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Research Report No. 97

An assessment of sediment chronologies for 35 lakes in Ireland based on skeleton spheroidal carbonaceous particle profiles

A report for IN-SIGHT (EPA/ERTDI Project #2002-W-LS/7)

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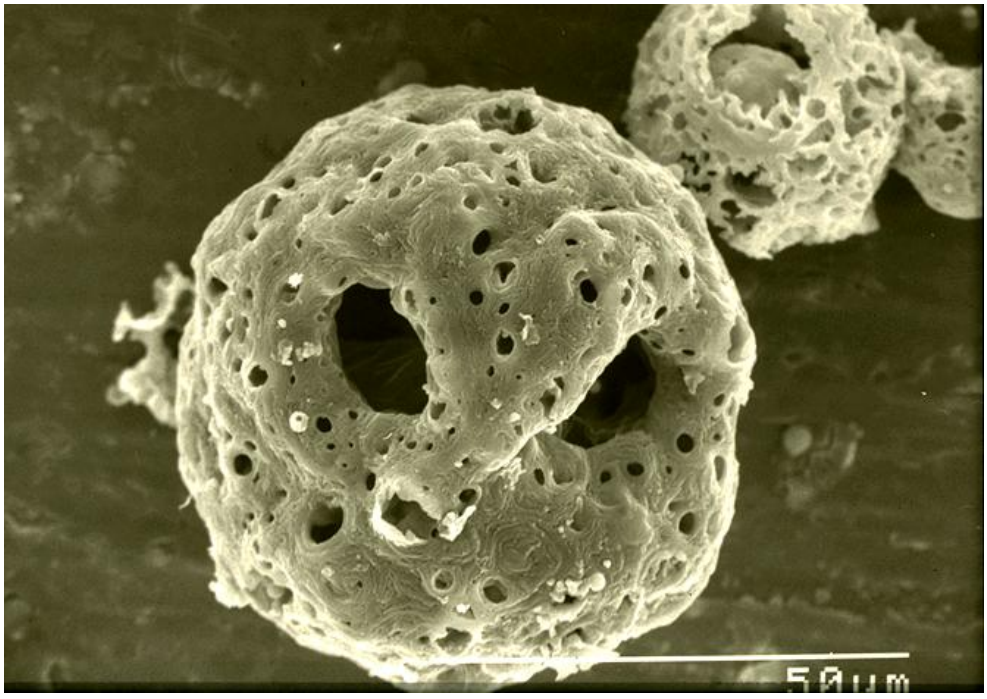

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Contents

Executive summary

- Five samples from each of 35 sediment cores were received for SCP analysis in order to determine an estimate for 1850 and if possible a rough sediment chronology for each core.

- Dates were ascribed using three SCP profile features for which dates had been attributed from previous studies: The start of the SCP record (1850 ± 25); the rapid increase in SCP concentration (1950 ± 10) and the SCP concentration peak (1980 ± 3).

- SCP profiles were seen to fall into three categories:

1. Incomplete, where SCPs were present in all samples. In these cases a depth for 1850 was extrapolated below the base of the core.
2. Complete, where the start of the SCP record, and hence 1850, lies within the length of the core. In these cases, depths for 1950 and 1980 were extrapolated assuming a reasonably constant sediment accumulation rate and assessed against available data.
3. Short or curtailed SCP profiles, where SCPs were only present in the upper one or two samples. These were assumed to be due to slow sediment accumulation rates and were found to be clustered in the mid-west and south-west.

   Approximately one third of cores were found in each category.

- Given the very small number and the coarse interval between samples any estimated chronology contains a lot of uncertainty. Further, to produce any chronology at all requires a number of assumptions. The main one of these is that sediment accumulation rate has not varied greatly over the last 150 years. Without this assumption, no chronologies can be attributed to the profiles, however, the lack of samples also means that it is not possible to determine whether this is a reasonable assumption or not. A number of external driving factors can influence sediment accumulation rate and it is therefore probable that this assumption is not valid in many cases.

- Further, it is possible that all SCP concentration profiles could be the result of sediment accumulation rate alterations. However, in general the main SCP features remain identifiable unless major sediment accumulation rate changes occur at key points in the profile. Such changes can usually be identified in a more detailed profile, but is not possible here.

- At one site, Nambrackkeagh, where radiometric data were available, estimated SCP chronologies appear to give good agreement with the preliminary ^{210}Pb dates.

- Estimated depths for 1850 and rough chronologies were produced for almost all sites. However, given the coarse nature of the samples it was not possible to say anything further about regional variability of the profiles. Independent dating of more detailed SCP profiles are required from across Ireland in order to calibrate the SCP chronology. This work would make the SCP dating technique more useful and reliable in future Irish studies.

- Spatial distributions of SCP surface sediment concentrations and inventories were found to agree well with data from the EU funded project 'FLAME' (1994 – 1996). Areas of low contamination were identified in central areas and the mid- and south-west. Areas of high contamination were identified in the north (possibly influenced by the power station at Coolkeragh, north of Derry), the east (from industry around Dublin) and around the Shannon Estuary (Moneypoint and Tarbert power stations).

Introduction

IN-SIGHT

The priority area Palaeolimnological Investigation for candidate reference lakes (2002-W-LS/7), established under Phase 3 of the ERTDI Programme 2000-2006, recognises the importance of palaeolimnological research to the effective implementation of the EU Water Framework Directive (WFD). Palaeolimnological techniques can help to establish baseline reference conditions in lakes, including those that have been heavily impacted by humans, and indicate the timing, rate and direction of changes to the ecological quality of aquatic ecosystems. The IN-SIGHT project (**I**dentification of refere**N**ce-**S**tatus for **I**rish lake typolo**G**ies using palaeolimnological met**H**ods and **T**echniques) builds upon recent and current monitoring programmes in Irish lakes, results from palaeolimnology techniques developed and applied in previous research, the varied experiences of the project personnel and ideas derived in co-operation with current work in Ireland, UK and further afield.

The project is comprised of three work packages that aim to a) identify candidate reference lakes; b) establish reference status across the spectrum of Irish lake typologies, including those for which no reference sites exist at present; c) contribute to the development of effective strategies for monitoring environmental changes in Irish lakes; and d) provide an indication of targets for restoration of water quality in anthropogenically-impacted lakes.

Spheroidal carbonaceous particles

In order to identify reference conditions for lakes selected for IN-SIGHT an estimate of sediment chronology is required so that analyses can be undertaken at appropriate sediment depths, equivalent to a date at which reference conditions were thought to prevail. There are a number of techniques available to provide such chronologies, and spheroidal carbonaceous particle (SCP) analysis was selected as the sediment concentration profiles of these contaminants can provide a rapid and reliable means of sediment dating (see below).

SCPs are produced only from the high temperature combustion of fossil-fuels and have no natural sources. Therefore, in lake sediments they provide an unambiguous record of industrially-derived, atmospherically deposited pollution. Apart from physical mixing, by bioturbation for example, little post-depositional alteration of the SCP record occurs and, once calibrated to an independent chronology, the resulting robust and replicable SCP concentration profile can be used to date sediment cores from across broad regions.

Sediment material from 35 selected lakes from the Republic of Ireland was received for SCP analysis. Five samples from within a single sediment core, taken at roughly equidistant levels from the sediment surface to the core base, were analysed with the aim of providing a broad estimate of sediment chronology for each core. The selected lakes were located mainly in the west of Ireland with a few sites in central and eastern areas. The names and locations of these sites are shown in Figure 1.

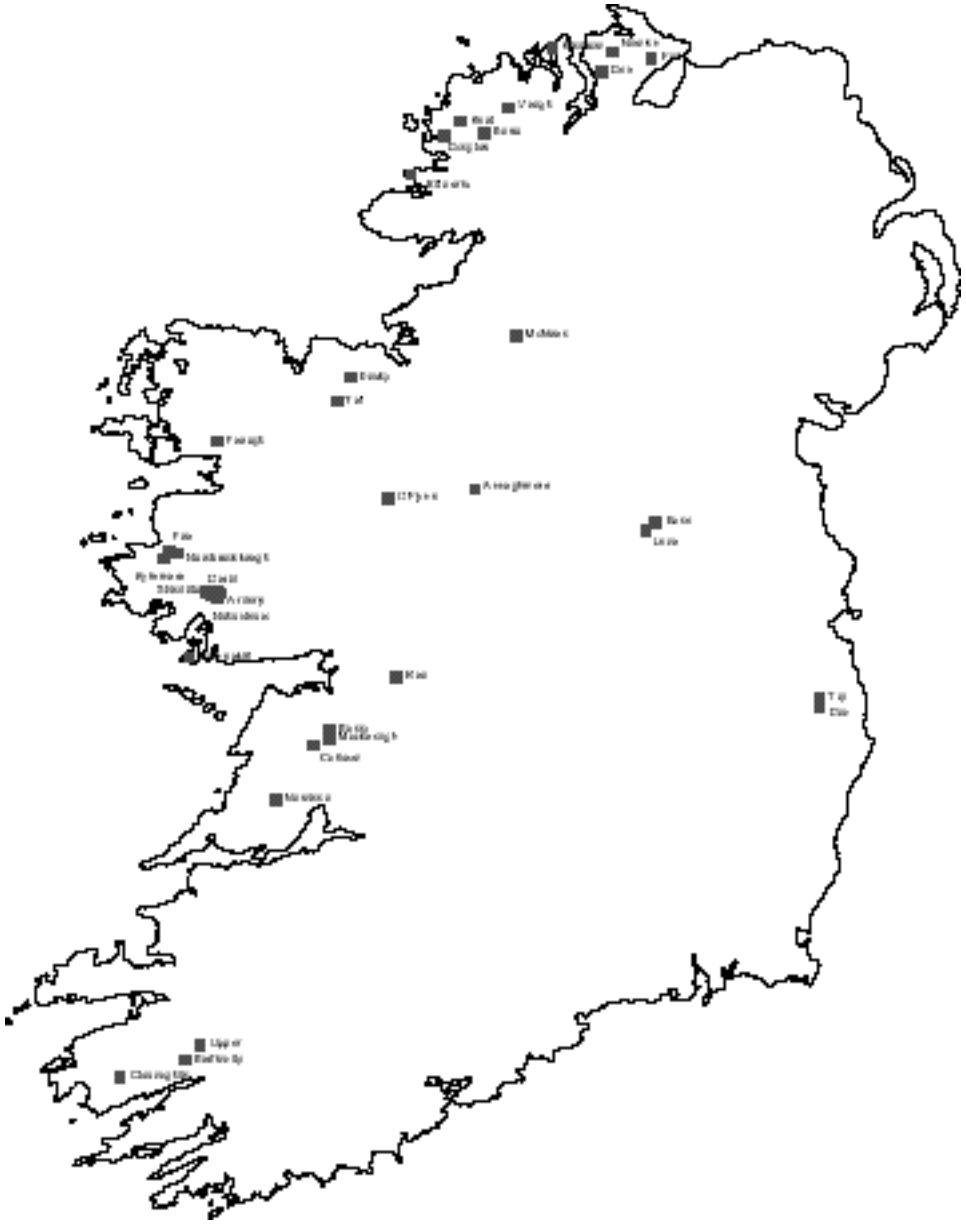


Figure 1. INSIGHT site location map.

Methods

Spheroidal carbonaceous particle analysis

SCPs are composed mainly of elemental carbon and therefore although physically fragile are chemically robust. Unwanted fractions of the sediment can therefore be removed by the use of strong mineral acids without affecting the particles. The procedure for extraction and enumeration of SCPs from the sediment samples followed Rose (1994). Sequential attack using HNO_3, HF and HCl removed organic, siliceous and carbonate fractions respectively resulting in a suspension of mainly carbonaceous material in water. A known fraction of this suspension was then evaporated onto a coverslip and the number of SCPs counted at 400 times magnification under a light microscope. Where no SCPs were found in a sample, slides were re-made and re-counted in order to confirm this result. Sediment concentrations are calculated in units of 'number of SCP per gram dry mass of sediment' or gDM^{-1}. Cumulative SCP inventories were also calculated for each core.

For each set of sediment digestions, a SCP reference sediment was also included. This SCP standard is currently under development (Rose, unpublished data) but allows an indication as to the comparability of the data resulting from each sediment digestion. Reference SCP concentrations for the INSIGHT sample digestions had a mean of 6395 gDM^{-1} compared to the SCP reference mean (currently N = 24; this work is still in progress, so this value will eventually change) of 6152 gDM^{-1} suggesting that the SCP concentration data from the INSIGHT sediment digestions are reliable.

Sediment dating

The identification of SCP dating horizons for Irish sediment cores, used in this study, is mainly based on Rose et al (1995). In this paper, good agreement was found for the main SCP dating features at all Irish sites for which ^{210}Pb-dated SCP profiles existed. These were as follows: the start of the SCP record: 1880s; the start of the rapid increase in SCP concentration: 1960s and the peak in SCP concentration, 1981 ± 2. However, these Irish cores were few and were limited to sites in Donegal. It is therefore uncertain how these dates relate to sediment cores further south.

More recently, further work has been undertaken in the north of Ireland (including Northern Ireland) where the dated SCP features were found to relate closely to a broad geographic area covering much of northern UK (Rose & Appleby, in prep). Here, the start of

the SCP record was found to be 1850 ± 25, whilst the SCP concentration peak was found to be 1980 ± 3. Hence, whilst there are differences between the two datasets, given the errors involved in the calibration chronologies, they do give broad, reasonable agreement. However, there is currently a lack of independently dated SCP profiles in southern Ireland with which to calibrate a SCP dating chronology.

SCP records for many sites across Europe (Rose et al., 1999) show the start of the record to be c. 1850, whilst the rapid increase is found to be c.1950 resulting from the post-Second World War boom in the electricity generation industry and the first widespread availability of cheap oil. Therefore, it may be that the later dates for the start of the SCP record in the Donegal sites (Rose et al., 1995) is due to the detection limit of the technique (these early studies employed an early variation on the SCP digestion; Rose, 1990) and given the transboundary pollutant transfer between the UK and Ireland (Bowman & Harlock, 1998; Rose & Harlock, 1998) it is likely that the start of the SCP record in Ireland is similar to that of the UK and much of Europe i.e 1850 ± 25.

The peak in SCP concentration, whilst being the most reliable and easily definable feature in a SCP profile, is also the most locally variable (Rose & Appleby, in prep) and this results from regional differences in industrial emissions, introduction of particle arrestor technology and flue-gas desulphurisation, and changes in fuel-types and industry. This feature has been seen to vary considerably across the UK (Rose & Appleby, in prep) from 1970 in southern England to 1990 in the north-east and it is therefore currently unknown uncertain how this varies across the Republic of Ireland. However, as the Donegal sites gave a date of 1981 ± 2 and the north of Ireland (including Northern Ireland) gives a date of 1980 ± 3, a date of 1980 is probably not unreasonable, especially given the coarseness of the sampling interval within this project.

The rapid increase in concentration is likely to be reasonably consistent as it relates to a Europe-wide phenomenon. Rose & Appleby (in prep) suggest that regionality of the SCP record within the UK converges at this point and it is likely, given the European dimension to this feature and its cause, that this is similar across Ireland.

Finally, Rose & Appleby (in prep) have found that the use of a cumulative SCP percentage profile allows more dates to be allocated to each core. However, such an approach is not applicable here due to the low numbers of samples from each core and the lack of calibration in most of the country. A future project to properly calibrate the SCP record across the whole of Ireland would therefore be a very useful exercise.

In summary, the following dates are employed in this report to allocate chronologies to the INSIGHT sediment cores:

The start of the SCP record:	1850 ± 25
The rapid increase in SCP concentration	1950 ± 10
The peak in SCP concentration	1980 ± 3

Results

Sediment chronologies based on coarse sampling intervals will have high levels of uncertainty. The main aim of this work was to provide an estimate for the date 1850 AD identifiable as the start of the SCP record. Therefore, identification of the presence or absence of SCPs in the lower samples was crucial and additional counts were made on samples where SCP concentrations were found to be 0 gDM^{-1}.

Given this primary aim, three main profile types were identified amongst the 35 sediment cores.

1. Those in which SCPs were found in all samples, including the basal sample. This suggests that the full core represents a post-1850 period, and any estimate of this date will be an extrapolation beyond the base of the core.
2. Profiles in which at least the bottom sample has 0 gDM^{-1}. This allows an estimate of 1850 to be made within the current core, with the obvious caveats relating to the sampling interval for that core.
3. Profiles for which SCPs only appear in the surface sample or in the two uppermost samples where the lower sample has low SCP concentration. Profiles of this sort imply one of three things. First, this is a very slow accumulation rate core and the entire profile is contained within the interval of the upper one or two samples. Second, the sediment record, or core, has been disturbed (e.g. by dredging) thereby removing some of the profile. Third, this is a clean area into which a recent, new source has been commissioned thereby taking the SCP record from below to above detection limit in recent times. If the second hypothesis is true then it is not possible to interpret the SCP profile. It is also difficult to do this in the third case, unless there is knowledge of the new source. However, the analytical detection limits within this project are good (where available sample weight allows) and therefore it is unlikely that recent sediments would be below detection limit anywhere in Ireland unless accumulation rate was very high. Therefore,

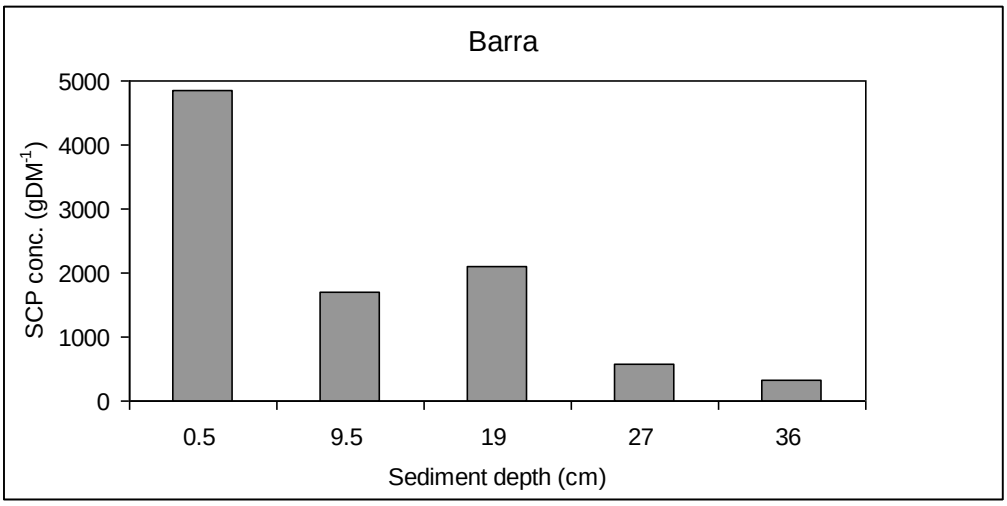
here it has been assumed that the record is intact and that these profiles are due to slow accumulation rates.

For a few samples, only a very small sediment weight was received. This increases the limit of detection, makes error margins large and in one instance suggests a concentration of 0 gDM^{-1}in the surface sample of a core where SCP concentrations are elevated below it. Such small sample weights therefore make interpretation more difficult. These instances are discussed in more detail with the relevant sites.

The results for each site are given below sub-divided into the three profile categories. Summary figures are presented for each site whilst full data are provided in an Appendix. At a few sites (Veagh, Naminna) previous data are available and these are used to provide additional interpretation. At two other sites (Tay, Nambrackkeagh) preliminary dates from INSIGHT itself were available and these are also used. It may be that more recent dating is now available for these or other sites but if so, these have not been made available at the time of writing this report.

Section 1: Incomplete SCP profiles.

Barra: (B 935 120)



SCPs are present in all samples from Barra suggesting that the entire core represents a post-1850 period. The maximum observed SCP concentration of almost 5000 gDM^{-1} is in the surface sample and the peak concentration therefore probably lies somewhere between 0.25 and 9.5 cm. However, unless there has been a great change in sediment accumulation rate over the course of the period covered by the core it is unlikely that the SCP concentration peak is in this surface sample.

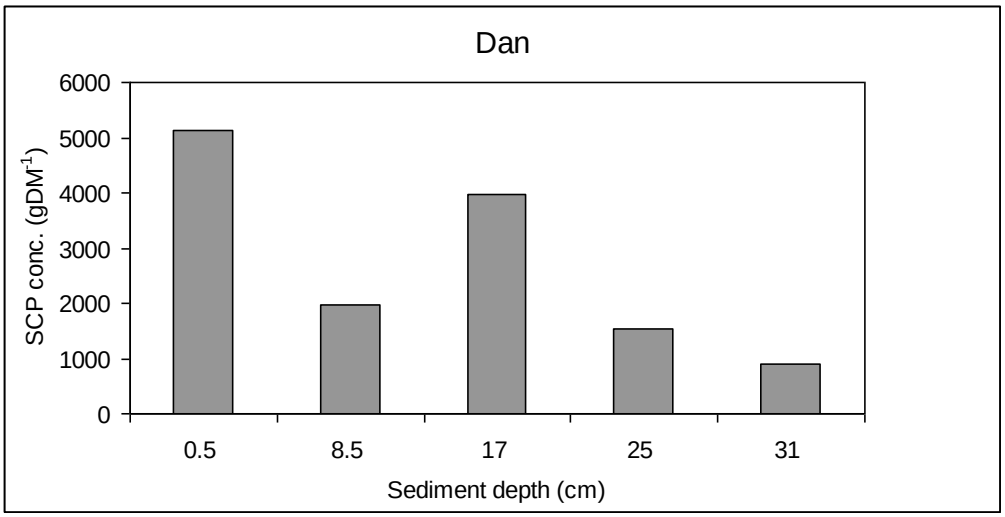
Assuming a reasonably constant accumulation rate then if the peak concentration falls between 5.5 cm and 9.5cm then this would be sufficient for the start of the SCP record (and hence 1850) to fall below the base of the core. Given the concentration at 36cm is still easily detectable, it is likely that the peak lies somewhere near the mid-point of this range. This being the case, then 1950 would lie between 17 and 22 cm and 1850 would fall between 50 and 63 cm.

Therefore, best estimate chronology: 1980: 7.5 – 9.5 cm

1950: 17 – 22 cm

1850: 50 – 63 cm

Dan: O 150 040



SCPs are present in all samples from Dan suggesting that the entire core represents a post-1850 period. The profile is also similar to that of Barra. The maximum observed SCP concentration of just over 5000 gDM^{-1} is in the surface sample and the peak concentration therefore probably lies somewhere between 0.25 and 8.5 cm. However, unless there has been a great change in sediment accumulation rate over the course of the period covered by the core it is unlikely that the SCP concentration peak is in this surface sample.

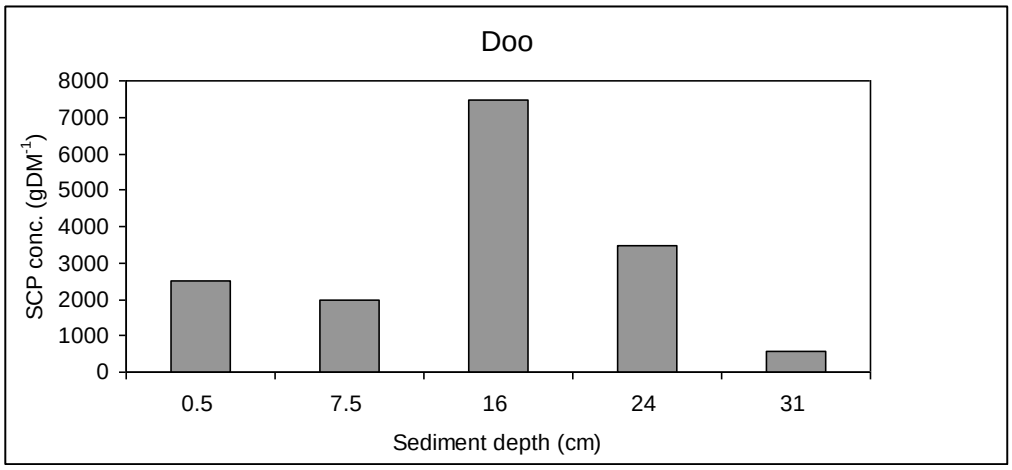
Assuming a reasonably constant accumulation rate then if the peak concentration falls between 5 cm and 8.5cm then this would be sufficient for the start of the SCP record (and hence 1850) to fall below the base of the core. Given the concentration at 31cm is still easily detectable, it is likely that the peak lies somewhere near the mid-point of this range. This being the case, then 1950 would lie between 17 and 22 cm and 1850 would fall between 50 and 63 cm.

Therefore, best estimate chronology: 1980: 6.5 – 8.5 cm

1950: 15 – 20 cm

1850: 43 – 57 cm

Doo: C 359 394



SCPs are present in all samples from Doo suggesting that the entire core represents a post-1850 period. The maximum observed SCP concentration of almost 7500 gDM^{-1} is in the 15 – 16cm sample and the peak concentration therefore probably lies somewhere between 8 and 23 cm. If the peak were to lie towards the bottom of this range this would imply a sediment accumulation rate of almost 1 cm yr^{-1} and this seems high given the SCP concentrations present throughout the core.

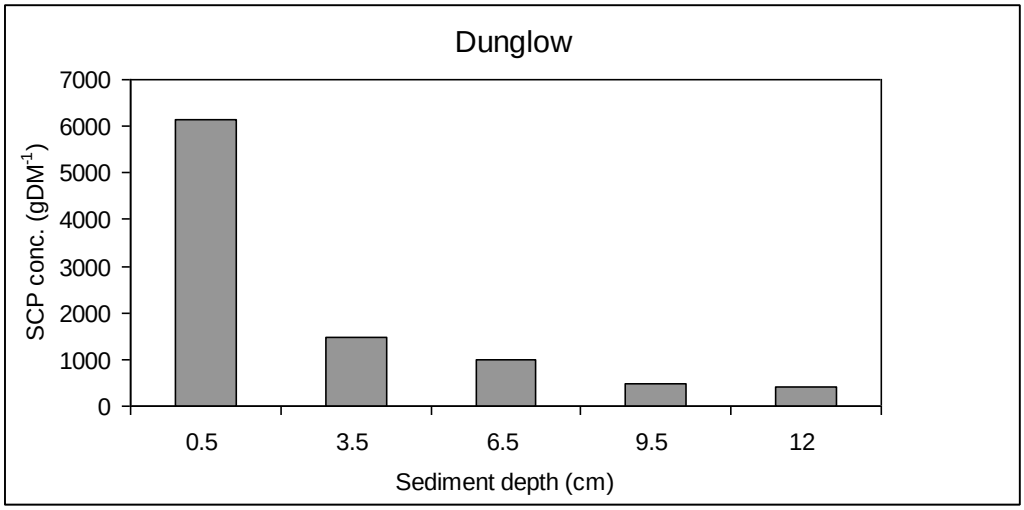
If the trend observed in the lower samples is real then it maybe the rapid increase in concentration lies between 25 and 30 cm suggesting an accumulation rate of c. 0.5 cm yr^{-1}. Assuming a reasonably constant accumulation rate this would place the SCP concentration peak between 10.5 cm and 13 cm and the start of the SCP record (and hence 1850) somewhere between 72 and 86cm. This certainly fits the observed data, but remains rather speculative.

Therefore, best estimate chronology: 1980: 10.5 – 13cm
1950: 25 – 30 cm
1850: 72 – 86 cm

Further note:

This site is located reasonably close to Barra but the (incomplete) SCP inventory is almost three times higher and, despite being incomplete, is one of the highest inventories in the INSIGHT dataset. It is difficult to explain these data unless Doo lies downwind of a local source and Barra, upwind.

Dunglow: B 782 117



SCPs are present in all samples from Dunglow suggesting that the entire core represents a post-1850 period. However, this is a short core and so perhaps this is not surprising. The maximum observed SCP concentration of just over 6000 gDM^{-1} is in the surface sample and the peak concentration therefore probably lies somewhere between 0 and 3 cm. However, unless there has been a great change in sediment accumulation rate over the period covered by the core it is unlikely that the SCP concentration peak is in this surface sample.

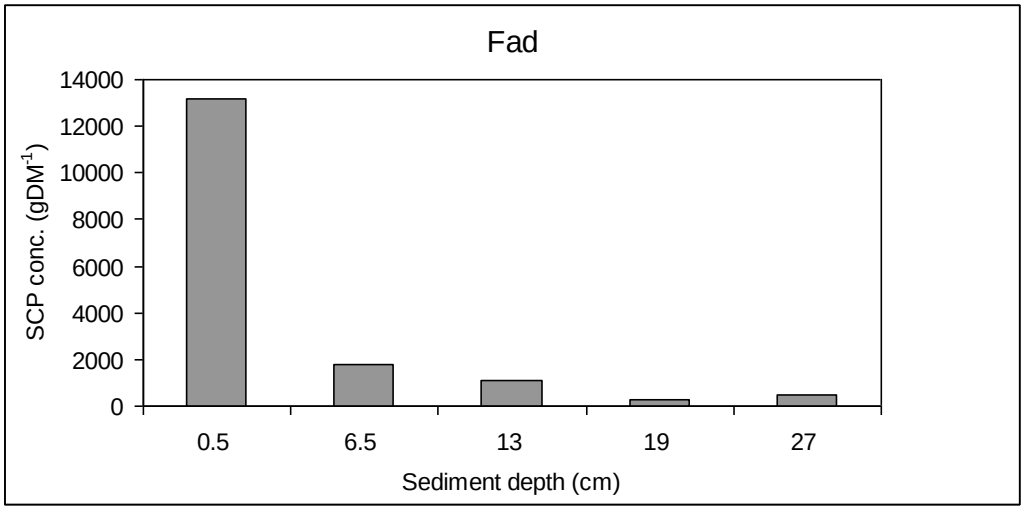
Assuming a reasonably constant sediment accumulation rate then the dating must be reasonably constrained in order to fit the observed data. If the SCP peak is above 1.5cm then the start of the record should be observed. If the peak is below 2.5 cm then the start of the rapid increase (1950) would be between 6.5 and 9.5cm which would seem unlikely. If the peak is at 2cm, then the rapid increase would start at c. 4.5 cm and the SCP record would start at c. 13 - 14 cm, just below the base of the core, which from the data seems reasonable. It should be stressed that all this speculation is reliant on a constant sediment accumulation rate. The data could also be explained by a period of elevated accumulation rate at some earlier point in the lake's history, in which case 1850 could be lower than 13 – 14cm. If recent accumulation rate had increased then this would shift the SCP concentration peak to a lower depth, but it cannot move too far in this direction as the 3 – 3.5cm concentration is considerably lower than the surface concentration.

Therefore, best estimate chronology: 1980: 1.5 – 2.5 cm

1950: 4 – 6 cm

1850: c. 13 – 15 cm

Fad Inishowen East: C 439 439



SCPs are present in all samples from Fad suggesting that the entire core represents a post-1850 period. The maximum observed SCP concentration of over 13000 gDM^{-1} is in the surface sample and the peak concentration therefore lies somewhere between 0.25 and 6 cm. If there has been a reasonably constant sediment accumulation rate then the concentration peak needs to be below 4 cm in order that 1850 lie below 27cm. However, the shape of the profile would suggest that the rapid increase should also fall above the 6 – 7cm sample. If this is the case then for SCPs still to be present at 27cm then there must have been a period of elevated sediment accumulation rate at some earlier point in the lake's history.

It would seem that the lowest sediment depth at which the start of the rapid increase (1950) could lie would be 6 – 7cm. If this is the case then the SCP peak would be at 2.5 – 3cm but 1850 would be at c. 19cm unless a period of elevated accumulation rate had occurred prior to 1950. Assuming sediment accumulation rate variations at this site does not preclude the identification of any of the key SCP dating features, then the best estimate chronology is:

1980: 2 – 4 cm

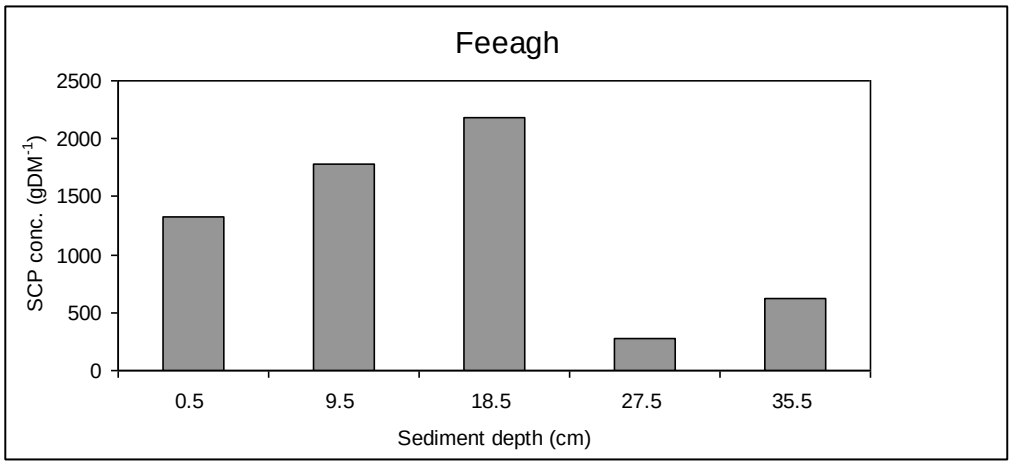
1950: 6 – 7 cm

1850: > 27 cm

Further note:

This site is located reasonably close to Doo, has a high surface concentration and a reasonably high (incomplete) SCP inventory. It would therefore seem likely that the site is impacted by the same source as Doo.

Feeagh: F 965 000



SCPs are present in all samples from Feeagh suggesting that the entire core represents a post-1850 period. The maximum observed SCP concentration of almost 3000 gDM^{-1} is in the 18 – 19 cm sample and the peak concentration therefore probably lies somewhere between 10 and 27 cm.

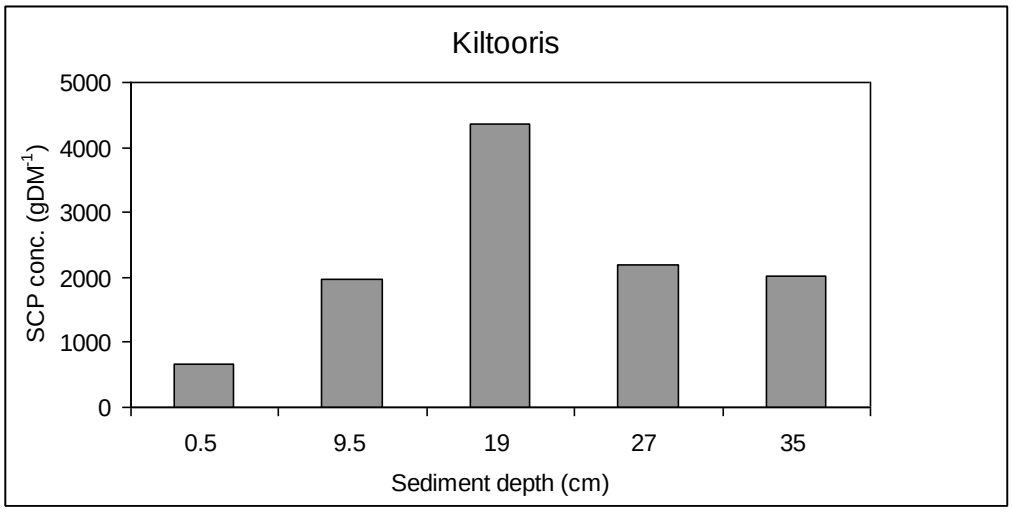
Assuming a reasonably constant accumulation rate then any depth below 4.5 cm for the SCP concentration peak is sufficient for the start of the record to fall below 37 cm. If the trend observed in the lower samples is real then it maybe that the rapid increase in SCP concentration lies between 19 and 27 cm. If this is the case, then for the SCP concentration peak to fall below 10 cm then the rapid increase should lie below 23 cm. Further, an accumulation rate sufficient to put the rapid increase at the bottom of its possible depth range would place the SCP concentration peak at around 12 cm. A peak between 10 and 12 cm and a rapid increase between 23 and 17cm would 1850 and hence the start of the record in the range 66 – 76cm. This certainly fits the observed data, but remains rather speculative.

Therefore, best estimate chronology: 1980: 10 – 12cm

1950: 23 – 27 cm

1850: 66 – 76 cm

Kiltooris: G 676 972

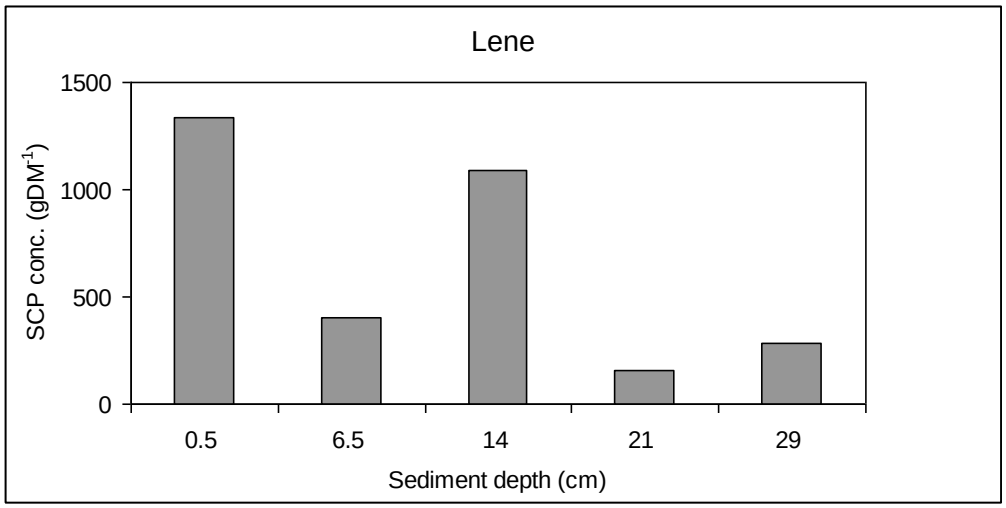


SCPs are present in all samples from Kiltooris suggesting that the entire core represents a post-1850 period. The maximum observed SCP concentration of over 4000 gDM^{-1} is in the 18 – 19 cm sample and the peak concentration therefore probably lies somewhere between 10 and 26 cm. Assuming a reasonably constant accumulation rate then any depth below 4.5 cm for the SCP concentration peak is sufficient for the start of the record to fall below 35 cm. Unlike Feeagh, the data does not allow an estimate of possible 1950 dates. However, assuming a reasonably constant rate of sediment accumulation, the depth range for the SCP concentration peak provides ranges for the rapid increase (1950) of 23 – 53cm and for the start of the record (1850) of 66 – 150cm.

Given the shape of the profile from the available data and assuming that sediment accumulation rate variations at this site are not obscuring the identification of any of the key SCP dating features then it would seem more probable that these features fall in the upper half of these ranges.

Therefore, best estimate chronology: 1980: 10 – 19 cm (possibly 10 – 26cm)
1950: 23 – 40 cm (possibly 23 – 53cm)
1850: 66 – 110 cm (possibly 66 – 150cm)

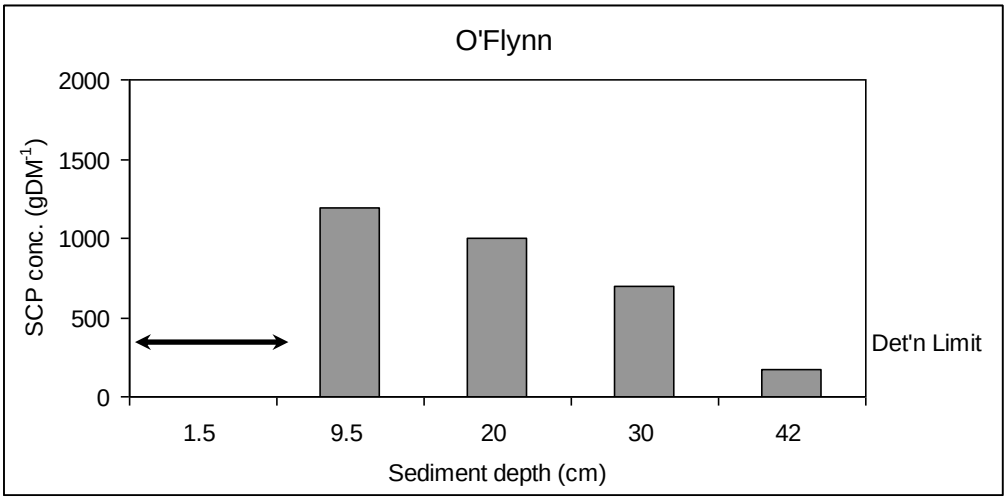
Lene: N 510 685



SCPs are present in all samples from Lene suggesting that the entire core represents a post-1850 period. The maximum observed SCP concentration of just less than 1500 gDM^{-1} is in the surface sample, but the 13 – 14cm sample shows similar concentrations and given the low resolution of sampling interval it is not possible to determine where the true SCP concentration peak might lie. Indeed, assuming a reasonably constant sediment accumulation rate then for SCPs to be present below 29cm then the SCP concentration peak should lie below 4.5 cm. Given the concentration at 6.5 cm it would seem more likely that the peak would therefore lie between 7 and 20cm.

If the rapid increase lies between 14 and 21 cm as seems possible, then this accumulation rate would place the peak at 6 – 9.5 cm and the start of the record at 40 – 62cm. Again, given the concentration at 6.5 cm it would seem more likely that these features lie in the bottom half of these ranges. These dates certainly fit the observed data, but remain very speculative. The observed data would also be explained by a rapid, variable accumulation rate or a disturbed sediment record. In fact, the only definite conclusion is that 1850 lies below 29cm.

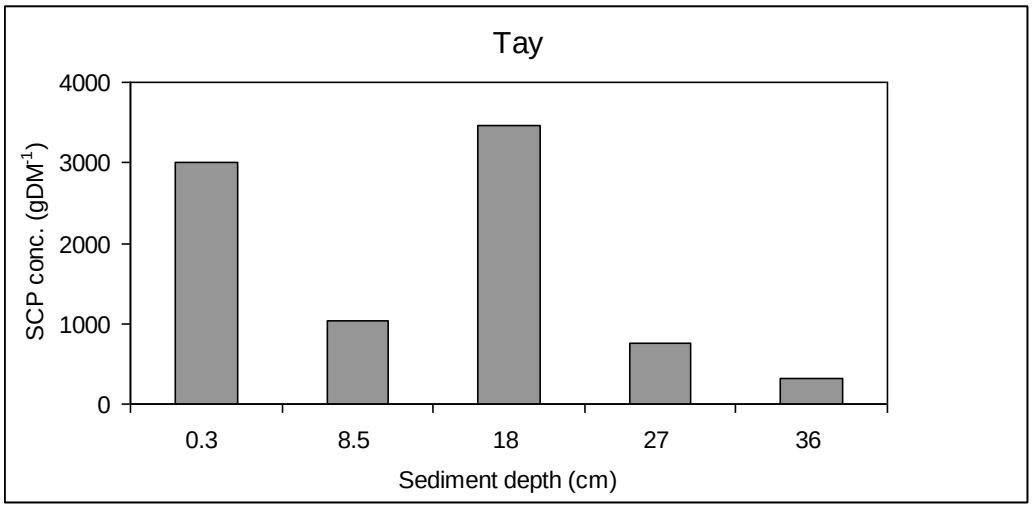
O'Flynn: M 585 795



No surface sample was received for this core and the 1 – 1.5cm sample was very small (< 0.03g). No SCPs were detected in this sample and the low sample weight raised the detection limit considerably. However, this detection limit is still much lower than the concentration in the 9 – 10cm sample suggesting that the SCP concentration peak lies between 1.5 and 19 cm.

Assuming a reasonably constant sediment accumulation rate then for SCPs to be present at 42 cm then the peak must be below 6 cm. Similarly, if the rapid increase lies between 30 and 41 cm as seems possible, then the peak would lie in the range 13 – 17 cm and the start of the record would lie between 85 and 120 cm. However, as with Kiltooris, the only definite conclusion is that 1850 lies below 42 cm.

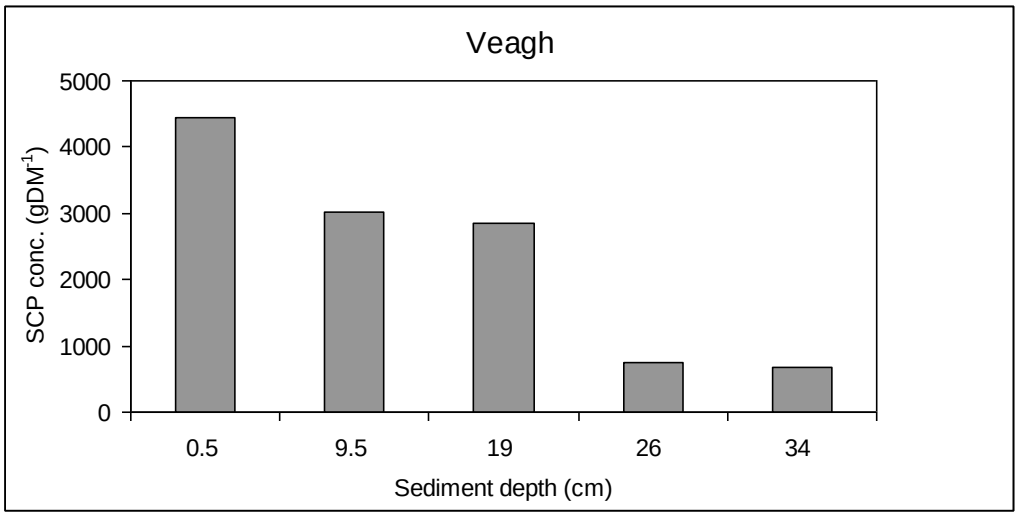
Tay: O 160 750



SCPs are present in all samples from Tay suggesting that the entire core represents a post-1850 period. The maximum observed SCP concentration of almost 3500 gDM^{-1} is in the 17 – 18 cm sample and the peak concentration therefore probably lies somewhere between 9 and 26 cm. Although, the surface concentration is similar, assuming a reasonably constant accumulation rate then a depth of below 5.5 cm for the SCP concentration peak is required for the start of the record to fall below 36 cm. If the rapid increase lies between 18 and 26 cm as seems possible, then the peak would lie in the range 8 – 12 cm and the start of the record would lie between 50 and 75 cm. Given the SCP concentration at 8 – 9 cm it seems likely that these features lie in the lower half of these ranges.

However, data from radiometric dating (David Taylor's e-mail of 4 Dec 2003) suggests that the upper 15cm is disturbed possibly as a result of in-washes from the catchment or disturbance during coring. If this is the case then the SCP profile is impossible to interpret except that 1850 lies somewhere below 36cm.

Veagh: C 022 215



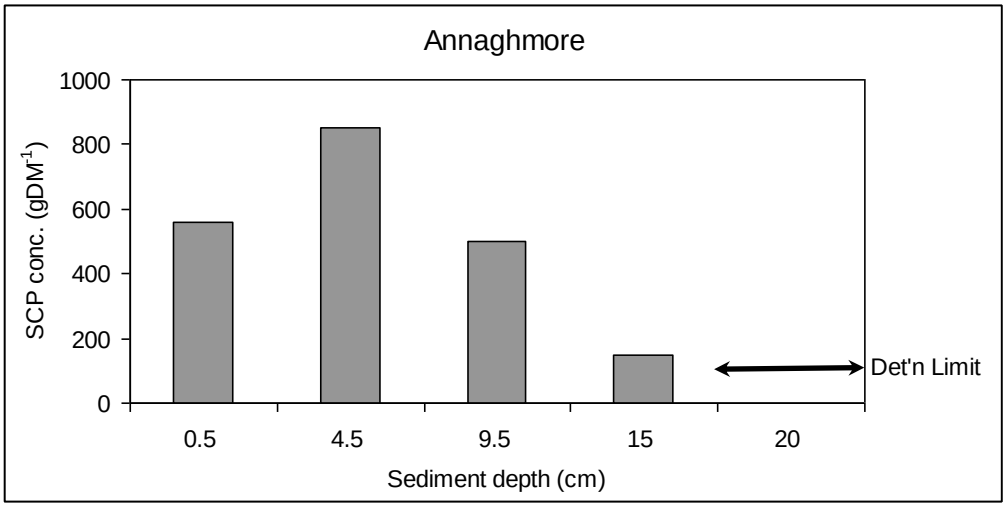
SCPs are present in all samples from Veagh suggesting that the entire core represents a post-1850 period. The maximum observed SCP concentration of almost 4500 gDM^{-1} is in the surface sample and the peak concentration therefore probably lies somewhere between 0.5 and 9 cm. However, unless there has been a great change in sediment accumulation rate over the course of the period covered by the core it is unlikely that the SCP concentration peak is in this surface sample. Indeed, assuming a reasonably constant accumulation rate then a depth of below 5.5 cm for the SCP concentration peak is required for the start of the record to fall below 34 cm. A core taken from Veagh in 1988 and ^{210}Pb-dated (Rose et al., 1995) showed a constant sediment accumulation rate of 0.145 cm yr^{-1} throughout, but the accumulation rate of the current core is considerably faster than this as 1850 would otherwise be at 22-23 cm.

If sediment accumulation rate in the current core is also constant, although faster, then if the SCP peak is between 5.5 and 9 cm, then the rapid increase would lie at 12.5 – 20cm and the start of the record at 37 – 60cm. The shape of the current profile would suggest that the rapid increase lies below 19cm and therefore the lower ends of these ranges seems more likely. This suggests an accumulation rate 2.5 – 3 times faster than the 1988 core, as long as a constant rate is assumed, whilst for SCPs to be present at 34 cm the rate must be at least twice as fast. Interestingly, the peak concentration in the 1988 core is 2.6 times higher than that observed here.

Therefore, best estimate chronology: 1980: *c*. 9cm
1950: *c*. 20cm
1850: *c*. 60cm

Section 2: Complete SCP profiles.

Annaghmore: M 900 837

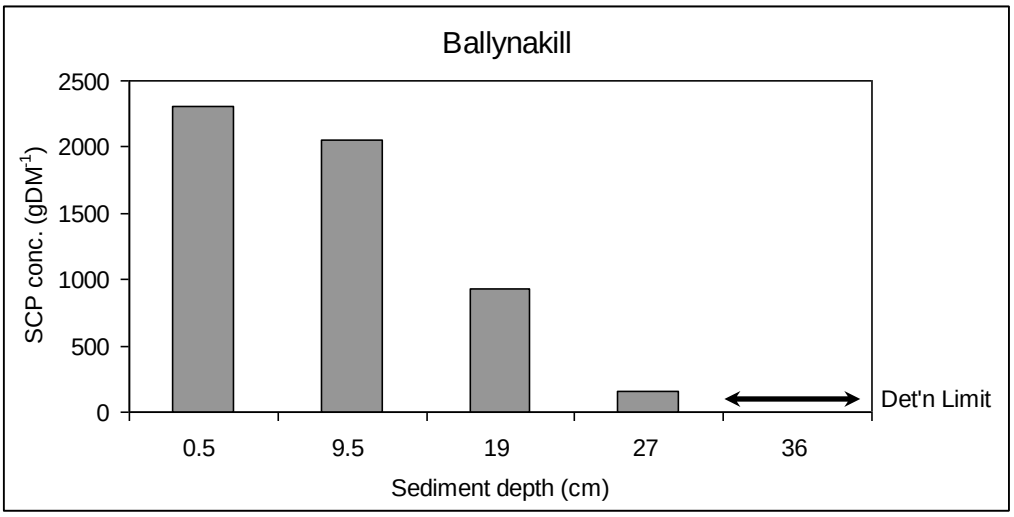


No SCPs are recorded in the 19 – 20 cm sample of Annaghmore suggesting that 1850 lies between 15 and 19 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 2 – 3cm for 1980 (the SCP concentration peak), and 5 – 7cm for 1950 (the start of the rapid increase in SCP concentration). The available data do not contradict these possibilities.

Therefore best estimate chronology: 1980: 2 – 3cm
1950: 5 – 7cm
1850; 17 – 19cm

Ballynakill: L 856 225



No SCPs are recorded in the 35 – 36 cm sample of Ballynakill suggesting that 1850 lies between 27 and 35 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

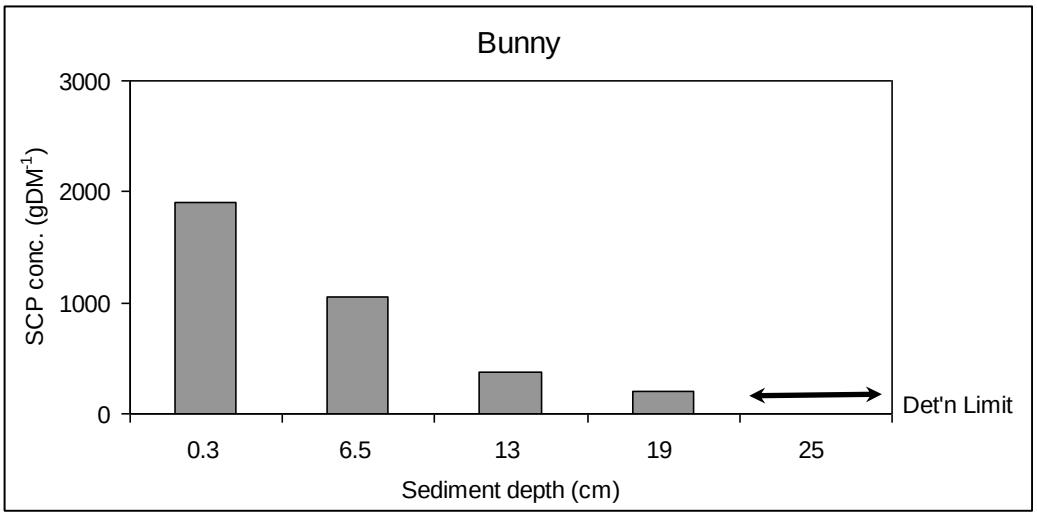
Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 4 – 5.5 cm for 1980 (the SCP concentration peak), and 9 – 13 cm for 1950 (the start of the rapid increase in SCP concentration). However, the available data would suggest that the rapid increase is likely to be below 10 cm.

Therefore best estimate chronology: 1980: 4 – 5.5 cm

1950: 10 – 13 cm

1850; 29 – 35 cm

Bunny: R 375 967

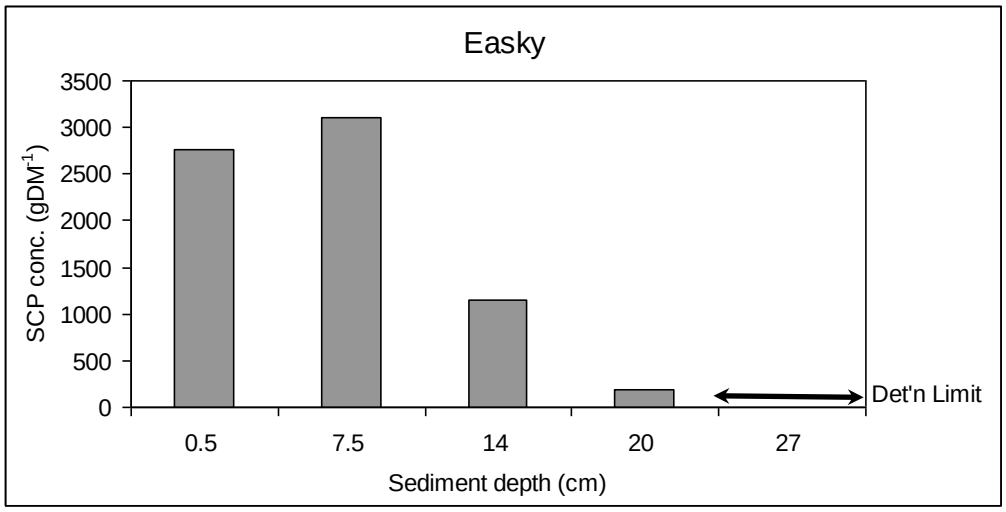


No SCPs are recorded in the 24 – 25 cm sample at Bunny suggesting that 1850 lies between 19 and 24 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 2.5 – 4 cm for 1980 (the SCP concentration peak), and 6 – 8.5 cm for 1950 (the start of the rapid increase in SCP concentration). However, the available data would suggest that the rapid increase is likely to be below 7 cm and hence the other ranges shifting down slightly.

Therefore best estimate chronology: 1980: 3 – 4 cm
1950: 7 – 8.5 cm
1850: 21 – 24 cm

Easky: G 442 225

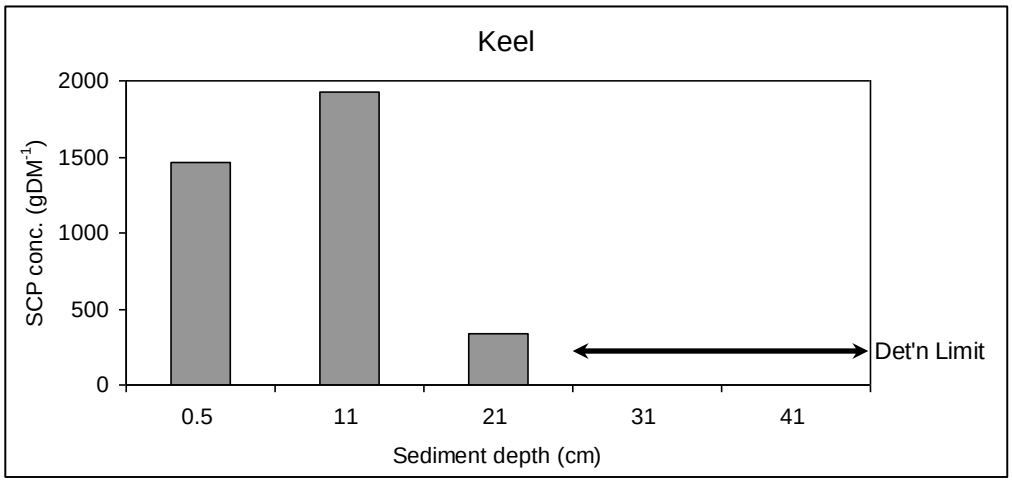


No SCPs are recorded in the 26 – 27 cm sample at Easky suggesting that 1850 lies between 20 and 26 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 3 – 4 cm for 1980 (the SCP concentration peak), and 7 – 9 cm for 1950 (the start of the rapid increase in SCP concentration). However, the available data would suggest that the rapid increase is likely to be below 8 cm and hence the other ranges shift down slightly.

Therefore best estimate chronology: 1980: 3 – 4 cm
1950: 8 – 9 cm
1850: 23 – 27 cm

Keel: B 847 162



No SCPs are recorded in the 30 – 31 cm or 40 – 41 cm samples at Keel suggesting that 1850 lies between 22 and 30 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 3 – 4.5 cm for 1980 (the SCP concentration peak), and 7 – 11 cm for 1950 (the start of the rapid increase in SCP concentration). However, the available data would suggest that the rapid increase is likely to be below 11 cm and in which case there may have been changes in sediment accumulation rate in this core.

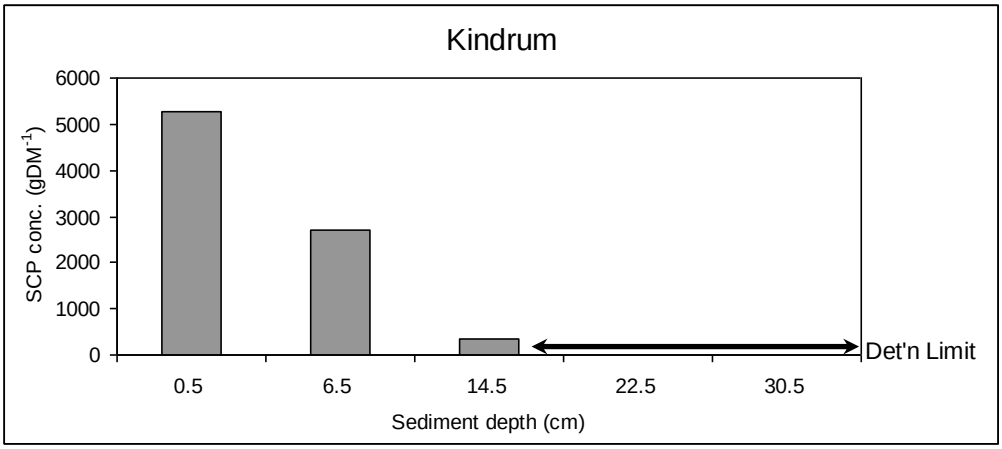
Therefore, without any further available information, the best estimate chronology is as follows:

1980: 3 – 4.5 cm

1950: 11– 15 cm

1850: 28 – 30 cm

Kindrum: C 185 430

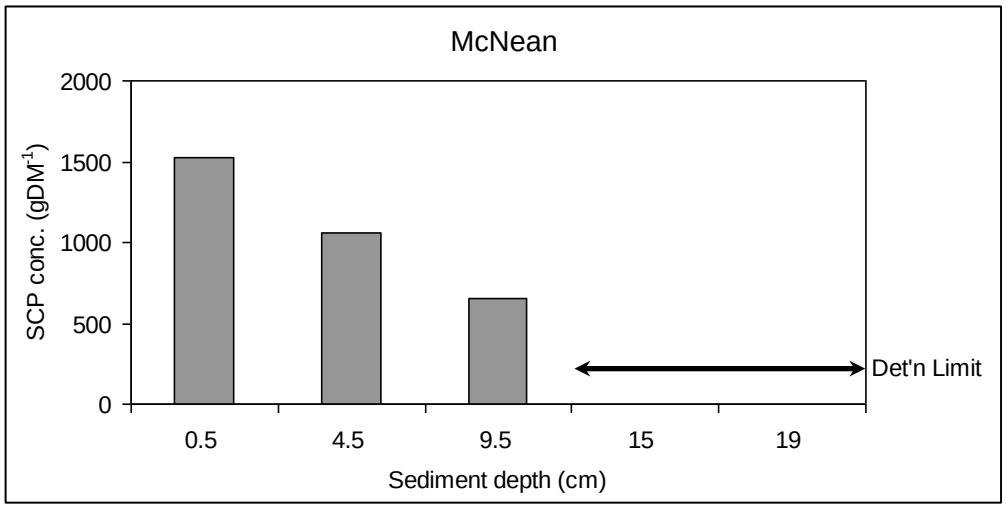


No SCPs are recorded in the 22 – 23 cm or 30 – 31 cm samples at Kindrum suggesting that 1850 lies between 15 and 22 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 2 – 3.5 cm for 1980 (the SCP concentration peak), and 5 – 8 cm for 1950 (the start of the rapid increase in SCP concentration). However, the available data would suggest that the rapid increase is likely to be below 7 cm and hence the other ranges shift down.

Therefore best estimate chronology: 1980: 3 – 4 cm
1950: 7 – 8 cm
1850: 20 – 22 cm

McNean: H 040 400



No SCPs are recorded in the 22 – 23 cm sample at McNean suggesting that 1850 lies between 10 and 14 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

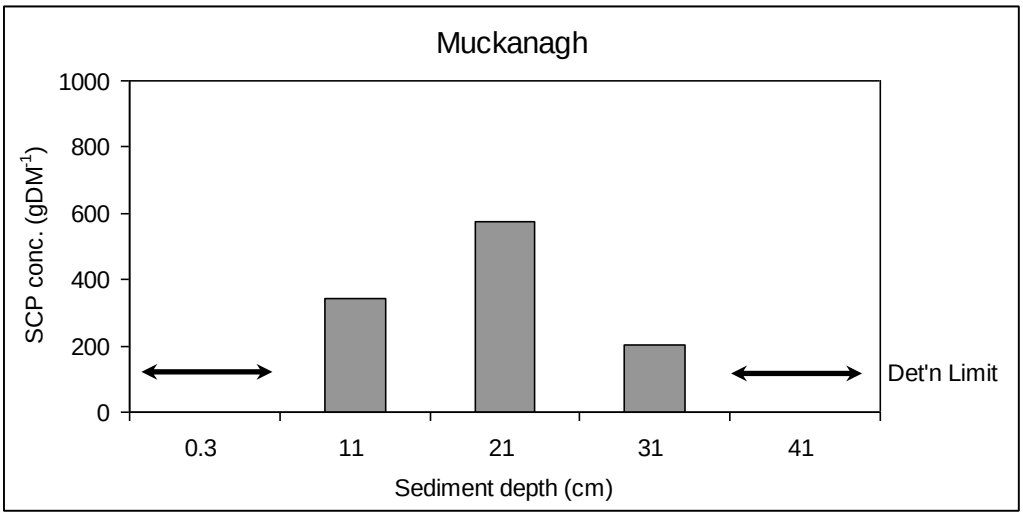
Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 1.5 – 2.5 cm for 1980 (the SCP concentration peak), and 3.5 – 5 cm for 1950 (the start of the rapid increase in SCP concentration) and the available data do not contradict these possibilities.

Therefore best estimate chronology: 1980: 1.5 – 2.5 cm

1950: 3.5 – 5 cm

1850: 12 – 14 cm

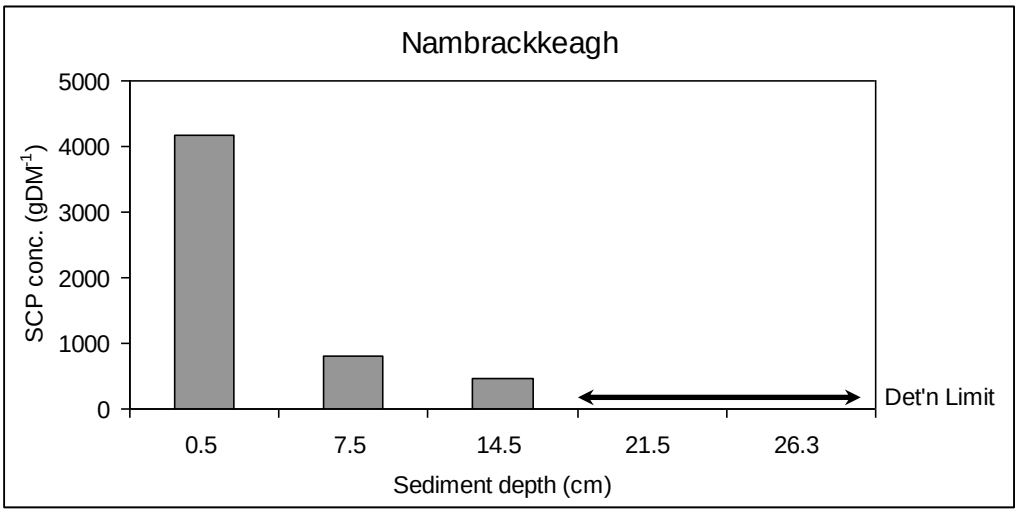
Muckanagh: R 370 925



No SCPs were recorded in the uppermost sample resulting in a concentration below the limit of detection of 150 gDM^{-1}. Further, no SCPs were recorded in the 40 – 41 cm sample at Muckanagh suggesting that 1850 lies between 31 and 40 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 4.5 – 6 cm for 1980 (the SCP concentration peak), and 10.5 – 14 cm for 1950 (the start of the rapid increase in SCP concentration). However, all SCP concentrations are very low and the concentration peak could lie anywhere between 0.5 and 30 cm. However, the low concentrations suggest a rapid sediment accumulation rate and therefore, despite a good detection limit, the start of the record may lie below 40 cm. With, effectively, only three data-points to work from and all with very low SCP concentrations, it is not possible to interpret this profile further.

Nambrackkeagh: L 821 603



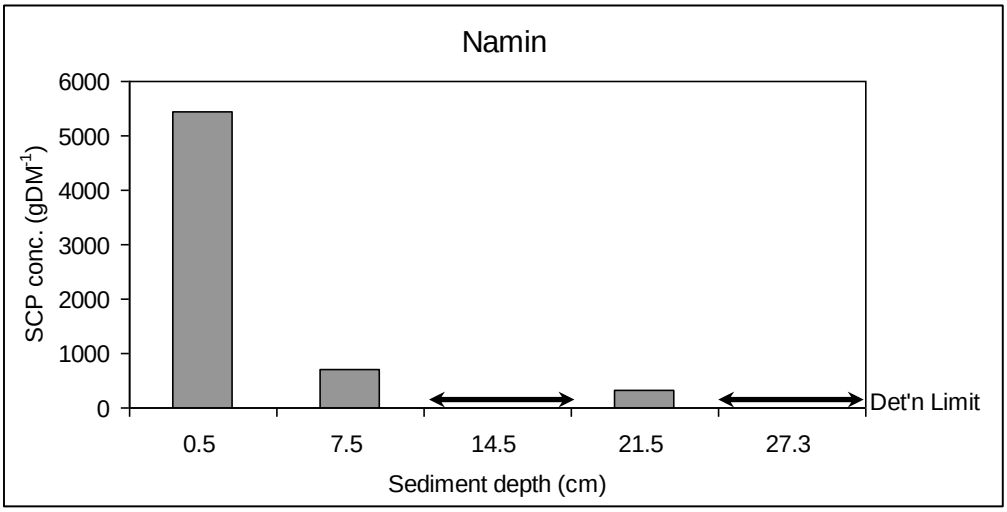
No SCPs are recorded in the 21 – 22 cm sample at Nambrackkeagh suggesting that 1850 lies between 15 and 21 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 2 – 3.5 cm for 1980 (the SCP concentration peak), and 5 – 7.5 cm for 1950 (the start of the rapid increase in SCP concentration). The available data would suggest that the rapid increase is likely to be above 7 cm and hence the other ranges shift up slightly.

Therefore best estimate SCP chronology: 1980: 2.5 – 3.5 cm
1950: 6 – 7 cm
1850: 17 – 21 cm

This is in reasonable agreement with preliminary data from radiometric dating (David Taylor's e-mail of 4 Dec 2003) which suggests an accumulation rate of 0.11 cm yr^{-1}. This rate would give 1850 at c. 17cm; 1950 at c. 6cm and 1980 at 2.5 cm.

Namin: C 396 419



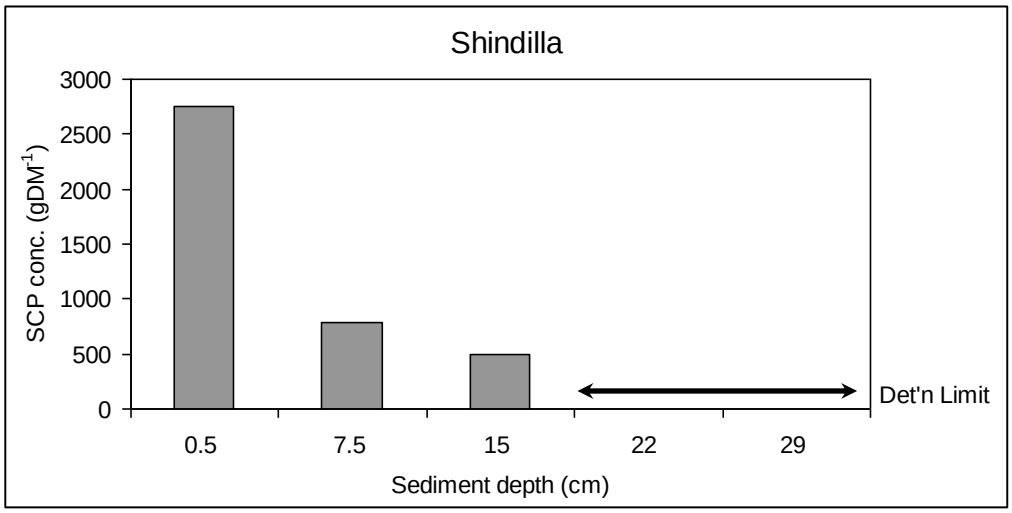
No SCPs are recorded in either the 14 – 15 cm sample or the 27 – 27.5 cm sample at Namin. Assuming no core smearing has occurred, the SCP concentration in the 14 – 15 cm sample is very low (< 138 gDM^{-1}) and the SCP record probably starts between 22 and 27 cm. If core smearing has occurred then the SCP record probably begins between 8 and 14 cm.

However, although the profile shape in the upper levels suggests a slow sediment accumulation rate, Namin is located close to other sites (e.g. Doo, Fad) that show relatively high levels of contamination and high SCP concentrations. Therefore, here it is assumed that the concentrations are real and the profile is correct, i.e. that no smearing has occurred.

This being the case, 1850 lies between 22 and 27 cm. Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 3 – 4.5 cm for 1980 (the SCP concentration peak), and 7.5 – 10 cm for 1950 (the start of the rapid increase in SCP concentration). The available data would suggest that the rapid increase is not likely to be below 7 cm and hence the other ranges must shift upwards, or otherwise there must have been changes in sediment accumulation rate.

Therefore best estimate SCP chronology: 1980: 2.5 – 3.5 cm
1950: 6 – 7 cm
1850: 22 – 24 cm

Shindilla: L 960 460



No SCPs are recorded in the 21 – 22 cm sample at Shindilla suggesting that 1850 lies between 15 and 21 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

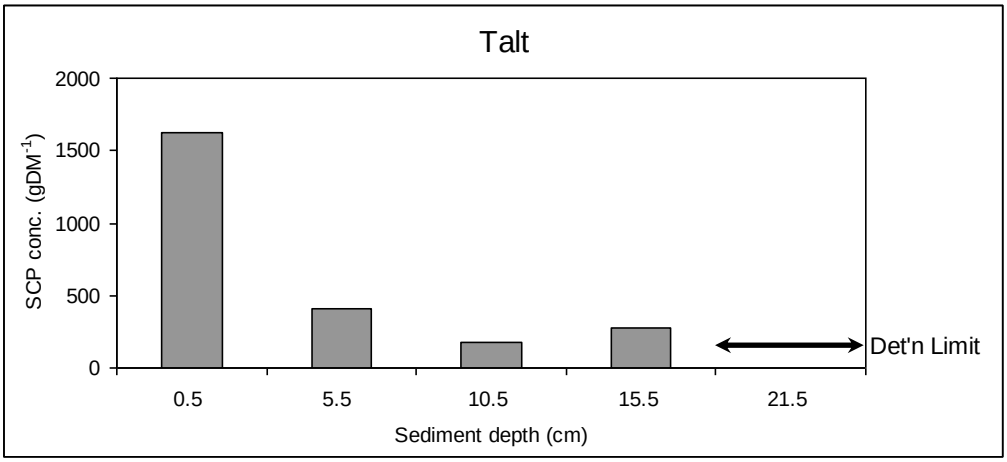
Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 2 – 3.5 cm for 1980 (the SCP concentration peak), and 5 – 7.5 cm for 1950 (the start of the rapid increase in SCP concentration). The available data would suggest that the rapid increase is likely to be above 7 cm and hence the other ranges shift up slightly.

Therefore best estimate SCP chronology: 1980: 2.5 – 3.5 cm

1950: 6 – 7 cm

1850: 18 – 21 cm

Talt: G 398 150



No SCPs are recorded in the 21 – 22 cm sample at Talt suggesting that 1850 lies between 16 and 21 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

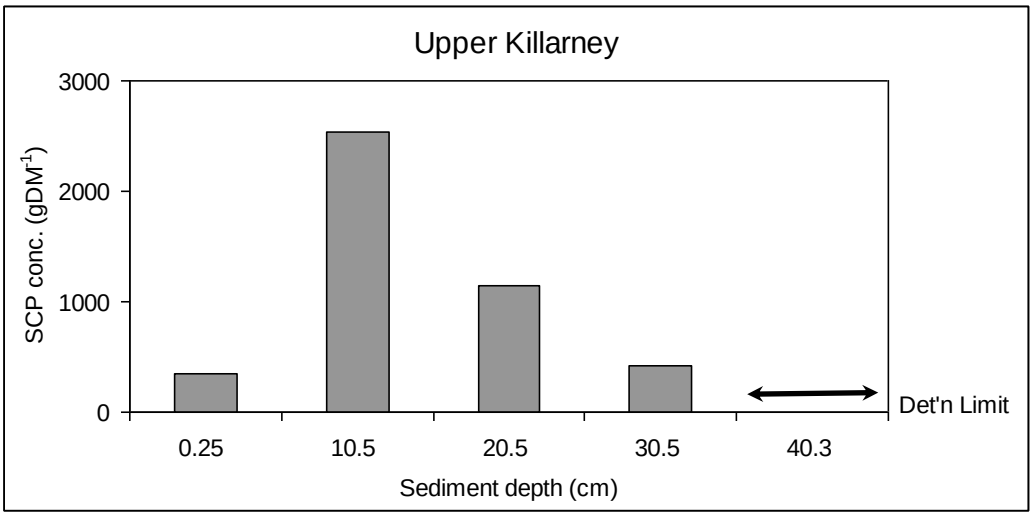
Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 2 – 3.5 cm for 1980 (the SCP concentration peak), and 5.5 – 7.5 cm for 1950 (the start of the rapid increase in SCP concentration). The available data would suggest that the rapid increase is unlikely to be below 6 - 7 cm and hence the other ranges shift up slightly.

Therefore best estimate SCP chronology: 1980: 2 – 3.5 cm

1950: 5.5 – 7 cm

1850: 18 – 21 cm

Upper Killarney: V 900 817



The received surface sediment sample was very small and whilst SCPs were identified in the sample, the errors are large and confidence in this concentration low.

No SCPs are recorded in the 40 – 40.5 cm sample at Upper Killarney suggesting that 1850 lies between 31 and 40 cm. The shape of the profile suggests that it is probably towards the lower end of this range.

Assuming a reasonably constant rate of accumulation, this depth range for 1850 would suggest a depth of between 4.5 – 6 cm for 1980 (the SCP concentration peak), and 10.5 – 14 cm for 1950 (the start of the rapid increase in SCP concentration). The available data would suggest that the rapid increase is likely to be below 11 cm and hence the other ranges may shift up slightly.

Therefore best estimate SCP chronology: 1980: 4.5 – 6 cm

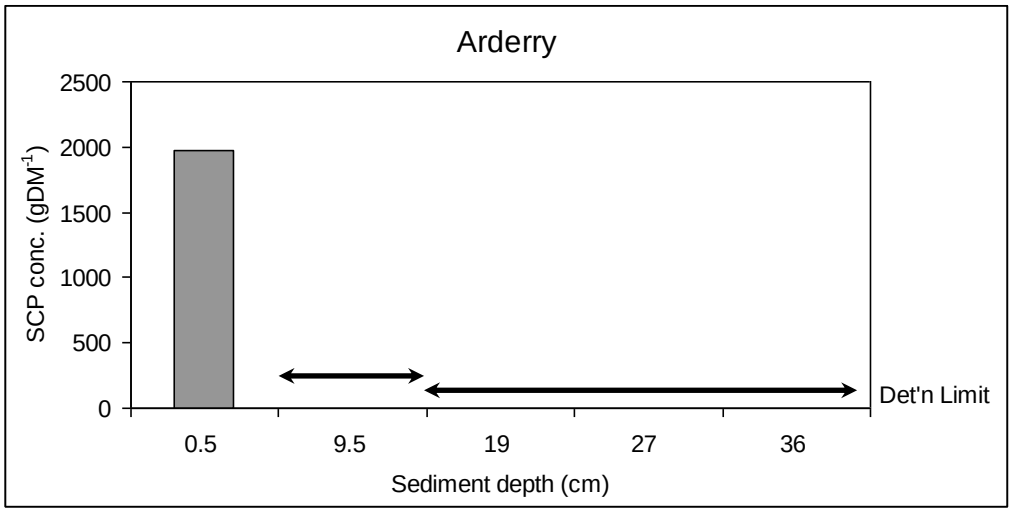
1950: 11 – 14 cm

1850: 35 – 40 cm

Section 3: Short or curtailed SCP profiles.

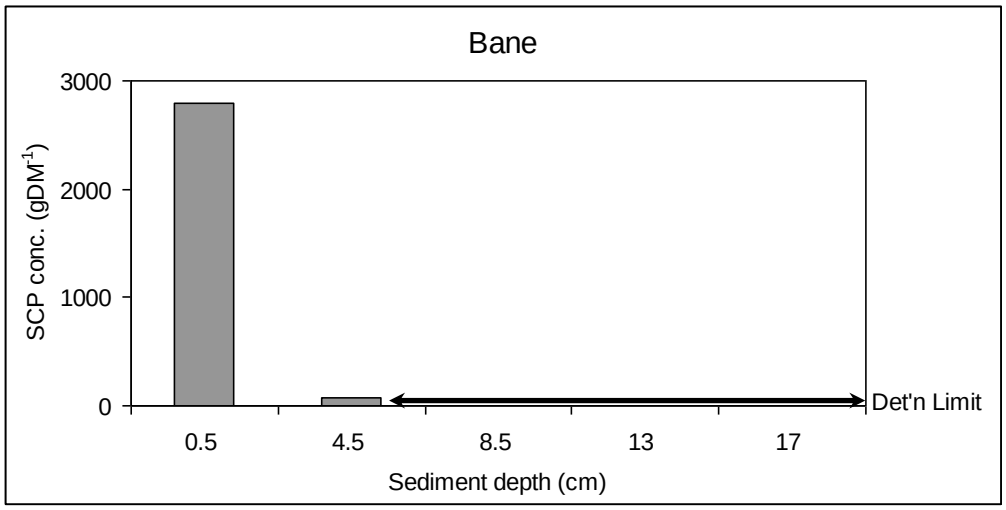
Possible explanations for SCP profiles of this type are described in the methods section. Here, it is assumed that the cores are intact and that the short profiles are due to slow sediment accumulation rate. Some support for this is derived from the location of these lakes. With the exception of Bane, all sites with short SCP profiles are clustered in two areas, the far south-west but mainly the mid-west area from Fee south to Naminna (see Figure 1).

Arderry: L 965 457



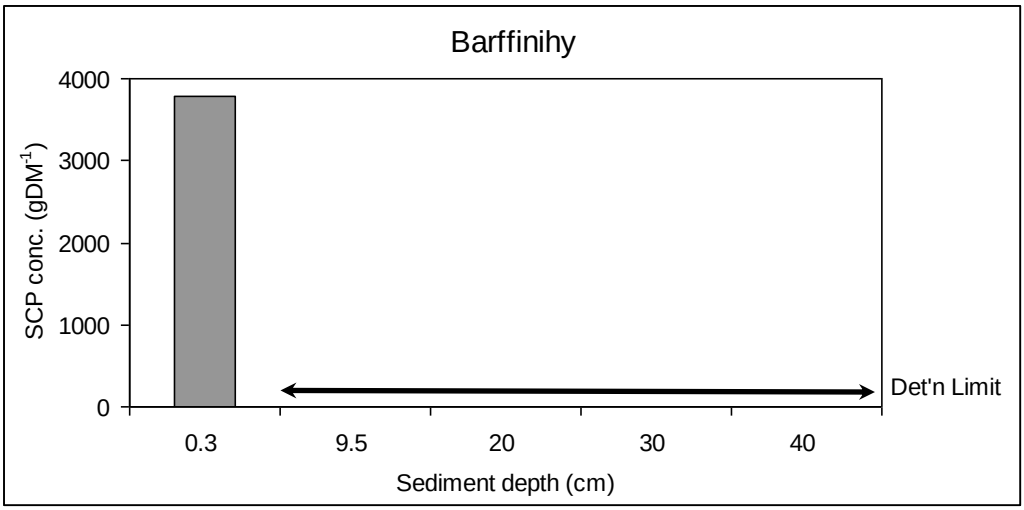
SCPs were only found in the surface sample of the Arderry core. Therefore, assuming this short SCP profile is due to a slow sediment accumulation rate, the whole post-1850 sediment record must lie above 9 cm. No further chronological information is can be determined.

Bane: N 550 712



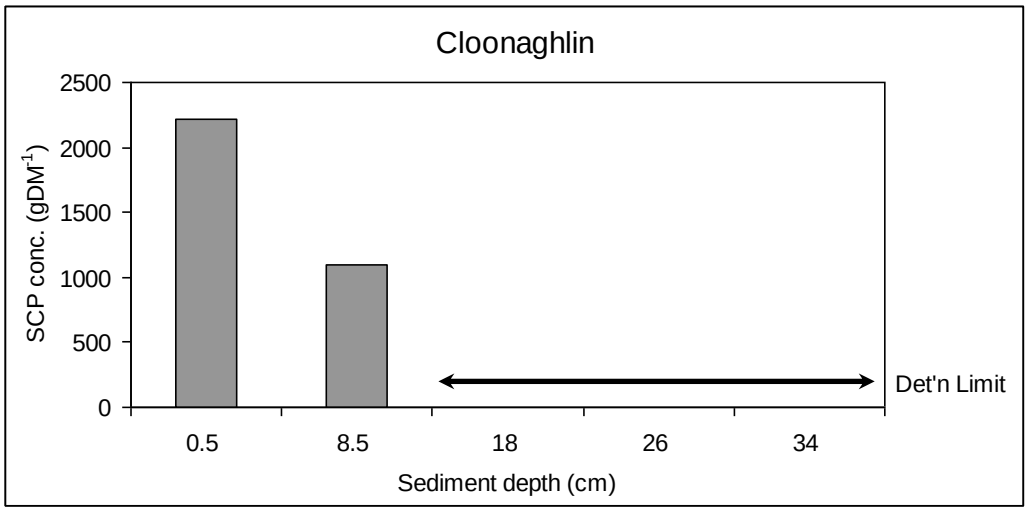
SCPs were only found in the two upper samples of the Bane core. The lower of these contained a very low concentration. Assuming the SCP concentration in this lower sample is not due to core smearing from the higher concentrations in the upper levels then 1850 must lie between 4.5 and 8 cm. If this is the case then, assuming a reasonably constant sediment accumulation rate, 1950 (and the rapid increase in SCP concentration) should be in the range 1.5 – 3 cm and 1980 (the SCP concentration peak) should be between 0.5 – 1.5 cm. It is not possible, from the available data, to confirm this further.

Barfinihy: V 850 768



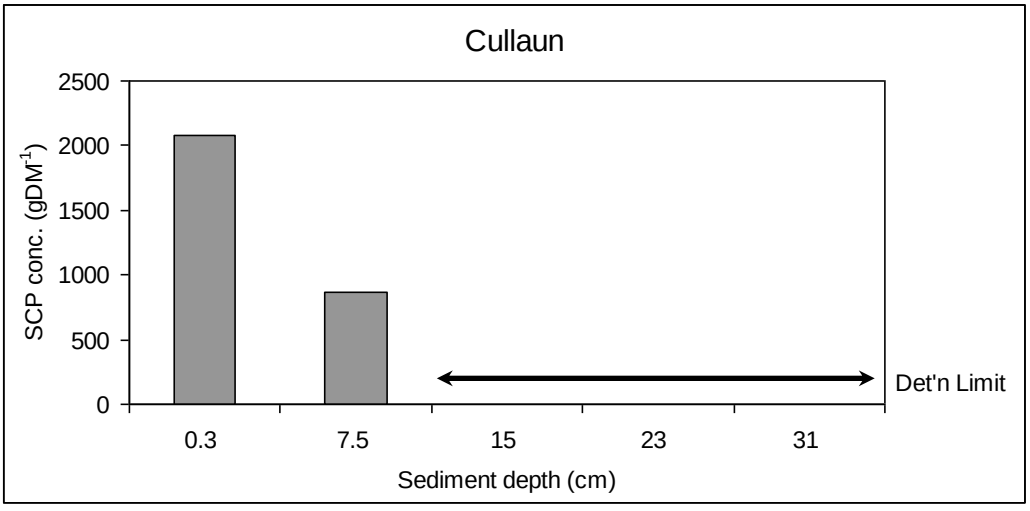
SCPs were only found in the surface sample of the Barfinihy core. Therefore, assuming this short SCP profile is due to a slow sediment accumulation rate, the whole post-1850 sediment record must lie above 9 cm. No further chronological information can be determined.

Cloonaghlin: V 610 709



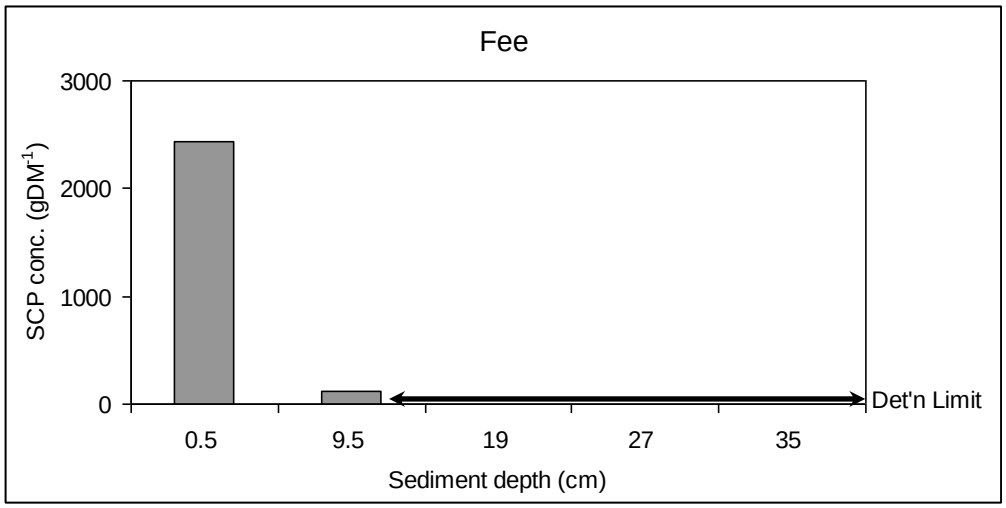
SCPs were only found in the two upper samples of the Cloonaghlin core. Therefore, assuming this short SCP profile is due to a slow sediment accumulation rate, then 1850 must lie between 9 and 17 cm. If this is the case then, assuming a reasonably constant sediment accumulation rate, 1950 (and the rapid increase in SCP concentration) should be in the range 3 – 6 cm and 1980 (the SCP concentration peak) should be between 1 – 2.5 cm. It is not possible, from the available data, to confirm this further.

Cullaun: R 315 905



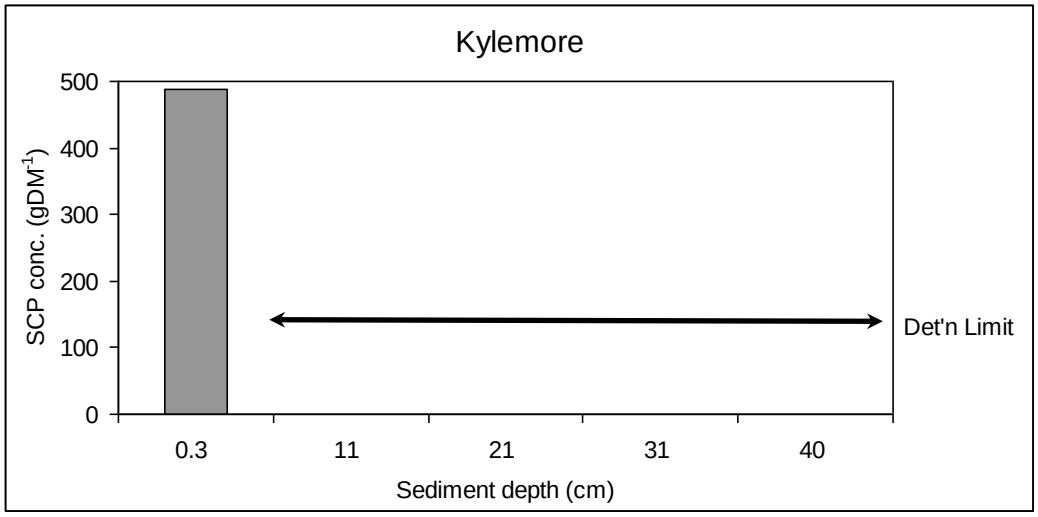
SCPs were only found in the two upper samples of the Cullaun core. Therefore, assuming this short SCP profile is due to a slow sediment accumulation rate, 1850 must lie between 8 and 14 cm. If this is the case then, assuming a reasonably constant sediment accumulation rate, 1950 (and the rapid increase in SCP concentration) should be in the range 2.5 – 5 cm and 1980 (the SCP concentration peak) should be between 1 – 2.5 cm. It is not possible, from the available data, to confirm this further.

Fee: L 790 613



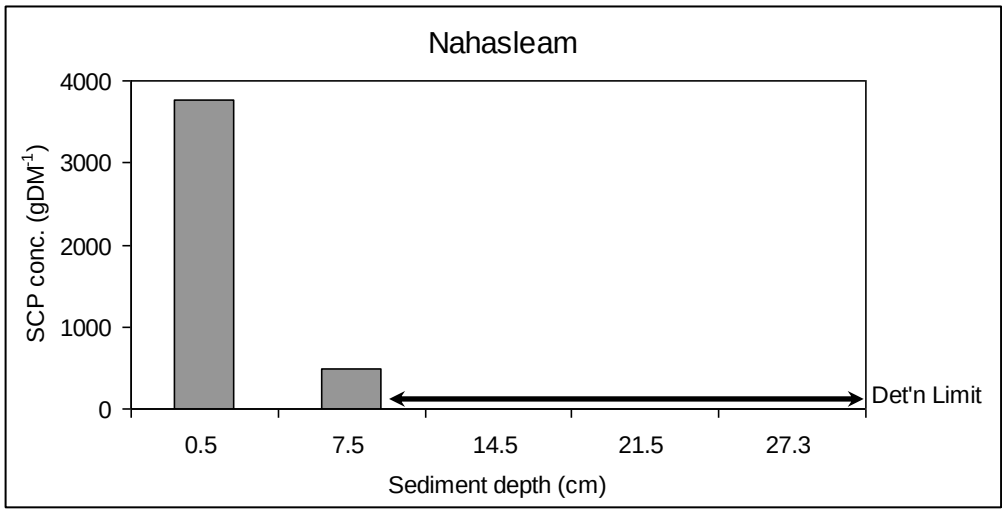
SCPs were only found in the two upper samples of the Fee core. The lower of these contained a very low concentration. Assuming the SCP concentration in this lower sample is not due to core smearing from the higher concentrations in the upper levels then 1850 must lie between 10 and 18 cm. If this is the case then, assuming a reasonably constant sediment accumulation rate, 1950 (and the rapid increase in SCP concentration) should be in the range 3.5 – 6.5 cm and 1980 (the SCP concentration peak) should be between 1.5 – 3 cm. It is not possible, from the available data, to confirm this further.

Kylemore: L 770 552



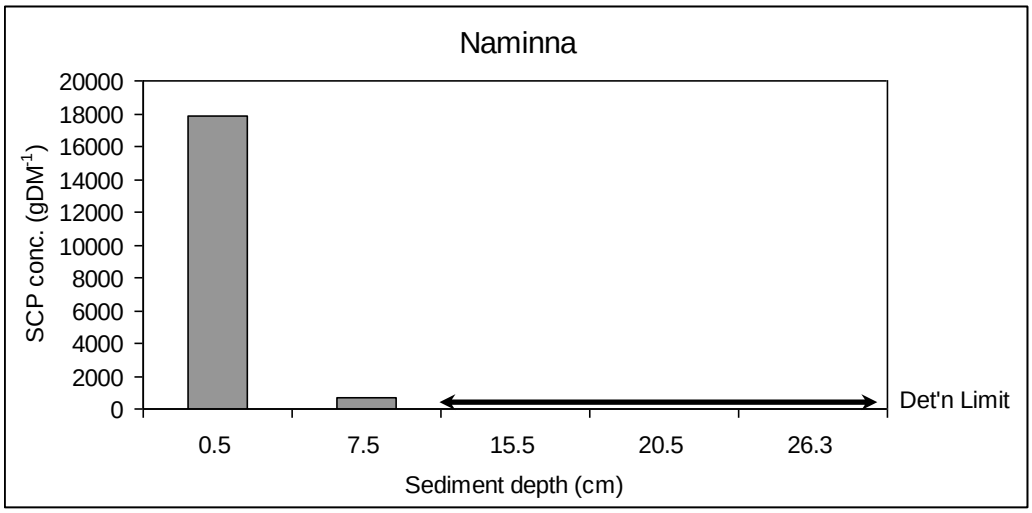
SCPs were only found in the surface sample of the Kylemore core. Therefore, assuming this short SCP profile is due to a slow sediment accumulation rate, the whole post-1850 sediment record must lie above 10 cm. No further chronological information can be determined.

Nahasleam: L 971 244



SCPs were only found in the two upper samples of the Nahasleam core. The lower of these contained a low concentration. Assuming the SCP concentration in this lower sample is not due to core smearing from the higher concentrations in the upper levels then 1850 must lie between 8 and 14 cm. If this is the case then, assuming a reasonably constant sediment accumulation rate, 1950 (and the rapid increase in SCP concentration) should be in the range 2.5 – 5 cm and 1980 (the SCP concentration peak) should be between 1 – 2.5 cm. It is not possible, from the available data, to confirm this further.

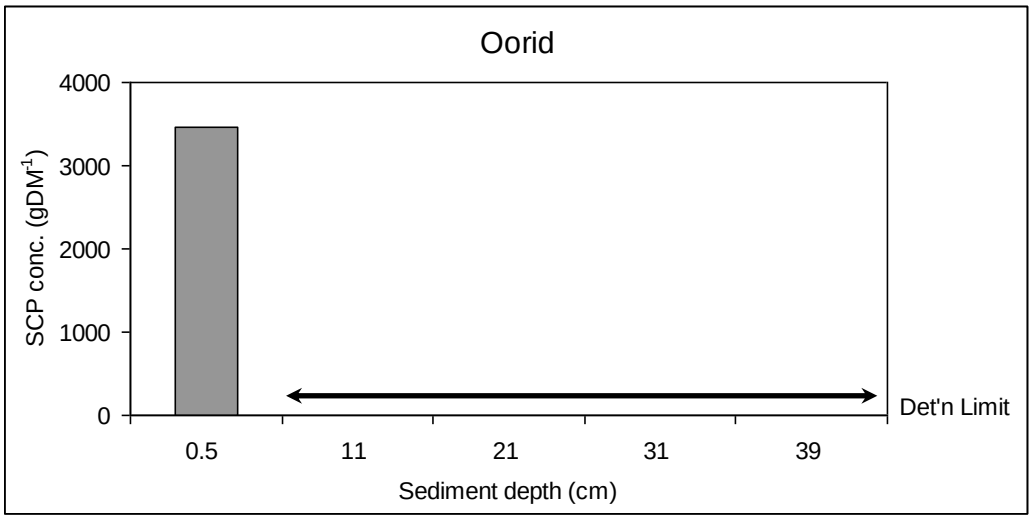
Naminna: R 176 710



SCPs were only found in the two upper samples of the Naminna core. The 7 – 8 cm sample contained a very low concentration. Assuming the SCP concentration in this lower sample is not due to core smearing from the higher concentrations in the upper levels then 1850 must lie between 8 and 15 cm. If this is the case then, assuming a reasonably constant sediment accumulation rate, 1950 (and the rapid increase in SCP concentration) should be in the range 2.5 – 5.5 cm and 1980 (the SCP concentration peak) should be between 1 – 2.5 cm. It is not possible, from the available data, to confirm this further.

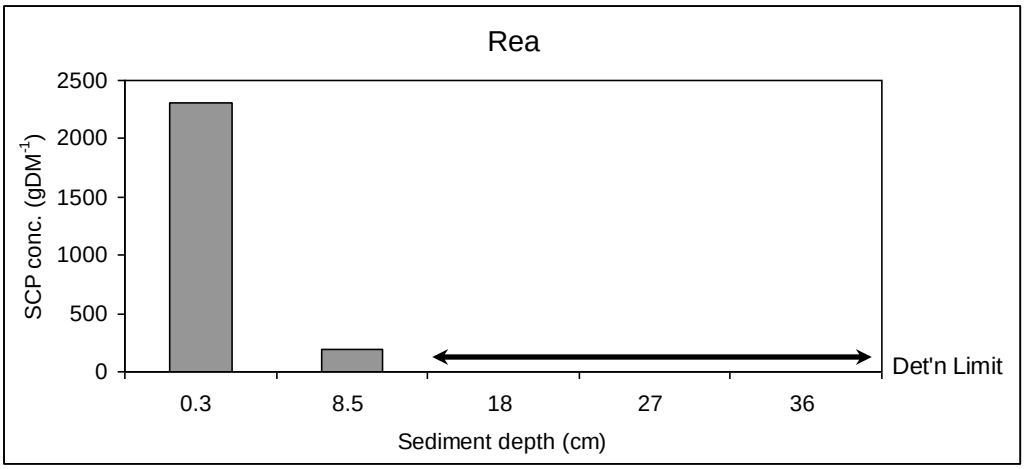
The surface sample from Naminna contains the highest SCP concentration found in the INSIGHT dataset and this may be due to the proximity of the Moneypoint coal-fired power station and the Tarbert oil-fired power station on the River Shannon to the south of this site. This concentration is three times as high as the peak concentration in an undated core taken in 1988. In this earlier core, the SCP profile was incomplete, but extended below a depth of 10 cm.

Oorid: L 930 460



SCPs were only found in the surface sample of the Oorid core. Therefore, assuming this short SCP profile is due to a slow sediment accumulation rate, the whole post-1850 sediment record must lie above 10 cm. No further chronological information can be determined.

Rea: M 615 155



SCPs were only found in the two upper samples of the Rea core. The lower of these contained a low concentration. Assuming the SCP concentration in this lower sample is not due to core smearing from the higher concentrations in the upper levels then 1850 must lie between 9 and 17 cm. If this is the case then, assuming a reasonably constant sediment accumulation rate, 1950 (and the rapid increase in SCP concentration) should be in the range 3 – 6 cm and 1980 (the SCP concentration peak) should be between 1 – 2.5 cm. It is not possible, from the available data, to confirm this further.

Section 4: Some notes on spatial distribution.

Whilst the sites selected for inclusion within IN-SIGHT do not cover the whole of Ireland, some interesting spatial distributions are apparent in both surface sediment concentrations and in full core inventories and it is perhaps worth comparing these with the surface sediment concentration data generated for Ireland within the EU's FLAME project (Bowman & Harlock, 1998).

Surface sediment concentrations are influenced by sediment accumulation rate and therefore, it is difficult to compare these data between sites. However, two sites within the INSIGHT dataset show exceptional surface sediment SCP concentrations, Fad (13200 gDM^{-1}) and Naminna (17900 gDM^{-1}) and it is possible that these reflect atmospherically deposited contamination from local power station sources, Coolkeragh (north of Derry) and Tarbert and Moneypoint (north and south of the River Shannon east of Kilrush) respectively. These areas were also shown to be contaminated areas in the FLAME project.

However, a better inter-site comparison and a better indication of the full historical atmospherically deposited contamination receieved by a site is available from the use of SCP inventory data. A full comparison is not possible at all INSIGHT sites where the SCP record extended below the base of the core, but the spatial distribution can still highlight areas of contamination. In general, SCP inventories fall in the range 100 – 550 x 10^5 m^{-2}. Sites with lower inventories than this (Kylemore, Fee, Arderry, Talt and Bane) are all 'complete' profiles and lie in a band across central Ireland to the west. This was also identified as a low contamination area in Bowman and Harlock (1998).

Six sites in four areas show SCP inventories >700 x 10^5 m^{-2} and interestingly only one of these (Naminna) has a 'complete' profile i.e. the remainder should all have still higher SCP inventories than determined here, thus emphasising the distinction between contaminated and less-contaminated areas. Of these four areas, two were the ones highlighted by surface sediment concentrations, the north (Doo – 1800; Fad - 1040) and around the Shannon estuary (Naminna - 970) whilst the others can also be related to power station sources and were also identified by FLAME. They are: Kiltooris (760) in the north-west possibly influenced by the power station at Bellacorrick, and Tay (1030) and Dan (1130) near the east coast possibly influenced by emissions from electricity generation and industry around Dublin (e.g. North Wall generating station).

In summary, SCP spatial distributions confirm the contaminated areas identified in FLAME and high deposition areas can be attributed to electricity generation sources.

Conclusions

SCP profiles were seen to fall into three categories:

1. Incomplete, where SCPs were present in all samples. In these cases a depth for 1850 was extrapolated below the base of the core.
2. Complete, where the start of the SCP record, and hence 1850, lies within the length of the core. In these cases, depths for 1950 and 1980 were extrapolated assuming a reasonably constant sediment accumulation rate and assessed against available data.
3. Short or curtailed SCP profiles where SCPs were only present in the upper one or two samples. These were assumed to be due to slow sediment accumulation rates and were found to be clusterd in the mid-west and south-west.

Given the very small number and the coarse interval between samples any estimated chronology contains a lot of uncertainty. Further, to produce any chronology at all requires a number of assumptions. The main one of these is that sediment accumulation rate has not varied greatly over the last 150 years. Without this assumption, no chronologies can be attributed to the profiles, however, the lack of samples also means that it is not possible to determine whether this is a reasonable assumption or not. A number of external driving factors can influence sediment accumulation rate and it is therefore probable that this assumption is not valid in many cases.

At one site, Nambrackkeagh, where radiometric data were available, estimated SCP chronologies appear to give good agreement with the preliminary ^{210}Pb dates.

It is not possible to draw any conclusions regarding the regional variability of SCP profiles acoss Ireland and hence the validity of the dates used here. Independent dating of more detailed SCP profiles are required from across Ireland in order to calibrate the SCP chronology. This work would make the SCP dating technique more reliable in future studies.

Spatial distributions of SCP surface sediment concentrations and inventories were found to agree well with data from the EU funded project ‘FLAME’ (1994 – 1996). Areas of low contamination were identified in central areas and the mid- and south-west. Areas of high contamination were identified in the north (possibly influenced by the power station at Coolkeragh, north of Derry), the east (from industry around Dublin) and around the Shannon Estuary (Moneypoint and Tarbert power stations).

References

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Appendix: INSIGHT SCP data.

Site	Top depth (cm)	Bottom depth (cm)	Mean depth (cm)	SCP concentration (gDM^{-1})	90% confidence limits (gDM^{-1})	
KINDRUM	0	0.5	0.25	5259	6474	4044
KINDRUM	6	7	6.5	2706	3369	2043
KINDRUM	14	15	14.5	337	528	146
KINDRUM	22	23	22.5	0	0	0
KINDRUM	30	31	30.5	0	0	0
TALT	0	0.5	0.25	1624	2155	1094
TALT	5	6	5.5	405	685	124
TALT	10	11	10.5	173	343	3
TALT	15	16	15.5	274	465	84
TALT	21	22	21.5	0	0	0
FEEAGH	0	0.5	0.25	1326	2076	576
FEEAGH	9	10	9.5	1775	2780	771
FEEAGH	18	19	18.5	2183	2896	1470
FEEAGH	27	28	27.5	281	557	6
FEEAGH	35	36	35.5	618	1046	190
KEEL	0	0.5	0.25	1463	2291	635
KEEL	10	11	10.5	1931	2777	1085
KEEL	20	21	20.5	340	674	7
KEEL	30	31	30.5	0	0	0
KEEL	40	41	40.5	0	0	0
O'FLYNN	1	2	1.5	0	0	0
O'FLYNN	9	10	9.5	1190	1602	778
O'FLYNN	19	20	19.5	998	1344	652
O'FLYNN	29	30	29.5	694	1087	301
O'FLYNN	41	42	41.5	176	348	4
McNEAN	0	0.5	0.25	1523	2269	777
McNEAN	4	5	4.5	1057	1790	325
McNEAN	9	10	9.5	651	1102	200
McNEAN	14	15	14.5	0	0	0
McNEAN	18	19	18.5	0	0	0
LENE	0	0.5	0.25	1333	1866	799
LENE	6	7	6.5	406	636	176
LENE	13	14	13.5	1093	1416	770
LENE	20	21	20.5	158	313	3
LENE	28	29	28.5	287	486	88
ANNAGHMORE	0	0.5	0.25	559	876	243
ANNAGHMORE	4	5	4.5	852	1167	536
ANNAGHMORE	9	10	9.5	501	784	217
ANNAGHMORE	14	15	14.5	147	291	3
ANNAGHMORE	19	20	19.5	0	0	0
EASKY	0	0.5	0.25	2760	3511	2010
EASKY	7	8	7.5	3112	4076	2148
EASKY	13	14	13.5	1152	1716	587
EASKY	19	20	19.5	181	357	4
EASKY	26	27	26.5	0	0	0

Site	Top depth (cm)	Bottom depth (cm)	Mean depth (cm)	SCP concentration (gDM^{-1})	90% confidence limits (gDM^{-1})	
NAHASLEAM	0	0.5	0.25	3757	5404	2110
NAHASLEAM	7	8	7.5	481	953	10
NAHASLEAM	14	15	14.5	0	0	0
NAHASLEAM	21	22	21.5	0	0	0
NAHASLEAM	27	27.5	27.25	0	0	0
BANE	0	0.5	0.25	2796	3831	1760
BANE	4	5	4.5	74	147	1
BANE	8	9	8.5	0	0	0
BANE	12	13	12.5	0	0	0
BANE	16	17	16.5	0	0	0
FEE	0	0.5	0.25	2429	3493	1364
FEE	9	10	9.5	0	0	0
FEE	18	19	18.5	0	0	0
FEE	26	27	26.5	0	0	0
FEE	34	35	34.5	0	0	0
DAN	0	0.5	0.25	5125	6639	3610
DAN	8	9	8.5	1963	2748	1178
DAN	16	17	16.5	3980	5359	2601
DAN	24	25	24.5	1538	2408	668
DAN	30	31	30.5	904	1530	277
DOO	0	0.5	0.25	2485	3575	1396
DOO	7	8	7.5	1957	2740	1174
DOO	15	16	15.5	7468	9298	5639
DOO	23	24	23.5	3493	4575	2410
DOO	30	31	30.5	587	994	180
BARRA	0	0.5	0.25	4843	6275	3412
BARRA	9	10	9.5	1697	2440	953
BARRA	18	19	18.5	2111	2956	1266
BARRA	26	27	26.5	581	1151	12
BARRA	35	36	35.5	318	538	98
NAMINN	0	0.5	0.25	5441	6980	3902
NAMINN	7	8	7.5	713	1411	14
NAMINN	14	15	14.5	0	0	0
NAMINN	21	22	21.5	315	624	6
NAMINN	27	27.5	27.25	0	0	0
KILTOORIS	0	0.5	0.25	668	1131	205
KILTOORIS	9	10	9.5	1960	2819	1101
KILTOORIS	18	19	18.5	4360	5785	2936
KILTOORIS	26	27	26.5	2197	2879	1516
KILTOORIS	34	35	34.5	2012	2893	1130
ARDERRY	0	0.5	0.25	1977	2946	1008
ARDERRY	9	10	9.5	0	0	0
ARDERRY	18	19	18.5	0	0	0
ARDERRY	26	27	26.5	0	0	0
ARDERRY	35	36	35.5	0	0	0
SHINDILLA	0	0.5	0.25	2751	4307	1194
SHINDILLA	7	8	7.5	786	1330	241
SHINDILLA	14	15	14.5	493	976	10
SHINDILLA	21	22	21.5	0	0	0
SHINDILLA	28	29	28.5	0	0	0

Site	Top depth (cm)	Bottom depth (cm)	Mean depth (cm)	SCP concentration (gDM^{-1})	90% confidence limits (gDM^{-1})	
BALLYNAKILL	0	0.5	0.25	2305	3315	1295
BALLYNAKILL	9	10	9.5	2056	3063	1048
BALLYNAKILL	18	19	18.5	926	1567	284
BALLYNAKILL	26	27	26.5	155	306	3
BALLYNAKILL	35	36	35.5	0	0	0
VEAGH	0	0.5	0.25	4434	5639	3229
VEAGH	9	10	9.5	3020	4066	1973
VEAGH	18	19	18.5	2847	3986	1708
VEAGH	25	26	25.5	738	1249	227
VEAGH	33	34	33.5	686	1074	298
NAMBRACKKEAGH	0	0.5	0.25	4173	5619	2727
NAMBRACKKEAGH	7	8	7.5	808	1368	248
NAMBRACKKEAGH	14	15	14.5	462	914	9
NAMBRACKKEAGH	21	22	21.5	0	0	0
NAMBRACKKEAGH	26	26.5	26.25	0	0	0
DUNGLOW	0	0.5	0.25	6127	8026	4228
DUNGLOW	3	4	3.5	1463	2292	635
DUNGLOW	6	7	6.5	1007	1705	309
DUNGLOW	9	10	9.5	497	984	10
DUNGLOW	11	12	11.5	428	848	9
FAD	0	0.5	0.25	13199	15010	11387
FAD	6	7	6.5	1775	2553	997
FAD	12	13	12.5	1097	1718	476
FAD	18	19	18.5	290	575	6
FAD	26	27	26.5	491	831	151
MUCKANAGH	0	0.5	0.25	<158	0	0
MUCKANAGH	10	11	10.5	345	539	150
MUCKANAGH	20	21	20.5	577	860	294
MUCKANAGH	30	31	30.5	204	345	63
MUCKANAGH	40	41	40.5	<145	0	0
BARFFINIHY	0	0.5	0.25	3792	4623	2961
BARFFINIHY	9	10	9.5	<183	0	0
BARFFINIHY	19	20	19.5	<121	0	0
BARFFINIHY	29	30	29.5	<169	0	0
BARFFINIHY	39	40	39.5	<169	0	0
REA	0	0.5	0.25	2312	3068	1557
REA	8	9	8.5	193	383	4
REA	17	18	17.5	<135	0	0
REA	26	27	26.5	0	0	0
REA	35	36	35.5	0	0	0
CLOONAGHLIN	0	0.5	0.25	2219	2944	1494
CLOONAGHLIN	8	9	8.5	1100	1581	618
CLOONAGHLIN	17	18	17.5	<156	0	0
CLOONAGHLIN	25	26	25.5	<237	0	0
CLOONAGHLIN	33	34	33.5	<209	0	0
CULLAUN	0	0.5	0.25	2073	2598	1549
CULLAUN	7	8	7.5	867	1247	487
CULLAUN	14	15	14.5	<162	0	0
CULLAUN	22	23	22.5	<195	0	0
CULLAUN	30	31	30.5	<225	0	0

Site	Top depth (cm)	Bottom depth (cm)	Mean depth (cm)	SCP concentration (gDM^{-1})	90% confidence limits (gDM^{-1})	
TAY	0	0.5	0.25	3015	3949	2081
TAY	8	9	8.5	1035	1489	581
TAY	17	18	17.5	3465	4489	2441
TAY	26	27	26.5	754	1277	232
TAY	35	36	35.5	310	615	6
NAMINNA	0	0.5	0.25	17896	20141	15650
NAMINNA	7	8	7.5	668	1047	290
NAMINNA	15	16	15.5	<277	0	0
NAMINNA	20	21	20.5	<205	0	0
NAMINNA	26	26.5	26.25	<233	0	0
OORID	0	0.5	0.25	3467	4375	2559
OORID	10	11	10.5	<162	0	0
OORID	20	21	20.5	<242	0	0
OORID	30	31	30.5	<177	0	0
OORID	38	39	38.5	<209	0	0
UPPER	0	0.5	0.25	347	687	7
UPPER	10	11	10.5	2540	3205	1875
UPPER	20	21	20.5	1145	1705	584
UPPER	30	31	30.5	420	711	129
UPPER	40	40.5	40.25	<213	0	0
KYLEMORE	0	0.5	0.25	488	764	212
KYLEMORE	10	11	10.5	0	0	0
KYLEMORE	20	21	20.5	0	0	0
KYLEMORE	30	31	30.5	0	0	0
KYLEMORE	39	40	39.5	0	0	0
BUNNY	0	0.5	0.25	1906	2612	1200
BUNNY	6	7	6.5	1053	1568	537
BUNNY	12	13	12.5	371	736	7
BUNNY	18	19	18.5	200	395	4
BUNNY	24	25	24.5	<259	0	0