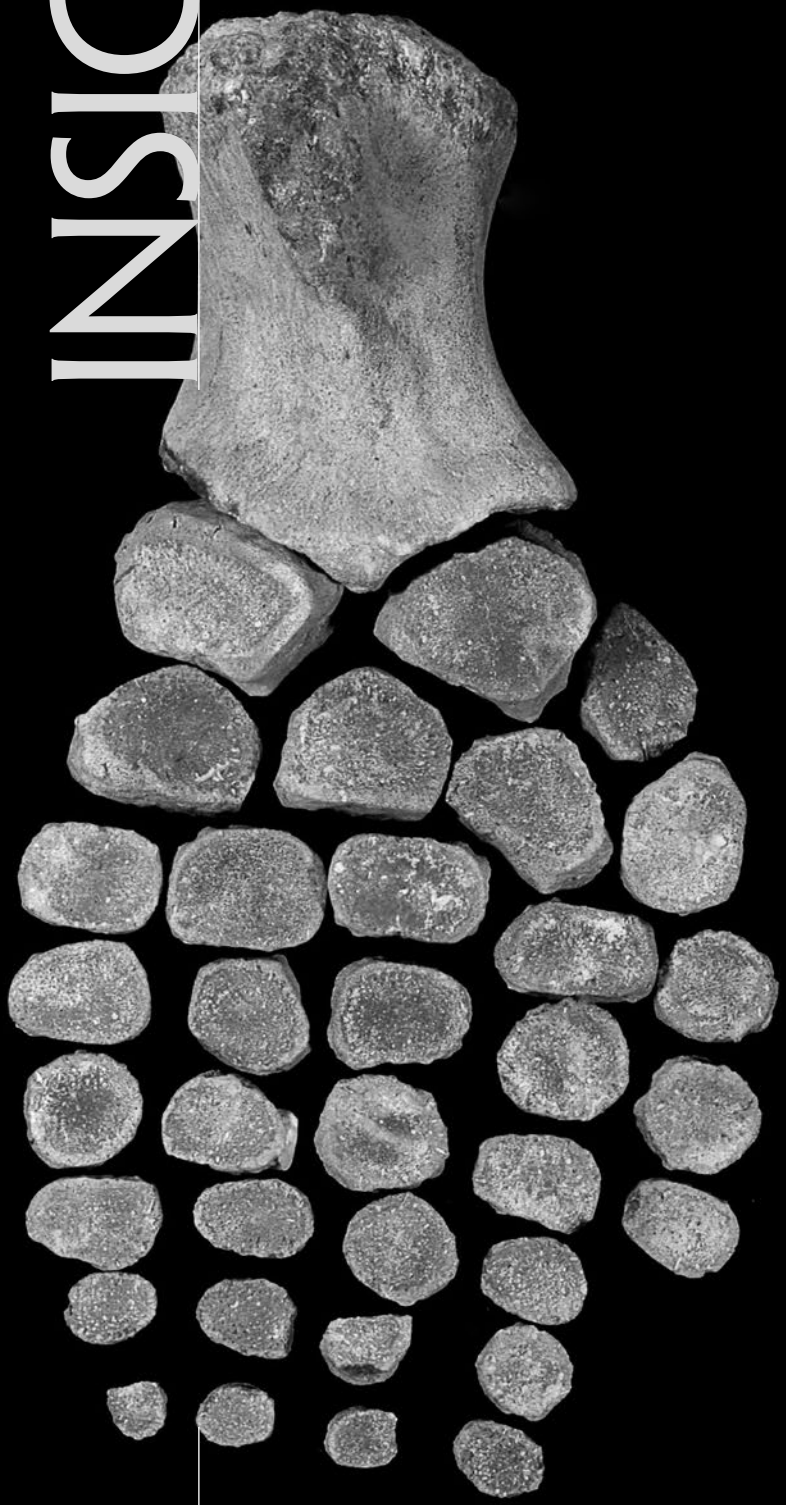
Face-to-Face



The Jurassic period is symbolized by large reptiles that dominated the land and seas. The most recent paleontological findings indicate that the territory of Poland was inhabited by several groups of large marine animals.

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The Mesozoic is typically referred to as the Age of Reptiles, in light of the huge evolutionary success achieved by those animals. Its best known period is the middle, Jurassic period, which started nearly 201 million years ago and ended 145 million years ago. It was characterized by the presence of marine reptiles represented by several evolutionary lineages that were not closely related and which had adapted to the marine environment independently. The most interesting fossils found in Poland come from the Jurassic Period.

The most important groups of Jurassic marine reptiles whose remains were found in Poland are: fish-shaped ichthyosaurs (Ichthyopterygia: Ichthyosauria), long-necked plesiosaurs (Sauropterygia: Plesiosauroidea), their short-necked relatives – pliosaurs (Sauropterygia: Pliosauroidea), and sea turtles (Testudinata: Pancryptodira). In Polish ecosystems, those reptiles were accompanied by large predatory bony fish (Osteichthyes: Actinopterygii).

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With Dragons

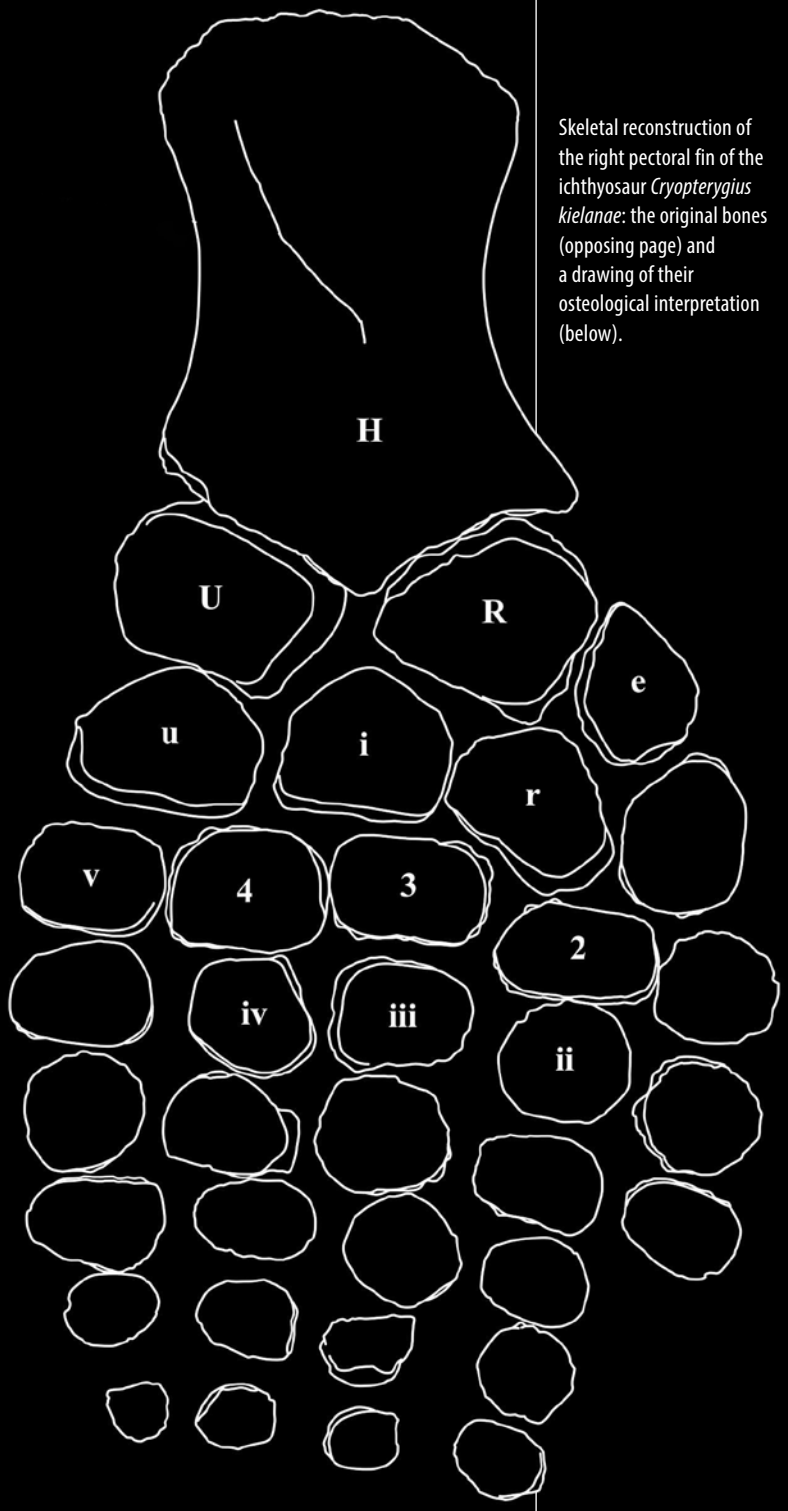
The most important site, characterized by an abundance of bones and teeth of marine vertebrates, is the Owadów-Brzezinki Quarry, situated on the north-western border of the Holy Cross Mountains (in the commune of Sławno in the Łódzkie Province). Every year, paleontologists conduct excavations of the quarry's carbonate rocks, dated as the end of the Jurassic (148 million years). During such excavations, my students and I search for the remains of extinct sea monsters. The fossils found in this Polish quarry constitute the most important achievements reported in recent years in the paleobiology of vertebrates. The Quarry was where researchers found the skeleton of a four-meter-long ichthyosaur of the ophthalmosaurid family (Ophthalmosauridae). It turned out to belong not only to a completely new species (named *Cryopterygius kielanae*) but also to the evolutionary lineage of what are called boreal ichthyosaurs, whose representatives had been previously known only from the distant Arctic, more specifically the Svalbard Archipelago. That discovery shed new light on the paleobiogeographic situation of Europe during the Late Jurassic.

Things got even more interesting when the excavations conducted at Owadów-Brzezinki brought more remains of large marine vertebrates – turtles and bony fish. It turned out that both the new genus of a hidden-necked turtle named *Owadowia borsukbialynickae* as well as the ray-finned fish of the genera *Caturus* and *Orthocormus* clearly preferred the ecosystems of warm southern seas.

So how can it be that a single quarry contains the bones of both Arctic ichthyosaurs and thermophilic turtles and fishes?

Creatures from two worlds

In the Late Jurassic, the entire European continent was divided into two large biogeographic provinces (called biochores). One was the Boreal Province, with its subboreal subprovinces, the other was the Mediterranean Province, related to the emerging Tethys Ocean in the south. Just as today's zoogeographic regions vary in terms of their faunal taxonomy and environmental conditions, so did the faunal composition of the northern boreal and subboreal seas in Europe in the Late Jurassic differ from that of the Tethyan seas in the south.



Skeletal reconstruction of the right pectoral fin of the ichthyosaur *Cryopterygius kielanae*: the original bones (opposing page) and a drawing of their osteological interpretation (below).

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Fig. 1
Daniel Tyborowski presents a life-size reconstruction of the ichthyosaur *Cryopterygius kielanae* that will be installed in the Paleontological Museum in the Owadów-Brzezinki Geopark.

Those two different worlds intersected in the region of today's Poland, creating a paleobiogeographic "contact zone" in Europe in the Late Jurassic. Despite the fact that paleozoology of northern regions differed from that of the southern part of the continent, the faunas of large marine vertebrates that migrated from the north and the south met in the region of the Owadów-Brzezinki Quarry and lived in the same ecosystem.

Studies of the ichthyosaurs from the Polish quarry made it possible to establish that these boreal marine reptiles, just like today's whales, migrated from high to low latitudes. The migration routes of those animals ran through the territory of today's England and France or through the Volga-Ural seas in Russia. Research on marine reptiles from new sites from the border of the Holy Cross Mountains appears to confirm this paleobiogeographic course of events.

Teeth reveal everything

The most frequently found remains of Jurassic marine vertebrates are their fossilized teeth. This is because each single animal, for example an ichthyosaur or a fish, could have an impressive collection of teeth; in addition, the teeth of most marine vertebrates were continually replaced – if one tooth fell out of its jaw, it was immediately replaced by another. This means that a single animal could produce an enormous number of teeth during its lifetime. And indeed, in the Owadów-Brzezinki Quarry, reptile and fish teeth are the most frequently found remains of vertebrates. The collection has several thousand specimens. Contrary to appearances, the analysis of even a single tooth reveals a lot of information. Its morphology and the presence of diagnostic characteristics make it possible to identify its owner (sometimes as accurately as down to the species). But that is not everything. The morphology of a tooth reveals an abundance of information about an animal's life, ecology, and foraging method, through a method known as feeding guild analysis. This research method made it possible to reconstruct the whole of the food chain of the Owadów-Brzezinki ecosystem from 148 million years ago. The round and flattened teeth of the fish of the order Pycnodontiformes show that the animals were adapted for durophagy, or the consumption of hard-shelled invertebrates. The long, thin teeth of the fish of the family Caturidae were typical tools for piercing the scales of other fish. Ichthyosaurs (Ichthyosauria) used their teeth, characterized by massive crowns with blunt edges, to catch and crush soft-bodied cephalopods. In turn, pliosaurs (Pliosauroidea) had curved teeth which sharp edges, which allowed them to tear apart the bodies of large victims.

The return of sea monsters

The bones of large vertebrates are relatively difficult to study. In the Polish paleontological sites, it is not easy to say at first glance which skeletal elements we are dealing with. Bone material often becomes similar in color or shape to the rock that surrounds it. For example, this holds true for the bones of the ichthyosaurs from the Owadów-Brzezinki Quarry. Although the remains of those reptiles are found in the form of massive concentrations, students often have great difficulty saying if a certain exhibit is a bone or a piece of limestone.

This situation is best illustrated by the reconstruction of a fin belonging to the ichthyosaur *Cryopterygius kielanae*. The bones that formed the fingers and the metacarpals of that reptile are highly reminiscent of small pieces of limestone rock. The matter is made even more difficult by the fact that ichthyosaurs were characterized by hyperphalangy (the presence of extra phalanges) and sometimes by hyperdactyly (the presence of extra fingers). Reconstructing an entire limb of an ichthyosaur from single bones extracted from sediment requires a good knowledge of the comparative anatomy of those reptiles.

Modern paleontology often uses advanced 3D reconstruction methods. Three-dimensional models of studied fossils (entire skeletons and skulls or individual structures) may be obtained with the help of x-ray tomography or microtomography or by scanning objects and processing the scans with relevant software. Methods of 3D reconstruction are especially important when we want to examine the inside of a fossil, for example the anatomy of the cranium or nasal cavity or the histology of a delicate tooth.

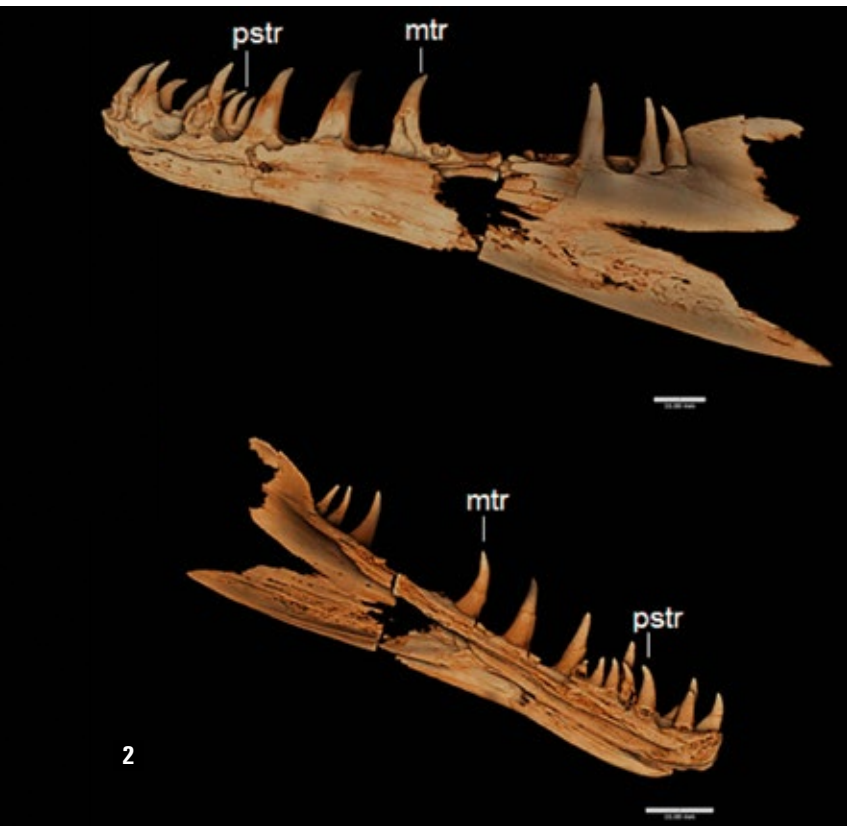

Fig. 2. A 3D model ("virtual fossil") of the lower jaw of the predatory fish *Caturus giganteus* obtained via non-invasive x-ray microtomography.

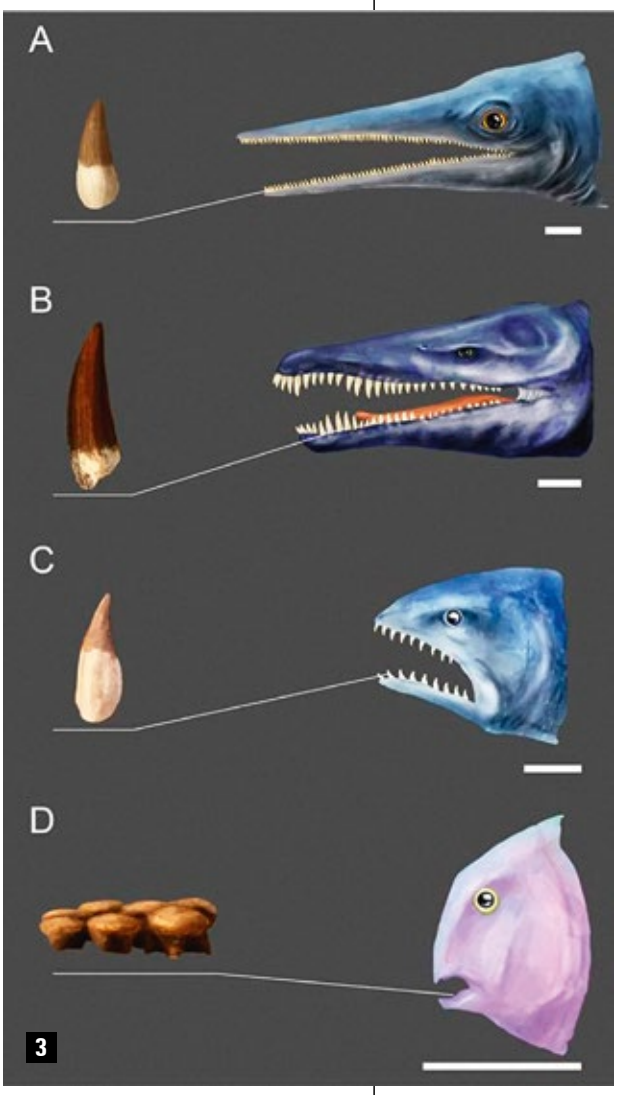

Fig. 3. Life-size reconstructions of the heads of marine vertebrates whose remains are found in the Owadów-Brzezinki Quarry and their distinctively shaped teeth: an ichthyosaur (A), a pliosaur (B), a bony fish from the group of caturid fishes (C), and a bony fish from the group of pycnodont fishes (D). Scale – 20 cm.

Examples of such analyses include my studies of a large ichthyosaur from the Morawica Quarry outside Kielce. Although the bones of that reptile were preserved in the form of cross-sections of the skull on the surface of limestone slabs, the use of computer software helped reconstruct the internal structure of the animal's nasal cavity. Those analysis brought a lot of valuable information about the functional anatomy of the Late Jurassic ophthalmosaurids and the biology of their senses. Another example is the x-ray analysis of the jaws and teeth of large predatory fish from the Owadów-Brzezinki Quarry. Analysis using computed microtomography helped determine the structure of the teeth of those animals and contributed significantly to our knowledge about the life and hunting techniques of extinct ray-finned fish.

However, the most interesting aspect of such work is the reconstruction of entire organisms and the creation of life-size models. In such situations, a paleobiologist must work with artists. This task is the next stage of our work in the context of studies of the Owadów-Brzezinki site. A modern geopark is being built near the quarry. It will host a Paleontological Museum with life-size reconstructions of animals whose fossils we have found in recent years. Visitors will be able to see life-size models of the *Cryopterygius kielanae* ichthyosaur, the *Owadowia borsukbialynickae* turtle, the *Caturus giganteus* fish, a large ammonite or a flying reptile – a pterosaur.

This modern museum will be the culmination of the past six years of research of this globally unique paleontological site. All paleontology aficionados will be able to see with their own eyes the "dragons" that ruled the seas that covered the territory of Poland 148 million years ago.

The reconstruction of the skeleton of the right pectoral fin of the ichthyosaur *Cryopterygius kielanae*: original bones (on the page opposite) and a drawing presenting their osteological interpretation.

Daniel Tyborowski

Further reading:

Tyborowski D., Błażejowski B., Krystek M. (2016). Szczątki gadów z górnojurajskich wapieni w kamieniołomie Owadów-Brzezinki (Polska środkowa) [Reptilian Remains from Upper Jurassic Limestones in the Owadów-Brzezinki Quarry] *Przegląd Geologiczny* 64 (8): 564–569.

Tyborowski D. (2016). A new ophthalmosaurid ichthyosaur from the Late Jurassic of Owadów-Brzezinki Quarry, Poland. *Acta Palaeontologica Polonica 61* (4): 791–803.

Tyborowski D. (2017). Large predatory actinopterygian fishes from the Late Jurassic of Poland studied with X-ray microtomography. *Neues Jahrbuch für Geologie und Paläontologie* 283 (2): 161–172.