INTRODUCTION

In geographic terms, Norway is Scandinavia’s west coast. Steep glacial mountains plunge into the sea and drop to considerable depths, even close to shore, creating Norway’s unique underwater topography. This underwater landscape has presented several challenges to Norway’s marine archaeologists, requiring innovation and creation of new methods to survey and explore the ocean floor. For these reasons, Norwegian marine archaeology (underwater archaeology in marine environments) has been at the cutting edge of development and use of advanced marine technology. This article presents an outline of Norwegian marine archaeology and field methods used in two select projects involving deep-water exploration.

For millennia, Norway’s history and culture has been inextricably linked with the sea. At over 25,148 km, Norway’s coastline is the longest in Europe and the 7th longest in the world. Archaeological sites scattered along coastal Norway provide rich evidence of early maritime cultural landscapes. [17], [18]. Norway’s earliest inhabitants from the First Maritime Adaptation in the early Mesolithicum period depended upon marine resources - mammals, crustaceans, mollusks and fish – in order to survive. The sea also had a profound influence on the spiritual beliefs and artistic expressions of Norway’s coastal communities [18]. Fact and fiction are interwoven in popular culture through the iconic Nordic Vikings, whose skill and resourcefulness with all things maritime led them explore and colonize parts of Europe and even portions of what is today the Middle East.[9] These long-term processes molded Norway into the maritime nation that it remains to this day.

1. OIL, GAS, OFFSHORE INVESTMENTS AND ADVANCED MARINE TECHNOLOGY

Until the 1960s, Norwegians regarded the sea as the source of its most abundant natural resource - fish. This view changed abruptly in August 1969 with the discovery of large oil and gas reserves in the North Sea [6]. Soon after, the Norwegian government passed a series of laws to regulate exploration and extraction of these resources. By 1972 the Norwegian government solidified its control over the oil and gas industry with the creation of the Norwegian Petroleum Directorate (Oljedirektoratet) and the state-owned oil and gas company Statoil [6]. For the next three decades, subsequent discoveries of large oil and gas deposits intensified the development of Norway’s oil industry. By the early 1980s Norway’s fishing industry, once the mainstay of the Norwegian economy, had been displaced by a far more profitable natural resource.

As part of its "environmental model," the Norwegian government dedicated a substantial portion of its oil and gas revenue to the development of new technology to extract deep-sea mineral resources and to provide incentives for expansion of the petroleum industry. These incentives spurred Norwegian research institutions to widen the scope of their research to include development of advanced underwater extraction technologies. The rapid pace of development in marine technologies added to the growing field of underwater research, leading to what might be termed a Second Marine Adaptation and/or the Marine Technological Revolution. Norway is now the world leader in oil and gas-related marine technology. This expertise has created a ripple effect on other fields of marine-related research. Modern tools and techniques initially developed for exploration and mapping of Norway’s vast undersea resources had the collateral effect of supporting marine research unrelated to the petroleum industry [6], [1].

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2. MARINE ARCHAEOLOGY IN NORWAY

Two terms are worth distinguishing here: “maritime archaeology” and “marine archaeology” [10]. Maritime archaeology refers to that wide range of research that includes marine and terrestrial (coastal) environments connected with sea activities [4], [16]. Marine archeology is narrower in scope, relating specifically to water environments and underwater research [4]. Our focus is on underwater research; accordingly, we will use the term “marine archaeology.”

The first worldwide scientific underwater exploration of archaeological sites and objects was conducted in the late 19th and early 20th centuries, with the most intensive period following the Second World War [15]. Today, marine and maritime underwater archaeology are highly developed aspects of both archaeology and the humanities [16].

Like its history and culture, archaeology in Norway is intimately connected with the sea. This is true even when evidence of earlier cultures are situated above water, as for example, the discovery of Viking grave boats on dry land (such as the Oseberg) in the early 20th century. Discoveries such as these led to the implementation of the Norwegian Heritage Act, one of the world’s first heritage laws. The Act provides legal protection to objects, sites, artifacts and other evidence of Norway’s cultural heritage. [1]. After the Second World War, the Norwegian Heritage Act was strengthened by several amendments (e.g. 1963, 1978) resulting in automatic protection of all terrestrial and underwater archaeological sites and objects pre-dating the Protestant Reformation in 1536. Its protection extends to underwater ship wreck sites in Norwegian territorial waters that are older than 100 years from the year of their construction date. [3] All shipwrecks in Norwegian waters are automatically deemed property of the Norwegian state regardless of their country of origin.

At present, the responsibility for surveying, supervision and research of Norwegian underwater archaeological sites is shared among six academic institutions. Each institution is assigned responsibly for a specific geographic area: The Norwegian Maritime Museum in Oslo; the Bergen Maritime Museum; the Stavanger Maritime Museum; University Museum of the Norwegian University of Science and Technology in Trondheim; Tromsø Museum- University of Tromsø, and the Office of Governor of Svalbard Archipelago (Spitsbergen) in the Arctic. Unlike other European countries, governmental and legal protection of Norway’s cultural heritage falls under the Ministry of the Environment (Directorate of Cultural Heritage) rather than under a Ministry of Culture. This is consistent with the Norwegian view that cultural heritage is an important environmental resource that deserves protection from human destruction. [3].

3. HIGH-TECHNOLOGY IN THE SERVICE OF ARCHAEOLOGY - NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

The Norwegian University of Science and Technology (NTNU) in Trondheim has a long tradition of interdisciplinary collaboration and co-operation between the humanities and social sciences departments and those associated with hard science and technology.

One of the first surveys of underwater archaeological site in Norway took place in the 1970s in Norway’s central region. Investigations of the Perlen shipwreck in Trondheim’s harbor marked the beginning of marine archaeological capacity building at the University Museum in Trondheim and brought the establishment of the institutional responsibility for underwater heritage in central Norway at this institution [15].

During the 1980s, the institutions assigned to cover a specific geographical area of Norway conducted many marine archaeological projects. Maritime, marine and underwater archaeology as an academic discipline in Norway originated in Trondheim (NTNU) by Marek E. Jasinski, who developed an academic framework to support this field of study and academic training in 1990s [15]. In addition to academics, NTNU Archaeology students receive cross-training in diving through affiliations with local SCUBA clubs. Underwater archaeology continued to evolve by co-operation between NTNU’s Institute of Marine Designs and the University Museum, through the adoption of advanced underwater technology to conduct archaeological research in deep water. [12], [15].
1.1. Selected Projects – Jedinorog and the Ormen Lange Marine Archaeological Project

The Jedinorog (Unicorn) Project was among the first deep-water archaeological research initiatives in the world [15]. Led by scientists affiliated with NTNU Trondheim, the project was also one of the first to use advanced technology in underwater research. In 1994, NTNU conducted the archeological deep-water investigation of the remains of the Russian Navy Pink called Jedinorog. The ship sunk in 1760 near the island of Sabuøya between Smøla and Hitra in Central Norway. Preparation for Statoil’s construction of an underwater gas pipeline from the offshore Haltenbanken gas-field to the mainland, along with earlier shallow-water surveys, revealed evidence of a shipwreck. Archaeological artifacts were discovered to be from the 18th century Jedinorog shipwreck, situated off the shore of Sabuøya island. Under the Norwegian Heritage Act, Statoil was required to provide funding for the archaeological deep-water surveys of the shipwreck site [12]. These surveys showed that the cargo of the shipwreck was spread over an area of the ocean floor within a narrow bay. Part of the shipwreck’s elements lay in shallow waters, but numerous objects of the Jedinorog’s cargo (cannons, blocks of lignum vitae hardwood, and rolls of lead sheets) were positioned alongside an underwater slope, down to depth of about 300 meters. Divers were able to investigate the portion of the Jedinorog site in shallow waters, but this method was impractical for conducting a large-scale archaeological survey at such depths.

The project employed the use of sophisticated devices specifically designed to map the deep ocean floor: an ROV (remotely operated vehicle) Sprint 101 equipped with video camera and Simrad 971/900 scanning sonar; the Hyball observation ROV equipped with camera, sonar and one function manipulator arm; the SeaOwl 507 observation ROV; Statoil owned SOLO work-class ROV; TOPAS (sub-bottom profiling system) which collected detailed 3D and 2D (vertical) topographic and seismic profiling data; and a 7-function Shilling manipulator arm and PhotoSea 2000 stereo camera [12]. ROVs were positioned by Simrad HPR 300P system and differential GPS system on board the research vessels. VETIS software was developed by NTNU researchers specifically for the purpose of collecting data [12], [15].

Project Jedinorog revealed the potential for further development of advanced marine technology in Norwegian archaeology. In the late 1990s and first years of new millennium, NTNU’s marine archaeologists and marine technologists collaborated on several marine archaeology field projects worldwide using the techniques and equipment initially developed for Project Jedinorog.

During a deep-water archaeological survey of the proposed Ormen Lange gas pipelines in August 2003, NTNU’s marine archaeologists and marine technologists discovered a historical shipwreck in the path of the pipelines. The shipwreck lay off the coast of the fishing village of Bud at a depth of 170 meters. The Norwegian Heritage Act required further exploration. For the next two years, teams from NTNU surveyed and partly excavated this shipwreck. NTNU and the Norwegian manufacturing company Sperre AS designed an ROV specifically for marine archaeological research [14]. It was equipped with specialized design features, including a GTO sediment dredge, a collection basket, a 7-function Kraft force-feedback manipulator arm, suction picker (for lifting fragile and small objects), high-resolution cameras, a gas lighting system and sonars [1]. A specially designed 10 X 10 m excavation support frame included a docking platform for the ROV, maneuvered and positioned by rotation sensors. The excavation frame functioned as an underwater grid, with the docked ROV operating from just above the shipwreck. A Kongsberg Simrad LBL acoustic positioning system provided acoustic references. The ROV was remotely operated by researchers aboard the project’s research vessel [14]. Site-specific photos and videos were used to create photogrammetric and videogrammetric images in 2D and 3D, along with 3D acoustic images of hull remains and artifacts [7], [8]. These technological advancements allowed for excavation of the site with an accuracy of less than 1 cm [1], [14], well within the highest archaeological standards [5].

Before its application to the Ormen Lange project, the role of ROVs in archaeological research and exploration were limited to non-invasive actions, such as taking photos or videos, or lifting and sampling separate artifacts. The custom-designed ROV used in Ormen Lange Project was the first to excavate a deep water site while maintaining archaeological standards and best practices. The Ormen
Lange Marine Archaeological Project remains the world’s first deep-water archaeological excavation and the most advanced deep-water archaeological project performed to date.

Fig. 1. The specially developed marine archaeology ROV. Photo: Fredrik Naumann, NTNU University Museum.

Fig 2. ROV on the excavation frame. Photo NTNU University Museum.
1.2. Ocean Science as a Strategic Area

Currently, marine archaeologists at NTNU in Trondheim are actively participating in interdisciplinary research and development on new methods of marine surveying and exploration. Recent innovations include synthetic aperture sonars and AUVs (Autonomous Underwater Vehicle) which will provide archaeologists with higher-quality images of marine archaeological sites [2], [11]. NTNU’s current marine and maritime research projects are organized within the Ocean Space Centre initiative and the Applied Underwater Robotics Laboratory (AUR-Lab).

CONCLUSION

Both deep-water archaeological projects discussed here – the Jedinorog Project and The Ormen Lange Marine Archaeological Project - were made possible by the Norwegian Heritage Act and extensive collaboration between Norway’s oil and gas companies and NTNU’s marine scholars and researchers.

Advanced technology such as ROV’s and AUV’s for archeological field surveys, documentation and excavations [2], [13], [14], [15] were necessary because of Norway’s coastal topography, deep fjords, straits and other features that rendered traditional methods of marine archaeological exploration impractical.

Both projects established that technology developed by the oil and gas industry can be adapted for deep-water archeological exploration while maintaining high scientific standards of accuracy and efficiency [14], [15]. In the future, use of sophisticated precision equipment will likely become an integral part of underwater archeological technique regardless of whether the area to be surveyed is deep or shallow [7]. The limiting factor is the relatively high cost of initial development and production, particularly for nations that are less well-resourced or where local government, industry, and academia are unable or unwilling to collaborate on these projects. In the meantime, Norway’s shared experiences and results of its maritime research endeavors may inspire greater interest in the field of underwater archaeology and foster creative ways to bring down costs through public-private partnerships.

Abstract

For millennia, the people living in what is today’s Norway have been intertwined with the marine environment. The discovery of large petroleum reserves in Norwegian waters in the late 1960s had an immeasurable impact on maritime research. Norway’s long coastline, and the sheer depth of its territorial waters, presented unique challenges for underwater archeologists wishing to survey and investigate sites from Norway’s maritime history. New technology and equipment initially developed by the petroleum industry was adapted by researchers at the Norwegian University of Science and Technology (NTNU) Trondheim for use in deep-water archeological projects. Both the Jedinorog and Ormen Lange Marine Archaeological Project demonstrate how modern archaeology spans multiple disciplines – science, technology and the humanities – to provide a better understanding of early Norwegian maritime culture.
BIBLIOGRAPHY


