Bureau. Maar anderzijds werden de verliezers van de oorlog, met name de Duitsers, uitgesloten van die samenwerking. Dat gold ook voor de ICES. Pas in 1926 zou Duitsland weer deel gaan uitmaken van de ICES. Gezien de belangrijke Duitse inspanningen in de oceanografie (de baanbrekende Meteor expeditie van 1925-1927) ruim over tijd!

Interessant is nog te melden dat de herstelbetalingen die Duisland kreeg opgelegd aanleiding waren voor een betere chemische analyse van de elementen in zeewater. De Duitse chemicus Fritz Haber (1868-1934) suggereerde om goud en zilver uit zeewater te winnen. Dat bleek echter onmogelijk doordat de juiste concentraties duizend keer lager zijn dan die waar Haber vanuit ging (Skinner & Turekian, 1973).

De invloed van de eerste wereldoorlog op de oceanografie is niet te vergelijken met die van de tweede, maar de oceaan beneden de zeespiegel werd tot oorlogsgebied. Daarmee kreeg het zeeonderzoek een extra dimensie.

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World War I and oceanography.

In connection with the commemoration of World War I some ideas are given about its influence on the development of oceanography. The outbreak meant an abrupt disruption of the international cooperation. But it also meant new submarine technologies. Especially submarine detection was important. Some observations as a consequence of the warfare are cited.

Research programmes came to an end, and resuming scientific work took years. The international cooperation suffered from the exclusion of German participation. The idea by Fritz Haber to extract gold from sea water proved to be an illusion when better data on the composition of sea water became available.

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Godfried W.N.M. van Moorsel & Floris P. Bennema: Diving techniques in use by marine biologists before 1940 with emphasis on the Dutch contribution

Introduction

Undoubtedly, the capability of man to study ecological relations and behaviour of marine organisms by observing them in their natural environment has led to significant contributions to scientific knowledge. Much has been written on early attempts of those who ventured under water with simple and often dangerous diving gear [1]. However, some of them have stayed unmentioned, among them the first Dutch scientific divers who were active in the Caribbean or in present day

[1] For those interested in history of science, Norton (1999) is a nice introduction. The marine biologist Trevor Norton covers the dive activities of 13 different men, among them the famous marine biologists Henri Milne Edwards, Louis Boutan and William Beebe. For an extensive review on scientific diving the reader is referred to Riedl (1967).

Indonesia. For example, Riedl (1967) lists 30 studies by diving scientists between both world wars, but none of them Dutch. But also in obituaries of the Dutch scientists the fact that they themselves ventured into the water with diving helmets in order to conduct field studies, is never mentioned. No wonder that even contemporary marine biologists in the Netherlands are generally unaware of this piece of scientific history.

For this paper, we critically studied diaries, field reports and scientific literature in order to pay special attention to the use of the diving helmet by Dutch scientists. Information is presented in the time frame of 1860 to 1940, among activities of other marine biologists who may be regarded as pioneers in this field as well. The context of scientific expeditions is mentioned and some scientific results are presented briefly. First, an overview of relevant underwater observation techniques will be given.

Underwater observation techniques

This paper deals with techniques in use before 1940 to observe marine life or collect specimens by hand in their natural sublittoral environment. It excludes atmospheric diving with devices such as submarines and bathysphere. Also the use of snorkelling gear or SCUBA (Self Contained Underwater Breathing Apparatus) is not treated. This is predominantly a post WWII development; before 1940 it was hardly possible to construct fitting facemasks and fins were not yet available commercially.

A simple instrument is the underwater viewer (also 'water viewer' or 'aquascope'), in essence a box with a glass bottom. It prevents reflections and distortion due to an uneven water surface. The observer doesn't need additional equipment (Fig. 1).

Fig.1. Verwey c.s. using an underwater viewer at Dapur, 13 July 1930 (Photo Tera Van Benthem Jutting, private archive FB)

A glass-bottom boat is in fact a large-size underwater viewer and has been used by marine biologists as well. An important drawback of these techniques is that they are only suitable in shallow water and that observations can only be made in a predominantly vertical direction. As a result, contrast is low and the observational power is generally limited.

Fig. 2. The Miller-Dunn open diving helmet Style2, a model popular among marine biologists, here worn by William Beebe (from Beebe, 1926)

In order to observe in a horizontal direction and at a greater depth, an open diving helmet may be used (Gudger, 1918; Conklin, 1933). It is shaped cylindrical or like a rectangular box and most often it has a handle on top to assist the diver when not under water. The helmet rests on the diver's shoulders and enables walking on the seabed while viewing though a transparent window. Air is pumped from the surface into the helmet to a pressure equal to the surrounding water. Surplus air escapes from below the rim of the helmet, giving surface operators an indication of the diver's location. The diver has to be careful not to bend over too much, as more air will escape from the back side of the helmet. When pumping is inadequate, the air quality will deteriorate due to oxygen consumption and the water level inside the helmet will rise. In this case, it is relatively easy to throw off the helmet and swim to the surface, but attention should be paid to exhale in order to prevent lung burst.

Some biologists used custom-made helmets, but the majority bought one. Popular 'Divinhood' open-helmet models came from the Miami (Florida)-based company Miller-Dunn. Three Divinhood types were developed: Style1 in 1915, Style2 in 1925 (Fig. 2), and Style3 in 1937. Especially Style2 was used by marine biologists. It had two vertical viewing windows placed at an angle, resulting in a distorted field of view. For co-ordination it was necessary to look through one of both windows at a time (Beebe, 1926).

Miller-Dunn also developed compact double cylinder pumps in three improving designs for each Divinhood Style (Dutton, 2011). These pumps were operated by one person at the surface by moving a 1.5 m stick back and forth (Fig. 3). Maximum pressure was enough to dive to a depth of 15 m.

Fig. 3. Manual 'wobble' pump in use with the Miller-Dunn diving helmet

In closed helmet systems the helmet, often spherical, is attached to a diving suit. This 'standard diving suit' keeps the diver dry but the operation is much more cumbersome compared to an open helmet. The majority of diving scientists, especially those working in tropical waters, therefore used open helmets.

A diving bell is in essence an over-sized open helmet providing space for an entire person.

All systems require heavy weights in order to compensate for buoyancy. Also precautions have to be taken to prevent condensation on the inside of the viewing window. Beebe (1926) used glycerine, Hass (1941) rubbed the glass with tobacco. Dependence on a surface crew limited the radius of action of the diver.

The first diver-biologists — the nineteenth century

Henri Milne-Edwards

Milne-Edwards (1800-1885) started his career as a student of Medicine. Soon it appeared that his interest in marine animals was much greater. In 1826 he joined Jean Victoire Audouin (1797-1841) to explore the marine fauna in Normandy. His publications soon drew attention and he was appointed as head of the department of arthropod research. Later on Milne-Edwards became professor of comparative physiology in Paris. At that time, Gustave Paulin, Commandant of the Paris fire department, received a governmental fund to redesign his air supplied 'smoke hood' for use under water. Milne-Edwards realized that this diving apparatus could be beneficial to zoological studies and decided to use it at the coast of Sicily. In March 1844, he left with fellow naturalist Armand Quatrefages (1810-1892) on a boat loaded with a large brass double forcing pump with balance beam and enough marines to operate this pump. The helmet appeared difficult to use, but after some time Milne-Edwards undertook underwater walks up to 45 minutes. There was always concern about security; a false alarm showed that, even in case of emergency, it took five minutes to pull him out of the water. For this reason he decided to restrict his dive depth to 8 m. Nevertheless, he succeeded to collect a great number of benthic animals, their eggs and larvae. Between dives he studied embryology and the blood circulation and nervous systems of various living marine animals (Milne Edwards, 1844).

Fig. 4. Milne-Edwards

After this fruitful expedition Milne-Edwards had some health problems and never dived again. However, he continued to be a very productive and awarded zoologist (Fig. 4).

Eugen von Ransonnet-Villez

Austrian born Baron von Ransonnet (1838-1926) was an artist as well as a scientist. In 1862, he travelled to Egypt to collect corals and other marine organisms in the Red Sea and tried to visualize his experiences in paintings. In 1864 or 1865, at Galle, Ceylon (nowadays Sri Lanka) he descended in a diving bell and painted the seascape (Kruspel & Hantschk, 2001). Doing so he provided the world with the first underwater images of a coral reef (Fig 5). Ransonnet (1867) nicely described the operation of his diving bell with 7 Cwts (= 353 kg) of weights (Fig. 6).

The Mediterranean

In the late 19th century, several workers in the Mediterranean used diving techniques for marine biological research. Already in 1879 Anton Dohrn (1840-1909), founder of Stazione Zoologica in Naples, writes that he stayed for more than half an hour in an underwater grotto. This biotope could not be investigated without a diving equipment. At the same time, Gottfried Berthold (1854-1937) used an open helmet to investigated algae (Riedl, 1967).

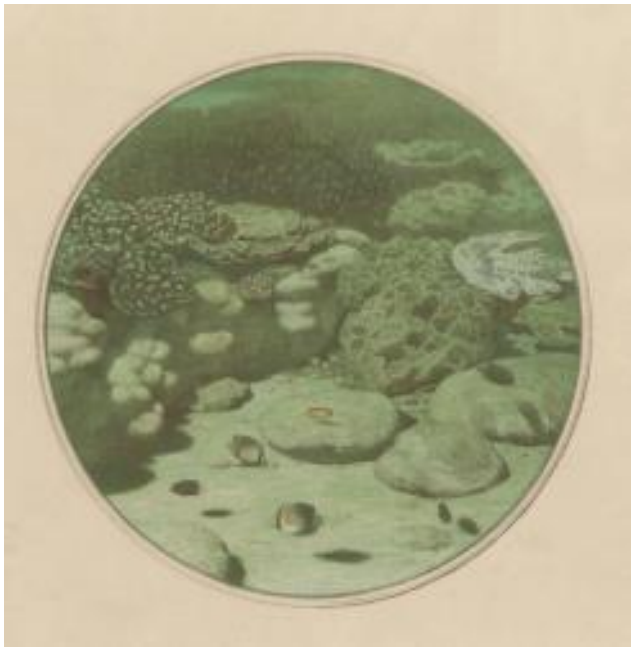

Fig. 5. Underwater painting (Ceylon) of Ransonnet (Ransonnet, 1867, Plate XXV)

Fig. 6 Baron Eugen von Ransonnet in his diving bell in Ceylon (ca. 1865), sketching the underwater seascape (from Plate VII in Ransonnet, 1867)

In Banyuls-sur-Mer, the French marine biologist Louis Boutan (1859-1934) used a standard diving suit around 1890 (Norton, 1999). He is famous for having taken one of the first underwater photographs in 1893. An 1899 photo shows Romanian oceanographer and biologist Emil Racovitza (1868-1947), under-director of the Laboratoire Arago, also in a standard diving suit.

US and British diver-biologists (1915–1929)

In 1905, Alfred Goldsborough Mayer [2] (1868-1922) built and directed the Carnegie Institution's Dry Tortugas Laboratory on Loggerhead Key, Florida. In 1917, he made observations of corals with a diving hood for the first time. Soon, he would also dive in the Pacific, off Pago Pago harbour, Samoa (Stephens & Calder 2006).

Mayor was not the first to use the brass helmet at Loggerhead Key for scientific research. As soon as the Miller-Dunn Style1 came to market in 1915, the botanist William Longley (1881-1937) tried it, as did octocoral specialist Lewis Cary (Gudger, 1918). Another biologist to use the diving helmet at Loggerhead Key was the sponge specialist Max Walker de Laubenfels (1894-1960).

For Longley it was the start of a long-lasting study of colour patterns and behaviour of reef fish. Longley, who was said to have become 'a fish among fishes', revealed the advantage of direct observation for ichthyology. By studying colour changes of individual fishes he proved that about 20% of the known marine fish species near Florida were to be considered synonyms. Another result of his observations was the description of 29 new reef species. Also he described the behaviour of fish and the interactions between different species (Lobel, 2011). Longley used an enormous underwater camera to make black and white photographs of fish skin patterns (Longley, 1918). In 1926, National Geographic photographer Charles Martin joined Longley at Dry Tortugas to help him with colour photography. Their picture of a hogfish is considered to be the first underwater colour photo ever.

[2] Due to anti-German sentiments he changed his name in Mayor

William Beebe (1877-1962), famous for his descents with Otis Barton (1899-1992) in their bathysphere in the 1930s, earlier used the diving helmet as well. He was one of the first to use the Style2 Divinhood during his expedition to the Galapagos Islands in 1925 (Beebe, 1926). In 1927 he even made over 300 helmet dives near Haïti.

Great Barrier Reef expedition

In the 1920s, British biologists started to use diving techniques during the Great Barrier Reef expedition (1928-1929) (Manton & Stephenson, 1935). A first-hand account of this expedition by its leader may be found in Sir Charles Maurice Yonge (1930). Thomas A. Stephenson, another famous biologist and leader of the shore party, remarked: "Nothing is more unearthly and miraculous than the view one obtains of a flourishing growth of corals from a depth of three or four fathoms, through the windows of a diving helmet". The GBR expedition resulted in important knowledge on the role of zooxanthellae in corals.

Curaçao 1920: Van der Horst

After his PhD, Cornelis J. van der Horst (1889-1951) studied scleractinian corals from the Siboga and Percy Sladen Trust expeditions and wrote several monographs. Having studied so many dead coral skeletons, he was eager to see live corals himself and undertook a journey to the Caribbean island of Curaçao. Here he stayed at the old Quarantaine Station in April and May 1920. In the narrative of his voyage Van der Horst (1924) remarks: "It is a splendid sight to look through the glass bottom of a little box on this mixed variety of creatures, but I only could fully enjoy it, when the Chief of Public Works put a diving suit at my disposal … Words fail to describe the splendour of such a submarine garden". While diving, he had to pay attention that his air tube did not get entangled between corals and he found the diving suit much impeding his movement. Later, he discovered that diving with the helmet only was much easier and less dangerous. Van der Horst saw the difference in coral growth between Caracas Bay and Spanish Water. He collected a considerable number of species, later to be used by some 20 specialists in publications.

The Netherlands East Indies 1922-1931: Boschma, Kuenen & Verwey

During expeditions, divers were sometimes hired [3]. For example the Siboga Expedition (1899-1900) co-incidentally met some pearl-divers whose services were used (Weber, 1902). For conducting coral reef research during the colonial past of Indonesia, it has been mentioned that diving was executed by helmet divers of the Dutch Navy (Hoeksema, 2006; Van der Meij & Visser, 2011). However, we did not find evidence to substantiate this [4]. As a matter of fact, during a decade, two Dutch biologists and a geologist did many discoveries diving themselves.

Hilbrand Boschma

According to Kuenen (1941), Boschma (1893-1976) learned about the use of the diving helmet in the West-Indies. Indeed, Boschma visited several field stations in the United States and Bermuda in 1924 and 1925. Especially at the Dry Tortugas Marine Laboratory he met several of the above-mentioned diving scientists. However, in one of his diaries, we found evidence that Boschma already used a

[3] Already in 1873, Ernst Haeckel depended on local divers to collect corals in the Red Sea near Tor, Egypt (Haeckel, 1876).

[4] More recently, Dutch navy divers, using SCUBA, have been active in collecting biological specimens. In 1972, during cruises of the HNLMS Luymes at the Saba Bank (CICAR programme). Photos in Hoeksema et al. (2011).

diving helmet in 1922 while he joined Theodor Mortensen (1868-1952) [5] on a Danish expedition to the Kei Islands and the Banda Sea in present-day Indonesia (Danske expedition til Key-Øerne).

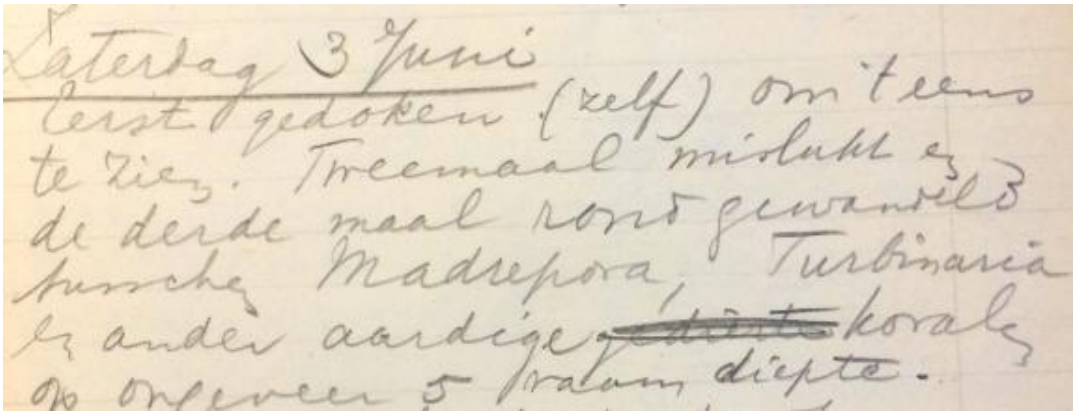

Fig. 7. Excerpt from the diary of Boschma, attest of his first attempt to use a diving helmet in 1922 (archive Naturalis, Leiden)

Fig. 8. Boschma (left) at a reef with Snellius Expedition leader van Riel (From: Van Riel, 1938)

From the end of January 1922 onwards, during four months, Boschma mainly worked the on gastric content of corals and was employed in collecting plankton. However, during the first two weeks of June a diver (Latinta) joined the expedition. Soon Boschma tried to dive himself. At 3 June, near Neira, he writes in his diary (translated from Dutch): "Dived first (myself) to see it. Failed twice but at the third attempt walked around among Madrepora, Turbinaria and other nice corals at approximately 5 fathoms depth" (Fig. 7). His diary lists additional dives. At the end of June he left the expedition.

Seven years later, Boschma returned to the Dutch East Indies to join the Snellius expedition to the eastern part of the Malay Archipelago (1929-1930). Leiden University granted him a leave of absence from 9 March 1929 till 9 September 1930 [6]. The expedition mainly served geological and oceanographic purposes. As expedition biologist, Boschma was mainly serving geology but of course this did not interfere with his interest in coral reefs (Fig. 8). During the onward journey, he explained the purpose of the expedition and mentioned that a diving helmet would enable to reach also the deeper part (down to 15 m) of the reef (Boschma 1929).

We even know that Boschma used the Miller-Dunn Style2 Divinhood in combination with 150 ft of air hose (Boschma, 1936). In the beginning of May 1929 the diving helmet was tested in Emmahaven (now Teluk Bayur), at the west coast of Sumatra (Van Riel, 1938). The same month Boschma attended the 4th Pacific Science

[5] Already in 1914, in the Sulu archipelago, Philippines, Mortensen collected specimens using a diver (Haig, 1964).

[6] The expedition lasted until November 1930.

Congress. From 2-11 July 1929, he worked on corals with Verwey (see below). Between 14 August 1929 and 14 June 1930, many expedition dives down to a maximum depth of 12 m were made (dive data available on request), some of them also by the expedition geologist Kuenen (see below). Boschma collected a large number of corals, providing study material for many Dutch taxonomists in decades to follow. In July 1930, Boschma left the expedition to return to the Netherlands, but not before transferring the diving helmet to Verwey (see below).

Philip H. Kuenen

Kuenen (1902-1976) joined Boschma on board the Willebrord Snellius as expedition geologist. In a popular book on the expedition (Kuenen, 1941) he describes his first diving attempt full of difficulties. For example, to remove condensation on the viewing glasses he bent forward in order to let seawater clean them. Doing so, too much air escaped from the back of his helmet and again in the upright position the water level was up to his eyes. He was only able to breathe after additional air was pumped into the helmet. A nice schematic figure (Fig. 9) shows Kuenen at work.

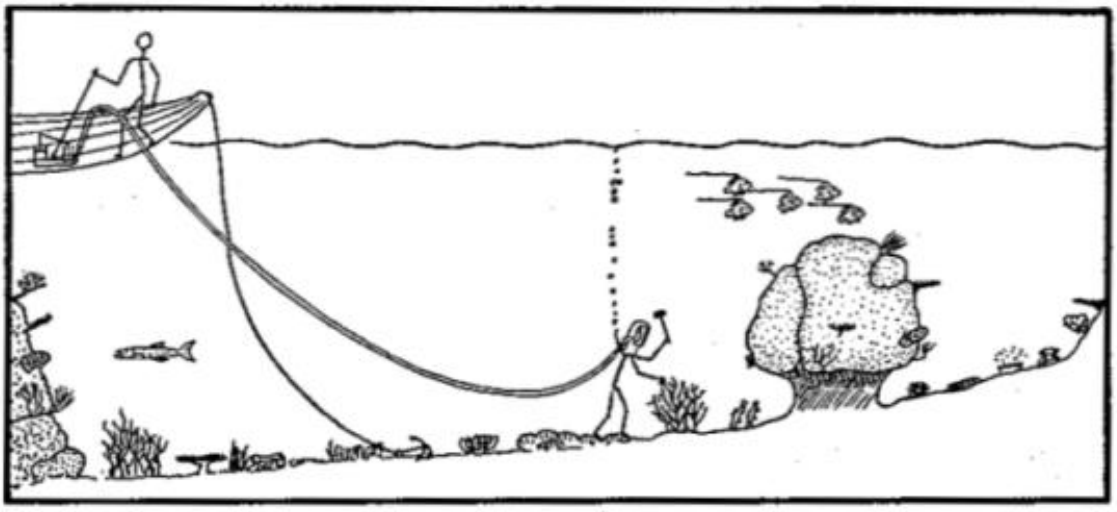

Fig. 9. Kuenen at work during the Snellius Expedition (1929-30). A surface operator handled the two-cylinder air pump manually from a small boat (From: Kuenen, 1941)

Jan Verwey

Verwey (1899-1981) was interested in the influence of light on reef corals. To figure out the role of zooxanthellae he measured oxygen concentrations in seawater around the reefs near Batavia (Jakarta) under different conditions. He also studied the effect of free silt on the attenuation of light in seawater (Verwey, 1929a). He must have been eager to use the diving helmet to determine the maximum reef depth. Also it could be used to study the relationship between sea anemones and fish species of Amphiprion and Premnas (Verwey, 1930).

In April 1929, Verwey visited Ajer Kecil together with Mortensen (see Boschma above). Although not yet diving, from his diary we may infer that he was already impressed by the underwater life. Not much later, Verwey must have been heavily involved in the 4th Pacific Science Congress at Batavia & Bandoeng (16-20 May 1929) and the accompanying field excursions (Verwey, 1929b). From 2-11 July 1929, he worked on coral with Boschma, who was on was on a break from the Snellius expedition (see above). When Boschma returned one year later Verwey took over the diving helmet for his laboratory. At 27 July 1930 they together prepared the helmet and pump for diving operations. The next day both men dove at Ajer Besar (diary Verwey). Until June 1931 Verwey made several dives in the Pulau Seribu archipelago (dive data available on request). In August 1930,

maximum reef depths were measured at several islands by walking down the reef slope while releasing a piece of bamboo attached to a measuring rope (Verwey, 1931). Verwey also succeeded in underwater photography (Fig. 10). On 8 July 1931 he ended his reef studies in the field, by visiting several Islands (without diving) for the last time.

Fig. 10. Part of the reef with Acropora species at Hoorn (Ajer Besar). Underwater photograph by Verwey at a depth of 5 m (From: Verwey 1934)

Diving biologists in Europe: 1925-1939

Also in Europe, diving was used to collect biological data. Conditions were harsh compared to the abovementioned (sub) tropical locations.

In British waters, diving was first employed for sampling marine life by Lilian Lyle (1864-1936), who used a diver in 1929 to collect algae from the scuttled warships in Scapa Flow (Lyle, 1929). Likewise in Sweden, a diver in standard gear was used by Torsten Gislén (1893-1954) to survey the sublittoral rock of Gullmar fjord.

Some biologists ventured into the water themselves. In Denmark, the cnidariologist Paul Kramp (1887–1975) used a full diving suit in 1925 to observe and sample marine life (Hiscock, 1998). Some even withstood the cold temperatures using an open helmet. From 1931 onwards, John Kitching (1908-1996) used it in Devon and in the Sound of Jura, Scotland, to describe the organisms of kelp forests and to measure amount and quality of light (Norton, 1999). In Poland the biologist Roman Wojtusiak (1906-1987) designed an open helmet himself, clearly inspired by the Miller-Dunn Style2 helmet. Wojtusiak and his team used the helmet from 1936 until 1987. In 1938, the Austrian zoology student Hans Hass (1919-2013) used a custom-made diving helmet in the Adriatic.

Modern techniques: 1938-1939

In 1939, Hass still used a diving helmet and 40 m of air hose to shoot underwater movies in Bonaire, Caribbean. Also here, he was one of the first biologists to introduce skin diving. However, using two-eyed goggles, diving depths were limited. His book with photographs (Hass, 1941) gives worthwhile details on marine life (Wagenaar-Hummelinck, 1944-45).

A precursor to the modern face mask was used by Vernon E. Brock (1912-1971?), an ichthyologist working in California. It consisted of a casted aluminium tube with front glass. A rubber 'inner tube' provided water-tightness to the face. The mask had an air supply like the open helmets but since it weighed 90% less, it gave the diver much more freedom. Also it had the advantage of permitting fish observations in a more downward direction (Brock, 1938).

Although the open diving helmet is still in use by some people up to the present day, after WWII its use was quickly replaced by SCUBA. So 1940 seems an appropriate year to finalize this overview.

Conclusion

Van der Horst, Boschma, Kuenen and Verwey all used diving gear for research in the beginning of their careers. Later they became well known as directors and/or university professors but their diving activities have remained underexposed. The availability of the open helmet enhanced their possibilities to study marine life in a safe way. As far as we know, no other Dutch scientists such as archaeologists have used a diving helmet before WWII. The four Dutch diving scientists (3 biologists and 1 geologist) took part in this activity within a short time frame (1922-1931). In the same period, several UK and USA based biologists had entered in similar activities. The four pioneers all picked up diving due to the fact that a diving helmet was present co-incidentally. Only Boschma decided to order one for his own needs as part of the equipment for the Snellius expedition. The diving helmet was used for coral reef research in the Caribbean as well as in the Indo-Pacific. After our compatriots returned to the Netherlands they were not inclined to pick up diving again.

We hope this story serves to appreciate how these early diving attempts helped to create a better understanding of tropical marine biology.

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