Kasey Asberry
Research Project: Way of Change in the Nile River Delta
Geography 317: Biogeography, Kurt Menning, instructor
May 2008

Nile Delta looking south. Asberry, Google Earth, 2008

Summary

This paper explores patterns of change in the biology and geography of the Nile River Delta from its formation through the present. An effort is made to understand ongoing interactions of hydrology, climate, plant and animal life through the fossil record, historical record and the living systems of the region. Finally, sources, degree and directionality of change are investigated to understand how the Nile Delta may function in the future and what opportunities exist for modifying deleterious effects.


Blue Lotus, *Nymphaea caerulea*
Both images WIKIPEDIA

Two varieties of lotus resident in the waters of the Delta; the Blue, endemic, sacred to the deity Nefertem and associated with movements of the sun, and the Red, introduced by Persians late in Dynastic Egypt.


Red Lotus, *Nelumbo nucifera*

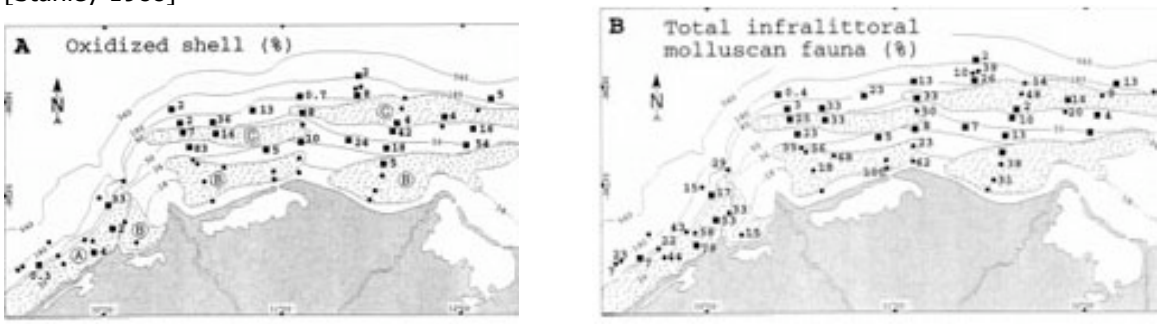
The word *delta*, represented by the greek letter Δ, was used first by Herodotus in the 5th Century BCE to describe the arcuate or arc-shaped landform

exemplified by the Nile Delta [Wikipedia: Herodotus], a prime place to study biogeographic dynamism. In addition to affording one of the longest continuous historical records on earth it is the site of at least four climatic changes. Other transformations include the restructure of the sea floor offshore from pelagic to benthic, modifications of chemical and microbiotic content of the waters and human population growth, decision-making, social and economic activity and how they have affected biogeographic systems.

Study Area

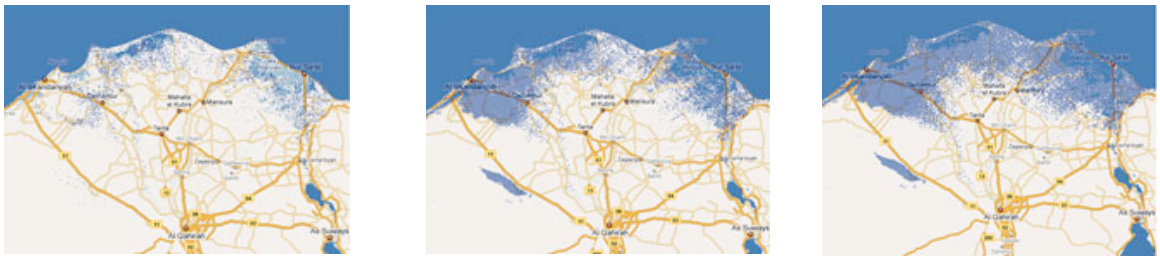
Comprised of approximately 45,500 sq km, the Nile Delta is characterized by abundant diversity in plants and animals. This has been possible although the Mediterranean climate of Northern Egypt produces and average 75 – 150 cm of rain annually due to the regulating and energizing effects of the Nile.
The Nile River is called an exotic stream because it carries snowmelt and monsoonal precipitation through an otherwise arid region. This concentrates life within a narrow band that extends over 4,000 miles from tropical to subtropical latitudes. The elevation gradient from south to north is relatively gentle, ~3000 m to sea level, with most of the elevation head occurring over the first 1000 miles. In contrast to river currents which travel south to north, the prevailing winds blow north to south. This two-way corridor promotes a lively exchange throughout the river system that is intensified in the Delta where Mediterranean and continental life forms commingle.

The watercourse, before 1965, carried a dense load of mineral sediment particularly during annual flood season. This sediment feeds subvisible life in water and soil that serves as the basis of the aquatic foodchain in phytoplankton and provides for vigorous recycling of nutrients through decomposers in the soil. Topsoil in the Delta can be up to 22 m deep. [Bell 1970] Civilization layers have been affected by agradation in the flood plain so that Greco-Roman layers lie 1 meter below ground level and protodynastic layers are ~2 m below the surface. [Hassan 1997]. Since the Pleistocene Era, the Delta has grown laterally at an average rate of approximately 10 m per year. The northeastern coastline of Egypt trended north to produce the Delta, prograding ~50 km in 5000 years. [Stanley 1988]



Stanley & Bernasconi, 1998

Study of littoral siltation patterns reveals that since primordial times there has been dynamic equilibrium between alluvial deposition and a prevailing easterly current in the Mediterranean. [Nyamweru 1989] Analysis of molluscan fossils deposited in offshore beds reveals both this ancient pattern and significant disturbance related to modern cessation of the Nile deposition. This is also demonstrated in dramatic excision of the ocean floor due to the uncontested easterly trend of the Mediterranean. Generally, during the last 50 years the distinctive fan shape of the Delta land mass has been eroding and subsiding while its lagoons and groundwater are becoming increasingly brackish from saltwater intrusion due to the combination of alluvial cessation from the dammed Nile and sea level rise from global warming.



2008 sea level 2025 1 m rise 2100 3 m rise
Sea Level Rise Map, available from: http://geology.com/sea-level-rise/nile-delta.shtml

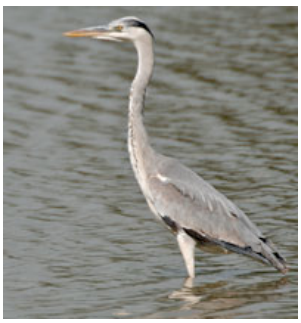
Floral Distribution

The distribution of all life in the Delta has been regulated by deltaic forces: daily tides and annual floods have supplied moisture and nutrients and a state of flux since the land mass formed near the late Pliocene/Pleistocene boundary, about 2 mya. [Sestini 1989] However this is overlaid upon the more ancient pattern of Northern Egypt as part of the Circumboreal Floristic / Palearctic Zoographic Realms. [Menning, 2008] It has been one of the more stable land masses relative to others since 250 mya. Floral distributions formerly reflected these relationships in realized habitat of many early plant forms. The Nile's influence expanded productivity of the region by extending availability of moisture into the warmer seasons with peak flooding in July/August when insolation is highest. Relative to the surrounding superheated continental landmass it is an oasis, and as such exhibits some characteristics of island biogeography, especially relative to plants. It is a moist and fertile enclave which has produced a regime of insular taxa in an arid, continental zone.

Cyperus Papyrus

As the Savannah retreated 20,000 years ago the edges of the Delta provided haven for moisture-dependent plants. The desert formed a longitudinal barrier to colonization and latitude limited dispersal in that dimension to Aeolian and avian vectors. The Modern Nile Delta demonstrates succession pattern of a disturbed zone whose former diversity is now dominated by a few introduced species of rushes and weeds. [McGinley 2007] Salinity, dredging and low water flow are all factors that undermine the indigenous matrix of plants. The papyrus and lotus, emblematic of the Delta reaches and once common, has virtually disappeared. The Ceratophyllum demersum, invasive in many bays and ponds worldwide, flourishes in Delta lagoons. [Shaltout, 1998]

Animal Inhabitants


Gray Heron

Ibis

Bird life in the Delta is rich, diverse and cosmopolitan.

Of 487 species there are no endemic species, 13 are endangered and fewer than 1% are introduced or invasive. [cite]

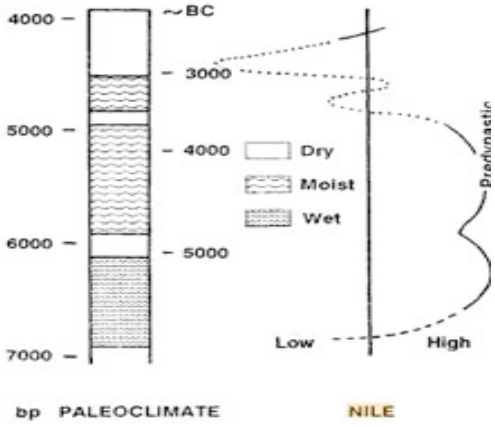
Faunal diversity has been impacted in the Delta during the modern period less dramatically than plantlife, perhaps because in this densely populated area animals have been under duress for a long time. Amphibians, turtles and insects all live close to the water and have reduced populations. Though not extinct in the Nile, the crocodile is no longer found in the Delta. Northern Egypt is situated on a major migratory route for birds that travel throughout Africa, the Middle East and Europe, the numbers of these birds have declined mostly due to habitat destruction elsewhere. The ostrich, was endemic and present in the wild since 22,000 BCE, and domesticly as late as 1950's. Documented through fossils, rock engravings, hieroglyphics and accounts of explorers from renaissance to modern. It is now l now locally extinct. [Manilus, 2001] The Mediterranean fishery has probably suffered the harshest decline, collapsing after the Aswan High Dam was closed in 1965. A recent unexpected rebound of the fishery occurred in the 1980's. Some have attributed this to an adaptation of the fish to commercial fertilizer and human sewage content in the runoff. [Nixon 2001] While there is a correlation between increased potassium and nitrogen levels and microbial life

which is a food source for fish, the fishery rebound could also be related to warmer water temperatures.

Lates nilotica, Wikipedia

The Nile Perch (*Lates nilotica)* provides information about temperature in paleo-environments. Its habitat is restricted to warm water; is often consumed by humans, may grow to 2 meters and lives for ~10 years.
In 1985 Paleobiologists analyzed vertebra of large sample of fish excavated from Hierankopolis from 4500 BCE strata.

Their vertebrae contain "growth rings", (see below). Because the species is ectothermic it grows larger in warmer water and there is more space between the rings. This was a period of reduced rainfall, lower flood levels and higher temperatures.
[Brewer 1991]



292 *D. J. Brewer*

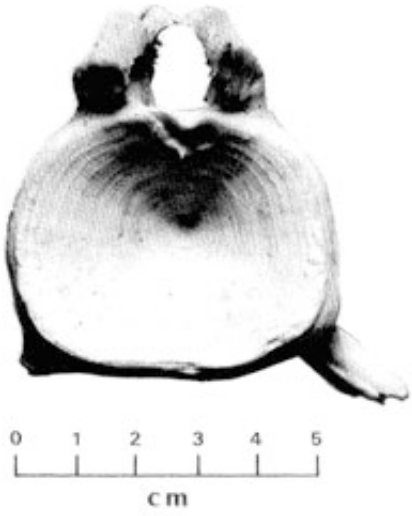


Figure 3 Growth rings of a *Lates niloticus* vertebra.

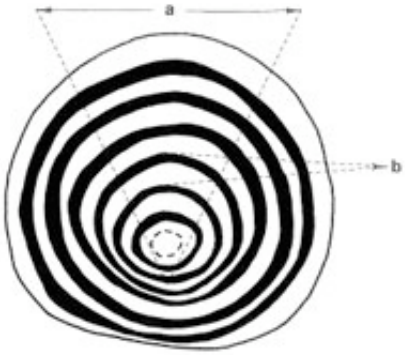


Figure 4 Schematic diagram of *Lates* vertebra showing section cut (a) and points of measurement (b) for five annual growth rings.

The Nile Perch is considered one of the hundred most invasive species worldwide. [cite] This illustrates that within a single ecological region some segments may be insular while others are cosmopolitan.

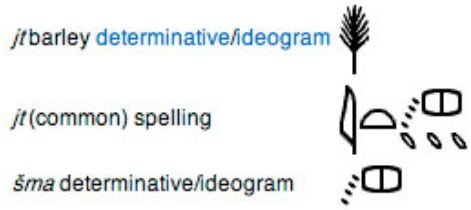
Human interactions

Evidence of earliest human habitation worldwide about 200,000 years ago comes from the Great Rift Valley, which lies in the mountain range that the Nile River drains. The fossil skeletons found there date from 195,000 years ago. Studies of the human genome reveal that the mitochondria which power every living cell, carry a DNA marker handed down from mother to daughter. Analysis of the genomic record indicates that some 60,000 years ago several formative events occurred. First there was an evolutionary bottleneck which may have reduced the human population, our ancestors, to as few as 1000 individuals. Perhaps related to the conditions that produced this reduction in alleles, the reason is unknown, daughters of one particular human female migrated out of the Ethiopian Highlands radiated to the North and East in adaptive response to changing climate and varied access to fluctuating resources. This can be tracked through mutations in the gene and followed from around the world back to this common female ancestor, our Mitochondrial Eve [Van Peer,et al, 1998] It is likely that many adaptations that have served human proliferation were developed and elaborated along the Nile. When the climate change that marked the boundary between the Pleistocene and the Holocene periods occurred, cultural development was concentrated in the Delta.

During the Pleistocene Era Northern Africa had been savannah and forest with more rain, animals and woodlands. 20,000 years ago Northern Africa began to desertify and the savannah ecosystem was constrained to the riparian corridor and its Delta by 10,000 years ago. At that time sea level there measured 41 meters below current levels, indicative of a warmer, drier regime than today. [Frihy 2001]

The earliest evidence of agriculture on the Nile found to date is near al-Qahira at the divergence of the Delta tributaries. Dated at 8,600 BCE, the site includes farmed grains, the remains of domesticated, non-indigenous animals, dwellings, hunting and fishing tools and ornaments. [Science Daily 2008] Warmer temperatures increase protein in barley so this warming trend may have contributed to yields of higher energy crops that made trade and divisions of labor possible.

This bracelet fragment is made from a sea shell only found in the Red Sea, indicating trade.



During this period the human adaptations to the Delta environment were successful. Culture thrived and was apparently stable without centralized management of the Nile.

Ceremonial cosmetic palette , 4000 BCE, northeastern Delta

Ceremonial cosmetic palettes dated to proto-Dynastic period (4000 BCE) have been recovered from several sites in the Delta. [Fischer 1958]
They are indicative of the co-evolutionary relationship that Delta residents developed with their ecosystem. These palettes (one example is provided above) share a common theme and spatiality. They are crowded with a plethora of animals from savannah habitat including lions, falcons, pheasants and both wild and domesticated dogs. By this time the savannah habitat had been constrained to the riparian corridor, where it had been desert stretched for thousands of miles. The large animals in particular would be cultural memories rather than cotidian realities. The wild dogs are shown subduing what must have been a symbolic "serpo-feline", the domesticated dogs are wearing collars and in one case are apparently the puppies of the wild adults. Spatial representation is also remarkable in that although the palettes are nearly flat the animals are shown from front and back on each side. Further detail of cultural significance is that although they contain "serkhs", rectangles typically used to set apart the royal name of the object's owner, the names written are not of any known kings. This may indicate a more equable distribution of wealth if non-royal people owned such ceremonial objects.

The environmental philosophy of the people who made and owned these objects did not include centralized management of the Nile because it was unnecessary. The un-dammed waters of the Delta produced so much abundance that very few acres were needed to provide sufficient and even surplus food for a family group. Although detailed records of water levels and taxation were kept and some of the largest scale capital projects ever built by humans were erected, the accomplished civil engineers of this period saw no need to build dams. [Bell 1970]

Agrarian to Extraction

After Dynastic Egypt faded from prominence waves of colonial powers controlled life in the Delta and resources, particularly water and land connected to it were centrally managed and only slowly began to displace traditional interaction with the river systems. But until the middle of the 19th Century the functionality of the Delta was not tampered with and Lower Egypt continued to provide rich human, animal and plant habitat. When Britain came into Egypt this changed. Britain needed a cheap source of cotton and sugar cane to fuel its burgeoning industrial economy and saw Egypt as a plantation. Cotton and cane require water asynchronously from northern African seasons to be profitable crops. Central management then lost its grounding in local well-being in favor of modern externalism. Europeans who were willing to be displaced to the "land of heathens" for the sake of profit did not feel the obligation to protect its sources of wealth.

The first cataract of the Nile was dammed in 1902 at Aswan. This triggered a massive malaria epidemic from standing water in irrigation ponds that decimated the rural population. The irrigation scheme began the process of soil contamination which afflicts Egyptian agriculture so severely today. [Mitchell 2002] The Aswan Low Dam, as its called since the High Dam was built, also initiated the economic policies which indebted Egyptian farmers so heavily that Britain could control the course of agricultural development. These effects were harsh and a lot of people suffered from them but the environmental effects were less dramatic than those produced by the High Dam because the first project did not fully impound the Nile and allowed a higher flow of sedimented water.
Since 1965 when the Aswan High Dam was completed, 90% of sedimentation is impounded behind the dam. The hydropower generated by the dam is almost entirely used to manufacture fertilizers which are sold to farmers below the dam.[Clarke, 2004] Ancient patterns of deposition have nearly ceased. Erosion, subsidence and saltwater incursion would now appear to be the dominant morphological forces in the Delta, which has become a system of canals, barrages and holding ponds. The effects of global climate change are already seen in rising sea level and predicted to accelerate the other destructive forces at work on the Delta.

But the worst of the extraction economy may not have yet occurred. Under the Delta and just offshore large deposits of natural gas and shale oil have been identified [Nile Delta Reservoir Case study 2007] Exploitation of these resources, if previous conservation patterns are followed, would surely eliminate the chances for the Nile Delta to regain its earlier vigor as an ecosystem.

That's one trajectory. Others include lowering the dam (even a few feet could help tremendously)[Bednarek, 2001], investing in conservation, in concert with emphasis upon eco-tourism to complement consistent interest in antiquities could help diversify industry. Consider foregoing the oil since it will so expensive to extract and invest in solar power which Egypt has an abundance of. Leadership from Egypt could encourage other Islamic republics to adopt similar policies which would promote increased independence, prosperity and health for their people and the region. Their success could provide an example for balanced development others would learn from. This level of transformation of human priorities is the opportunity represented by the need to restore the Nile Delta to a state of health or relegate one of the greatest biogeographical treasures the world has known to an historic episode that passed. We're standing on subsiding ground but there are options.


Aswan High Dam, looking south, 2007

Way of Change in the Nile Delta
Glossary

Anemophilous species	Pollinated by the wind
Bryophyte cover	Non-vascular plants that reproduce by spores, like ferns
bryozoans	Tiny colonial animals with calcium carbonate skeletons
chronostratigraphic	Time series in layers of rock
ectothermic	Organism that gains its heat from environment
euphotic	Zone of water that is exposed to enough light to enable photosynthesis
Entomophilous species	Pollinated by bees and other insects
infralittoral	Within the coastal zone; banks of a river or lake
graben	Pull-apart basin or like rift valley created by plate tectonics
isopach	Areal extent and thickness variation of a stratigraphic unit.
LAI	Leaf Area Index, dimensionless number that expresses the ratio of total leaf surface of vegetation divided by the surface area of the land where its growing; ranges from 0 – 6.
mesic	Moist environment; opposite is xeric.
neotectonics	Study of recent crustal movement
NPP	Net Primary Productivity; a measure of production of organic compounds from atmospheric or aquatic carbon dioxide
prograde	Direct or forward motion
relict	In situ, surviving remnants, not laterally displaced.
palimpset	Relict and reworked
taphonomic	Study of decaying organisms.

Works Cited, Way of Change in the Nile Delta

Ayyad, SM, Moore, PD, Zahran,MA, 1992
Modern Pollen Rain Studies of the Nile Delta
JStor: New Phytologist Vol 121 Aug 1992
Available from: http://www.jstor.org/stable/2557621

Barley Wikipedia. 2008
http://en.wikipedia.org/wiki/Barley#Production

Barley
http://www.gov.mb.ca/agriculture/crops/cereals/bfb01s01.html

Bednarek, A.T. 2001. **Undaming rivers: a review of the ecological impacts of dam removal.** Environmental Management 27 (6): 803-814. [SpringgerLink Online Database]. Available from: http://0-www.springerlink.com.opac.sfsu.edu/content/?mode=allwords&k=Undamming+rivers%3a+a+review+of+the+ecological+impacts+of+dam+removal&sortorder=asc&sw=Undamming

Bell, Barbara, 1970. **The Oldest Records of the Nile Floods**
The Geographical Journal, Vol. 136, No. 4 (Dec., 1970), pp. 569-573 (Published by: Blackwell Publishing on behalf of The Royal Geographical Society, with the Institute of British Geographers)
http://0-www.jstor.org.opac.sfsu.edu/stable/1796184?&Search=yes&term=modern&term=fauna&term=delta&term=nile&list=hide&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Dnile%2Bdelta%2Bmodern%2Bfauna%26dc%3DAll%2BDisciplines&item=14&ttl=470&returnArticleService=showArticle

Brewer, Douglas J., 1991
Temperatures in Predynastic Egypt Inferred from the Remains of the Nile Perch
World Archaeology © 1991 Taylor & Francis, Ltd..
Available from:
http://0-www.jstor.org.opac.sfsu.edu/stable/124789?seq=2&Search=yes&term=modern&term=fauna&term=delta&term=nile&list=hide&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Dnile%2Bdelta%2Bmodern%2Bfauna%26dc%3DAll%2BDisciplines&item=6&ttl=470&returnArticleService=showArticle

Clarke, Robin, King, Jannet, 2004
Water Atlas, New Press, New York, London

EAIS Egyptian Archaeological Mapping System
http://www.eais.org.eg/index.pl/mapping

Fischer, Henry, G. 1958
A Fragment of Late Predynastic Egyptian Relief from the Eastern Delta Artibus Asiae, Vol. 21, No. 1 (1958), pp. 64-88
http://0-www.jstor.org.opac.sfsu.edu/stable/3249028?&Search=yes&term=modern&term=fauna&term=delta&term=nile&list=hide&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Dnile%2Bdelta%2Bmodern%2Bfauna%26dc%3DAll%2BDisciplines&item=11&ttl=470&returnArticleService=showArticle

Frihy, Omran E.1
Holocene sea level changes at the nile delta coastal zone of Egypt
Coastal Research Institute, 15 El Pharaana Street, 21514 Alexandria, Egypt

Geology.com
Sea Level Rise Map
available from: http://geology.com/sea-level-rise/nile-delta.shtml

Hassan, Fekri A., 1997
The Dynamics of a Riverine Civilization: A Geoarchaeological Perspective on the Nile Valley, Egypt
World Archaeology, Vol. 29, No. 1, Riverine Archaeology (Jun., 1997), pp. 51-74
Published by: Taylor & Francis, Ltd.
http://0-www.jstor.org.opac.sfsu.edu/stable/124996?&Search=yes&term=delta&term=flow&term=nile&list=hide&searchUri=%2Faction%2FdoBasicResults%3FQuery%3Dnile%2Bdelta%2Bflow%26addArticle%3Dconfirm&item=1&ttl=1179&returnArticleService=showArticle

Manlius, Nicolas 2001
The Ostrich in Egypt: Past and Present
Journal of Biogeography, Vol. 28, No. 8 (Aug., 2001), pp. 945-953
http://0-www.jstor.org.opac.sfsu.edu/stable/827488?seq=3&Search=yes&term=modern&term=fauna&term=delta&term=nile&list=hide&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Dnile%2Bdelta%2Bmodern%2Bfauna%26dc%3DAll%2BDisciplines&item=10&ttl=470&returnArticleService=showArticle

McGinley, Mark. 2007
Nile Delta flooded savanna
Encyclopedia of Earth

Menning, Kurt, 2008
Biogeography lecture Notes
SFSU

Mitchell, Timothy, 2002
Rule of Experts: Egypt, Techno-politics & Modernity

University of CA Press, Berkeley, CA

Nyamweru, Celia. 1989
New Evidence for the Former Extent of the Nile Drainage System
The Geographical Journal Vol 155 No. 2 (Jul., 1989), pp. 179-188

Nixon, Scott W. 2007
Replacing the Nile: Are Anthropogenic Nutrients Providing the Fertility Once Brought to the Mediterranean by a Great River?
AMBIO: A Journal of the Human Environment
Article: pp. 30–39 | Abstract | PDF (344K)
Available from:
http://ambio.allenpress.com/perlserv/?request=get-document&doi=10.1639%2F0044-7447(2003)032%5B0030%3ARTNAAN%5D2.0.CO%3B2&ct=1#toclink3

[Predictor]Nile Delta Reservoir Case study 2007
www.geotrace.com/products/pdf/RockRes%20EAGE%202007LogoWeb.pdf

Science Daily 2008
Egypt's Earliest Agricultural Settlement Unearthed
(Feb. 18, 2008) —keywords: 8600 BCE, neolithic
Available from: http://www.sciencedaily.com/releases/2008/02/080212131300.htm

Sestini, G. 1989
Nile Delta: a review of depositional environments and geological history
Via Della Robbia 28, 50132 Florence, Italy
Geological Society, London, Special Publications; 1989; v. 41; p. 99-127;
DOI: 10.1144/GSL.SP.1989.041.01.09
© 1989 Geological Society of London
http://sp.lyellcollection.org/cgi/content/abstract/41/1/99

Shaltout, K. H. , El-Sheikh, M. A. 1993
Vegetation-Environment Relations along Water Courses in the Nile Delta Region
Journal of Vegetation Science, Vol. 4, No. 4 (Jun., 1993), pp. 567-570
Publisher: Opulus Press
URL: http://0www.jstor.org.opac.sfsu.edu:80/stable/3236085

Stanley, Daniel Jean. 1988
Subsidence in the Northeastern Nile Delta: Rapid Rates, Possible Causes, and Consequences
Science, New Series, Vol. 240, No. 4851 (Apr. 22, 1988), pp. 497-500

Stanley, D.J., Bernasconi, Maria Pia. 1989
Relict and Palimpsest Depositional Patterns on the Nile Shelf Recorded by Molluscan Faunas"

PALAIOS, Vol. 13, No. 1 (Feb., 1998), pp. 79-86

Van Peer, Philip, Demidenko, Yury E. , Garcea, Elena A. A., Otte, Marcel, Rolland, Nicolas, Ronen, Avraham & Schild, Romuald
1998
The Nile Corridor and the Out-of-Africa Model: An Examination of the Archaeological Record [and Comments and Reply]
Current Anthropology, Vol. 39, No. 2, Supplement: Special Issue: The Neanderthal Problem and the Evolution of Human Behavior (Jun., 1998), pp. S115-S140
Published by: The University of Chicago Press on behalf of Wenner-Gren Foundation for Anthropological Research
http://0-www.jstor.org.opac.sfsu.edu/stable/2744573?&Search=yes&term=hominid&term=habitation&term=delta&term=nile&list=hide&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Dhominid%2Bhabitation%2Bin%2Bnile%2Bdelta%26gw%3Djtx%26prq%3Dhumans%2Bin%2Bnile%2Bdelta%26Search%3DSearch%26hp%3D25&item=1&ttl=11&returnArticleService=showArticle