# Institutional Abbreviations

AMF – Australian Museum, Sydney, Australia

AMNH – American Museum of Natural History, New York, New York, USA

CAS – California Academy of Sciences, San Francisco, California, USA

CMC – Cincinnati Museum Center, Cincinnati, Ohio, USA

CMNH – Cleveland Museum of Natural History, Cleveland, Ohio, USA

FSBC – Florida State Biodiversity Collection, St. Petersburg, Florida, USA

GPIT – Institut für Geowissenschaften, Eberhard Karls Universität Tübingen, Tübingen, Germany

MNHM – Musée d’Histoire naturelle de Miguasha, Nouvelle, Québec, Canada

MNHN – Muséum national d'histoire naturelle, Paris, France

NHMUK – The Natural History Museum, London, London, U.K.

NMS – National Museum of Scotland, Edinburgh, UK

OSUM – Ohio State University Museum of Biodiversity, Columbus, Ohio, USA

ROM – Royal Ontario Museum, Toronto, Ontario, Canada

USNM – Smithsonian National Museum of Natural History, Washington, D.C., USA

WAM – Western Australian Museum, Perth, Australia

Note CMNH does not have separate abbreviations for vertebrate zoology and vertebrate paleontology, so numbers may possibly overlap between recent and fossil material.

# Recent Material

For recent material only fishes examined directly are listed. Other material was examined from the previously published literature, such as Garrick (1982, 1985), Randall (1997) or photographs of species on Wikimedia Commons. For additional literature references examined see Engelman (2023): supplementary files S1 and S4, and references therein. Pelvic fin position in *Chirocentrus* was determined based on x-ray images published in CAS online database (Monarch, 2022).

| **Taxon** | **Group** | **Specimens** |
| --- | --- | --- |
| *Galeocerdo cuvier* | Carcharhinformes: Carcharhinidae | FSBC unnumbered |
| *Carcharhinus acronotus* | Carcharhinformes: Carcharhinidae | FSBC unnumbered, 24310 |
| *Carcharhinus falciformis* | Carcharhinformes: Carcharhinidae | FSBC 7175 |
| *Rhizoprionodon terranovae* | Carcharhinformes: Carcharhinidae | FSBC unnumbered a-b |
| *Acipenser oxyrinchus* | Acipenseriformes: Acipenseridae | FSBC 32937 |
| *Polyodon spathula* | Acipenseriformes: Polyodontidae | OSUM 34195, OSUM 77243 |
| *Lepisosteus oculatus* | Lepisosteiformes, Lepisosteidae | CMNH 1b |
| *Lepisostus osseus* | Lepisosteiformes, Lepisosteidae | CMNH 1a, CMNH 2299a-c |
| *Amia calva* | Amiiformes: Amiidae | OSUM unnumbered, 14022a-c, 14023, 103663 |
| *Anguilla rostrata* | Anguilliformes, Anguillidae | CMNH 2504, 2109, 2571a-b, 3278, OSUM unnumbered |
| *Conger* sp. | Anguilliformes: Congridae | FSBC 7595 |
| *Conger oceanus* | Anguilliformes: Congridae | FSBC 18272 |
| *Rhyncoconger flavus* | Anguilliformes: Congridae | FSBC 32081 |
| *Gymnothorax moringa* | Anguilliformes: Muraenidae | FSBC 18272 |
| *Albula vulpes* | Albuliformes: Albulidae | FSBC 18801, 19093a-d |
| *Hiodon tergisus* | Hidontiformes: Hiodontidae | CMNH 35a-c, 3993a-b |
| *Araipaima gigas* | Osteoglossiformes: Osteoglossidae | OSUM 18523-S |
| *Colossoma macropomum* | Characiformes: Serrasalmidae | FSBC 8048 |
| *Cheirocentrus dorab* | Clupeiformes: Cheirocentridae | CAS SU 13609, 13665, 13763 |
| *Cheirocentrus nudus* | Clupeiformes: Cheirocentridae | CAS SU 20302, 35612 |
| *Alosa pseudoharengus* | Clupeiformes: Clupeidae | CMNH 5764a-f |
| *Dorosoma cepedianum* | Clupeiformes: Clupeidae | CMNH 40, 5088, 6388 |
| *Ariopsis felis* | Siluriformes: Ariidae | FSBC 1524, 4257, 4999 |
| *Bagre marinus* | Siluriformes: Ariidae | FSBC 1523, 5779, 7763 |
| *Ameiurus melas* | Siluriformes: Ictaluridae | CMNH 2538 |
| *Ameiurus natalis* | Siluriformes: Ictaluridae | CMNH 20245a-b |
| *Ameiurus nebulosus* | Siluriformes: Ictaluridae | CMNH 5213a-c |
| *Ictalurus punctatus* | Siluriformes: Ictaluridae | OSUM 58135, 80503 |
| *Noturus flavus* | Siluriformes: Ictaluridae | CMNH ze667a-b, ze725 |
| *Noturus miurus* | Siluriformes: Ictaluridae | CMNH 6152 |
| *Pylodictis olivaris* | Siluriformes: Ictaluridae | OSUM 8467, 13987, 14940 |
| *Esox lucius* | Esociformes: Esocidae | OSUM unnumbered |
| *Esox masquinongy* | Esociformes: Esocidae | OSUM 5031, 9276, 42103 |
| *Esox niger* | Esociformes: Esocidae | CMNH 2304, 10030 |
| *Umbra limi* | Esociformes: Umbridae | CMNH 10908a-m |
| *Oncorhynchus kisutch* | Salmoniformes: Salmonidae | OSUM 9132, 16772, 104830, 109450 |
| *Oncorhynchus mykiss* | Salmoniformes: Salmonidae | OSUM 10664, unnumbered |
| *Salmo salar* | Salmoniformes: Salmonidae | OSUM 65520a-b |
| *Salmo trutta* | Salmoniformes: Salmonidae | OSUM 1805, 9126a-b, 13655 |
| *Salvelinus fontinalis* | Salmoniformes: Salmonidae | CMNH 8657, OSUM 4245a-c |
| *Thymallus arcticus* | Salmoniformes: Salmonidae | OSUM 14845 |
| *Alepisaurus ferox* | Aulopiformes: Alepisauridae | FSBC 18926 |
| *Fundulus diaphanus* | Cyprinodontiformes: Fundulidae | CMNH 18620a-g |
| *Percopsis omiscomaycus* | Percopsiformes: Percopsidae | CMNH 2672a-b, 275a-d, 3015, 5380 |
| *Beryx decadactylus* | Beryciformes: Berycidae | FSBC 18172 |
| *Lobotes surinamensis* | Acanthuriformes: Lobotidae | FSBC 10817 |
| *Scombrops oculatus* | Acropomatiformes: Scombropidae | FSBC 19124, 19942a-b, |
| *Polyprion americanus* | Acropomatiformes: Polyprionidae | FSBC 19840 |
| *Labidesthes sicculus* | Atheriniformes: Atherinopsidae | CMNH 7285a-f |
| *Tylosurus crocodilus* | Beloniformes: Belonidae | FSBC 7656 |
| *Coryphaena hippurus* | Carangiformes: Coryphaenidae | FSBC 6710 |
| *Alectis cilaris* | Carangiformes: Carangidae | FSBC 2455, 35622 |
| *Caranx bartholomaei* | Carangiformes: Carangidae | FSBC 19067 |
| *Caranx lugubris* | Carangiformes: Carangidae | FSBC 3728 |
| *Echeneis naucrates* | Carangiformes: Echeneidae | FSBC unnumbered |
| *Centropomus parallelus* | Carangaria incertae sedis: Centropomidae | FSBC 36446 |
| *Centropomus undecimalis* | Carangaria incertae sedis: Centropomidae | FSBC 18806a-b, 19058, 19731 |
| *Micropterus dolomieu* | Centrarchiformes: Centrarchidae | CMNH 2186a-c, 7412a-c, 9141, ZE173a-b, teaching collection a-d |
| *Micropterus salmoides* | Centrarchiformes: Centrarchidae | CMNH 4758a-b |
| *Pomoxis annularis* | Centrarchiformes: Centrarchidae | CMNH 7163a-e |
| *Lepomis cyanellus* | Centrarchiformes: Centrarchidae | CMNH 2783a-c, 6174a-b |
| *Amblopites rupestris* | Centrarchiformes: Centrarchidae | CMNH 1997a-g, 9619a-f |
| *Caulolatilus cyanops* | Eupercaria incertae sedis: Latilidae | FSBC 3351 |
| *Caulolatilus chrysops* | Eupercaria incertae sedis: Latilidae | FSBC 8774, 11806 |
| *Caulolatilus microps* | Eupercaria incertae sedis: Latilidae | FSBC 7093 |
| *Malacanthus plumieri* | Eupercaria incertae sedis: Latilidae | FSBC 7207, 7683, 7987 |
| *Apsilus dentatus* | Eupercaria incertae sedis: Lutjanidae | FSBC 12633 |
| *Etelis oculatus* | Eupercaria incertae sedis: Lutjanidae | FSBC 7936 |
| *Lutjanus cyanopterus* | Eupercaria incertae sedis: Lutjanidae | FSBC 4001 |
| *Lutjanus purpureus* | Eupercaria incertae sedis: Lutjanidae | FSBC 12944 |
| *Morone saxatilus* | Eupercaria incertae sedis: Moronidae | FSBC 33946 |
| *Heteropriacanthus cruentatus* | Eupercaria incertae sedis: Priacanthidae | FSBC 11731 |
| *Cynoscion nebulosus* | Eupercaria incertae sedis: Sciaenidae | FSBC 6712 |
| *Pogonias cromis* | Eupercaria incertae sedis: Sciaenidae | FSBC 6411 |
| *Gobiomorus dormitor* | Gobiiformes: Eleotridae | FSBC 7519 |
| *Neogobius melanostomus* | Gobiiformes: Gobiidae | CMNH 10031a-o |
| *Mugil curema* | Mugiliformes: Mugilidae | FSBC unnumbered a-c |
| *Brotula barbata* | Ophidiiformes: Ophidiidae | FSBC 11501 |
| *Dermatolepis inermis* | Perciformes: Serranidae | FSBC 9077 |
| *Epinephelus itajara* | Perciformes: Serranidae | FSBC 12632 |
| *Epinephelus morio* | Perciformes: Serranidae | FSBC 2457 |
| *Epinephelus striatus* | Perciformes: Serranidae | FSBC 24226 |
| *Mycteroperca interstitialis* | Perciformes: Serranidae | FSBC 1202, 7686 |
| *Mycteroperca tigris* | Perciformes: Serranidae | FSBC 11989, 11990 |
| *Mycteroperca venenosa* | Perciformes: Serranidae | FSBC 11631 |
| *Hyporthodus drummondhayi* | Perciformes: Serranidae | FSBC 7097 |
| *Hyporthodus mystacinus* | Perciformes: Serranidae | FSBC unnumbered |
| *Hyporthodus nigritus* | Perciformes: Serranidae | FSBC 12003 |
| *Etheostoma caerulum* | Perciformes: Percidae | CMNH 340, 8493a-b, 8921 9450a-c, 9469a-b 9478a-b, 18383, |
| *Etheostoma nigrum* | Perciformes: Percidae | 696, 1206, 6428, 6927, 6934, 9437, 11169a-c |
| *Percina caprodes* | Perciformes: Percidae | CMNH 5224a-e |
| *Sander canadense* | Perciformes: Percidae | OSUM1167, 1852, 14529, 78280 |
| *Sander vitreum* | Perciformes: Percidae | OSUM 1839, 3860, 12985 |
| *Taractes rubescens* | Scombriformes: Bramidae | FSBC 11654, 18715 |
| *Taractichthys longipinnus* | Scombriformes: Bramidae | FSBC 11638, 12956 |
| *Hyperoglyphe bythites* | Scombriformes: Centrolophidae | FSBC 9732, 18064 |
| *Pomatomus saltatrix* | Scombriformes: Pomatomidae | OSUM 5237a-e |
| *Acanthocybium solandrei* | Scombriformes: Scombridae | FSBC 6267 |
| *Katsuwonus pelamis* | Scombriformes: Scombridae | FSBC 5033 |
| *Scomberomorus maculatus* | Scombriformes: Scombridae | FSBC 6412 |
| *Scomberomorus regalis* | Scombriformes: Scombridae | FSBC 6404 |
| *Thunnus atlanticus* | Scombriformes: Scombridae | FSBC 2452, 6414 |
| *Calamus bajonado* | Spariformes: Sparidae | FSBC 7958 |
| *Aulostomus maculatus* | Syngnathiformes: Aulostomidae | FSBC 8282 |
| *Balistes capriscus* | Tetraodontiformes: Balistidae | FSBC 24286 |
| *Aluterus monoceros* | Tetraodontiformes: Monacanthidae | FSBC 3567, 24285 |
| *Canthernes macrocerus* | Tetraodontiformes: Monacanthidae | FSBC 6410 |
| *Lagocephalus laevigatus* | Tetraodontiformes: Tetraodontidae | FSBC 8018, 8814 |

# Fossil Taxa

Additional anatomical data for many data were taken from Denison (1978).

| **Taxon** | **Group** | **Specimens** | **References** | **Notes** |
| --- | --- | --- | --- | --- |
| *Xiphactinus audax* | Ichthyodectiformes (Actinopterygii) | USNM V21375 | — | Examined to determine pelvic fin position |
| *Gemuendina stuertzi* | Rhenanida | — | Gross (1963); Denison (1978) |  |
| *Australoptyctodus gardineri* | Ptyctodontida | — | Trinajstic et al. (2012) |  |
| *Campbellodus decipiens* | Ptyctodontida | — | Long (1997) |  |
| *Ctenurella gladbachensis* | Ptyctodontida | — | Ørvig (1960); Denison (1978); Long (1997) |  |
| *Materpiscis attenborughi* | Ptyctodontida | — | Trinajstic et al. (2012) |  |
| *Rhamphodopsis threiplandi* | Ptyctodontida | — | Miles (1967) |  |
| *Asterolepis ornata* | Antiarchi | — | Ivanov et al. (1996) |  |
| *Bothriolepis canadensis* | Antiarchi | — | Béchard et al. (2014) |  |
| *Bothriolepis gippslandiensis* | Antiarchi | — | Long and Werdelin (1986) | No mention of lateral line extending onto squamation, but it is unclear if trunk canal extended past posterior margin of armor. |
| *Microbrachius dicki* | Antiarchi | — | Hemmings (1978) |  |
| *Parayunnanolepis xitunensis* | Antiarchi | — | Zhu et al. (2012); Wang and Zhu (2022) |  |
| *Pterichthyodes milleri* | Antiarchi | — | Hemmings (1978) |  |
| *Remigolepis walkeri* | Antiarchi | — | Johanson (1997) | No mention of lateral line extending onto squamation, but it is unclear if trunk canal extended past posterior margin of armor. |
| *Bianchengichthys micros* | “Maxillate” Placoderm | — | Li et al. (2021) |  |
| *Entelognathus primordialis* | “Maxillate” Placoderm | — | Zhu et al. (2013); Cui et al. (2023) |  |
| *Qilinyu rostrata* | “Maxillate” Placoderm | — | Zhu et al. (2016a) |  |
| *Actinolepis spinosa* | Basal Arthrodira | — | Mark-Kurik (1985) |  |
| *Sigaspis lepidophora* | Basal Arthrodira | — | Goujet (1973) |  |
| *Bryantolepis brachycephalus* | Basal Arthrodira | — | Denison (1962) |  |
| *Austrophyllolepis ritchei* | Phyllolepida | — | Long (1983) |  |
| *Cowralepis mclachlani* | Phyllolepida | — | Ritchie (2005); Carr et al. (2009) |  |
| *Phlyctaenius acadicus* | Phlyctaeniidae | — | Heintz (1933a) |  |
| *Buchanosteus confertituberculatus* | Buchanosteoidea | — | White (1952); Young (1979); Long et al. (2014) |  |
| *Parabuchanosteus murrumbidgeenis* | Buchanosteoidea | — | White (1952); Long et al. (2014) |  |
| *Africanaspis dorissa* | Groenlandaspidae | — | Gess and Trinajstic (2017) |  |
| *Holonema westolii* | Holonematidae | — | Miles and White (1971); Trinajstic (1999) |  |
| *Homosteus sulcatus* | Homosteidae | — | Heintz (1933b) |  |
| *Rhachiosteus pterygiatus* | Eubrachythoraci incertae sedi | — | Miles (1966b) |  |
| *Eldenosteus arizonensis* | Coccosteomorpha | — | Johnson and Elliott (1995) |  |
| *Coccosteus cuspidatus* | Coccosteoid Coccosteomorph | **FMNH:** PF 1673  **NMS:** 1890.91.22, 1893.107.27, 1897.55.6, 1900.12.12, 1901.106.1, **ROM:** VP 52664 | Miles and Westoll (1968); Trewin (1986) |  |
| *Millerosteus minor* | Coccosteoid Coccosteomorph | FMNH PF 1089, 1090, NHMUK PV P16795, NMS 1859.33.986, NMS 1965.37.1 | Desmond (1974), van Mesdag (2018) |  |
| *Watsonosteus fletti* | Coccosteoid Coccosteomorph | NMS G.1995.4.2 | Miles and Westoll (1963) |  |
| *Dickosteus threplandi* | Coccosteoid Coccosteomorph | NHMUK PV P 49663, NMS 1987.7.118 | Miles and Westoll (1963) |  |
| *Compagopiscis croucheri* | Incisoscutoid Coccosteomorph | — | Gardiner and Miles (1994); Trinajstic (1995); Trinajstic and Hazelton (2007) |  |
| *Harrytoombsia elegans* | Incisoscutoid Coccosteomorph | WAM 70.4.254 | Miles and Dennis (1979) |  |
| *Incisoscutum ritchei* | Incisoscutoid Coccosteomorph | WAM 03.3.28 | Dennis and Miles (1981); Long (1994); Trinajstic et al. (2013) |  |
| *Mcnamaraspis kaprios* | Incisoscutoid Coccosteomorph | — | Long (1995) |  |
| *Pinguosteus thulborni* | Incisoscutoid Coccosteomorph | — | Long (1990) |  |
| *Torosteus* spp. | Incisoscutoid Coccosteomorph | — | Gardiner and Miles (1990) |  |
| *Fallacosteus turneri* | Incisoscutoid Coccosteomorph (Camuropiscidae) | — | Long (1990) |  |
| *Camuropiscis laidlawi* | Incisoscutoid Coccosteomorph (Camuropiscidae) | — | Dennis and Miles (1979b) |  |
| *Rolfosteus canningensis* | Incisoscutoid Coccosteomorph (Camuropiscidae) | — | Dennis and Miles (1979a) |  |
| *Tubonasus lennardensis* | Incisoscutoid Coccosteomorph (Camuropiscidae) | — | Dennis and Miles (1979a) |  |
| *Protitanichthys rockportensis* | Plourdosteidae (Coccosteomorpha?) | — | Miles (1966a) |  |
| *Plourdosteus canadensis* | Plourdosteidae (Coccosteomorpha?) | MNHM 02-177, 02-0557, 02-712, 02-901, 02-3375, 02-4988 | Vézina (1988, 1990) |  |
| *Heterosteus ingens* | Heterosteiidae (Dunkleosteoidea?) |  |  |  |
| *Yinosteus major* | Heterosteiidae (Dunkleosteoidea?) | — | Zhu et al. (2016b) |  |
| *Eastmanosteus calliaspis* | Dunkleosteoidea | — | Dennis-Bryan (1987) |  |
| *Kiangyousteus yohii* | Dunkleosteoidea | — | Zhu and Zhu (2013) |  |
| *Golshanichthys asiatica* | Dunkleosteoidea | — | Lelievre et al. (1981) |  |
| *“Dunkleosteus” magnificus* | Dunkleosteoidea | — | Hussakof and Bryant (1918) |  |
| *Dunkleosteus raveri* | Dunkleosteoidea | — | Carr and Hlavin (2010) |  |
| *Dunkleosteus terrelli* | Dunkleosteoidea | **AMNH**: FF 5, FF 6, FF 7301; **CMC**: VP8294, VP8543; **CMNH:** 5768, 5936, 5997, 6090, 6194, 7054, 7424, 7568, 8131, 8735, 8982, 50322; **USNM:** V 21314 | Dean (1909b), Stetson (1930), Heintz (1932), Hlavin (1976), Carr et al. (2010), Johanson et al. (2019) | Total *D. terrelli* holdings at AMNH, CMC, and NHMUK and most of CMNH were examined, but other specimens not complete enough to provide information beyond what is seen in these specimens |
| *Dunkleosteus marsaisi* | Dunkleosteoidea | GPIT/PD/9, MNHN MCD-5 | Rücklin and Clément (2017) |  |
| *Hadrosteus rapax* | “macropredator clade” Aspinothoracidan | — | Gross (1932); Stensiö (1963) |  |
| *Holdenius holdeni* | “macropredator clade” Aspinothoracidan | CMNH 8031 | Dunkle and Bungart (1942), Hlavin (1990) |  |
| *Dinichthys herzeri* | “macropredator clade” Aspinothoracidan | — | Hussakof (1906); Carr and Hlavin (2010) |  |
| *Gorgonichthys clarki* | “macropredator clade” Aspinothoracidan | CMNH 7129, CMNH 9875 | Dunkle and Bungart (1940), Dunkle and Bungart (1946) |  |
| *Heintzichthys gouldii* | “macropredator clade” Aspinothoracidan | AMNH FF 2426, CMNH 5266, CMNH 5291, CMNH 5648 | Dean (1896), Heintz (1931), Carr (1991) |  |
| *Titanichthys* spp. | Mylostomatoid? Aspinothoracidan | — | Dean (1909a), Boyle and Ryan (2017) |  |
| *Bungartius perissus* | Mylostomatoid? Aspinothoracidan | CMNH 6666, CMNH 7573 | Dunkle (1947) |  |
| *Mylostoma variabilis* | Mylostomatoid? Aspinothoracidan | CMNH 7256 | Dean (1901a); Hlavin and Boreske (1973) |  |
| *Paramylostoma arcualis* | Mylostomatoid? Aspinothoracidan | CMNH 5284, CMNH 6054 | Dunkle and Bungart (1945) |  |
| *Amazichthys trinajsticae* | Selenosteid Aspinothoracidan | — | Jobbins et al. (2022) |  |
| *Brachydirus grandis* | Selenosteid Aspinothoracidan | — | Gross (1932) |  |
| *Draconichthys elegans* | Selenosteid Aspinothoracidan | — | Rücklin (2011) |  |
| *Enseosteus* spp. | Selenosteid Aspinothoracidan | — | Gross (1932); Rücklin (2011) |  |
| *Gymnotrachelus hydei* | Selenosteid Aspinothoracidan | CMNH 8042 | Carr (1994) |  |
| *Oxyosteus rostratus* | Selenosteid Aspinothoracidan | — | Gross (1932) |  |
| *Pachyosteus bulla* | Selenosteid Aspinothoracidan | — | Gross (1932); Kulczycki (1957) |  |
| *Pholidosteus friedeli* | Selenosteid Aspinothoracidan | — | Gross (1932) |  |
| *Rhinosteus parvulus* | Selenosteid Aspinothoracidan | — | Rücklin (2011) |  |
| *Selenosteus brevis* | Selenosteid Aspinothoracidan | — | Dean (1901b) |  |
| Selenosteidae gen. et. sp. indet. | Selenosteid Aspinothoracidan | CMC VP8545, CMNH 50233 | — | Undescribed, may all pertain to a single, new species (R. Carr, pers. comm.), but has body outlines |
| *Stenosteus angustipectus* | Selenosteid Aspinothoracidan | CMNH 8055 | Carr (1996) |  |
| *Synauchenia coalescens* | Selenosteid Aspinothoracidan | — | Gross (1932) |  |
| *Walterosteus lelievrei* | Selenosteid Aspinothoracidan | — | Rücklin (2011) |  |

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