

# Report: Enhanced mapping of 1961-91 small area population counts to 2011 British wards

Humphrey Southall, Paula Aucott and Michael Stoner  
(Department of Geography, University of Portsmouth)

---

The aim of this project was to create the most accurate possible estimate of the populations of each of the 8,941 ward areas into which Great Britain was divided for the 2011 census, for the dates of four earlier censuses, from 1961 to 1991.

Our concern was only with total populations, rather than with counts by age or gender, but there are broadly two ways of counting: persons present on census night, or those “usually resident”. The preference was for “usually resident”, but for 1971 and earlier only “persons present” was available. We therefore calculated both measures for those dates where both were possible.

As the reporting geographies used in the earlier censuses differed substantially from that of 2011, GIS-based redistricting was required to convert between geographies, and consequently the quality of the results depend on the topographic accuracy of the available digital boundaries for each date, as well as on the detail available in the population counts.

As the calculations became progressively more problematic as we went back in time, they are reported on here in reverse order.

## **1981 and 1991**

The data for these years were identical and largely unproblematic.

For each year, digital boundary data for Enumeration Districts for each of England, Wales and Scotland were separately downloaded from the UKBORDERS system, assembled into a single dataset for Great Britain, and linked to population counts extracted from the CASWEB system, giving a total of 130,048 historical areas in 1981 and 147,904 in 1991. Unlike the calculations done in 2013, the sheer number of historical units we were working with, relative to the 8,941 modern units, meant that it made relatively little difference how much individual historical units differed from the modern ones.

Note that (a) the Scottish data for 1991 were labeled as “Output Areas” rather than “Enumeration Districts”, but their identifiers matched those in the Enumeration District data from CASWEB; and (b) changes to the UKBORDERS interface make it hard to find pre-1991 data (go to <http://census.edina.ac.uk/licenses.html>, and then type “Enumeration district” into the search box).

Once these datasets had been assembled into a single SHAPE file, they were loaded into our Postgres database and the PostGIS geospatial extension used to perform the re-districting; for example, this command straightforwardly computes 1981 “usually resident”, combining data on “all present residents” and “all absent residents”:

```

update gbhdb.ward_2011_gb mod set pop_1981_usu_res =
(select sum((old.allpreres + old.allabsres) *
st_area(st_intersection(mod.g_foot_etr89,
old.g_foot_etr89))/ST_area(old.g_foot_etr89))
from gbhdb.ed1981_gb_temp old
where st_intersects(old.g_foot_etr89, mod.g_foot_etr89) = TRUE);

```

Following each re-districting we firstly checked that every 2011 ward had some population allocated to it, which was not a problem for either 1981 or 1991, and secondly we compared the total population of the country as listed in the historical data with the sum of the re-districted data, with the results listed in the table below. For example, the total “usually resident population” of Great Britain in 1981 was 53,561,963 but the total of our first set of redistricting results was 53,513,328, a difference of 48,635 or 0.091 of the total:

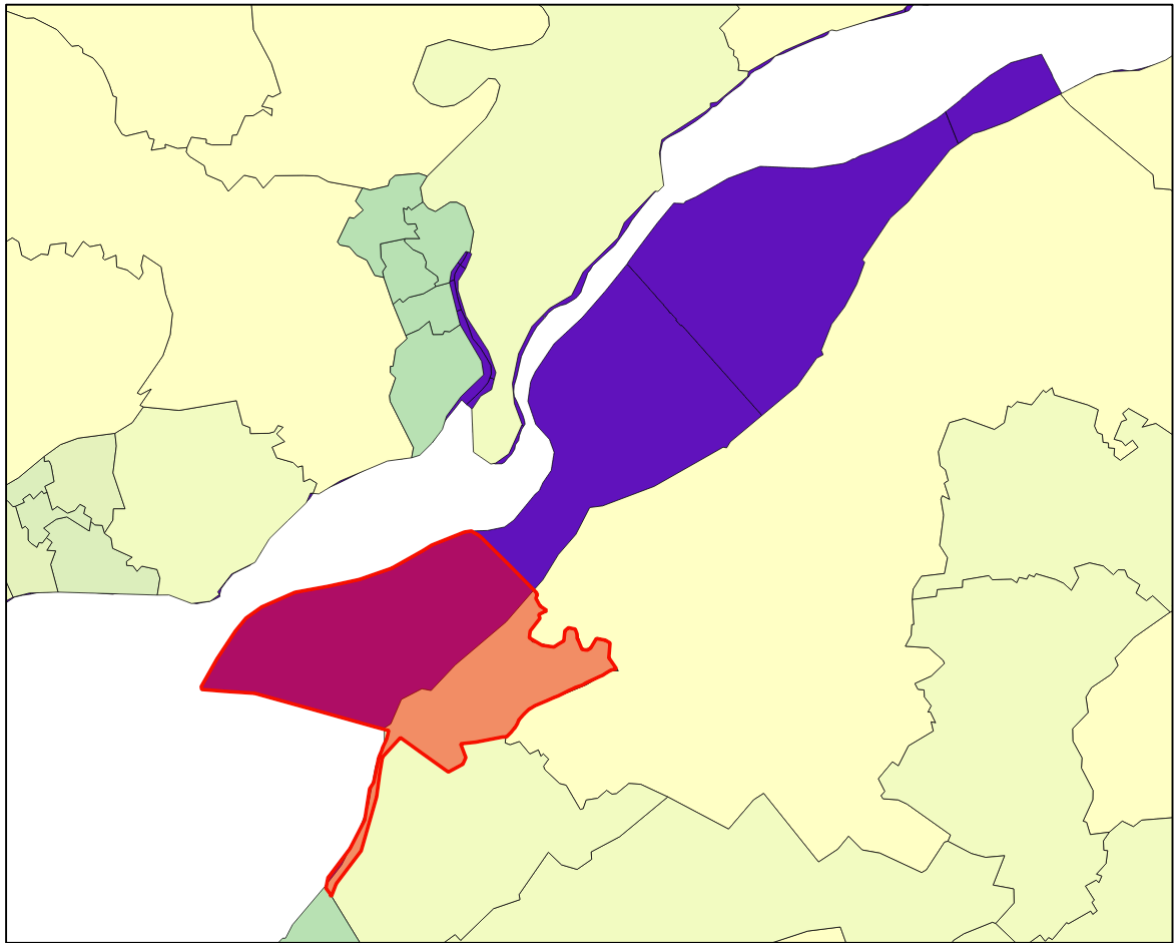
**Table 1: Statistics for population counts for re-districting of 1961-1991 Census population data**

Year	Count	Original Total	Redistrict -ing loss	Per Cent Lost	Adjusted Loss	Adj. Per Cent Lost
1961	Persons Present	52,274,403	1,120,068	2.143	-7,602	-0.015
1971	Persons Present	53,847,226	171,089	0.318	588	0.001
1981	Persons Present	54,283,940	51,422	0.095	1,495	0.003
1981	Usually Resident	53,561,963	48,635	0.091	1,479	0.003
1991	Persons Present	53,542,903	26,872	0.050	4,484	0.008
1991	Usually Resident	53,176,089	25,451	0.048	4,179	0.008

Some careful checking confirmed that the loss of population through the redistricting process was the result not of cumulative rounding errors in the redistricting calculations, but of mismatches between the historical and modern boundaries, leading to some historical population being redistricted into the sea or other water areas. This interpretation is confirmed by the results above: the closer to the present, the smaller the redistricting loss.

An example of this redistricting issue can be found where the M4 and the M48 crosses the River Seven (Figure 1). The polygon highlighted, in red, is from the 1981 data, and it intersects the 2011 polygons by less than half of its area. This 1981 ward would therefore contribute less than half of its population to the 2011 ward.

Had the problem been due to rounding, we would have made a small *pro rata* adjustment to all redistricted population results, but this is not appropriate if it is mainly affecting coastal areas. We therefore developed an alternative redistricting procedure which starts by computing a new set of polygons which is the intersection between the historical and modern sets:



**Figure 1 Population density for 2011 overlain on purple polygons, with one 1981 polygon highlighted in red for 1981**

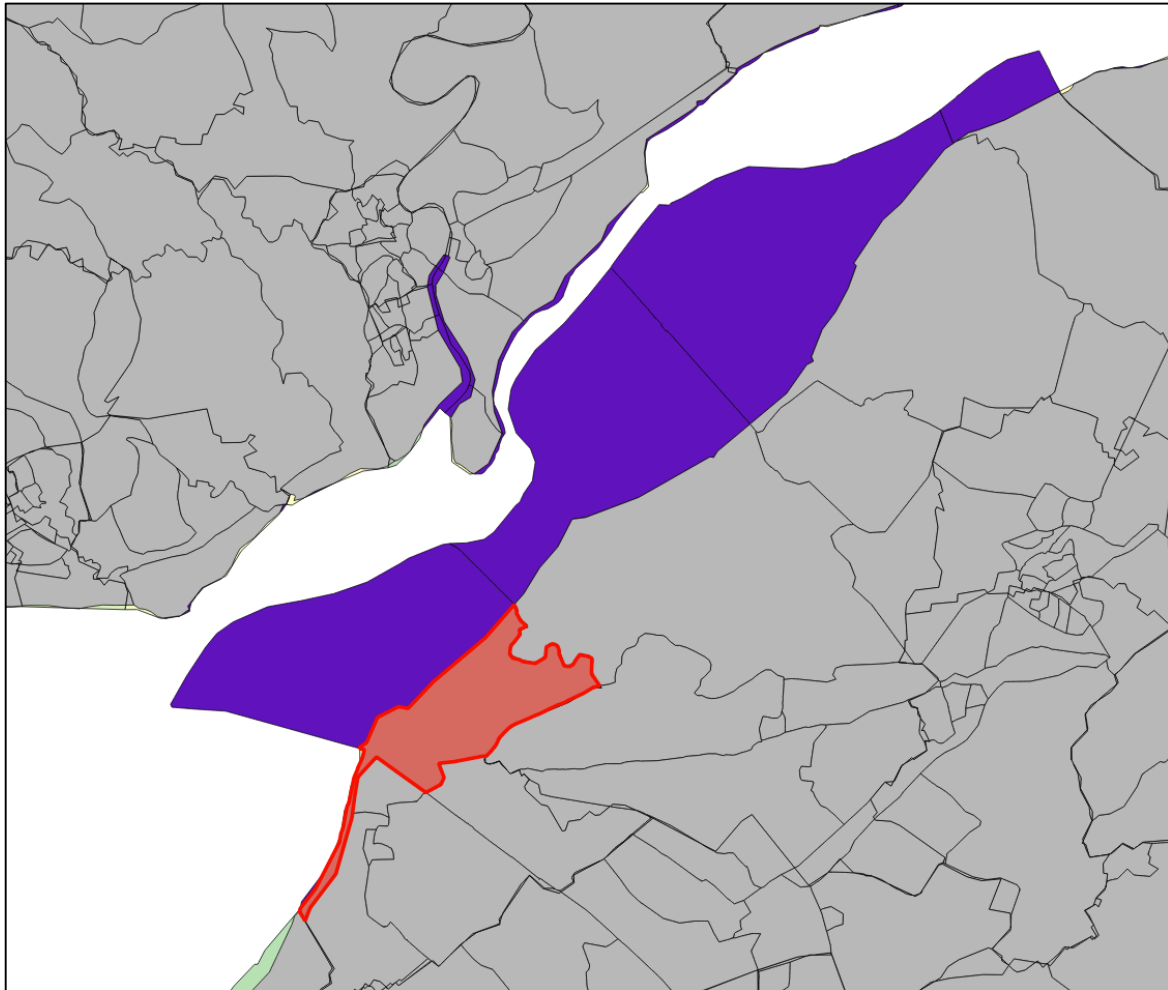
```

create table gbhdb.ed1981_gb_temp_intersect_ward_2011_gb as
SELECT gid, label, oid_, zone_id, allpreres, allabsres,
allvisitor, all71base, all81base, edarea_sqm, edarea_fra,
CASE
    WHEN ST_CoveredBy(old.g_foot_etr89, mod.g_foot_etr89)
    THEN
        old.g_foot_etr89
    ELSE
        ST_Multi(
            ST_Intersection(old.g_foot_etr89, mod.g_foot_etr89)
        )
    END AS g_foot_etr89,
    mod.ward_name as ward_2011,
    mod.g_seq as ward_2011_g_seq
FROM gbhdb.ed1981_gb_temp AS old
    INNER JOIN gbhdb.ward_2011_gb AS mod
        ON (ST_Intersects(old.g_foot_etr89, mod.g_foot_etr89)
            AND NOT ST_Touches(old.g_foot_etr89, mod.g_foot_etr89)
);

```

Figure 2 shows the new set of (smaller) polygons in grey, these have been overlaid on the data from Figure 1. The same 1981 ward is highlighted again, but now its boundary does not extend past the 2011 boundary, therefore its population will be redistricted correctly. Note the small area of green at the south west of the image is

an example where the 2011 boundary extends further in to the river compared to the 1981.



**Figure 2 Intersection between 1981 (purple) and 2011 (grey) polygons, with one intersection polygon highlighted**

These intersection polygons were then populated with their proportional share of the 1981 population:

```
update  gbhdb.ed1981_gb_temp_intersect_ward_2011_gb
set
    allpresres_proportional = proportional.prop_allpresres,
    allvisitor_proportional = proportional.prop_allvisitor,
    allabsres_proportional = proportional.prop_allabsres
from
    (SELECT
        old_poygon_intersection_with_new_polyon_id,
        allpresres * st_area (g_foot_etr89) /
            sum (st_area(g_foot_etr89))
            OVER (PARTITION BY gid ) as prop_allpresres,
        allvisitor * st_area (g_foot_etr89) /
            sum (st_area(g_foot_etr89))
            OVER (PARTITION BY gid ) as prop_allvisitor,
        allabsres * st_area (g_foot_etr89) /
            sum (st_area(g_foot_etr89))
            OVER (PARTITION BY gid ) as prop_allabsres
    FROM gbhdb.ed1981_gb_temp_intersect_ward_2011_gb
    ) AS proportional
```

```

where
gbhdb.ed1981_gb_temp_intersect_ward_2011_gb.old_poygon_intersection_with_new_polyon_id
= proportional.old_poygon_intersection_with_new_polyon_id
;

```

And then finally the redistricting was done using this new set of populated polygons:

```

update   gbhdb.ward_2011_gb
set
    pop_1981_present =
        prop_1981_ward_2011.sum_1981_allpresres_proportional +
        prop_1981_ward_2011.sum_1981_allvisitor_proportional,
    pop_1981_usu_res =
        prop_1981_ward_2011.sum_1981_allpresres_proportional +
        prop_1981_ward_2011.sum_1981_allabsres_proportional
from      (
    select
        ward_2011_g_seq,
        sum( allpresres_proportional ) over
            ( PARTITION BY ward_2011_g_seq )
        as sum_1981_allpresres_proportional,
        sum( allvisitor_proportional ) over
            ( PARTITION BY ward_2011_g_seq )
        as sum_1981_allvisitor_proportional,
        sum( allabsres_proportional ) over
            ( PARTITION BY ward_2011_g_seq )
        as sum_1981_allabsres_proportional
    from
        gbhdb.ed1981_gb_temp_intersect_ward_2011_gb
    ) as prop_1981_ward_2011
where     gbhdb.ward_2011_gb.g_seq = prop_1981_ward_2011.ward_2011_g_seq;

```

As can be seen in the table above, this adjusted procedure largely eliminated the loss of population through redistricting for both 1981 and 1991.

The only loss of population that now is possible is when the previous wards do not form any intersection with the 2011 wards. A possible improvement would be to assign these to the nearest ward.

## 1971

While for 1981 and 1991 we were able to use detailed boundaries for Enumeration Districts, constructed at the time of those censuses, the only digital boundary data available for 1971 are retrospective. For our work in 2013, we used boundaries for wards created from aggregating Thiessen polygons generated from Enumeration District point data. In this new work, we used the non-aggregated sets of “synthetically generated” Enumeration District boundaries, again available from the UKBORDERS service, the only “real world” boundary being the coastline.

One problem with these data was that 595 of the 125,476 districts for which population counts were available did not appear in the boundary data set, so their total population of 131,372 could not be assigned.

A second problem for 1971 was that the redistricting operation initially failed due to topology problems, specifically non-noded interceptions. This clearly resulted from peculiarities of the synthesized polygons, and was resolved by generating a new set of 1971 polygons using the PostGIS ST\_SimplifyPreserveTopology function.

However, as the table above shows, the “redistricting loss” is substantially larger than for the later years, and this loss was additional to the loss due to there being districts with no associated polygon, so 302,461 persons in all were lost, which was 0.56% of the total population of 53,978,598.

One particular problem was that two of the 2011 wards received no 1971 population at all. These were “Walney North and Walney South”, within Barrow in Furness district in north west England. Checking the underlying census data, Walney Island was a single ward in 1971 containing 21 Enumeration Districts. The map below shows 2011 ward in orange with 1971 ED polygons overlain in purple and the sea left as white, and it will be clear that none of the 1971 IDs on the island have a polygon. We dealt with this problem in the delivered result by manually adding Walney population figures to the 2011 Walney wards, as these wards and their populations were completely missing from the 1971 polygon data set.

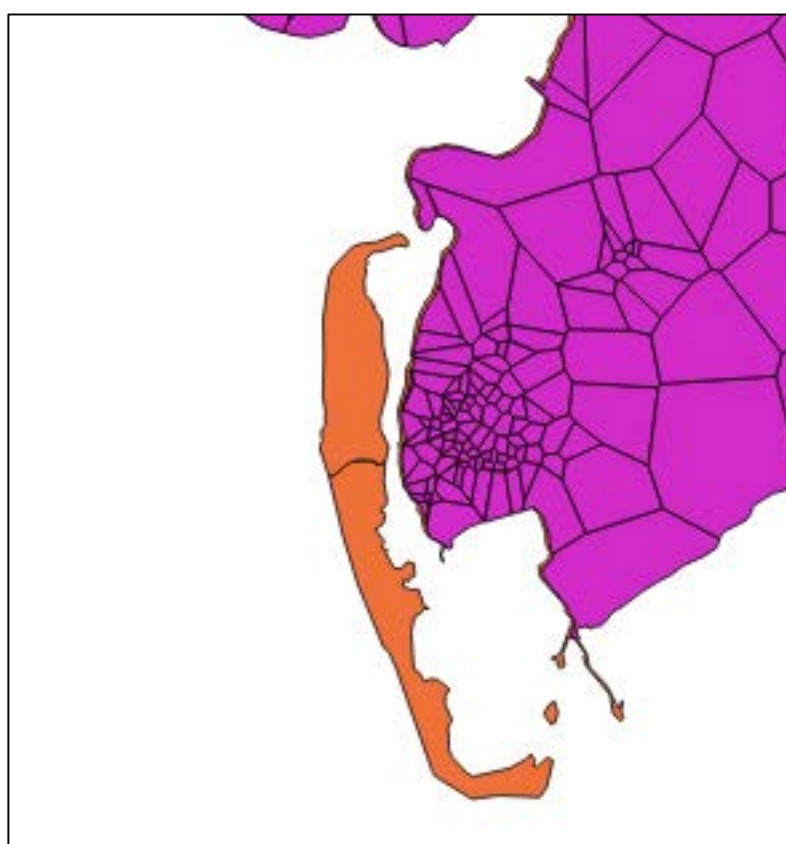


Figure 3 Walney Island and Barrow in Furness: 1971 and 2011 boundaries

## 1961

While the 1971 boundary data available from official sources are problematic, no computerized 1961 data existed at all, so this part of the project depended on us computerizing census statistics from the published reports and building a boundary GIS. Work on 1961 consequently occupied far more of our time than the other three years together.

Statistical data for England and Wales came from table 3 in the County Reports, which lists “Acreage, Population, Private Households and Dwellings” for Civil Parishes, in rural areas, and Wards, within towns. Data for Scotland came mainly

from table 3A in the County Reports, “Population, Historical Table” for Civil Parishes, but for the four Cities (Aberdeen, Dundee, Edinburgh and Glasgow) we used “Acreage, Population, Private Households and Dwellings” which listed data by City Ward.

Much earlier work by us had constructed digital boundaries for Civil Parishes in 1961, manually digitizing Ordnance Survey “County Administrative Diagrams” at two miles to one inch (1:126,720) scale, so new construction work focused on ward boundaries within urban areas.

Ward boundaries did in fact appear on published Ordnance Survey maps, but only at 1:2,500 or 1:1,250 scale, i.e. approximately twenty-five or fifty inches to one mile. Although we had access to digital versions of this mapping, computerised by Landmark Information and accessed via Digimap Historic (<http://digimap.edina.ac.uk>), these scales meant that a city such as Manchester involved hundreds of map tiles, and it is hard to fit the entire boundary line for a single ward into a computer screen. The limited work we did with this mapping confirmed our earlier decision that systematic boundary mapping from this source was impractical without at least ten times more resources than were available to this project; and we would probably revise this to at least twenty times.

The challenge was therefore to locate smaller scale maps, in which all the ward boundaries of a city fitted on a single sheet. Three sources were identified before the project began:

- In 1996, we obtained many of the maps from the library Office of National Statistics’ London offices at St Catharine’s House, when they moved out. These included OS “County Administrative Diagrams” for certain counties which had been marked up by hand to show Ward boundaries in addition to parishes. The largest city covered was Bristol, and we made full use of these maps in the earlier redistricting project in 2013.
- Through a meeting with the Greater London Authority in October 2014, mainly to discuss another census redistricting project for them, we obtained a large map showing the 1961 Ward boundaries for the whole of Greater London.
- The Scottish 1961 census reports for the four Scottish cities each include ward boundary maps exactly suited to our needs.

A major part of this new project was to systematically contact urban governments across England and Wales seeking maps showing ward boundaries, at manageable scale. The following work was done:

- We identified the modern local authority corresponding to each of the ninety County Boroughs existing in 1961, excluding those within Greater London.
- Through online searches, we located e-mail addresses for (a) seventy-two planning or development departments and (b) seventy municipal archives for each authority (some modern authorities covered more than one 1961 borough, and some archives covered more than one modern authority).
- Starting in late November 2014, we sent individualised emails to each address, with somewhat different wording for the planners and the archives and each with an attached Excel file listing the 1961 wards in just that town: a total of 116 separate e-mails.



A considerable amount of time was spent on this mailing, but we were disappointed by the results. Many planning departments did not reply, or simply said they had no historical information. The vast majority of archives did reply, but relied on their catalogues which meant looking for map sheets which were separately catalogued, whereas our emails suggested suitable maps were more likely to be found as pages within old council reports. A number of less systematic approaches were also made:

- General enquiries were sent to the [archives-nra@jiscmail.ac.uk](mailto:archives-nra@jiscmail.ac.uk) and [lis-maps@jiscmail.ac.uk](mailto:lis-maps@jiscmail.ac.uk) mailing lists, systematically contacting archivists and map librarians.
- We contacted several current and retired geographical researchers involved in demographic research on and to some extent during the 1960s and 1970s. The main result from this was identifying a map compiled by the Ministry of Housing and Local Government, *Population change 1951-1961 by wards and civil parishes: compiled from the 1961 census. Scale 1:625,000.* (Ordnance Survey, Southampton, 1966), but this shows wards only as point symbols and says that locations are approximate, so confirming that no accurate statistical mapping was produced at the time.



Figure 4 Peterborough Ward boundaries in 1961



- We contacted the National Archives, the main outcome of which was a formal visit to us seeking to retrieve those maps from St Catharine's House covered by the Public Records Act, which it seems we should never have been given.

Overall, we obtained twenty-six maps from the emailing activities, plus the map of the area covered by the Great London Authority and the four Scottish cities. We include here as examples the maps obtained from Birmingham, the largest 1961 urban government unit by area, and from Peterborough, a much smaller city. These maps were then manually digitized and inserted into our master GIS coverage by Stuart Lanham, our GIS assistant.

**Table 2: Non-London urban ward boundaries drawn from paper maps, listed by population size**

Birmingham CB	1,107,187	Wigan CB	78,690	Wirral UD	21,894
Liverpool CB	745,750	Lincoln CB	77,077	Colne Valley UD	21,298
Bristol CB	437,048	Barnsley CB	74,704	Swadlincote UD	19,221
Leicester CB	273,470	Carlisle CB	71,101	Matlock UD	18,505
Stoke on Trent CB	265,306	Worcester CB	65,923	Holmfirth UD	18,404
Southampton CB	204,822	Peterborough MB	62,340	Kirkburton UD	18,030
Swansea CB	167,322	Wakefield CB	61,268	Belper UD	15,552
Middlesbrough CB	157,395	Harrogate MB	56,345	Skelton and Brotton UD	13,179
Bournemouth CB	154,296	Great Yarmouth CB	52,970	Saltburn & Marske by the Sea UD	12,499
Wolverhampton CB	150,825	Dewsbury CB	52,963	Mirfield UD	12,294
Birkenhead CB	141,813	Bebington MB	52,814	Denby Dale UD	9,380
Huddersfield CB	130,652	Haltemprice UD	42,386	Loftus UD	8,112
Norwich CB	120,096	Batley MB	39,639	Lakes UD	6,061
Grimsby CB	96,712	Spenborough MB	36,417	Mablethorpe & Sutton UD	5,388
Halifax CB	96,120	Hoylake UD	32,273	Bewdley MB	5,041
West Bromwich CB	96,041	Malvern UD	24,382	Wirksworth UD	4,931
Rotherham CB	85,478	Colwyn Bay MB	23,201	Fishguard and Goodwick UD	4,899
Bath CB	80,901	Cwm Bran UD	22,486	Pwllheli MB	3,647

Through these various routes we were able to add boundaries from paper maps for the whole of Greater London plus the 54 cities and towns listed in descending order of population size in table 2. However, this did not include many of the largest cities in the country so wards were added for another 29 towns, as listed in table 3, using some combination of two methods:

- Using the synthesized boundaries for 1971 as discussed above, where the names of these matched those in the 1961 tables. Even where the names of all the wards exactly matched all of those in the table some manual editing was needed, as the approximate external boundaries of the city in the 1971 polygons had to be replaced by the actual external boundaries from the 1961 GIS.
- Where the 1971 ward list did not exactly match the 1961 list, point locations for the non-matching wards were found using the 1:2,500 maps in Digimap Historic, and then Thiessen polygons constructed around these.



Figure 5 Birmingham Ward boundaries in 1961

Table 3: Non-London urban ward boundaries places drawn using methods other than directly from a paper map, listed by population size

Manchester CB	661,791	Plymouth CB	204,409	Walsall CB	118,498
Leeds CB	510,676	Sunderland CB	189,686	Ipswich CB	117,395
Sheffield CB	494,344	Southend On Sea CB	165,093	Oldham CB	115,346
Nottingham CB	311,899	Bolton CB	160,789	Thurrock UD	114,263
Coventry CB	305,521	Salford CB	155,090	Preston CB	113,341
Kingston upon Hull CB	303,261	Blackpool CB	153,185	Pudsey MB	34,851
Bradford CB	295,922	Stockport CB	142,543	Exmouth UD	19,753
Newcastle upon Tyne CB	269,678	Derby CB	132,408	Horsforth UD	15,343
Cardiff CB	256,582	Luton MB	131,583	Brecon MB	5,766
Portsmouth CB	215,077	Reading CB	119,937		

Given the limited time available, our aim here was to ensure we had covered the forty largest towns outside London. The smallest stand-alone towns so covered were Oldham with a population of 115,346 and Preston with a population of 113,341, although some smaller towns were included as a by-product of other work. The

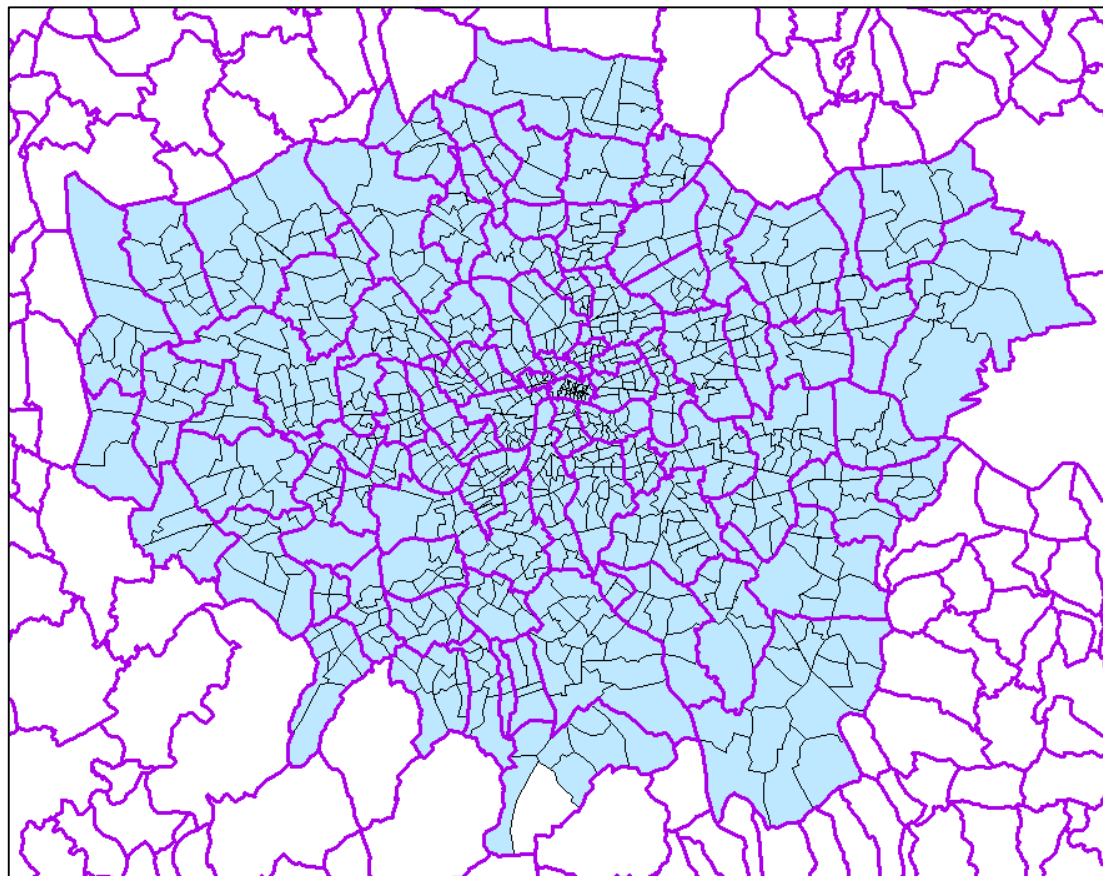
largest town **not** covered was Brighton, the thirty-third largest urban population in England and Wales with 163,159 people spread across nineteen wards. This was the result of our having been promised a paper map from East Sussex archives which showed Brighton, Hastings and Eastbourne, which was ordered in early January but had not arrived by early March.

Table 4 sums up our work on 1961 for England and Wales. Twenty per cent of the population lived in Rural Districts, divided into the already mapped parishes, and another 2.7 per cent lived in small towns which were not divided into wards. The remainder lived in 754 towns which were so divided, and although we have mapped ward boundaries for under a quarter, by concentrating on the larger towns we have covered well over half of the population living in wards. Even so, over a third of the total population were living in subdivided towns we have been unable to map.

**Table 4: Statistics for the division of mapped and unmapped areas into area types in England and Wales**

Area Type	Count	Total Population	% of Total Pop.
Rural Districts	474	9,232,880	20.0
Undivided Urban	239	1,255,413	2.7
Divided, Unmapped	585	16,135,516	35.0
Divided, Mapped	169	19,480,739	42.3
Total:	1467	46,104,548	

Finally, figure 6 presents our 1961 work on London, which has not been emphasized elsewhere but is arguably our greatest success. This map shows 870 wards across 86 separate local government districts, and by itself represents ten days work.



**Figure 6 Borough and Ward boundaries of Greater London in 1961, as added to the GIS**

## Conclusion

This project was an exercise in statistical archaeology, and in particular in locating and assembling historical boundaries from a variety of sources, both paper and digital, to give meaning to the historical statistics and enable their re-districting to modern boundaries. Unsurprisingly, it was only partially successful.

We had expected locating 1961 boundary maps to be hard, but are still surprised that we were unable to find ward boundary maps for most large cities in northern England. As a result, the time and methods we had expected to use to synthesise boundaries for medium sized towns had to go into areas such as Manchester. Longer term, we hope that publicity for the current work will enable us to locate additional maps, and we hope to also use the 1:2,500 maps to create accurate boundaries for small towns near London, enabling accurate analysis of south east England.

What was unanticipated were the mis-matches between 1971-91 data and modern 2011 boundaries, leading to large numbers of persons being “redistricted into the sea”. A significant amount of time had consequently to be spent of developing redistricting procedures which compensated for this. The “Redistricting Loss” column in table 1 records exactly the results we obtained before we did this.

Finally, figure 7 shows the kinds of analysis now possible from consistent population data over multiple decades:

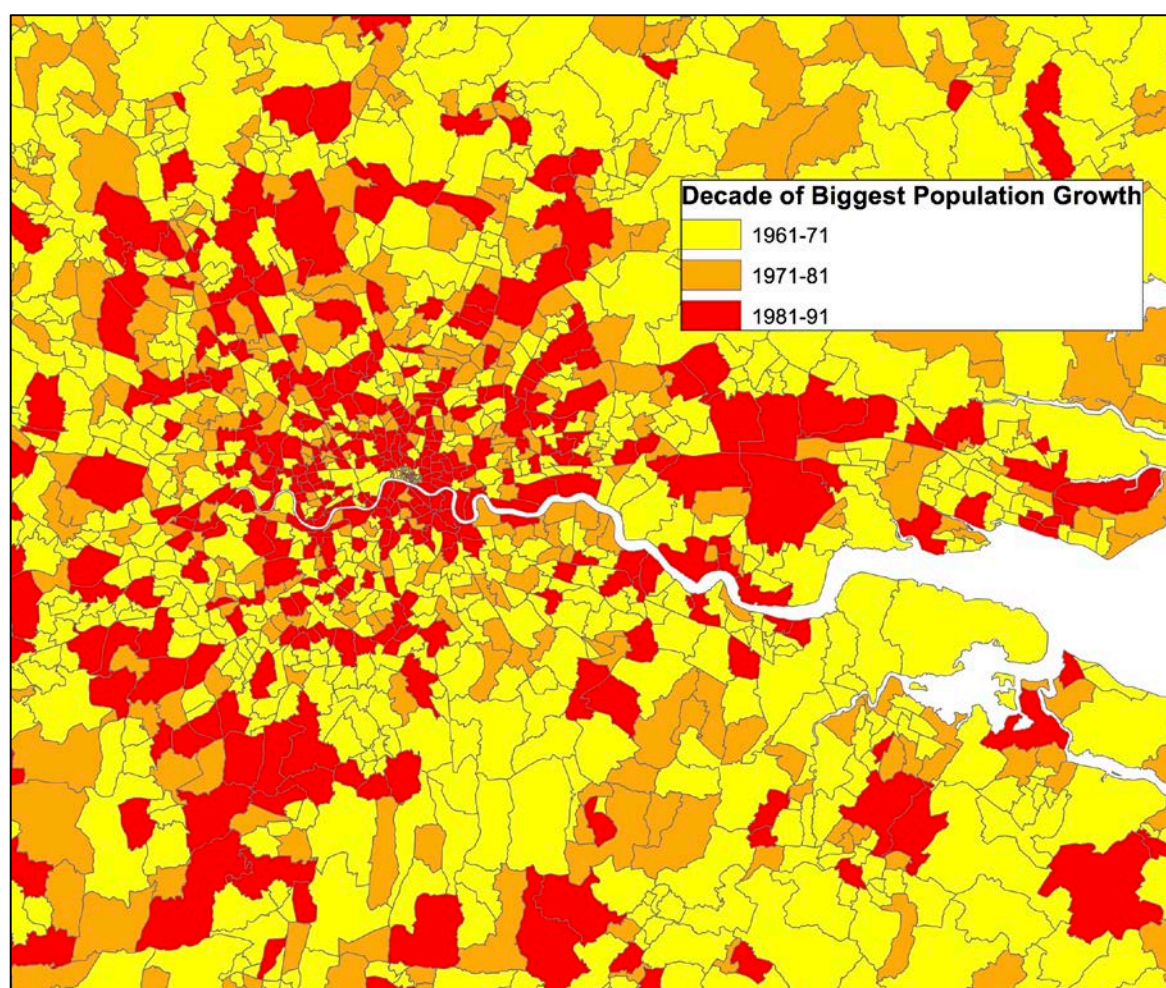


Figure 7 2011 wards for London area, colour-coded to show decade of greatest population change 1961-71-81-91