Lucas, S.G., Spielmann, J.A., Hester, P.M., Kenworthy, J.P. and Santucci, V.L., eds., 2006, Fossils from Federal Lands. New Mexico Museum of Natural History and Science Bulletin 34.

A PRELIMINARY INVENTORY OF FOSSIL FISH FROM NATIONAL PARK SERVICE UNITS

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Abstract—Fossilized fish remains are widespread throughout the continental United States. At this time 42 park units are identified to contain these remains, although this number will surely increase as further investigations are conducted. The stratigraphic record of these remains range from Silurian to Holocene ages and preserves both marine and freshwater forms. Large concentrations and varieties of these remains are found in Fossil Butte National Monument, Grand Canyon National Park, Death Valley National Park, Petrified Forest National Park, Santa Monica Mountains National Recreation Area and Big Bend National Park. The diversity, record and availability of these fish remains in national park units emphasizes future research needs while also informing both park staff and visitors of these important resources for stewardship and interpretation of the past.

INTRODUCTION

At least 180 units of the National Park Service (NPS) preserve paleontological resources. A number of these units preserve a wide array of fossil fish resources, possibly larger than ever thought before. A comprehensive look at the park service units containing the remains of fish has not been previously undertaken and currently 42 of 180 NPS units preserving fossils have been identified with fossil fish remains (Fig. 1). These parks contain fish remains spanning the Silurian to Holocene and tell of the ecological history that existed during these times. While parks such as Fossil Butte and Florissant Fossil Beds National Monuments are very well known for the fossilized fish remains, many other parks also contain a great diversity. The purpose of this report is to review the records of these fossil fish remains, identify their occurrence, distribution and scientific importance, report on new findings, inform park staff and highlight possible research opportunities.

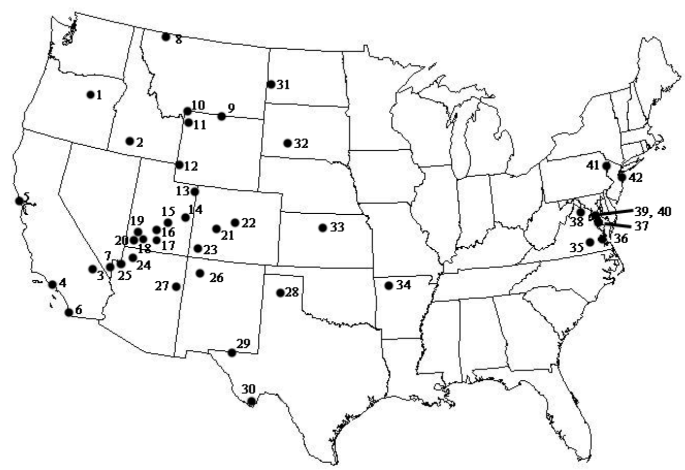

FIGURE 1. Distribution of fossil fish in National Park Service areas: **1**. John Day Fossil Beds, Oregon; **2**. Hagerman Fossil Beds National Monument, Idaho; **3**. Death Valley National Park, California; **4**. Santa Monica Mountains National Recreation Area, California; **5**. Point Reyes National Seashore, California; **6**. Cabrillo National Monument, California; **7**. Lake Mead National Recreation Area, Nevada and Arizona; **8**. Glacier National Park, Montana; **9**. Bighorn Canyon National Recreation Area, Montana and Wyoming; **10**. Yellowstone National Park, Wyoming and Montana; **11**. Grand Teton National Park, Wyoming; **12**. Fossil Butte National Monument, Wyoming; **13**. Dinosaur National Monument, Utah and Colorado; **14**. Arches National Park, Utah; **15**. Canyonlands National Park, Utah; **16**. Capitol Reef National Park, Utah; **17**. Glen Canyon National Recreation Area, Utah; **18**. Bryce Canyon National Park, Utah; **19**. Cedar Breaks National Monument, Utah; **20**. Zion National Park, Utah; **21**. Curecanti National Recreation Area, Colorado; **22**. Florissant Fossil Beds National Monument, Colorado; **23**. Mesa Verde National Park, Colorado; **24**. Grand Canyon National Park, Arizona; **25**. Parashant National Monument, Arizona; **26**. Chaco Culture National Historical Park, New Mexico; **27**. Petrified Forest National Park, Arizona; **28**. Lake Meredith National Recreation Area, Texas; **29**. Guadalupe Mountains National Park, Texas; **30**. Big Bend National Park, Texas; **31**. Theodore Roosevelt National Park, North Dakota; **32**. Badlands National Park, South Dakota; **33**. Tall Grass Prairie National Park, Kansas; **34**. Buffalo National River, Arkansas; **35**. Petersburg National Battlefield, Virginia; **36**. Colonial National Historical Park, Virginia; **37**. George Washington Birthplace National Monument, Virginia; **38**. Manassas National Battlefield Park, Virginia; **39**. Fort Washington Park, Maryland; **40**. Piscataway Park, Maryland; **41**. Delaware Water Gap National Recreation Area, New Jersey and Pennsylvania; **42**. Gateway National Recreation Area, New Jersey and New York.

PALEOZOIC FISH FOSSILS

The oldest known fish fossils from within an NPS unit are contained in the Silurian and Devonian rocks of Death Valley National Park, California and Delaware Water Gap National Recreation Area of Pennsylvania and New Jersey.

Death Valley National Park

A comprehensive survey of the paleontological resources of Death Valley National Park (DEVA) was completed by Nyborg and Santucci (1999). The Lippincott Member of the Hidden Valley Dolomite Formation (Silurian/Devonian**)** has produced the remains of *Panamintaspis snowi* and *Blieckaspis priscillae*, together with other agnathan fishes and a small arthrodire (placoderm; Elliot & Ilyes, 1993, 1996a, 1996b). The placoderm, *Dunkeleosteus terrelli*, a small cladodont shark and a cochliodont crushing tooth were also reported from within the Lost Burro Formation (Middle to Upper Devonian; Dunkle and Lane, 1971).

Delaware Water Gap National Recreation Area

The Late Silurian Bloomsburg Formation of the Delaware Water Gap National Recreation Area (DEWA) has been reported to contain the remains of the agnathan fish *Vernonaspis* and *Americaspis* (Epstein, 2001; Monteverde, 2001). Beerbower and Hait (1959) reported two fish localities near the recreation area that produced significant specimens of *Vernonaspis vaningeni* (Denison, 1964; Koch and Santucci, 2004). The Middle Devonian Mahantango Formation has been noted to contain a wide array of fossils within the park area, including plant impressions and carbonized fragments, four coral species, three bryozoan species, crinoid columnals and trace fossils (burrows, tracks and trails). While no fish remains have been discovered from this formation within the park, fish remains are known from this formation outside of the park, leading to the plausibility of similar fossils within the park (Parris and Albright, 1979a). Fish specimens have also been recovered from the Trimmers Rock Formation (Upper Devonian; Parris and Albright, 1979b).

Lake Mead National Recreation Area and Parashant National Monument

Paleozoic rocks are extensively exposed in northwestern Arizona. Lake Mead National Recreation Area (LAME) and Grand Canyon-Parashant National Monument (PARA) contain bony plates of freshwater fish, including *Bothriolepis*, along with "placoganoid" fish, which are recognized from the eastern facies of the Middle to Upper Devonian Temple Butte Formation (Beus, 1990). The remains of placoderm fish (both antiarchs and arthrodires) have been discovered in the Devonian Mountain Springs Formation (Johnson, personal commun., 2003).

Grand Canyon National Park

Of the many geologic formations exposed in the Grand Canyon National Park (GRCA) area, three formations of Paleozoic age are know to contain fish remains. The Temple Butte (Late Devonian; Frasnian) and the Redwall (Late Mississippian; Chesterian) formations are reported to contain marine fish remains, such as bony plates. The Permian Kaibab Limestone is well known for its shark teeth, some of which have been assigned to *Cladodus* sp. and *Deltodus mercurii.* The remains of other chondrichthyans such as *Coolyella peculiaris, Cooperella striatula* and *Mooreyella typicalis*, along with phyllodont tooth plates are also reported (Hunt et al., 2005).

Bighorn Canyon National Recreation Area, Dinosaur National Monument and Buffalo National River (additional Mississippian fossil fish)

Parks containing additional Mississippian fish remains, other than Grand Canyon National Park, include Bighorn Canyon National Recreation Area (BICA), Dinosaur National Monument (DINO) and Buffalo National River (BUFF). Santucci et al. (1999) notes the presence of crushing teeth belonging to the cochliodont *Hybodus* in the Madison Limestone (Mississippian) of BICA, which sits on the Wyoming-Montana border. DINO, which lies on the border of Colorado and Utah, preserves fishes in the shales of the Upper Mississippian Doughnut Formation (Hansen et al., 1983; Scott et al., 2001). The Boone Formation (Mississippian) of northwestern Arkansas, is highly fossiliferous and occasionally preserves the remains of sharks' teeth in outcrops along BUFF (Bitting, personal commun., 2001; Santucci et al., 2001).

Yellowstone National Park and Grand Teton National Park

While Yellowstone National Park (YELL) and Grand Teton National Park (GRTE) national parks are more often observed for their modern megafauna and scenic beauty, several fossiliferous units are exposed within these parks. The Mississippian Madison Group of YELL was reported to contain a cochliodont (primitive holocephalian chondrichthyes) along with a crushing tooth plate, while the Permian Phosphoria Formations is known to yield the shark *Helicoprion* in YELL and the possible dentical of a undetermined Paleozoic fishes in GRTE. Unidentified phosphatized fish remains are also known from the Permian Shedhorn Sandstone outcrops of YELL (Santucci, 1998; Tracy, 2003).

Tall Grass Prairie National Preserve

Tall Grass Prairie National Preserve (TAGR) was established in 1996 and contains 10,894 acres of land situated in the center of the Flint Hills region of Kansas. Fossils have yet to be reported from the Pennsylvanian and Permian limestones that underlie the grasses. However, Mike Everhart collected a *Ctenacanthus* from the Grant Member of the Winfield Formation, 48 km to the northwest of the park (Lower Permian; Everhart, personal commun., 2006).

Guadalupe Mountains National Park

The Permian formations of Guadalupe Mountains National Park, Texas (GUMO) are renowned for the well-preserved Capitan Reef complex. The middle Permian submarine fan sandstones of the Brushy Canyon and Cherry Canyon Formations within the park contain hundreds of fish remains, including shark's teeth, in small phosphatic nodules. The younger Lamar Limestone Member of the Bell Canyon Formation has also preserved the dentition of a holocephalan (Bell, personal commun., 2005).

MESOZOIC FOSSIL FISH

The Mesozoic formations hold the widest array of fossilized fish remains known in national park units. Much of this is due to the presence of the Cretaceous Western Interior Seaway in the middle of North America and to fluvial drainage during the Triassic and Jurassic (Heckert, personal commun., 2006).

Petrified Forest National Park

The fossils of Petrified Forest National Park (PEFO) are well known from the Chinle Formation (Upper Triassic). During this time, large fluvial systems were draining the area towards the western coast of Pangea. The Blue Mesa Member contains the chondrichthyes "*Xenacanthus*" *moorei, Lissodus humblei* and "*Acrodus*" sp., along with the osteichthyans *Arganodus dorotheae,* redfieldiid indet., Actinopterygii indet. and Paleoniscidae indet. aff. *Turseodus*. The Painted Desert Member preserves the chondrichthyan *Reticulodus synergus* and the osteichthyans *Arganodus dorotheae,* Redfieldiidae indet., Paleoniscidae indet. aff. *Turseodus* and Semionotidae indet. (Heckert, 2004, personal commun., 2006; Heckert et al., 2005; Irmis, 2005; Kirby, 1993; Murry, 1989; Murry and Kirby, 2002; Murry and Long, 1989).

Canyonlands National Park and Glen Canyon National Recreation Area (Chinle Formation)

The Chinle Formation is also exposed in Canyonlands National Park (CANY) and Glen Canyon National Recreation Area (GLCA). The Rocky Point Member of the Chinle Formation within GLCA contains unidentified fish remains, while in CANY, the remains of semionotid and redfieldiid fishes, along with lungfish burrows are reported (Santucci, 2000).

Manassas National Battlefield Park

On the opposite side of the United States, Manassas National Battlefield Park, Virginia (MANA), contains the remains of Triassic aged fish. The Culpeper Basin, one of the Newark Supergroup's Triassic rift basins, which frames the eastern front of the Appalachian Mountains from Culpeper County, Virginia into Maryland, exposes the Triassic Groveton Member of the Bull Run Formation. This formation has produced disarticulated fishes, including scales and isolated bones (Gore, 1988; Garland, 1997; Kenworthy and Santucci, 2004).

Zion National Park

In Zion National Park (ZION), a large amount of semionotid and coelacanth remains are represented in the Whitmore Point Member of the lower Jurassic Moenave Formation (Hettangian). In the same member, to the southwest of ZION, *Ceratodus* n. sp., along with the *Chinlea*-like coelacanth, *Semionotus* n. sp. and a hybodont shark, *Lissodus* n. sp., have been discovered at the Saint George Dinosaur Discovery Site at

Johnson Farm in Saint George, Utah (Milner et al., 2005, in review). The holostean fish, *Semionotus kanabensis*, is also known from skeletal remains and scales within the Whitmore Point Member (Schaeffer and Dunkle, 1950; DeBlieux et al., 2004; Milner et al., in press) and in the Kayenta Formation (DeBlieux et al., 2004; Milner et al., in press).

Bighorn Canyon National Recreation Area, Yellowstone National Park and Grand Teton National Park (Cretaceous Mowry Shale)

The Cretaceous Mowry Shale (Cenomanian) is exposed in several parks and contains a wide array of remains. Santucci et al. (1999) note that Bighorn Canyon National Recreation Area (BICA) includes unidentified fish scales from the Mowry Shale, the Niobrara Shale Member and the Shale Member (equivalent to the Eagle Sandstone) of the Cody Shale (Richards, 1955; Santucci et al., 1999). The Mowry Shale is also present in Yellowstone National Park (YELL) and Grand Teton National Park (GRTE), along with the Frontier Sandstone (Cenomanian), which reportedly contains unidentified fish scales and teeth (Santucci, 1998).

Dinosaur National Monument, Currecanti National Recreation Area, Capitol Reef National Park and Cedar Breaks National Monument (Cretaceous Mancos Shale)

Similar to the Mowry Shale, the Upper Cretaceous Mancos Shale (middle to upper Turonian) is also present in several parks. Dinosaur National Monument contains shark teeth in this formation (Mowry Shale "member"; Hansen et al., 1983; Scott et al., 2001). According to Koch (personal commun., 2006), fish scales were also recently discovered in the Mancos Shale (Late Turonian) of Curecanti National Recreation Area (CURE). Both the Tununk Shale and Blue Gate members of the Mancos Shale in Capitol Reef National Park (CARE) are known to contain sharks teeth, while the Straight Cliffs Formation (Turonian) of Cedar Breaks National Monument (CEBR) is reported to contain unidentified fish remains (Santucci, 2000).

Bryce Canyon National Park

While no fish fossils have been reported from within Bryce Canyon National Park (BRCA) at this time, the Cretaceous Dakota Formation and Cretaceous Tropic Shale from outside of the park have yielded many different varieties. The Dakota Formation is known to contain sharks, rays and other fish, along with the last known North American lungfish (Kirkland, 1987; Eaton, personal commun., 1999; Santucci, 2000)..

Glen Canyon National Recreation Area

Shark teeth and the extinct skate *Ptychodus* sp. have been recovered from within the upper Tropic Shale (Cenomanian/Turonian) outside of Glen Canyon National Recreation Area (GLCA; Santucci, 2000).

Mesa Verde National Park

The Cretaceous (late Campanian) Cliff House Formation within Mesa Verde National Park (MEVE) has been noted to contain shark teeth along with jaws, fins and isolated teeth from the teleost fish *Enchodus*. To the north of the park, the Mancos Shale has been reported to contain shark teeth in the Graneros Shale and Fairport Shale members (Scott et al., 2001).

Fort Washington Park

In Maryland, the Cretaceous (Campanian) Severn Formation of Fort Washington Park (FOWA) contains the fossil teeth from the mako shark *Isurus*? and the snaggletooth shark *Hemipristis serra*, along with other shark, ray and sawfish teeth, bones and otoliths, the calcareous concretions in the internal ear of some fish (Kenworthy and Santucci, 2004).

Glacier National Park

The Cretaceous (Campanian) Two Medicine Formation is known from the eastern border of Glacier National Park, Montana (GLAC), on the Blackfeet Indian Reservation, and contains the remains of fish scales, possibly lepisosteid fish scales. While this formation has yet to be mapped within the park, there is a high probability that it exists there and could yield similar fossils (Rice and Cobban, 1977; Whipple, 1992; Hunt, 2005a).

Cabrillo National Monument

Cabrillo National Monument, California, is known to contain a single tooth of the chondrichthyan *Squalicorax* sp. in the Cretaceous (Maastrichtian) Cabrillo Formation of the Rosario Group (Koch and Santucci, 2003).

Big Bend National Park

The Cretaceous units of Big Bend National Park, Texas (BIBE) have been known to yield abundant remains of fish. The Boquillas Formation (Turonian) is noted to contain the remains of fish bones and shark teeth (Maxwell et al., 1967). The remains of the giant teleost fish *Xiphactinus* and the ray *Ptychotrygon,* along with gar, are noted from the Campanian Pen Formation (Standhardt, 1986; Wick, personal commun., 2006). Sharks are well known from both the Pen and the Aguja Formation, with known species including *Lissodus selachos, Squalicorax kaupi*, *Cretorectolobus olsoni, Ischyrhiza mira, Scapanorhynchus texanus*, *S. raphidon*, *Cretolamna appendiculata*, *Odontaspis*, *Anomotodon angustidens* and *Lamna appendiculata* (Fig. 2; Standhardt, 1986; Lehman, 1985). The sawfish *Ochopristis*, the rays *Squatirhina americana, Myledaphus bipartitus, Ptychotrygon agujaensis,* along with the bowfin *Melvius thomasi* and the gars *Lepisosteus* and *Atractosteus* are also known from the Aguja Formation (Late Campanian/Early Maastrichtian; McNulty and Slaughter, 1972; Boreske, 1974; Davis, 1983; Lehman, 1985; Standhardt, 1986; Mosley, 1993; Wick, personal commun., 2006). The Javelina (Maastrichtian) and Black Peaks formations (Maastrichtian/Paleocene) are also contain a local abundance of gar scales and a contain the rays *Rhombodus* and *Dasyatis* (Hunt, 2005b; Schmidt, personal commun., 2006).

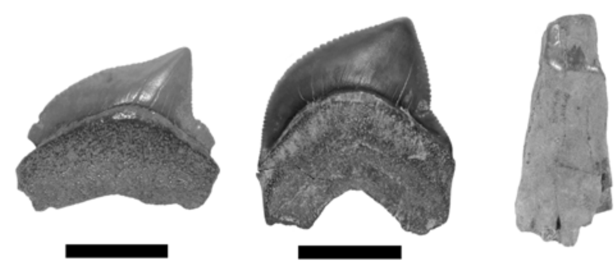

FIGURE 2. Shark teeth from the Aguja Formation: *Squalicorax kaupi*, (left: TTU-P11558; center: TTU-P11557) and *Ischyrhiza mira* (right: TTU-P10992). All collected and photographed by Bill Mueller in 1977, reposited and used with permission from the Museum of Texas Tech University.

CENOZOIC FOSSIL FISH

At the end of the Mesozoic, the Cretaceous Western Interior Seaway began its final regression from the North American continent. Within the continent, Cenozoic fossil fish are limited to lacustrine and fluvial dwellers, while marine forms are limited to the formations deposited by the former extents of the Atlantic and Pacific Oceans.

Fort Washington Park and Piscataway Park

The Paleocene Aquia Formation of Fort Washington Park (FOWA) and neighboring Piscataway Park (PISC) in Maryland, has been known to produce sharks teeth, assigned to the genus *Odontapsis*, according to a 1901 summary (Clark and Martin, 1901; Kenworthy and Santucci, 2004). The lower Piscataway Member of this same formation could be the setting for numerous ray teeth and crushing plates, identified as belonging to the cow nosed ray *Rhinoptera* sp. These fossils are accessioned into PISC museum collections (Kenworthy and Santucci, 2006).

Big Bend National Park

The Black Peaks Formations (Maastrichtian/Paleocene) of Big Bend National Park, Texas (BIBE) are locally abundant in gar scales and are known to contain the rays *Rhombodus* and *Dasyatis*. The Eocene Hannold Hill Formation also contains the ray *Myliobatis* and gar (Hunt, 2005b; Schmidt, personal commun., 2006).

Death Valley National Park

Death Valley National Park, California (DEVA) preserves the remains of the Eocene osteichthyan fishes *Fundulus* and *Cyprinodon.* These were collected by H. Donald Curry from the Titus Canyon Formation and first reported by R.R. Miller (1945). Curry also collected three type specimens of osteichthyan teleost fish from Titus Canyon: *Fundulus curryi, Fundulus euepis* and *Cyprinodon breviradius* (R.R. Miller, 1945; Nyborg and Santucci, 1999).

Fossil Butte National Monument

Fossil Butte National Monument, Wyoming (FOBU) was established to preserve spectacular geologic exposures and fossils of the Eocene Green River Formation in Fossil Basin. The Green River Formation is world renowned for the extraordinary abundance, diversity and preservation of fossils found in the lacustrine sediments of ancient Fossil Lake. These fossils include many invertebrates, reptiles, birds and plants in addition to a number of terrestrial reptiles, birds, mammals and plants, typical of a subtropical environment. However the formation is probably most famous for its abundant fossil fish. The Green River fish fauna (summarized here by Aase, personal commun., 2006) from Fossil Basin include 14 genera and 21 valid species: *Amia* and *Cyclurus* (bowfin), *Amphiplaga* (trout-perch), *Asineops* (pirate perch), "*Atracosteus*" and "*Lepisosteus*" (gar), *Crossopholis* (paddlefish), *Diplomystus* ("herring"/ shad), *Knightia* (herring), *Eohiodon* (mooneye), *Esox* (pike), *Mioplosus* (perch), *Notogoneus* (sand fish), *Phareodous* ("arawana") and *Priscacara* (superficially resembles sunfish, but is not related). Freshwater stingrays (*Asterotrygon* and *Heliobatis*) are also spectacularly preserved. Many of these fish are found in sometimes unusual taphonomic conditions such as immense mass death layers or aspirations, where one fish chokes and dies while eating another fish.

Knightia eocaena is by far the most abundant and may in fact be the most common articulated vertebrate fossil in the world. It's abundance in Fossil Basin led to the declaration of *Knightia eocaena* as the Wyoming official state fossil. FOBU is the only NPS unit established to steward primarily fish fossils. However, the park preserves less than 2% of the former area covered by Fossil Lake and as such the diversity of fish found within park boundaries is considerably smaller than the fauna found outside the park. Fish species found within the park are limited to *Knightia eoceana* (most common), *K. alta*, *Diplomystus dentatus*, *Mioplosus labracoides*, *Phareodus encaustus*, *P. testis*, *Priscacara liops* and *P. serrata* (Aase, personal commun., 2006).

Information on the fish of Fossil Basin, which have been scientifically studied since the 1870s (E.D. Cope), can be found in numerous scientific publications including the first comprehensive review (Grande, 1984, and references therein) and other papers such as McGrew and Casilliano (1974), Grande (1982a,b) and Loewen and Buchheim (1998). Dr. Lance Grande of Chicago's Field Museum has studied the fish of Fossil Basin for nearly three decades.

The park has a unique visitor accessible interpretive quarry where fossil fish can be excavated, with assistance from park staff and collected scientifically for use in the park's museum or study collections (no fish are removed from the park). A large number of commercial quarries are found outside of the park in Fossil Basin. Cooperative efforts between the park and local quarriers seek to raise scientific awareness of the incredible fish fossils excavated in Fossil Basin.

Florissant Fossil Beds National Monument

The most abundant fish fossils known from Colorado are from Florissant Fossil Beds National Monument (FLFO), which includes varieties of bowfin, catfish, pirate perch and sucker. These fish were preserved in the Oligocene Florissant Formation and described originally by E.D. Cope during the 1870s. The most primitive of the fish known from the park belongs to the bowfin, *Amia scutata*. The catfish are known from only two incomplete specimens, both assigned to *Ictalurus pectinatus*. The suckers represent a poorly studied and larger, more diverse group, containing three species: *Amyzon commune*, *A. fusiforme* and *A. pandatum*. The pirate perches are represented by one species, *Trichophanes foliarum* (Meyer, 2003).

Glacier National Park

Glacier National Park, Montana (GLAC) has limited exposures of the Coal Creek Member of the Late Paleogene Kishenehn Formation, which is reported to contain the fossil remains of amiiforms and a variety of teleost fishes (Constenius et al., 1989).

Badlands National Park

The Oligocene Brule Formation (White River Group) of Badlands National Park, South Dakota (BADL), contains catfish and sunfish remains (Benton, personal commun., 2006; Foss, personal commun., 2006).

George Washington Birthplace National Monument

Within the George Washington Birthplace National Monument, Virginia (GEWA) the Miocene Calvert Formation is exposed. This formation is very well known in the eastern United States for its marine fossils and has produced abundant shark teeth of *Hemipristis serra*, *Oxyrhina desorii* and *Otodus obliquus* from within the monument (Fig. 3; McLennan, 1971; Morawe, personal commun., 1999). Additionally, teeth from sand, mako, silky and white sharks have been recovered from the beaches of GEWA (Morawe, personal commun., 1999, 2003). Excavations of marine mammals from within the Calvert Formation in the park has resulted in the recovery of shark teeth belonging to the tiger

FIGURE 3. *Hemipristis serra* (left) and *Isurus hastalis* (right) from the Calvert Formation of George Washington Birthplace National Monument (Photo by Rijk Morawe).

shark *Galeocerdo contortus*, the white shark *Carcharodon* and the snaggletooth shark *Hemipristis* (Bohaska, unpubl., 1989; Kenworthy and Santucci, 2003). Interestingly, some of the shark's teeth have been found in direct association with archeological sites, suggesting their use as "scrapers" (Morawe, personal commun., 2005; Kenworthy and Santucci, this volume).

Santa Monica Mountains National Recreation Area

A large amount of the fossil resources preserved within California's Santa Monica Mountains National Recreation Area (SAMO) are those of fish. The middle Miocene Calabasas (and/or Upper Topanga Formation?) contains fish scales, while the middle to Late Miocene Modelo Formation (and/or Monterey Formation?) contains shark's teeth and several well-preserved fish (Fig. 4; Hoots, 1930; David, 1943; Yerkes and Campbell, 1979). These include fish scales and skeletons, often representing mass death assemblages, with seven genera of chondrichthyans and 41 genera of osteichthyans known from these Miocene units. The Pliocene Repetto, Pico and Fernando formations contain shark teeth (Koch et al., 2004).

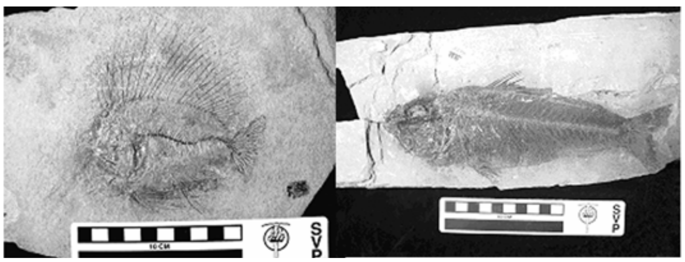

FIGURE 4. *Chalcidichthys malacopterygius* (left; LACM (CIT) 317/10228 Holotype) and *Scorpaena ensiger* (right; LACM (CIT) 317/10226 Figured). Photos by Alison Koch.

Lake Meredith National Recreation Area

Lake Meredith National Recreation Area, Texas (LAMR) has outcrops of the Ogallala Formation (Miocene-Pliocene, dating from approximately 5-12 Ma), which are reported to contain the remains of fish (Phillips, unpubl. report to LAMR, 2000; Hunt and Santucci, 2001). Similar remains may be found in the same formation at nearby Alibates Flint Quarry National Monument, Texas.

Hagerman Fossil Beds National Monument

The Glenns Ferry Formation (Pliocene) of Hagerman Fossil Beds National Monument, Idaho (HAFO) contains seven fish species, five of which are now extinct (Malde, 1972). These include the teleosteans, *Mylopharodon hagermanensis*, *Sigmopharyngodon idahoensis* and *Ptychochilus oregonensis*, the catfish *Ameiurus vespertinus* and the sunfish, *Archoplites taylori* (Uyeno, 1961; Miller and Smith, 1967; Smith et al., 1982). A nearly complete skull of the catfish, *Ameiurus vespertinus* was recovered in 2001 from the wall of the Smithsonian Horse Quarry (Gensler, 2002).

Colonial National Historical Park

The Pliocene Yorktown Formation of the Colonial National Historical Park (COLO) yields the remains of shark teeth and fish vertebrae (Johnson, 1972). Burns (1991) listed the sharks found locally as *Isurus hastalis*, the sand tiger shark *Eugomphodus* sp., the cow shark *Notorhynchus primigenius*, the tiger shark *Galeocerdo aduncus* and the gray shark *Carcharinus egertoni*. Teleost fish bones are largely unidentified, although a dental plate belonging to the parrot fish *Diodon* is reported. Rays are also known from unidentified dermal and dental plates (Burns, 1991).

Petersburg National Battlefield

Two undiagnosed shark teeth were also discovered in the lower Yorktown Formation of Petersburg National Battlefield in a core sample (Pranger, unpubl. report to PETE, 2000).

Point Reyes National Seashore

During a 1993 excavation in the Drake Bay Formation (Pliocene) of Point Reyes National Seashore, California (PORE) fish vertebrae, possibly belonging to a giant salmon and sharks teeth were found associated with the remains of a whale skeleton (Galloway, 1977).

Gateway National Recreation Area

Gateway National Recreation Area (GATE), situated on the New York-New Jersey border, contains exposures of the Gardiner's Clay (Pleistocene), noted to hold the remains of fish vertebrae and teeth (Stoffer, 1996; Kenworthy and Santucci, 2003).

ACKNOWLEDGMENTS

I would like to offer my thanks to my co-authors, Vince Santucci and Jason Kenworthy, who invited me to participate on this project. This paper would not have come together without the help of numerous people including Arvid Aase, Michelle Arsenault, Gorden Bell, Rachel Benton, Dave Bohaska George Callison, Dan Chure, Mike Everhart, Scott Foss, Phil Gensler, Andrew Heckert, Randal Irmis, Allen J. Kihm, Alison Koch, Wann Langston Jr., Rijk Morawe, Bill Muler, William Parker, Robert Purdy, William Simpson, Robert Weems, Steve Wick and Brett Woodward. The paper was greatly improved by the reviews of Andrew Milner and Dave Elliot. I would also like to thank Dr. Bill Hammer for allowing me time to work on this project.

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