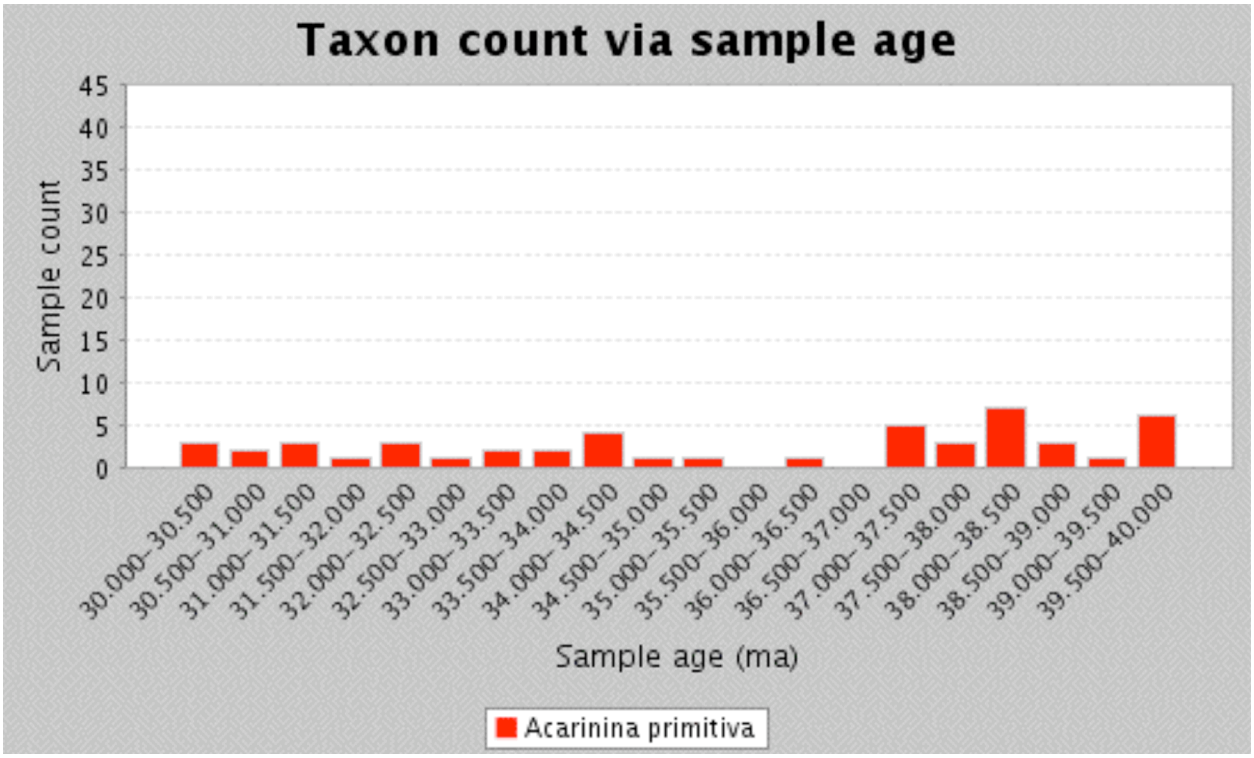
Guidelines for determining first and last occurrences of microfossil species, and graphing results

This document provides guidance for selecting first and last occurrences (FOs and LOs) of microfossil species compiled from the Neptune database hosted by CHRONOS. You have generated species age range data for a 10 million-year-long interval between 70 Ma (Late Cretaceous) and 30 Ma (Oligocene)(Ma = mega-annum, or million years). You may have data for 3 or 4 different groups of microfossils (calcareous nannofossils, planktic foraminifera, diatoms, and radiolarians). These data represent a compilation of all the deep-sea sites with microfossil data in the Neptune database. These deep-sea sites are from the Atlantic, Pacific, and Indian olcean basins. The output that you generated using the Age Range Chart tool on the CHRONOS Portal (http://portal.chronos.org/gridsphere/gridsphere?cid=arc&JavaScript=enabled) shows the distribution of species as a function of time. The data are plotted as a series of histograms for each group of microfossils. For example, if you requested data for the 40 to 30 Ma interval, then you should have 91 calcareous nannofossil species, 52 planktic foraminifers, 69 diatoms, and 54 radiolarian species. For each species, the histogram shows the number of samples for each half-million age segment (0.5 Ma) containing a record of that species.

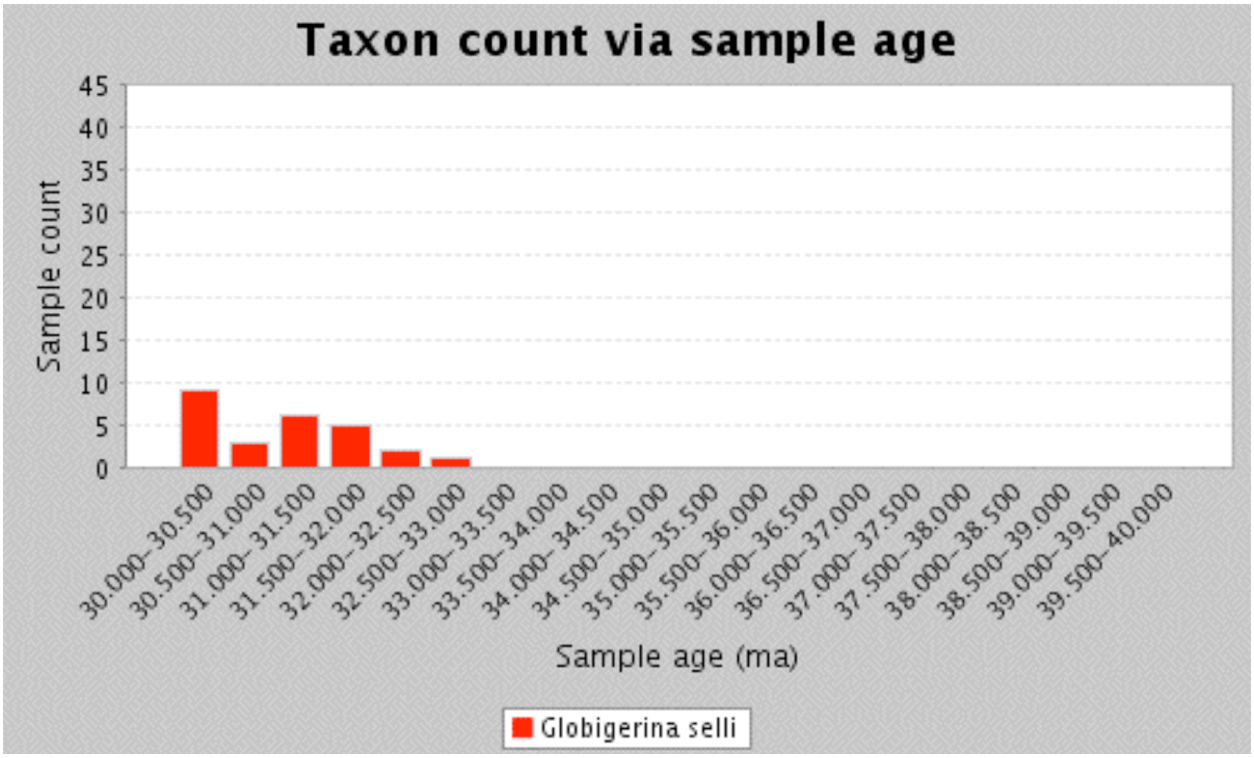
In order to quantify rates of evolution and extinction, you first need to determine the number of FOs and LOs per 0.5 Ma, for each of the microfossil groups represented in your 10 Ma interval of study. For some species, this exercise will be straight-forward. For example, a species will have a clear FO and/or LO in your study interval (i.e., a continuous range without gaps in the 0.5 Ma bins). A number of species may range through your study interval with no obvious FO or LO. But for other species, you will need to make an interpretation of what the data represent. There are a number of reasons why the age range of a species will not appear to be continuous. For example, deep-sea sediments can be eroded by currents or gravity slides many years, even millions of years after they are deposited. Microfossils displaced by these currents or gravity slides may be redeposited in younger age sediments, potentially creating a situation where the range of a species is artificially extended beyond its true age range. This is called reworking, and it does occur in the deep-sea. Reworking can produce a range that appears discontinuous. Another reason for an age range that appears discontinuous may be related to inaccurate age models in some of the sites in the Neptune database, which are used to assign ages to each of the samples in a particular deep-sea drill site (age models are themselves are interpretations of sediment accumulation rate history for each drill site). Lastly, it is possible that some misidentification of species by the numerous microfossil specialists who have contributed data to the Neptune database may have contributed to some of the anomalous ranges.

For our purposes here, let's assume that if there is a gap of 4 half-million-year bins (i.e., 2 Ma), then assume that this is an anomalous range and pick the FO or LO at the end of the continuous part of the range. What follows are several examples for how to identify whether a species has a FO, LO, or ranges continuously through your 10 million year interval.

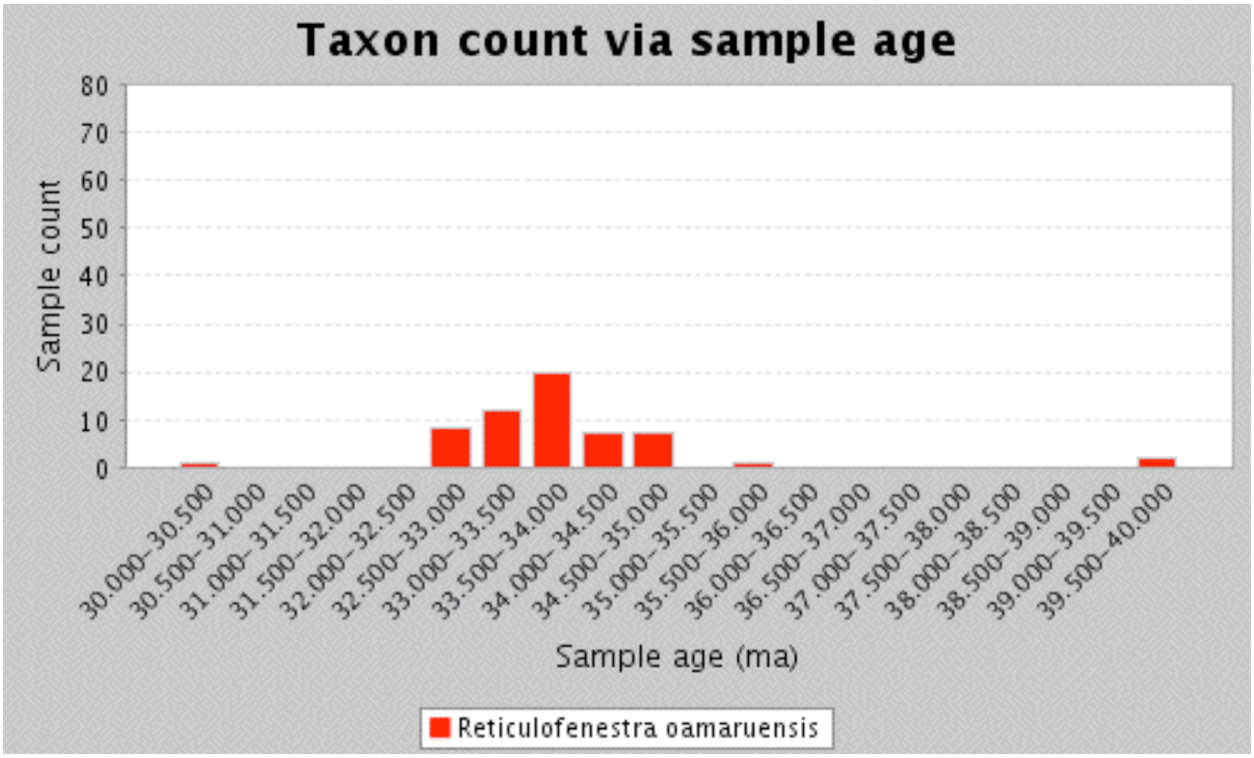
The planktic foraminifer *Acarinina primitiva* (below) shows a continuous range through the 40-30 Ma interval.



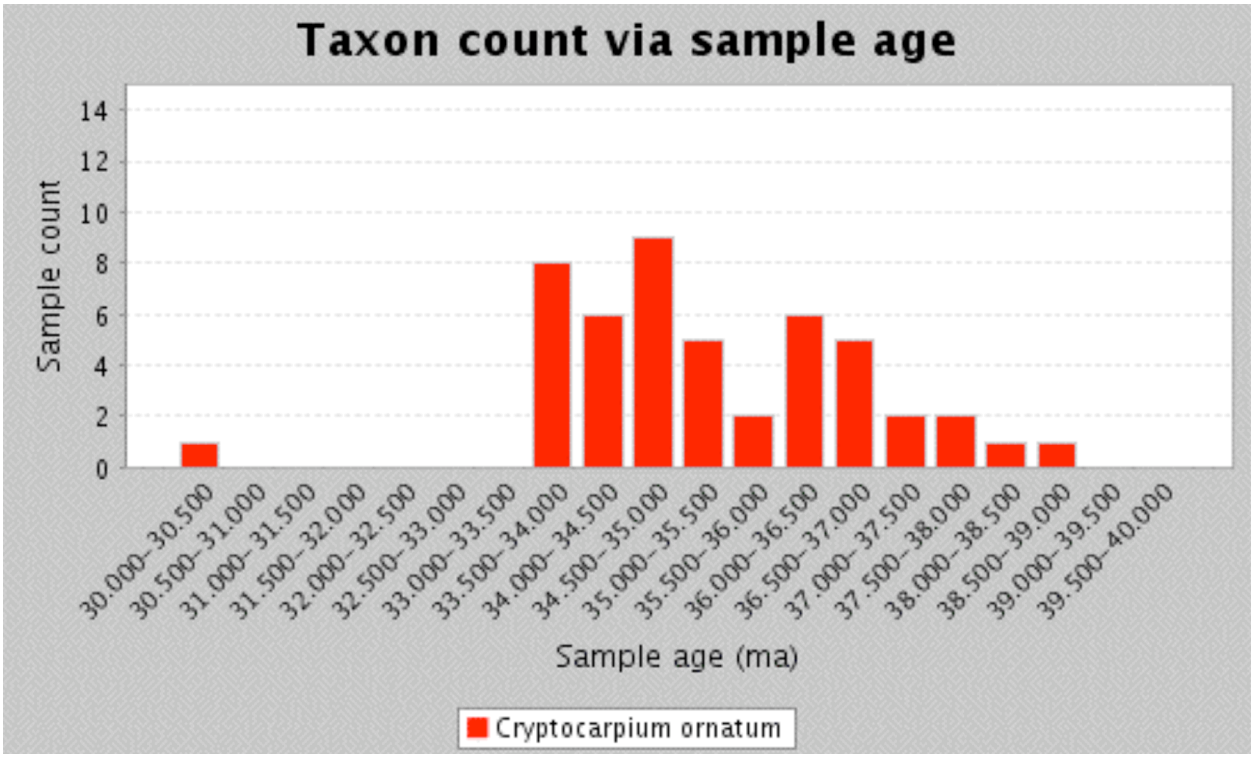
The planktic foraminifer *Globigerina sellii* (below) has a FO (first occurrence) at 32.5-33.0 Ma.



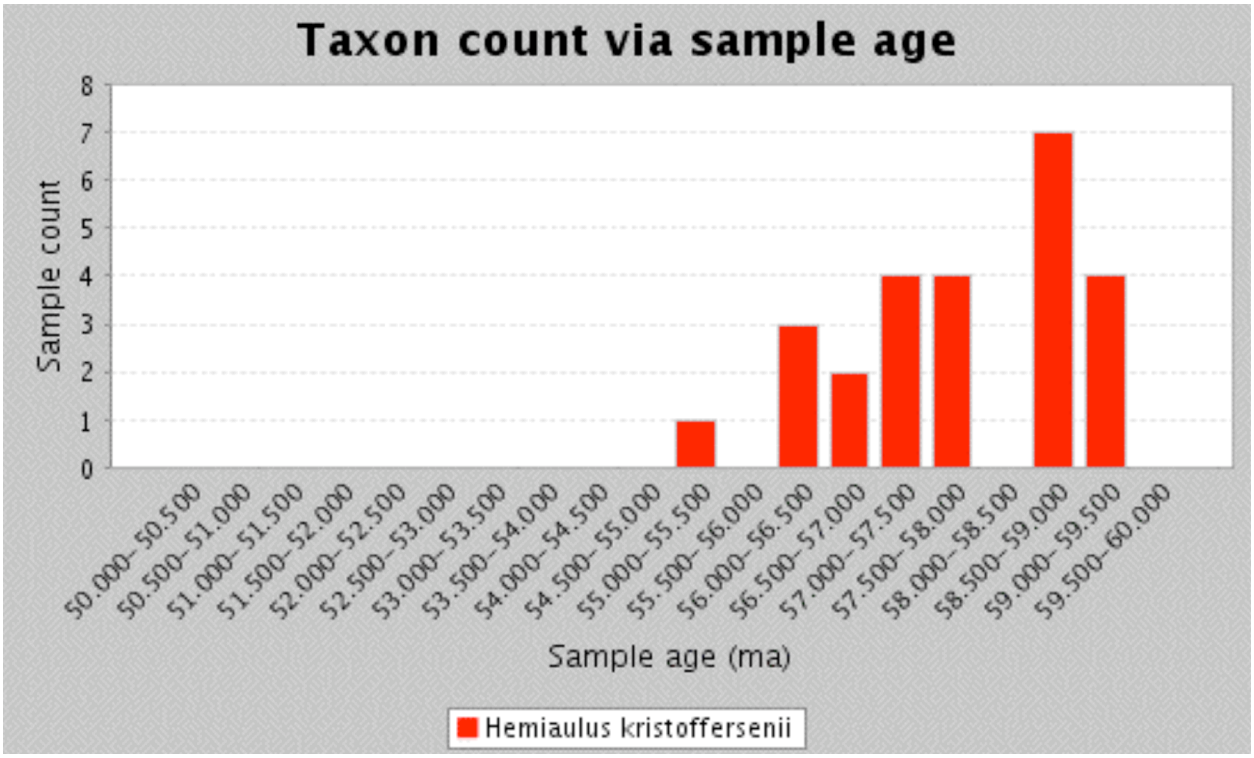
The calcareous nannofossil species *Reticulofenestra oamaruensis* (below) has a FO at 35.5-36.0 Ma and a LO (last occurrence) at 32.5-33.0 Ma.



The radiolarian species *Cryptocarpium ornatum* (below) has a LO at 33.5-34.0 Ma.



The diatom species *Hemiaulus kristoffersenii* (below) has a LO at 55.0-55.5 Ma (it may also have a FO at 59.0-59.5 Ma, but there are not enough data presented here to tell for sure).



Using the histograms of species occurrences, compile the number of FOs and LOs per half-million year interval of all species for all 3 or 4 groups of microfossils. Set-up your data table like the one illustrated below for the interval 40-30 Ma (CN – calcareous nannofossils, PF – planktic foraminifers, D – diatoms; FO – first occurrence, LO – last occurrence). Notice that the youngest half-million interval is at the top and the oldest at the bottom, thereby replicating the stratigraphic order of deposition.

	# FO CN	#LO CN	# FO PF	# LO PF	# FO D	# LO D
30.0-30.5						
30.5-31.0						
31.0-31.5						
31.5-32.0						
32.0-32.5						
32.5-33.0						
33.0-33.5						
33.5-34.0						
34.0-34.5						
34.5-35.0						
35.0-35.5						
35.5-36.0						
36.0-36.5						
36.5-37.0						
37.0-37.5						
37.5-38.0						
38.0-38.5						
38.5-39.0						
39.0-39.5						
39.5-40.0						

Next, generate a bar graph showing the number of evolutionary events through your 10 million year interval, with age on the “y” axis, and number of events on the “x” axis. Age should be displayed with the oldest at the bottom and youngest at the top (similar to a sequence of layered sedimentary rocks).

Questions to consider:
What interval or intervals contain the greatest rates of evolutionary activity (i.e., originations and extinctions)?
Do these intervals correspond with period or epoch boundaries?
Does evolutionary activity correspond with other evidence of global change such as changing sea level, temperature fluctuations, or changes in the carbon cycle?