Ecology & Evolution | Nov 22, 2026 | 5 min read | By Bryan White

# Early Pleistocene North Sea Fossils Push Back Apex Macropredation in Killer Whales Past Two Million Years

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Modern killer whales ( Orcinus orca ) sit atop marine food webs worldwide, with specialized mammal-hunting ecotypes capable of subduing seals, sea lions, and even baleen whales. Until recently, paleontologists and evolutionary geneticists largely viewed this large-bodied apex predation as a relatively late innovation within the oceanic dolphin family (Delphinidae). Now, a November 2026 study published in PeerJ by H. Bakker and colleagues from the Natural History Museum Rotterdam, the Geological Survey of the Netherlands, and the University of Pisa overturns that timeline. Analyzing cranial and mandibular fossils dredged by fishing trawlers from the Southern North Sea Basin, the researchers document a giant Early Pleistocene Orcinus -- dating to the Gelasian age roughly 2.6 to 2.1 million years ago -- that already possessed the body size and skull architecture of a dedicated marine macropredator.

Using 3D morphometric modeling and regression scaling against modern cetaceans, the team estimates that the North Sea individual reached 7.2 to 7.7 meters in total length , matching the largest living adult male killer whales such as Antarctic Type A ecotypes. Rather than emerging only during the Middle or Late Pleistocene, grip-and-tear macropredation on large vertebrate prey has been an active ecological force in the genus Orcinus for more than two million years.

## Rewriting a Sparse Cetacean Fossil Record

Despite the global distribution of living killer whales, the fossil record of Orcinus is notoriously fragmentary. For decades, evolutionary models leaned heavily on Orcinus citoniensis , a small-bodied extinct relative recovered from Pliocene marine sediments in Italy dating to roughly 3.5 to 2.6 million years ago. Measuring approximately 3.5 to 4 meters in length and carrying higher tooth counts -- 14 or more relatively slender teeth per quadrant -- O. citoniensis was interpreted as a generalist fish -eater (piscivore) resembling modern false killer whales or pilot whales.

That contrast fueled a tidy evolutionary narrative: ancestral delphinids began as small, fast-swimming fish predators in the Pliocene and only much later scaled up in body mass and dental robustness to tackle marine mammals. Compounding this view, molecular phylogeographic studies of modern Orcinus orca -- including mitogenomic analyses by Morin et al. (2010) and genome -culture coevolution work by Foote et al. (2016) -- demonstrated that living killer whale ecotypes diverged relatively recently, within the past several hundred thousand years.

| Taxon / Specimen | | Geological Epoch & Age | | Estimated Body Length | | Cranial & Dental Ecology |

| Orcinus citoniensis (Italy) | | Pliocene (~3.5-2.6 Ma) | | ~3.5 to 4.0 meters | |

Higher tooth count (~14+ per quadrant); primarily piscivorous |

| Southern North Sea Orcinus | | Early Pleistocene / Gelasian (~2.6-2.1 Ma) | | ~7.2 to 7.7 meters | | Deeply anchored, widely spaced teeth; grip-and-tear macropredator |

| Modern Orcinus orca (Type A Male) | | Holocene / Recent | | ~7.0 to 8.5+ meters | | 10-14 interlocking conical teeth; apex marine mammal predator |

## Biomechanics of Grip-and-Tear Macropredation

The Southern North Sea Basin fossils bridge the morphological chasm between diminutive Pliocene O. citoniensis and modern apex orcas. Detailed osteological inspection revealed large, deep, and widely spaced tooth sockets (alveoli), with root depths reaching roughly 9 centimeters (about 3.5 inches). In marine tetrapods, deep alveolar anchoring paired with reduced tooth counts is a classic biomechanical adaptation for resisting extreme lateral shear and torsional loads generated when biting into struggling, thick-skinned prey.

Equally telling are the deeply excavated condylar fossae at the rear of the cranium, where the skull articulates with the atlas vertebra. Enlarged muscle attachment surfaces around the occipital condyles indicate powerful cervical musculature capable of rapid head shaking, twisting, and tearing -- precisely the "grip-and-tear" feeding kinematics modern mammal-eating killer whales use to dismember pinnipeds and cetaceans too large to swallow whole. In contrast, suction-feeding or small-prey piscivorous odontocetes exhibit shallower alveoli, more numerous teeth, and far less robust atlanto-occipital bracing.

## Reconciling Deep-Time Fossils With Modern Ecotype Genomics

At first glance, pushing giant macropredatory Orcinus back past 2.1 million years appears to conflict with genomic clocks that place the radiation of modern Orcinus orca ecotypes -- such as fish-eating "Resident" versus mammal-hunting "Transient" (Bigg's) killer whales in the North Pacific -- within the last 200,000 to 350,000 years. In reality, the two datasets measure fundamentally different evolutionary processes.

Modern ecotype genomics tracks the matrilineal and nuclear divergence of extant populations surviving today, many of which passed through severe Pleistocene glacial bottlenecks before culturally and genetically specializing in coastal habitats. The Gelasian North Sea specimen, by contrast, records an ancient stem or early crown Orcinus lineage that already occupied the apex macropredator niche during the Plio-Pleistocene transition, when cooling oceans, expanding Northern Hemisphere ice sheets , and productive North Atlantic shelf seas reshaped marine mammal and seabird communities.

## Ecological Significance in Plio-Pleistocene Shelf Seas

The Southern North Sea during the Gelasian was a shallow, dynamic marine embayment teeming with seals, early baleen whales, and schooling fishes, while older giant macropredatory sharks such as Otodus megalodon had already vanished from global oceans by the early Pliocene. The rapid emergence of 7.5-meter macropredatory

delphinids shortly thereafter suggests that ancestral Orcinus populations swiftly capitalized on newly vacated top-predator guilds.

Whether the Early Pleistocene North Sea giant represents a direct ancestor of living Orcinus orca or an extinct sister species within the genus remains an open systematic question awaiting more complete cranial material. Either way, the fossils establish that the anatomical toolkit for apex marine-mammal predation -- massive body size, deeply rooted dentition, and reinforced neck biomechanics -- was already forged at the dawn of the Ice Ages, demonstrating that killer whales have shaped top-down marine trophic cascades for over two million years.

## References & Primary Sources

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