Historic variations in Sea Levels Part 1- from the Holocene to Romans

Introduction

Due to a printing error, the information that puts modern sea level rise into its historic context was accidentally omitted from Chapter Five of AR4. The missing section-reproduced below-should have been included in appendix 5a here;

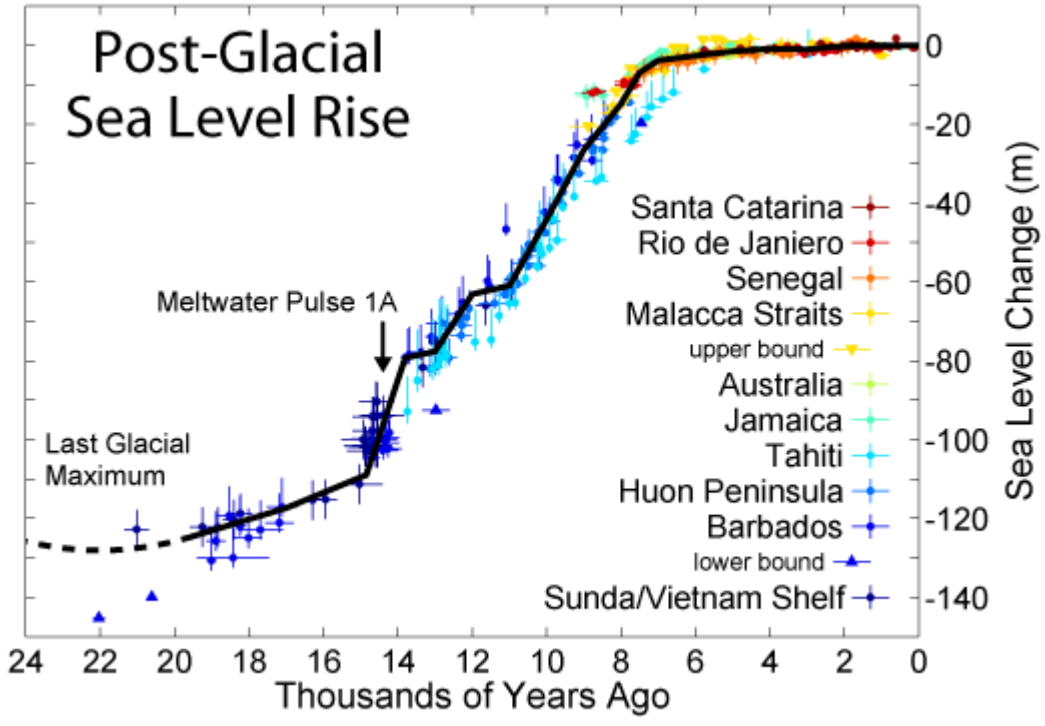
http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter5.pdf

Alright a confession. This is the section that SHOULD have been there but wasn't, so I have helpfully written it on the IPCC's behalf. **'Historic variations in sea levels'** is in three parts. Part 1 covers the Holocene to Roman times. Part 2 traces sea level changes to the Medieval Warm Period. Part 3-the modern age from 1700 to today.

Those familiar with my historic articles know I like the journey with all its byways as much as the destination, so don't expect the short sharp prose of the IPCC. But would they have brought you legends of drowned lands, King Arthur, Hitler's Foreign Minister and poetry from Tennyson amidst the numerous tedious-but robust- scientific references? No of course not. This first part covers a lot of years to set the scene, and when I say it's a bit of an epic, think Ben Hur. There will however in due course be a summary of all three parts for those with limited attention spans. Sit back and enjoy the ride.

From the Holocene to the Romans

This first part examines the period from the initial post glacial rise, through Roman times, so our story begins some 12000 years ago or more when sea levels rose dramatically.

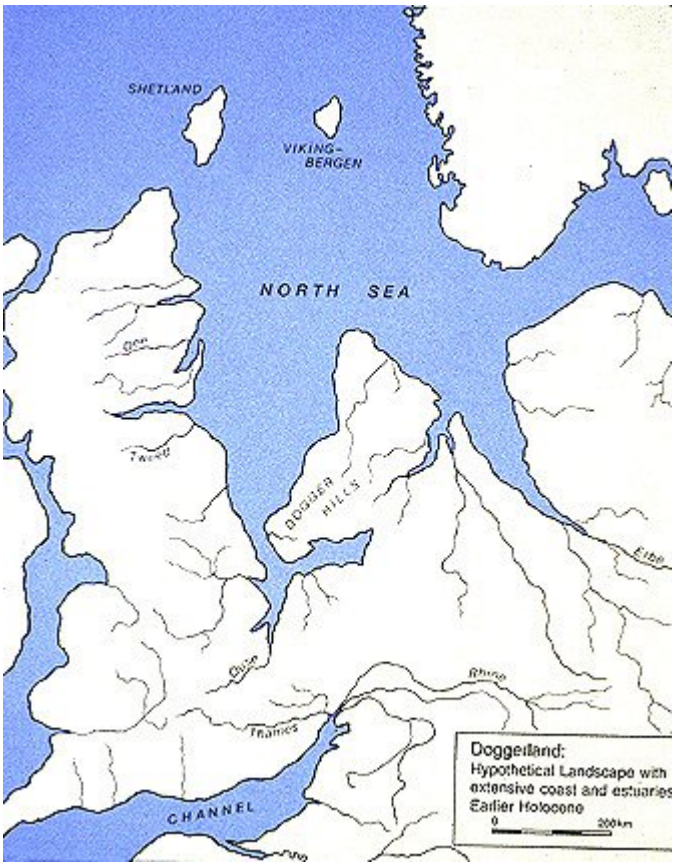


http://commons.wikimedia.org/wiki/File:Post-Glacial_Sea_Level.png

We commence our long watery journey with this short excerpt from the book ‘The Little Ice Age’ by Brian Fagan, Professor of Archaeology at the University of California.

“Ten thousand years ago the southern North sea was a marshy plain where elk and deer wandered…England was part of the continent until as recently as 6000 BC when rising sea levels caused by post ice age warming filled the North sea.”

We can scientifically verify this statement. ‘Doggerland’ -an inhabited area in what is now the North Sea- was swamped by rising sea levels around 8000 years ago when Britain was separated from Europe and became an island. Here is the map showing the land bridge that existed at that time.



The story is here

“Prof. Bryony Coles has been examining the archaeology of "Doggerland", which now lies under the North Sea. Its highest point is the submerged Dogger Bank where prehistoric artefacts are occasionally found by fishermen and geologists. At the height of the last Ice Age, Doggerland was dry and stretched from the present east coast of Britain and the present coasts of The Netherlands, Denmark and North Germany.

Thus, the so-called land-bridge, was a place where people settled as the ice-sheets wasted and north Western Europe became habitable once more. But, as the ice-sheets retreated further and sea levels rose, the North Sea encroached on the land, eventually separating the British Peninsula from the mainland."

http://humanities.exeter.ac.uk/archaeology/research/rdoggerland.shtml

"LANDSCAPE features off the North East coast include the Farne Deeps trench which is more than 100 metres deep. Doggerland, an area of the Dogger Bank, has the remains of more than 30 seabed villages. Expanses of the North Sea off the North East are dominated by underwater hills and plains of sand and gravel. In some parts of the Dogger Bank the hills are as high as Big Ben. The Dogger Bank sand hills were once a land bridge between modern day Denmark and England. This landscape is hunted over by thornback rays, dogfish, and large plaice. "

http://www.journallive.co.uk/north-east-news/environment-news/2008/09/25/dogger-bank-hills-as-high-as-big-ben-61634-21896536/

Referring to a harpoon found in the area, this article comments**;"…But later tests showed that the freshwater peat it (the harpoon) came from, would have been on land thousands of years ago. They realised the existence of land in the North Sea, long since drowned, called Doggerland."**

http://www.edp24.co.uk/content/edp24/news/story.aspx?brand=EDPOnline&category=News&tBrand=EDPOnline&tCategory=xDefault&itemid=NOED17%20Mar%202010%2021%3A13%3A47%3A633

It is a sobering thought that where once our ancestors hunted, fish now take their place, and graphically illustrates that sea level rise is by no means a modern phenomenon.

Any study of sea level needs to take into account deposition and erosion, land movement- often through post glacial rebound- and tectonic activity, as these can cloud the picture. With regards to the first, a reference is made at the end of this article to an excellent book on the subject by Professor R Duck. As regards tectonic activity the reader should be aware that historic studies (including mine) may refer to evidence-for example Roman ruins- that are found in areas of substantial tectonic activity-such as the Mediterranean.

http://www.oberlin.edu/Geopage/projects/204projects/kolker/kolker.html

These historic changes in land level-dramatic or gradual- will have been taken into account in academic studies (although there is not unanimity over the rate of change) but it means that a casual observer can't simply assert the sea level as they see it now is the same as when they were a child half a century ago, without taking a host of factors into account. However all these factors demonstrate that accurate sea level reconstruction is problematic.

In private email correspondence that he has given me permission to reproduce, Dr Simon Holgate of Proudman Oceanographic Observatory refers to sea level reconstructions back to 200AD-which covers several warm periods such as the Roman Optimum and MWP- and remarks;

"It seems plausible that sea level would be higher in a warmer period (how warm and how much of the Earth was actually affected by the warm period is debated) but it isn't clear how sea level would respond. So maybe it was higher than today, or maybe it wasn't. We have no observations and we just don't know. For me, there is far too much uncertainty in the 'reconstructions' of sea level for them to be very useful...Overall I would say that the evidence from the (Roman) fish tanks etc suggests that there has been no real change in the average height of sea level over the last c. 2000 years prior to the mid to late 1800s."

To add to the complications, sea levels do not find a constant level around the world but can vary considerably one place to another, with some places dropping as others rise;

http://www.insidescience.org/research/1.1766

We can more specifically deal with land movement by reference to a new map from Durham University which shows how the UK and Ireland are responding to the ice sheet compression of the earth's core and the current rate of land tilt across the UK-some areas rising and others falling. This next link contains their article and map showing relative sea level rise or fall.

http://www.dur.ac.uk/geography/news/allgeognews/?itemno=8816

This gives a slightly better view of the map, and a technical description:
http://www.geosociety.org/gsatoday/archive/19/9/pdf/i1052-5173-19-9-52.pdf

It is important to fix in our minds therefore that sea level change is not necessarily as a result of their being less or more water (through glacier melt and thermal expansion) but that much of what we might observe is as a result of changes in the height of the land relative to the sea. This is illustrated here in a quote from the University study;

"Since the end of the last Ice Age 20,000 years ago, land and sea-levels around the UK coastline have changed in response to the retreat of the ice sheets. As the ice melted, the release of this enormous weight resulted in the landmass slowly tilting back up in the north or down in the south, a process called isostatic adjustment….These rises and falls come on top of any changes in sea-level caused by global warming. In Scotland, the rise of much of the coastline will offset some of the predicted rises in sea-level due to climate change."

" In Northumberland, researchers found sediments from 7,000 years ago five metres below, and others from 4,000 years ago at 1 metre above the present sea level. This indicates that the sea level rose above present levels from around 7,500 years ago to 4,500 years ago, and then dropped and is continuing to fall. Sea-levels in most of Scotland peaked even higher about 4,500 years ago and have been falling ever since because the land has risen."

To put these changes into a human perspective, the remains of a drowned Mesolithic village was found on what is now the sea bed off the Isle of Wight on Britain's South coast.

"A few Archaeologists originally found Mesolithic flint tools within a 1km stretch of seabed over a decade ago. This was the first time such pieces were found in their original location underwater around the British coast. Ten years on, continued searching has recently resulted in much more startling finds.

Elements of a substantial wooden structure (found in 2009) built about 8,000 years ago by our Mesolithic ancestors. Some of the recovered timbers have very clear, distinct and sophisticated cut marks, so we know they have been worked on by humans capable of craftsmanship. These could be part of a collapsed structure, or perhaps a platform built close to a waterway."

http://www.iwcp.co.uk/news/news/stone-age-village-found-under-sea-28794.aspx

According to the BBC 'Britain's Drowned World' TV programme carried out by 'Time Team', the inundation was caused by a prolonged sea level rise at 2cm per year (around 10 times the current rate) and exacerbated over a 15 year period by a 7 degree Fahrenheit temperature rise.

Let us now briefly return to Professor Fagan-by no means a climate sceptic- who continues in his book 'The Little Ice Age;'

"By 3000 BC the ocean was at near modern levels. Sea levels fluctuated continually through late prehistoric and Roman times.

So to verify this statement let us move forward from Doggerland on the east coast of Britain, through several thousand years to the Roman period on the Western coast of Britain. Where better to examine sea level fluctuations than a place especially susceptible to them -a tidal island? This is a photo of St Michaels Mount in Cornwall.

http://www.stives.co.uk/images/golfing/st-michaels.jpg

"Spectacular St. Michael's Mount near Penzance occupies a granite outcrop which rises dramatically from Mount's Bay and is England's most scenic coastal attraction, a medieval castle with sub tropical hanging gardens and a church perched on top of a rocky island, cut off from the mainland at high tide. The island, which can claim to be Cornwall's most celebrated landmark, can be reached via the causeway at low tide; a boat service operates across at times of high tide."

"…The mount has been a trading place for tin since the Iron Age and was known to the Greeks and the Romans. According to one legend St Michael is believed to have appeared there in AD 710. The island was given by Robert Count of Mortain, the half-brother of William the Conqueror to the Norman Abbey of Mont St. Michel. Bernard le Bec, Abbot of Mont St. Michel, to which the mount bears a striking resemblance, founded the Priory in 1135, which was later to become a place of pilgrimage in the Middle Ages."

http://www.cornwalltour.co.uk/st_michaels_mount.html

Wiki are somewhat more prosaic and say this; (edited for space reasons)

"St Michael's Mount (Cornish: *Karrek Loos y'n Koos*) is a tidal island located 366 m (400 yd) off the Mount's Bay coast of Cornwall, United Kingdom. It is a civil parish and is united with the town of Marazion by a man-made causeway of granite setts, passable between mid-tide and low water.

The island exhibits a combination of slate and granite (see *Geology* below). Its Cornish language name — literally, "the grey rock in the wood" — may represent a folk memory of a time before Mount's Bay was flooded. Certainly, the Cornish name would be an accurate description of the Mount set in woodland. Remains of trees have been seen at low tides following storms on the beach at Perranuthnoe, but radiocarbon dating established the submerging of the hazel wood at about 1700 BC.[1] The chronicler John of Worcester[2] relates under the year 1099 that St. Michael's Mount was located five or six miles from the sea, enclosed in a thick wood, but that on the third day of the nones of November the sea overflowed the land, destroying many towns and drowning many people as well as innumerable oxen and sheep; the Anglo-Saxon Chronicle records under the date 11 November 1199, "The sea-flood sprung up to such a height, and did so much harm, as no man remembered that it ever did before".[3] The Cornish legend of Lyonesse, an ancient kingdom said to have extended from Penwith toward the Isles of Scilly, also talks of land being inundated by the sea."

http://en.wikipedia.org/wiki/St_Michael's_Mount

So let's try to separate fact from fiction, legend from science. The attribution to John of Worcester of 1099 is more usually made to the 11th century chronicler William of Malmesbury who recorded that '**the Mount was formerly surrounded by a very dense wood, and was five or six miles from the sea."**

The ancient Cornish name for the mount certainly suggests it was once firmly dry land, as for the woods, in his **'Report on Cornwall'**, Sir Henry de la Beche remarked that;

'Submarine forests are so common that it is difficult not to find traces of them in the district at the mouths of all the numerous valleys which open upon the sea and are in any manner silted up'.
http://en.wikipedia.org/wiki/Henry_De_la_Beche

The folk memory of woods and a rock is supported by modern observational evidence which confirms that the woods existed, with radio carbon dating suggesting they were submerged around 1700BC. So William of Malmesbury could not possibly have personally observed that the Mount was 5 miles from the sea, nor seen the woods. However, this anecdote can be fairly attributed to listening to the local legends, most likely that of the flooding of Lyonesse, which occurred around 3000 BC.

Sir Gavin de Beer, F.R.S., a former Director of the Natural History Museum, wrote in his book ***Reflections of A Darwinian***, published in 1962, that scientific methods of analysing the traces of old tree trunks still found in Mount's Bay had indicated that the forest was submerged by the sea at least 1,500 years before Pytheas came there on his voyage of exploration in about 325 B.C
http://www.jstor.org/pss/1793956

That the flooding was widespread is recounted in a number of places;

'The drowning of Mounts Bay is just one instance of a phenomenon visible all round the south - western promontory of Britain, once known as Dumnonia.'

"The Roman historian, Marcelinus, who lived in the fourth century of the Christian Era, described the swallowing up of 'a large island' in 'the Atlantic Sea'. This has always been identified as Atlantis, though it may equally be a record of the disintegration of islands on the coast of Britain, including parts of the Scillies, which probably went down during his lifetime. From; "Lost Lands and Sunken Cities"

'It is recorded that as late as the fourth century, the Scillies, (South west of Cornwall) now an archipelago of many islets, was but a single large island. In the year 387 a heretic was banished there by the would -be emperor Maximus.'

http://www.lundyisleofavalon.co.uk/history/sealevels.htm
(Whilst heavy on legend, this site is supported by some verifiable facts which make it a fascinating read)

Modern science does not confirm precise dating, but the legend talks of a Kingdom stretching from Penwith in Cornwall to the Scilly isles. Page 3 of this study from 2006 seems to confirm a series of inundations, suggesting some truth in the older legends, and that the earlier Romans-or their predecessors- may have viewed the Scillies as one land mass rather than the series of islands it has subsequently become;

"From the beginning of the Holocene period, as the ice sheets melted and sea level rose, the submergence of low-lying areas led to the formation of one main island by about 3,000 BC.
This included the present islands of St Mary's, Bryher, St Martin's, Tresco, Samson and the Eastern Isles, with three smaller tracts of land around St Agnes, Annet and the Western Rocks (Ratcliffe and Johns 2003, 4). Charles Thomas' model for sea level change in Scilly suggests that at around 1000 BC Mean Sea Level (MSL) was 7.25m lower than today, with the modern 5m marine contour roughly representing the coastline at that time (Thomas 1985, 17–64). The main island may have survived until the end of the Roman period but further rises in sea level, and perhaps a final inundation during the early second millennium AD, resulted in the eventual submergence of the 'flats' in the middle of the land mass and formation of the present pattern of islands. Final separation of the islands might not have been complete until the early sixteenth century."

http://www.cornisharchaeology.org.uk/index_htm_files/Documents/Cornish%20Archaeology%2041-42-opt.pdf

Interestingly, this last account places the inundation at around the period that Lyonesse was said to be drowned- around 3000BC.

Various chroniclers describe Lyonesse as the site of the final battle between Arthur and Mordred. One passage in Tennyson's epic poem references legends of Lyonesse as a land fated to sink beneath the ocean:

> **Then rose the King and moved his host by night**
> **And ever pushed Sir Mordred, league by league,**
> **Back to the sunset bound of Lyonesse--**
> **A land of old upheaven from the abyss**
> **By fire, to sink into the abyss again;**
> **Where fragments of forgotten peoples dwelt,**
> **And the long mountains ended in a coast**
> **Of ever-shifting sand, and far away**
> **The phantom circle of a moaning sea.**

It is said (by the local tourist board) that King Arthur's castle is located at nearby Tintagel on the North Cornish coast.

http://www.tintagelweb.co.uk/Tintagel%20Castle.htm

Whatever the truth of the legends, Tintagel Castle is a highly atmospheric place and can be usefully combined with a visit to the equally charismatic St Michaels Mount.

So the area-whether or not as part of some legendary Arthurian Kingdom-was undoubtedly inundated by rising sea levels, and here we can find some definitive scientific information about the subsequent rise to prominence of St Michaels Mount, following its transition from an inland place in a forest to a port.

"Dr. H. O'Neil Hencken in *Archaeology of Cornwall and Scilly* (1932), suggests that by the Iron Age the island of St. Michael's Mount would have become a highly important port. St. Michael's Mount was also at one time probably the island of 'Ictis' from which Cornish tin was exported to the Greek trading communities in the Mediterranean. But note the caution by John MacCormack who believes 'Ictis' refers to the Channel Islands *(13)*.

Towards the end of the fourth century B.C., shortly after the death of Alexander the Great, Pytheas, a Greek geographer from Marseilles, had made a voyage of exploration round the coast of Britain looking for the source of amber in the Baltic. Unfortunately, the records of his voyage were lost but they were known to later classical writers such as Timaeus, Posidonius and Pliny. The evidence of these writings is vague and conflicting but represents all that was known about the tin trade in the ancient classical world. In particular, Diodorus, a Sicilian Greek historian, writing in the first quarter of the first century A. D., gives an account which is probably a description of the working of Cornish tin (by streaming from the rocks) about the time of the voyage of Pytheas, and how it was carried over to St. Michael's Mount. *"The inhabitants of that part of Britain which is called Belerion"* [that is to say Land's End]. Diodorus says, *"are very fond of*

strangers and from their intercourse with foreign merchants are civilised in their manner of life. They prepare the tin, working very carefully the earth in which it is produced. The ground is rocky but it contains earthy veins, the produce of which is ground down, smelted and purified. They beat the metal into masses shaped like astralgi **[knuckle-bones]** ***and carry it off to a certain island off Britain called Ictis. During the ebb of the tide the intervening space is left dry and they carry over to the island the tin in abundance in their wagons."*** In a later passage in the same context Diodorus says, ***"Here then the merchants buy the tin from the natives and carry it over to Gaul, and after travelling overland for about thirty days, they finally bring their loads on horses to the mouth of the Rhone."***
http://www.christopherlong.co.uk/oth/msm-smmtin.html

This extract provides further background;

"England-Cornish Tin. Cornwall has a long history as a leading producer. Cornish tin deposits have been worked extensively for many centuries, dating back to at least Roman times: there is in fact strong evidence of tin working in Cornwall from the early Bronze Age, 2100-1500BC. Even after the Romans reached Cornwall however, tin must have been scarce and costly. There are actually few historical references to the tin trade of the Phoenicians, Greeks, Gauls or Romans. Brief statements about production were made from time to time after 1066 in Stannary Court proceedings, charters and other official documents.
http://earthsci.org/mineral/mindep/depfile/tin.htm

So to summarise, over historic- rather than geological time, St Michaels Mount- which was originally some distance from the sea -became flooded following several periods of dramatic sea level rise. The first during the Doggerland era and then also at some point around 3000 BC or so, of which the folk memory of Lyonesse still lingers, and possibly again 1000 years later. Whether the levels fell in the interim period is outside the scope of this study, but we do know that by 350BC at the latest St Michaels Mount was a thriving port for the export of tin, which during the ebb tide was carried over in wagons i.e. by that time it was a tidal island.

To put in context that sea level fluctuations are often about the characteristics of land rise or fall, we refer again to the earlier study from Durham University

According to this academic study, Cornwall, together with the adjacent counties of Devon and Somerset, is one of those areas of falling land which (apart from any other reasons such as thermal expansion and glacial melting) is thereby causing rising sea levels. The land is falling at 0.5mm/yr which comes to some 1 meter over 2000 years.

http://www.dur.ac.uk/geography/news/allgeognews/?itemno=8816

http://www.geosociety.org/gsatoday/archive/19/9/pdf/i1052-5173-19-9-52.pdf

In a personal email to the author Simon Holgate of Proudman Observatory amplified this study;

"With respect to Newlyn, (close to St Michaels Mount**) it is probably the highest quality tide gauge record in the world. The land is the region is subsiding by about 1 mm per**

year due to the effects of the last glaciation. You can see the data for yourself at: http://www.psmsl.org/data/obtaining/stations/202.php. Once we've taken the "glacial isostatic adjustment" into account we're left with about 1.4 mm/yr, which is typical of Europe and slightly less than the global average of 1.8 mm/yr over that time period."

So taking this into account we should reasonably assume that the sea level we see now is going to be around 1 meter greater than was current in 350BC for reasons of the land sinking and quite apart from any genuine sea level rise. Is that increase verified by the observations we can make?

No. Today St Michaels Mount is still not navigable for large parts of the tidal cycle as was also observed in historic times. There are better places nearby to have acted as a historic tin port, for the Mount is dangerous when the wind is from the wrong direction. This beggars the question as to what sort of boats could have used it when it was a thriving port over 2000 years ago, if there was a metre less water than today (as the land was higher) and hoving too was so problematic?

This is a description of a Roman boat at the time of Julius Caesar;

"They have flat bottoms which enables them to sail in shallow coastal water. Their high bows and sterns protect them from heavy seas and violent storms, as do their strong hulls made entirely from oak. The cross-timbers -- beams a foot wide -- are secured with iron nails as thick as a man's thumb. Their anchors are secured with chains not ropes, while their sails are made of raw hide or thin leather, so as to stand up to the violent Atlantic winds." (Johnstone, The Sea-Craft of Prehistory)
http://www.dark-age-boats.co.uk/britishromanboats.php

There were many different types used for different purposes
http://www.bbc.co.uk/dna/h2g2/alabaster/A69451572

A rough calculation for carrying a cargo is;

Floating Volume in cubic feet multiplied by the weight of a cubic foot of water, 62.5 lbs. So a 15 foot long 5 foot wide boat would need a draught of six inches to carry a load of under a ton.

Diodoris Siculus who wrote in the reign of Augustus mentioned the way in which tin ore was dug and prepared by the Britons as mentioned in the link below and already quoted above as follows;
"They beat the metal into masses shaped like astralgi **[knuckle-bones]"**

As a merchant, Pytheas- 125BC –much the same time as Diodoris- knew much about the tin trade.

'The inhabitants of Britain who live in the south-west are especially friendly to strangers and from meeting foreign traders have adopted civilized habits. It is these people who produce the tin, cleverly working the land that bears it. They dig out the ore, melt it and purify it. They then hammer the metal into ingots like knuckle-bones and transport them to an island off the coast called Ictis, for the channel dries out at low

tide and they can take the tin over in large quantities on their carts. Merchants purchase the tin from the natives there and ship it back to Gaul.'
http://www.missgien.net/arthurian/ancient.html

Other accounts mention that it had always been smelted in Cornwall. Therefore we can assume that refined metal rather than raw ore was exported.
http://books.google.co.uk/books?id=4QgVAAAAQAAJ&pg=PA621&lpg=PA621&dq=cornish+tin+ore+exported+by+romans&source=bl&ots=wIGVuoa6_U&sig=RWHEheUzd-VPYrtr7EMO9MV0u4E&hl=en&ei=WM5CTe2XOMmYhQf2rLDnAQ&sa=X&oi=book_result&ct=result&resnum=2&ved=0CCMQ6AEwAQ#v=onepage&q=cornish%20tin%20ore%20exported%20by%20romans&f=false

Roger David Penhallurick in his book **'Tin in antiquity'** says a tin ingot dug up in a garden in St Austell-very close to St Michaels Mount-weighed 7.7kg and measured 41.8 by 14.7 by 4.4 cm. So how big a ship was used, and what draught did it need to carry a cargo, as the weight would have been very considerable to justify its international trading to Gaul-France? We are fortunate to know the dimensions of a trading ship found at nearby Guernsey –one of the Channel Islands

"The Asterix Ship was, almost certainly, based directly on the pre-Roman Venetic ships, vessels Julius Caesar described thus:25 by 6 metres made of oak

> **'The Gauls' [Veneti] ships were made with much flatter bottoms [than Roman ships] to help them ride shallow water caused by shoals or ebb tides. Exceptionally high bows and sterns fitted them for use in heavy seas and violent gales, and the hulls were made entirely of oak, to enable them to stand any amount of shock and rough usage. The cross-timbers, which consisted of beams a foot wide, were fastened with iron bolts as thick as a man's thumb. The anchors were secured with chains instead of ropes. They used sails of raw hides or thin leather, either because they had no flax and were ignorant of its use, or more probably because they thought that ordinary sails would not stand the violent storms and squalls of the Atlantic and were not suitable for such heavy vessels … adapted for sailing such treacherous and stormy waters. We could not injure them by ramming because they were so solidly built, and their height made it difficult to reach them with missiles or board them with grappling irons. Moreover, when it began to blow hard and they were running before the wind, they weathered the storm more easily; they could bring in to shallow water with greater safety, and when left aground by the tide had nothing to fear from**

reefs or pointed rocks.'

The waterline length of such vessels was determined by the size of the tree used for the backbone (Figure 1), hence an oaken vessel would have to rely on a keel of a maximum approaching 16 metres; the *Asterix Ship* had a keel-plank of 15 x 0.4 x 0.1 metres.

These, in turn, supported a full deck, probably with the aid of strategic bulkheads, thereby creating a cargo hold of 200 cubic metres plus within a substantial vessel, conceivably of trans-ocean potential
www.swan.ac.uk/grst/student%20papers/CLH292%20asterix.doc

This article provides further evidence of the size of contemporary Roman vessels.

http://www.artsales.com/Ancient%20Ships/mRomanGalleons.htm

This link gives some more details of Phoenician boats-earliest users of the port at St Michaels Mount.
http://phoenicia.org/trade.html

So scaling up the draught of the 15 foot boat our best estimate is that trading boats would have a draught of up to around 1.2 metres, when laden with some tons of tin, plus crew and other supplies.

St Michaels Mount remains a tidal island today, although the studies seem to indicate that after 2000 years it should now be surrounded by sea at all stages of the tide due to land movement alone-irrespective of the notion of modern sea level rise. The tide window today for a fairly deep draught ship who had travelled some distance and who would be unwilling to hove to in treacherous waters is still fairly small-a matter of a few hours in each tidal cycle.

If the port was bustling 2000 years ago it is reasonable to suppose that tidal access was less limited then than it is today-or was at least as good. Consequently the evidence suggests that in 350BC there was probably a little more water than exists today in order for it to be a worthwhile place to ship cargo from, and therefore current ocean volume (glacier melt and thermal expansion) is less now than then, to take into account the known land changes. There was speculation that in Phoenician times the island was still connected to the mainland by a spine of land (Bloch et al) but that can not be authenticated by recent archaeological evidence, and as other accounts clearly describe it as a tidal island the apparent higher sea levels of the Roman age- compared to today- can be fairly attributed as factual, as we shall try to verify by looking further afield, after this more recent historic snippet.

Joachim von Ribbentrop was Hitler's foreign minister and paid various visits to Britain immediately prior to the war. He was seen locally in my area of the South Coast in 1938 purchasing postcards, which we now know were used to provide pictorial scenes of possible invasion sites. He had a particular liking for Cornwall and planned to retire to St Michael's Mount upon a successful invasion. Would the IPCC have told you that in their version of section 5A?

http://www.guardian.co.uk/world/2010/oct/03/nazi-foreign-minister-planned-cornwall-retirement

Thus far we have concentrated on one small part of one small country, albeit the tidal island is an interesting proxy. Britain, as one of the world's largest islands, is a good place to examine sea level changes, helped by the wealth of visual evidence and written records created through a long period of continual habitation.

At this stage of the study therefore we will look elsewhere in the UK for evidence of likely sea levels in the Roman period and then expand the search further afield. Of course we must remember the caution that needs to be exercised due to the complications of erosion and deposition and all the other factors already noted, but also that academic studies would be aware of these.

Pevensey in Sussex (South Eastern Coast) was one of the 'forts of the Saxon shore'-built by the Romans in the 3rd century to keep out the Saxon invaders. The castle -still visible-now lies a mile or two inland but was very important at the time of the Romans.

Archaeologists Discover Roman Coastline – Two Miles Inland

The need for this fort is graphically described here;

"The North Sea had a nasty little jump between 350 and 550AD, flooding the coasts of northern Europe with an extra 2 feet of water and sending its inhabitants — folk known as Angles and Saxons — fleeing (although "conquering" might be the better word) into ill-prepared Roman territories. At the start of this rise, the areas we know as the Fens were a well-settled part of Roman Britain ruled from the town of Duroliponte (Cambridge) by its native people, the Christianized Romano-Celtic Iceni. Then the sea level rose, and history's curtain went down for two centuries."
http://www.historynet.com/the-fens-england-below-sea-level.htm

The Roman castle evolved into a Saxon fort and then a medieval castle. When it was built it commanded the entrance to a harbour and was surrounded by the sea on three sides.

http://www.absoluteastronomy.com/topics/Anderitum

Thanet, on the South East coast of England, yields further evidence

"Rectangular and curvilinear enclosures have been recorded at Dumpton Gap and Broadstairs on the east coast of the island (both of which may indicate small subsistence farming communities) whose incomes were bolstered by the extraction of salt from sea-water, as evidence linked to this activity has been found at both of these sites. The industry was probably curtailed by the early 3rd century at these sites, however, due to the rising sea-levels. Burials have also been recorded at both sites."

http://www.roman-britain.org/places/tanatus.htm

"At Faxfleet a Roman site was probably abandoned in the 4th century AD as a result of rising sea levels."

"A Roman road was built northwards from South Ferriby towards the Humber during the 1st and 2nd century ad but this became buried by estuarine sediment within around 200 years of its construction indicating rising sea levels" (also see further references on Page 114 of the link below)

http://books.google.co.uk/books?id=eBwQzsBTWWAC&pg=PA114&lpg=PA114&dq=rising+sea+levels+in+the+12th+century&source=bl&ots=KyZhabZa_Z&sig=-7es_kab48FTmL_GgbzbLr_hAPI&hl=en&ei=2hOMTObrA4_f4gbH29XnCg&sa=X&oi=book_result&ct=result&resnum=2&ved=0CBsQ6AEwAThk#v=onepage&q&f=false

This next item refers to an academic study made to the east of London;

"These indicate a sequence of oscillations of relative sea levels to land mass as the sea has advanced and regressed over the last 10,000 years. The mean relative sea level curve shows an overall trend of a steadily rising sea level with time (see Devoy 1977: 714 fig 2) with levels in our period of +0.4m above present (OD) (Newlyn). For our period the Thames IV transgression phase equates to the middle of the third century AD (*c* 1750 yr bp), when sea levels at Tilbury were approximately +0.4m above present OD ordnance datum (Newlyn) (Devoy 1977; D'Olier 1972: 127)."

http://www.soton.ac.uk/archaeology/docs/Roman%20Resource%20Assessment%20-%20WORKING%20DRAFT%20-%20march2010.pdf

"There appears to have been a general abandonment of settlements across the region during the late Roman Iron Age and the Migration period, probably due to rising sea-levels and storm-tides in the 4th century. Settlement recommences in the 7th or 8th centuries, often in areas that had been previously favoured as settlements sites in the Roman Iron Age."

http://www.lancewadplan.org/Cultural%20atlas/WaddenSea/waddensea.htm

Still in the Roman era we now travel further afield to ascertain the characteristics of sea levels in other countries;

The first study is by Lambeck et al. in the scientific journal *(Earth and Planetary Science Letters)* entitled **"Sea level change from Roman times in Mediterranean,"** which illustrates some of the complexities of this subject;

"Here, we present results for sea-level change in the central Mediterranean basin for the Roman Period using new archaeological evidence. These data provide a precise measure of local sea level of -1.35±0.07 m at 2000 years ago. Part of this change is the result of ongoing glacio-hydro isostatic adjustment of the crust subsequent to the last deglaciation. When corrected for this, using geologically constrained model predictions, the change in eustatic sea level since the Roman Period is -0.13±0.09 m."

http://clima.casaccia.enea.it/staff/antonioli/Articoli/29.pdf

This second study by the same author;

"During the detailed excavations of ancient Caesarea, Israel, East Mediterranean, 64 coastal water wells have been examined that date from the early Roman period (with the oldest occurring in the 1st century AD), up to the end of the Crusader period (mid-13th century AD). The depths of these coastal water wells establish the position of the ancient water table and therefore the position of sea level for the first century AD up to 1300 AD. The connection between the coastal water table and changes in sea level has been established from modern observations in several wells on time scales of days and months and this is used to reconstruct sea level during historical time. The results indicate that during the Byzantine period, sea level at Caesarea was higher by about 30 cm than today. The Late Moslem and Crusader data shows greater fluctuations but the data sets are also much smaller than for the earlier periods."

http://people.rses.anu.edu.au/lambeck_k/pdf/237.pdf

This next study is of a Roman market;

"After rapid submersion of the Roman market, crustal uplift explains the death of the marine organisms. These radiocarbon dates are compatible with epigraphic data, which mention the Roman market for the last time in A.D. 394. This implies a rapid relative sea-level rise during the fourth century A.D."

".. According to the new data, submersion of Pozzuoli was not a unique event, but included three maximum threshold oscillations between the fifth and fifteenth centuries A.D. (1) During the first phase, marine transgression of the Roman market ended ca. A.D. 400–530 after its last restoration in A.D. 394."
http://www.mediterranean-geoarchaeology.com/USERIMAGES/PozzuoliGEOL.pdf

This of an earlier Egyptian harbour;

http://gsa.confex.com/gsa/2010NE/finalprogram/abstract_170165.htm

"Archaeological investigations along a carbonate / conglomerate terrace located 600 m landward of the Red Sea coast in Egypt have uncovered the existence of an ancient (~4 kya) Egyptian harbor, a site from which seafaring ships departed for trade routes along the African Red Sea coast. Nearly 10 years of excavations at Mersa / Wadi Gawasis, a Middle Kingdom Egyptian site, have documented evidence for occupation on the top and at the base of the terrace, including temporary shelters, rock-cut caves, ceremonial structures, and industrial areas for metal working.

Ground penetrating radar, sediment coring, malacological and foraminiferal studies, radiocarbon dates, and rheological models demonstrate that the wadi bed adjacent to the terrace was once an open, protected bay. The base of the corraline / conglomerate terrace consists of a narrow coral-beach rock platform (dated at ~3500 BP) presently buried by anthropogenic, eolian, and colluvial sediments. Ubiquitous medium-fine wadi sediments underlie and extend beyond the beach rock. Malachological analyses, foraminifera distributions, radiocarbon dates, and sedimentological data indicate that these sediments were deposited in a protected tidal lagoon receiving infrequent freshwater inputs. Wave-cut notches along the seaward shoreline confirm a site-specific rheological model for the northern the Red Sea that indicates a sea-level highstand (~1 m above present MHW) during or immediately prior to occupation. Late during the

period of occupation, the lagoon began to close as equatorial siphoning forced a regional sea-level fall while at the same time, riverine discharge through the wadi processes were infilling the bay at rates on the order of .25 cm/year."

"Ostia Antica is a large archeological site, close to the modern town of Ostia, that was the location of the harbour city of ancient Rome, which is approximately 30 kilometres (19 mi) to the northeast. "Ostia" in Latin means "mouth". At the mouth of the River Tiber, Ostia was Rome's seaport, but, due to silting and a drop in sea level, the site now lies 3 kilometres (2 mi) from the sea.[1] The site is noted for the excellent preservation of its ancient buildings, magnificent frescoes and impressive mosaics."

http://en.wikipedia.org/wiki/Ostia_Antica

To date there appears to be solid evidence that, after taking land changes into account, sea levels in Roman times were rather higher than today, as measured in a variety of locations. At this point any author after having proven their hypothesis (to their own satisfaction) would be wise to quit whilst they're ahead and not face up to contradictory information. However that would lead to a charge of cherry picking, so it must be said that my assertions to date seem to be refuted by this 2010 article that comes from much the same part of the world as earlier studies. It appeared in a variety of places including Science Daily

http://www.sciencedaily.com/releases/2010/01/100126101411.htm

Science Daily featured a mix of selected quotes from the press release of a new study on sea levels, with which they combine their own narrative; This is the press release from which large sections of the text was lifted.

http://www.eurekalert.org/pub_releases/2010-01/uoh-tsl012610.php

"The sea level in Israel has been rising and falling over the past 2,500 years, with a one-meter difference between the highest and lowest levels, most of the time below the present-day level." (This from the Science daily narrative)

"These revealed that the sea level during the Crusader period -- just 800 years ago -- was some 50-90 centimeters lower than the present sea level. Findings from the same period at Caesarea and Atlit reinforced this conclusion. When additional sites were examined from periods before and after the Crusader period, it was revealed that there have been significant fluctuations in sea level: During the Hellenistic period, the sea level was about 1.6 meters lower than its present level; during the Roman era the level was almost similar to today's; the level began to drop again during the ancient Muslim period, and continued dropping to reach the same level as it was during the Crusader period; but within about 500 years it rose again, and reached some 25 centimeters lower than today's level at the beginning of the 18th century."(Science Daily narrative) .

So the conclusion would be reached from reading the article that although the sea level was almost as high as today in Roman times it subsequently dropped, rose again to some 25cm, lower than today and as we all 'know' has surged to new levels in the last century.

This is the original study

http://wcrp.ipsl.jussieu.fr/Workshops/SeaLevel/Posters/1_1_Sivan.pdf

It appears that inexplicably a significant portion of this study was omitted, which throws a rather different light on the Science Daily story-which in fairness was carried elsewhere with a similar slant.

It is this;

"The Caesarea results indicate that about 2000 years BP sea levels was at its present elevation, (note; not 'almost similar to today's) while during the Byzantine period it was at or ABOVE its present level by (about 30cm- plus or minus 15cm) During the Crusader period "(around 1300AD)"sea level may have been lower than today by about 40cm, plus or minus 15cm." (my capitalisation)

So a reference to up to 500 years of higher sea levels than today has been removed from the Science Daily version of History. We then have this piece of subtle rephrasing of the history narrative;

"…but within about 500 years it rose again, and reached some 25 centimeters lower than today's level at the beginning of the 18th century."

That may be true, the period running up to the beginning of the 18th Century was one of the severest episodes of the LIA during which sea levels may be expected to drop as water was frozen in glaciers and thermal expansion reduced. But the original study notes that 'it **seems that sea levels rose slowly from the relatively low levels of the Crusader period to the present level by the 19th century."** In other words the overall heights haven't changed much since, despite modern rises, which is rather different to the inference made by Science Daily.

That the Science Daily version can have a rather different inference than the study and that some key parts have been omitted can be seen in the attribution by SD;

Story Source:
The above story is reprinted (with **editorial adaptations** by Science*Daily* staff) from materials provided by **University of Haifa**. (Their link then originally lead to the University's home page in Hebrew)

(My highlighting of the words 'editorial adaptations)

Let Dr Sivan himself have the last word which can put the Science Daily reporting of this section into its proper context now we know the complete story;

"Over the past century, we have witnessed the sea level in Israel fluctuating with almost 19 centimeters between the highest and lowest levels. Over the past 50 years Israel's mean sea level rise is 5.5 centimeters, but there have also been periods when it rose by 10 centimeters over 10 years. That said, even acute ups and downs over short periods do not testify to long-term trends. An observation of the sea levels over hundreds and

thousands of years shows that what seems a phenomenon today is as a matter of fact "nothing new under the sun," Dr. Sivan concludes.

This observation is interesting as the use of the word ‘fluctuating’ can be matched to an earlier reference in other studies to ‘oscillating’ whereby it seems to be implied that over the last few thousand years or so sea levels have moved up and down around a central average by up to 30cm or so.

These following references covering our period of study are from the Middle East, Holland, Britain, Greece, Egypt, Germany and the Pacific.

“In the ancient port Caesarea, south of Haifa, stands a wall which must have been built between the time of Herod and the 2nd century. (A. Negev , personal communication , 1962). The top of this wall, now 1.50 m above the present sea level, is perforated with the typical holes made by the Lithophaga. The wall stands vertical and shows no sign of tilting. Near this wall are the remains of two aqueducts which once supplied Caesarea with water. Of the two, the older one was built near the present shore line; the parallel and newer aquaduct, situated further inland, must have been constructed when the sea was threatening and ultimately destroying the first one (REIFENBERG, 1951, pp. 27-28). It is most probable that the original aqueduct was constructed during Herod’s reign or shortly after, and that it was situated at that time quite far inland. It is estimated that it was destroyed towards the middle of the first millennium A.D. and the sea, therefore, must have been temporarily 1-2 m higher than it is now ((Fig.4C) “.

“**Not only are the aquaducts of Caesaria (REIFENBERG, 1951) and the columns at Puteoli still in the original positions of construction (two things which would be almost impossible if there had been a tectonic movements of 3 m vertical amplitude since their erection) but many other old buildings in the reputedly unstable Mediterranean area are still vertical, a sign that the instability in many places was not great enough to cause a tilt. At the old shore the Etang of Vendres, near the mouth of the Aude, are the ruins of a Roman Therme of the 1st or 2nd century A.D. (locally called the temple of Venus). There the walls have been washed out by waves so that they now have a deep double notch about 1.80 m above present sea level (Fig. 4C). The remaining walls of the “temple” are not tilted at all.”**

“Unfortunately these methods can only give estimates of within time intervals of several hundred years and differences of heights of half metres at best. Still, it is clear that the sea level at the Frisian coast according to 14C peat determination was higher ((Fig. 4C) in the middle of the first millennium A.D. than it is today and much higher than it was in the first millennium B.C. (Fig. 4F). The maximum in the middle of the first millennium A.D. is also supported by 14C data in the stable Recife area of Brazil (VAN ANDEL and LABOREL, 1964) (Fig. 4D).”

“Similarly the studies of GODWIN (1943), (archaeological , palynological and ecological) show for the middle of the first millennium A.D. (Fig. 4C) a definite rise of 1 m in the Fenlands of East Anglia over the present day sea level there, and a subsequent fall of several metres below today’s level in the 11th century A.D. (Fig. 4B).”

“A short rise of the ocean levels might be indicated for about 400 B.C. (THUKYDIDES) by high salt prices reported for Athens (EHRENBERG, 1951, p. 223), and by the fact

that at about that time new positions were selected for salt pans in the Ostia area (MEIGGS, 1960, p. 269).”

“Between 1200 and 7 B.C. (Fig. 4C) we have evidence of an high sea level: Ramses II succeeded in connecting the Niles to the Red Sea by a canal (1200 B.C.) (Fig. 4G) (MUIR, 1924) which re-used later by Trajan and still later by the Arabs, as mentioned before (650 A.D.) (Fig. 4C).”

“In Schleswig (Haitabu area) a cutba river is indicative of a sudden rise of the sea level (1000 B.C.) (Fig. 4G) (K(STER, 1960).”

http://www.salt.org.il/sealevel.html

Whilst not specifically about sea levels, this study provides some interesting context to the possible reasons for the sea level rise and fall we can observe-temperature change affecting glacial melt and thermal expansion;

“Oxygen isotope values for the two oldest bivalves in the study show a cold spell between 360 BC to 240 BC that has some of the coldest temperatures in the entire series of observations that stretch to about 1660 AD. Following this period it seems that temperatures increased rapidly such that temperatures from 230 BC are significantly higher. In fact a shell from 130 BC recorded the highest temperature in the entire 2,000-year dataset. Between 230 BC and 40 AD there was a period of exceptional warmth in Iceland that was coincident with the Roman Warm Period in Europe that ran from 200 BC to 400 AD. This Icelandic shell data series suggests that the RWP had higher temperatures that those recorded in modern times.

By 410 AD there had been a return to cooler temperatures presaging the onset of a cold and wetter era called the Dark Ages Cold Period between 400 AD and 600 AD.

The subsequent warming trend in Iceland took place from 600 AD to 760 AD about a century before prolonged warming began in Europe than in the subsequent centuries led to the Medieval Warm Period that was about as warm as the Roman one.”

http://www.pnas.org/content/early/2010/03/02/0902522107.full.pdf

This in the Pacific;

“**LAST-MILLENNIUM CLIMATE AND SEA-LEVEL CHANGES IN THE PACIFIC**

Almost all paleoclimate records for the Pacific Basin show a period of warmer-than-present climate known as the "Holocene Climatic Optimum," approximately 6000-3000 B.P. in the central tropical Pacific (Nunn 1999). This period marked a time of maximum opportunity for biota, warm temperatures, and higher sea level, which produced a greater range of habitat diversity than today. In most parts of the Pacific Basin, mean annual precipitation also appears to have been greater than today. Since the Holocene Climatic Optimum ended, this region has generally experienced cooling, sea-level fall and, in places, a fall in precipitation and loss of biodiversity attributable to climate change.”

http://goliath.ecnext.com/coms2/gi_0199-7024384/The-A-D-1300-Event.html

At this stage it would be useful to summarise what we have learnt so far and compare that to the official viewpoint.

This is the official IPCC position in AR4 on historic sea level rise from AD0, presumably meticulously garnered as a result of serious studies, although the references and the studies themselves seem to be missing from the report, or at the least are not directly referenced .

http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter5.pdf

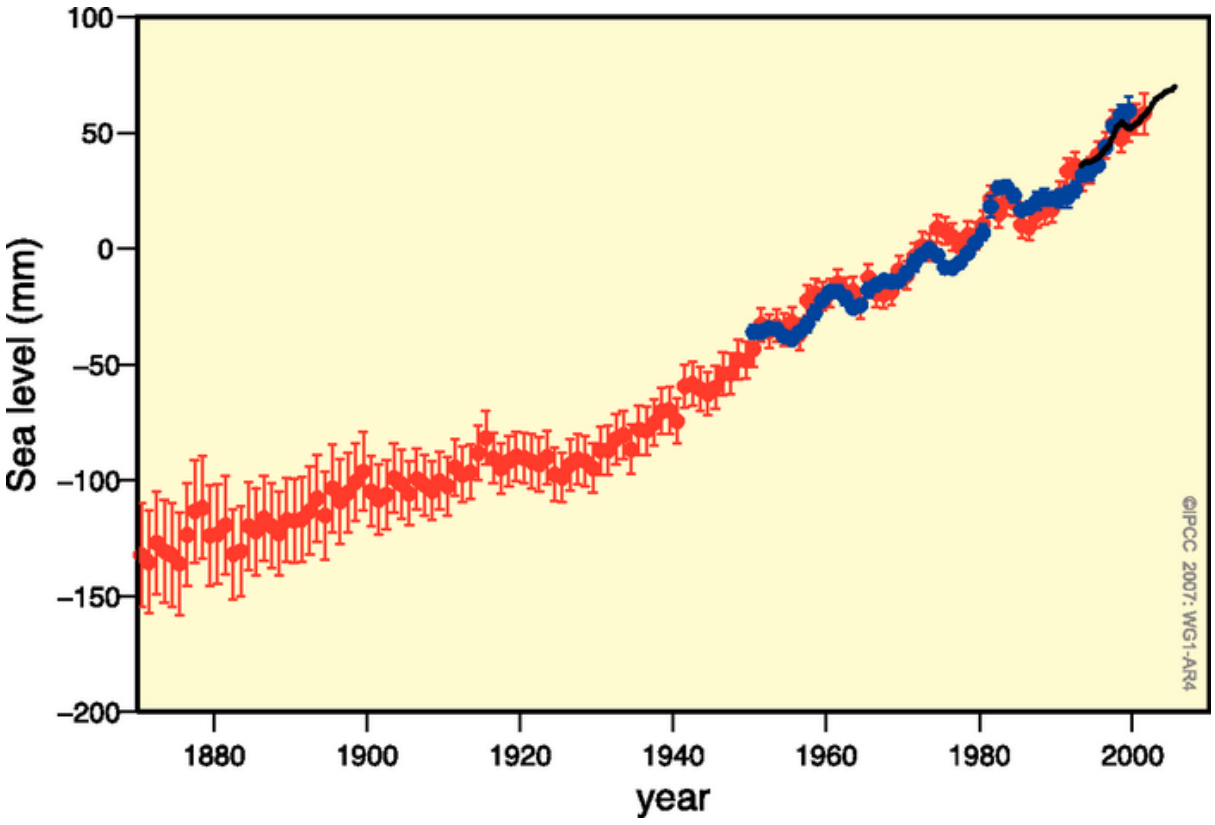
faq 5.1

"Yes, there is strong evidence that global sea level gradually rose in the 20th century and is currently rising at an increased rate, after a period of little change between AD 0 and AD 1900. Sea level is projected to rise at an even greater rate in this century. The two major causes of global sea level rise are thermal expansion of the oceans (water expands as it warms) and the loss of land-based ice due to increased melting…

Global sea level rose by about 120 m during the several millennia that followed the end of the last ice age (approximately 21,000 years ago), and stabilised between 3,000 and 2,000 years ago. Sea level indicators suggest that global sea level did not change significantly from then until the late 19th century. The instrumental record of modern sea level change shows evidence for onset of sea level rise during the 19th century. Estimates for the 20th century show that global average sea level rose at a rate of about 1.7 mm yr–1."

See also the summary for policymakers referenced below, with one paragraph referring to changes since 1961 and the familiar graph relating to 1870 onwards-there is no historical perspective or references to put the graph into context

http://docs.google.com/viewer?a=v&q=cache:vNYdjg_5J8EJ:www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf+global+sea+level+relative+to+1980-1999&hl=en&gl=uk&pid=bl&srcid=ADGEEShE4bFPcJH2WJv3zVCqaGdiOVWykz-54cCEUX0pwFec-6kz60MXHiypLZHnKj0zDKywVTh2bA3_DQpfDczRPS4cPRRBHK53I52TFT8eGbT7v6beH6DbE0tq6saFCptfQ2OB3JrZ&sig=AHIEtbR3J3Jn7vKe1A4pg8z1N_yVV67ATA



.

So notwithstanding the apparent vagueness of the IPPC who, despite lack of substantive evidence, assert a sea level status quo from ancient until modern times (which will be dealt with in article 2 and 3) we seem to have many studies that point to a picture of relatively static sea levels after the initial Holocene rise. These then show that some 3000 years ago there was a further inundation (think Lyonesse in Cornwall) and in early Roman times levels were somewhere around current levels. Levels then rose strongly through the Roman period peaking around the 700 AD Byzantine period at levels higher than today, which concludes at this period of study for Part 1.

A fluctuating climate between warm and cold periods may have a correlation with rising or falling of sea levels if the research of today's scientists is correct-but note the caution of researchers such as Holgate.

What happened next with sea levels will be the subject of Part Two which covers the Medieval Warm period. To ease us into that era and provide a taster for Part 3 on Modern sea levels we can usefully allude to three graphs.

The first relates to a number of studies -referenced here- carried out around 1965. (scale is in metres)

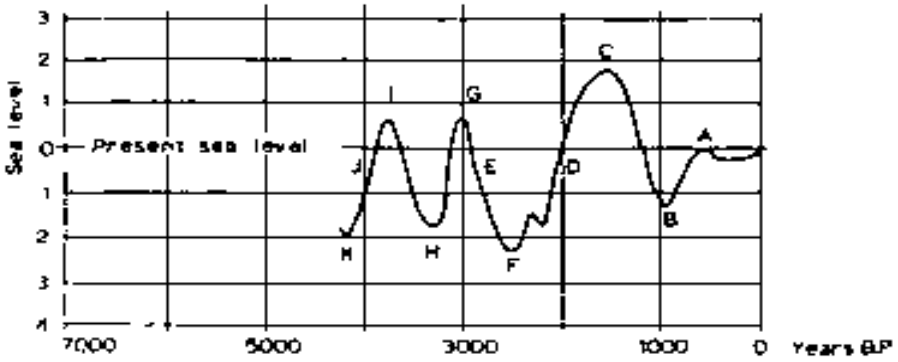
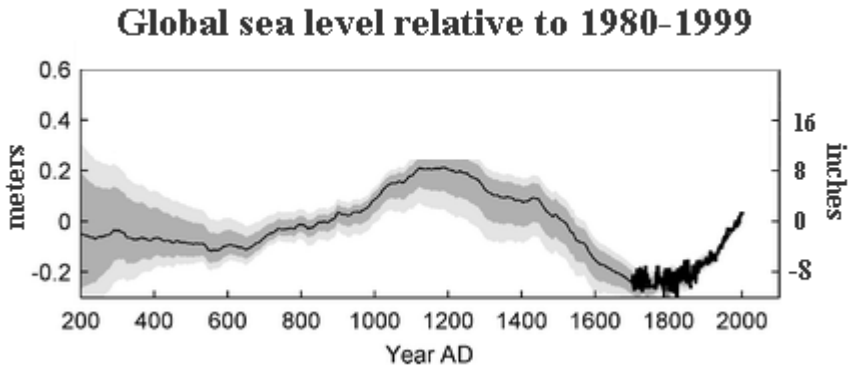


Figure4a http://www.salt.org.il/sealevel.html

The author asserts **"As we are not in a position to estimate the sea level at any time before 1850 exactly, a difference of 30 cm cannot be considered as significant. The more general term "present sea level" will therefore be used here; to this we will relate all indications of "sea level changes" compiled from data relating to historic or pre-historic times The "present sea level" seems to have been reached in the 16th century; since that date there have been no indications of any permanent change of an order greater than 30 cm. However, there are definite signs that between 700 A.D. and 1600 A.D. one or more distinct sea level minima occurred (Fig. 4B)."**

This ties in with other comments throughout these various studies that there was a high point reached around 500-700AD with a decline thereafter. The author places a low point around 1000AD with a slow rise again to broadly current levels in the 16th century thereby covering first the MWP and also the most severe of the early LIA episodes.

We don't want to get ahead of ourselves, but are there any studies with a graph that can confirm the Roman temperatures and act as the launch pad for an examination of the MWP? I'm glad you asked. Here it is from 2009.



Note the above period ends 1999-add around an inch (2cm) to it to meet official modern levels. This appears to have been compiled by Jeff Masters at Wundeground based on work by Grinsted and others. It is carried in a general article on sea level change referenced here;

http://www.wunderground.com/blog/JeffMasters/comment.html?entrynum=1240

The chart has a description as follows;

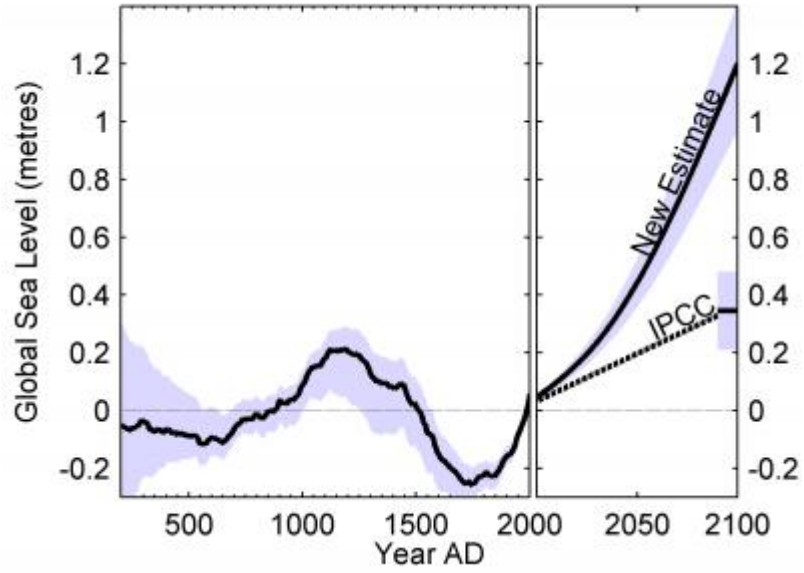
"Figure 1. Global sea level from 200 A.D. to 2000, as reconstructed from proxy records of sea level by Moberg *et al.* 2005. The thick black line is reconstructed sea level using tide gauges (Jevrejeva, 2006). The lightest gray shading shows the 5 - 95% uncertainty in the estimates, and the medium gray shading denotes the one standard deviation error estimate. The highest global sea level of the past 110,000 years likely occurred during the Medieval Warm Period of 1100 - 1200 A.D., when warm conditions similar to today's climate caused the sea level to rise 5 - 8" (12 - 21 cm) higher than present. Image credit: Grinsted, A., J.C. Moore, and S. Jevrejeva, 2009, "Reconstructing sea level from paleo and projected temperatures 200 to 2100 AD", Climate Dynamics, DOI 10.1007/s00382-008-0507-2, 06 009.

Here it is again (below) in a different form, which we shall catch up with in part 3 of our study, as it also concerns itself with the modern era with some astonishing projections. (Note-the study stops at 1999). This study is headed **'Sea level rise of 1 meter within 100 years.'**

http://www.physorg.com/news150645386.html

A further study uses the same information and is headed; **"Reconstructing sea level from paleo and projected temperatures 200 to 2100 AD"**

This rather apocalyptic version-as do the other variations- starts towards the end of our studied period, but the margins of error show the high levels in earlier Roman times, then a dip, then a rise to the MWP peak, a decline, then a rise in modern times to below that of Roman and MWP before a dramatic projected increase closely linked to the future temperature increase expected by some researchers.



http://www.glaciology.net/Home/PDFs/Announcements/gslprojection

Again this is getting ahead of ourselves, as Part 1 of our study finishes before the MWP. So there seems to be some disagreement. On the one hand we have a 45 year old graph showing a peak in Roman times above todays levels, then a similar peak to today around 16th century at substantially lower levels than in late Roman times (The Salt studies) This study is especially interesting in its assertion that rises or falls of 30cm (1 foot) would appear to be the norm;

We also have several graphs- but from the same sources- showing a peak in Roman times but with considerable margin of possible error, and a much more confident MWP peak to levels greater than today. In article 2 I shall use Jeff Masters graph to head my next study on the MWP as the calibration is rather better, and it has a joint scale in metres and inches. In that study we shall find what evidence there is to suggest levels were higher in the MWP than the Roman period. At this stage I don't know who is right, but certainly the picture does not appear to be as the IPCC paint it, as levels appear to have been higher in the historic past than today, not lower.

Further reading;

“This Shrinking Land” by Professor Robert Duck, usefully catalogues examples of erosion and deposition around Britain’s Coast and describes the processes involved. Published by Dundee University Press ISBN 978-1-84586-118-6