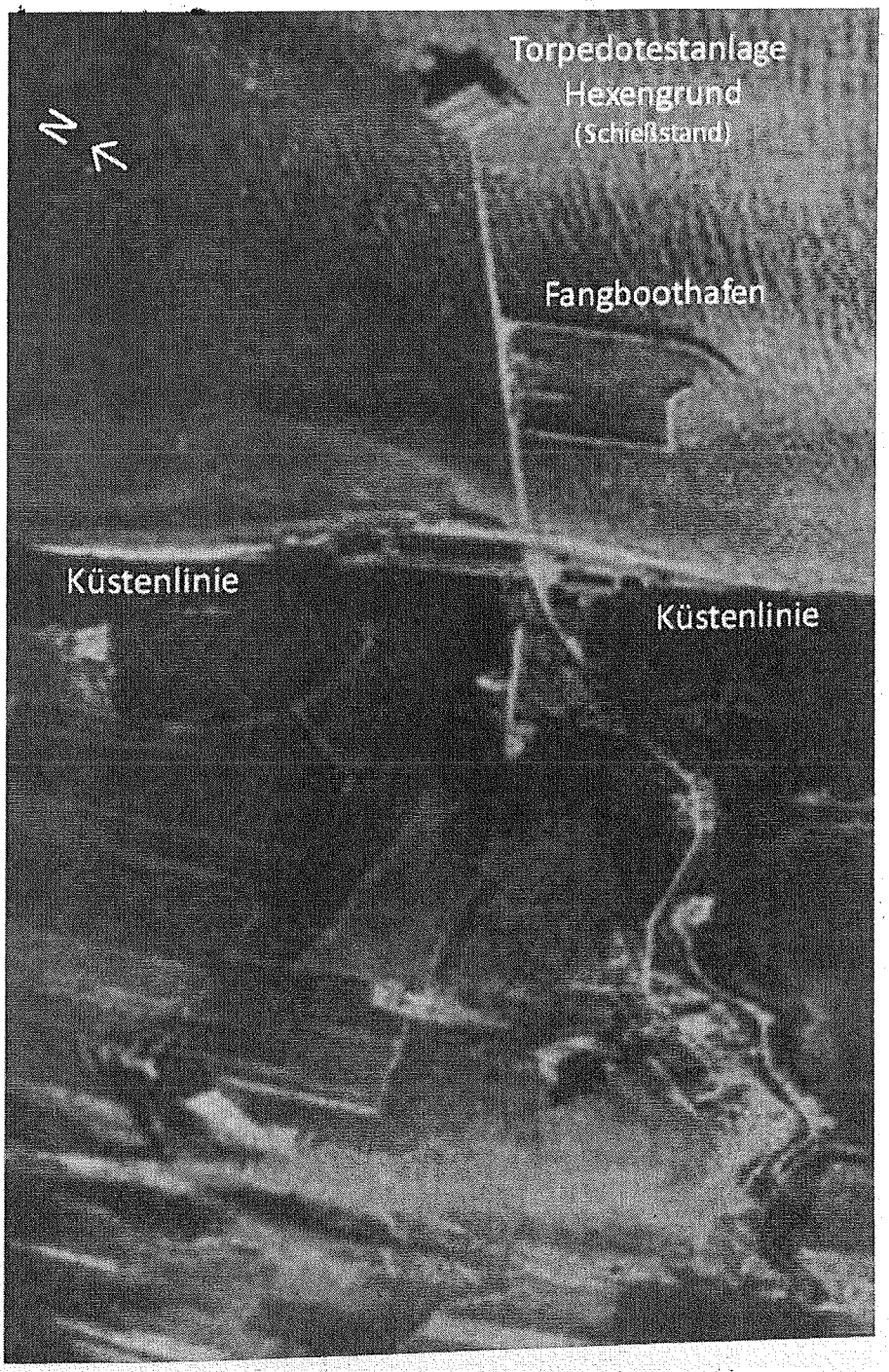
After first firing tests at the shooting range in Gotenhafen, which was not very satisfactory due to an unbalance of the torpedo, the first test at the front took place with six submarines during February/March 1943. For want of tube security of the ignition pistol the operation was restricted to the stern tube. After some technical modifications, like the expansion of the arming range, the *"Falcon"* was available for the general service at the front on 1 July 1943 (Krauß, 2006). In the meantime the whole North Atlantic became under Allied air sovereignty. It followed a reinforced securing of the Allied convoys and 41 German submarines were scuttled during May 1943. These occurrences during the service at the front compelled Dönitz to demand the succession torpedo *"Wren"* G7es (T V) against fast anti-submarine (A/S) ships under increased degree of urgency on 1 October 1943. The date could be moved up on 1 August 1943 due to special authorization of the armaments minister and without further carefully tests. Except of a higher velocity this torpedo should also possess a non-contact firing unit because of flat-bottomed targets and the available minimum distance of the torpedo path from the

surface due to avoid acoustic background noise, only one impact fuse has become not into question. To solve the last mentioned problem was the most difficult one during the development process and has not been solved completely due to multitude of misfires. The *"Wren"* was a homing torpedo type which could be fired off from any position out of the submarine against the "enemy" after a specified migration distance and searching the target due to propeller noise of the hostile ship itself. Because of the short arming range the submarine must go down to the depth after the shot immediately thereby the success-control of the score impact was restricted. On 1 August 1943, 80 T V torpedoes had been at disposal for operation (Krauß, 2006). The tests of the homing torpedoes have been carried out from on board *U 970*, a type VIIC submarine, from 9 October to 9 December 1943. At this time the submarine belonged to the 5th training flotilla in Kiel. From the middle of 1943 to the end of the war on 8 May 1945 a total of about 5000 torpedoes had been shot off.

While the principal task of the TVA-Gotenhafen should be kept for further testing and improving the *"Wren"* (T V), plenty of additional specialists have been transferred from the TVA to the test facilities of the Navy bases to repair the meanwhile arising defects. Not before 1945 again a push in the development process at the TVA-Gotenhafen has been expected (Krauß, 2006). It meant the further development on the *"Wren 2"* (T XI) with an improved control system and it should not be disturbed by dragged noisemakers as easy as the T V. Principally, this torpedo has been scheduled for the equipment of the new submarines of type XXI. About 500 torpedoes equipped with homing devices had been shot off until the end of the Second World War.

How intensive the development of different test types predominantly of acoustic homing torpedoes during the second half of the Second World War was will be presented in the following. The G7es has been used manifold for test torpedoes (Rössler, 2005). Thus the torpedo type *"Lark"*, developed by the Allgemeine Elektricitäts-Gesellschaft (AEG), possessed a passive homing device with a remote controlled directional microphone, a swiveling magneto-strictive microphone with a well-focused directional characteristic, which was connected with the submarine by a 1.2 mm strong wire. Therefore, the bearing of the target and the steering of the torpedo were possible up to a range of 6000 m. The steering wire consisted of 0.45 mm hard copper with plastic-isolation (igelit) and run through the hollow propeller axis out of the torpedo. This torpedo constituted the forerunner of the wire-steered torpedo *"DM2"* which was established by the West German Navy after the war. The torpedo type *"Vulture"*, developed by the compa-

Figure 6: Undated air photo acquired in the 1940's of the torpedo test facility Hexengrund (Babie Doly) with the building of the shooting range (Torpedotestanlage Hexengrund (Schießstand)) and the torpedo recovery boat harbor (Fangboothafen). The building of the torpedo test facility (shooting range) shown in the upper middle section of the image is still be preserved as a ruin until today (see Fig. 7). The coast line (Küstenlinie) is also marked.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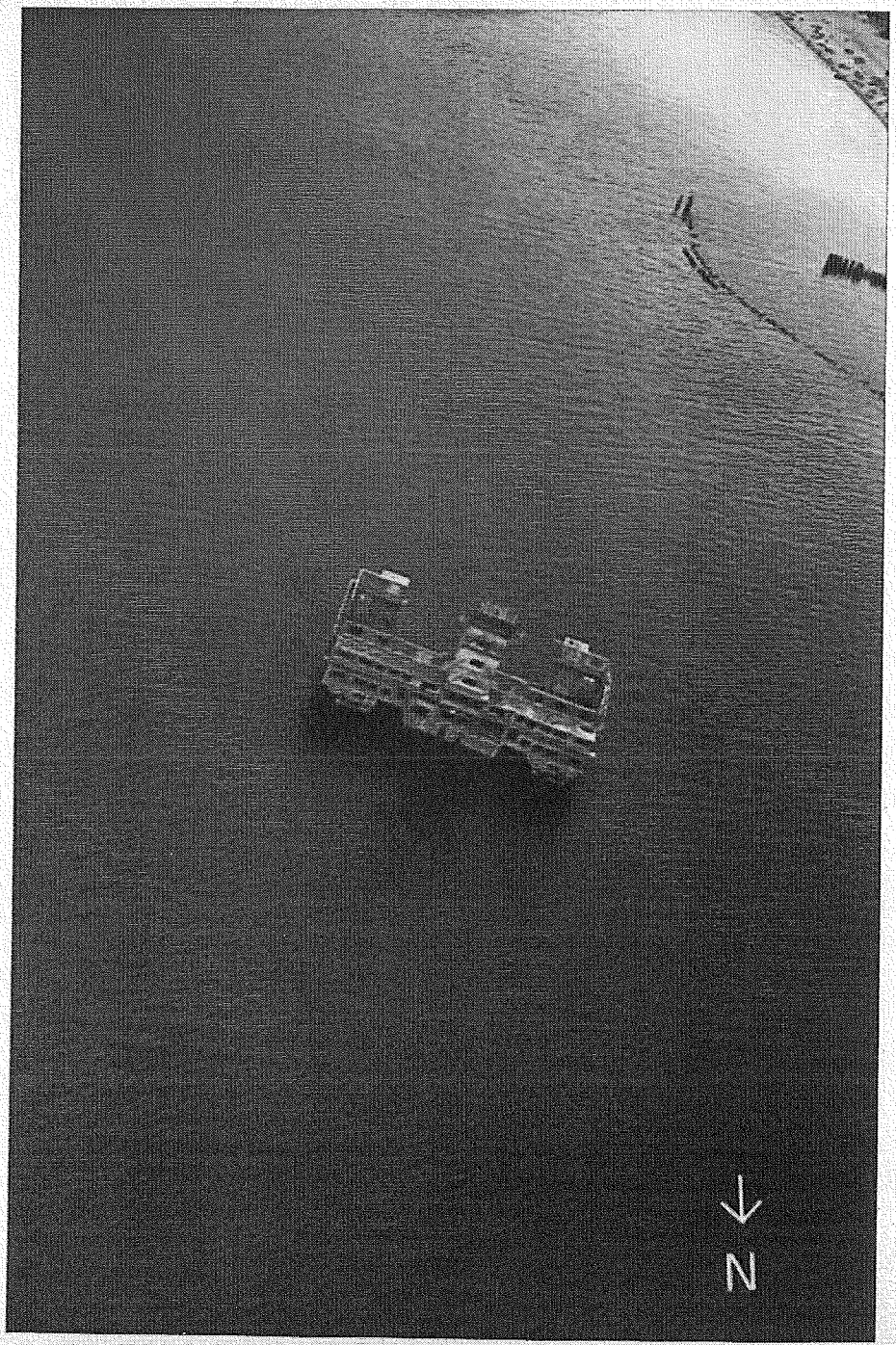
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ny Atlas/Minerva, had a difficult to disturb acoustic active homing head with two transducers and receivers, respectively, and was tested for the first time during summer 1944. From the acoustic data the target positions must be calculated. In this way it rendered the torpedo to detect and approach the target itself. However, the response range was substantially smaller than that of the *"Wren"*. Therefore, the target has to be steered for acoustic-passive up to a distance of 250 m. During autumn 1944 the *"Vulture"* was ready for operation and 50-100 torpedoes have been delivered. The steering of the so called *"Wake Wriggler Ackermann" ("Kielwasserschlängler Ackermann")*, developed by Prof. Ackermann, Technical University (TH) of Danzig, ensued on different pressure stages at the wake and the steering of *"Ibis"*, constructed by Dr. Gützmacher, Physical Technical Reichs Institution (Physikalisch-Technische Reichsanstalt (PTR)), had been made possible by reflection of ultrasonic at the wake. The steering of the torpedo type *"Fairytale"* (Prof. Schwenkhagen, TH Danzig) was realized by magnetic field distortion in the surrounding of the ship. The torpedo type *"Pigeon"* (developer: Siemens & Halske (S & H)) was equipped with an acoustic passive steering system with very low characteristic frequencies of 50-100 Hz and the releasing of the independent of position torpedo *"Pheasant"* (Dr. Unkelbach, OKM) occurred by reflection of ultrasonic signals at the wake passage.

Even within the collection of the "Navy Museum" ("Museum der Kriegsmarine") of the OKM of the Institute and Museum of Oceanography in Berlin the development of torpedoes up to the torpedo G7 of the German Navy has been presented in room VIII of the ground floor at Georgenstraße No. 34-36 and mainly should serve for the common national education (Führer durch das Museum für Meereskunde in Berlin, 1939). Dismantled torpedoes for illustration of the construction and torpedo sighting gears completed the collection. After outbreak of the war in 1939 this museum was one of few in Berlin which has been opened for public still until 1941.

The investigation of the fine structure of water stratification and the acoustic propagation within stratified sea-water was also important for testing of passive and active sonar devices on board of submarines. Tests with a listening apparatus, denoted as multiple-listening apparatus (GHG) (Gruppenhorchgerät (GHG)) *"Balcony"*, in a special gondola in front of the ballast keel of *U 719*, a type VIIC submarine, in water depths of 60-70 m, northerly of the island of Bornholm in the Baltic Sea, have been carried out on 31 August 1943 and on 1 September 1943, respectively. At this time *U 719* belonged to the 5th training flotilla in Kiel. The listening apparatus *"Balcony"* warned the submarine from sound emissions under water. It could record a horizontal sound range of about 74 km.

Figure 7: Air photo acquired on 5 July 2007 which shows the ruin of the building (shooting range) of the torpedo test facility Hexengrund (Babie Doly) and remnants of the foundation of the torpedo recovery boat harbor (see also Fig. 6). The ruin of the building can be identified as a small bright point in Fig. 2.

The acoustic passive listening apparatus *"Balcony"*, which was installed on the type XXI submarines, have been equipped with 2 x 24 diaphragm-crystal-hydrophones arranged in an arched manner below the keel. A short-range listening apparatus (NHG) (Nahhorchgerät (NHG)) warned the come running up torpedoes during submerged passage in a distance of 1000-2000 m. Due to the acoustic frequency of about 15 kHz the acoustic active echo ranging set *"Nibelung"* of AEG could determine the direction, the range, and approximately the velocity of the "enemy" by using the Doppler Effect (Rössler, 2006).

According to the physical connections it was obvious that investigations of the acoustic propagation in the ocean have been required by the Navy urgently. Just before the end of the Second World War a summary about the coherence between oceanographic stratification conditions and acoustic propagation in the water was published by Thorade (1945). Especially these investigations have been served for the development, analysis and impact of acoustic homing torpedoes and listening apparatuses on board of submarines. The reason for these investigations of the fine structure of the water column carried out in the Baltic Sea even until August 1944 was also predominantly due to the equipment of homing devices of torpedoes like the *"Vulture"* with active sonar. The target detection was realized by echo bearing, i.e., the transducer of the torpedo generates acoustic waves by itself and steered to the wake of the ship due to reflected and scattered echos of the target. Consequently, investigations of reflecting and scattering stratification layers in the water column were important for the depth-setting of torpedoes and especially for active methods like the acoustic target finding.

4. The preliminary end of acoustic propagation investigations in the ocean

During the end of July 1944 out of Memel (Klaipeda), Lithuania, as the evacuation of people and material already had been started the *Gauss* was still on expedition in the Baltic Sea. These investigations further served for the research of the fine structure of water stratification and acoustic propagation within stratified seawater, presumably in connection with the test of the pinpoint accuracy of torpedoes. On 24 July 1944 a station at Hel on position 54° 36.3' N, 18° 46.8' E in the Bay of Gdańsk has been approached, 170 km away from Memel. About one month later, on 27 August 1944, *Gauss* achieved the gaging station in the Stolper Rinne at 55° 9' N, 16° 53' E (Kalle, 1953). How absurd the general event is judged today as a prime example, especially at the end of the Second World War, is the fact that on 22 September 1944 the steamer *Moero* (5272 GRT) has been fired by hostile bombing planes westerly of Windau (Ventspils), Latvia (Courland/Kurland), in the Baltic Sea and sunk. During this bombardment 655 people died (Schön, 2004). The *Moero* was the first refugee ship that was lost by the "enemy" in the Baltic Sea. On 4 December 1944 the steamer *Seeburg* (12181 GRT) was scuttled by the Soviet submarine *SC-407* in the Puck Bay. It was the first loss of a ship above 10000 GRT and the first success of a Soviet submarine in the Bay of Gdańsk (Schön, 2004). During this time the Second World War was already lost

for the Großdeutsches Reich at all fronts. After the submarine types XXI and XXIII have been developed in the meantime the promised "miracle boat" should be produced in series: The new submarine type XXVI, the so called "Walter submarine", with a submerged speed of 12.35 m s^{-1}. For the listening apparatuses of the hostile submarine chasers the submarine type XXVI would have been almost unattainable. Because of the end of the Second World War the project could not be realized anymore.

In the meantime, on 30 July 1944, the German *U 250*, a type VIIC submarine, was scuttled by the Soviet coast defense boat *MO 103* in the Baltic Sea at the Koivisto Sound at position 60°27.9' N, 28°24.9' E and sunk in a water depth of 27 m. During August/September 1944 *U 250* was lifted by the Soviet navy. On 24 October 1944 three *"Wren"* (T V) torpedoes were salvaged from on board *U 250* lying in a dry dock of Kronstadt, Kotlin Island, Russia. During this time the *"Wren"* torpedoes were classified as so called "secret weapon". The salvage of *U 250* disclosed another "explosive effect". The British Prime Minister Winston Churchill (1874-1965) sent a top secret telegram to Josef Stalin (1878-1953) with the content that he was interested to investigate one *"Wren"* by specialists of the British Navy (Karschawin, 1994).

The reason for the temperature measurements from on board the *Gauss* carried out in the Baltic Sea still until August 1944 can only be assumed: The analysis of these data have been required urgently for the impact of operations of the passive and active acoustic homing torpedoes of the type *"Wren"* (G7es T V) and *"Vulture"* due to the optimal use for the new submarine types of the Navy.

On 21 January 1945 under the code word "Hannibal" Dönitz personally arranged that the ports in the Bay of Gdańsk have to give up by both submarine training flotillas. The submarine training flotillas immediately have to move to the ports in the Bay of Lübeck where the education has to continue and complete as fast as possible for the employment at the front. Also the already educated crews of submarines, the female marine assistants and the shipyard staff have to embark on board the ships within the scope of the "withdrawal action" and to transfer them to still to be determined more westerly ports of the Baltic Sea. There, the educated crews of the submarines are to be hoisted on board the new submarines (Dönhoff & Berg, 2008). Still during spring 1945 Dönitz had turned back every thought of an early truce as bad defeatism and planed with the new developed types of boats indefatigable a new submarine offensive for the later months in 1945. Until his death on 24 December 1980 Dönitz avoided his own coping with the past (Der Spiegel, 1961; 1981 & Taylor, 1996).

During the Second World War 2882 merchant vessels and 175 warships had been scuttled by German submarines at which more than 30000 people died .

On 12 December 1945 the German Hydrographic Institute (DHI) (now: Federal Maritime and Hydrographic Agency (BSH)) has been established which carried on distinct tasks of the former DSW. Here, K. Kalle first worked as an employee and later on as an official (Weichart, 2010).

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Die ozeanographische Messboje des Warnemünder Instituts für Meereskunde – die erste deutsche Entwicklung zur Umweltüberwachung der Ostsee?

Wolfgang Matthäus

Es wird über die Geschichte einer fernmessenden ozeanographischen Boje berichtet, die in der 2. Hälfte der 1950er Jahre für das Hydro-Meteorologische Institut in Warnemünde entwickelt und erprobt wurde. Vor allem wegen fehlender wirtschaftlicher und technischer Möglichkeiten in der damaligen DDR konnte die Entwicklung nicht erfolgreich zu Ende gebracht werden. Diese Boje dürfte aber zu den ersten Versuchen gehören, verankerte Messbojen für ozeanographische Zwecke in Deutschland zu entwickeln.

The oceanographic buoy of the Warnemünde marine institute (Germany) – the first German development for monitoring of the Baltic Sea? It is reported on the history of an oceanographic long range telemetering buoy which was constructed and tested for the Hydro-Meteorological Institute in Warnemünde in the second half of the 1950s. The development could not be completed successfully mainly because of lacking economic end technical possibilities in the former GDR. However, this construction is probably one of the first mooring buoys for oceanographic purposes developed in Germany.

1. Einleitung

Automatisch registrierende ozeanographische Bojen mit Datenfernübertragung gehören heute zum Standard für die Überwachung der Umwelt in Schelf- und Randmeeren. Erste Entwicklungen in Deutschland gehen auf die 1940er Jahre zurück. Im Auftrage der Kriegsmarine entwickelten und bauten die Siemens-Schuckert-Werke in Berlin und Stettin die Wetterfunkgeräte-See (WFS), die neben Luftdruck und Lufttemperatur auch die Wassertemperatur über Kurzwellensender übermitteln konnten (Selinger, 2001). In der Bundesrepublik begann sich Anfang der 1950er Jahre Werner Kroebel (1904-2001), angeregt durch den damaligen Direktor des Instituts für Meereskunde in Kiel Georg Wüst (1890-1977), mit der Entwicklung und den Bau von elektronischen Messgeräten für die Meeresforschung zu befassen (Kroebel, 1985; Prof. Krause, Bremerhaven, 2008, pers. Mitt). Dabei