Introduction

A Year of Preparation

The ISC achieved significant goals during 2000. In operations we very nearly eliminated the publication delay, we offered a wider range of Internet data services, and we implemented a new association algorithm. Financially, we maintained our modest surplus of income over expenditures, partially thanks to development grants and robust sales. In development we replaced our suite of programs for collecting data, completed a complex program required to process data stored in the relational database, and modified our location program so that it can use alternative travel time models and additional types of phases.

Nevertheless, many of the activities at the ISC this year were in preparation for important changes in the near future. Eliminating the publication delay will give the ISC flexibility for seismologists editing the Bulletin to participate more in development projects. The new association algorithm is but one step in an envisaged sequence of improvements. Work under the largest development grant is intended to make more data available from the ISC when it is completed. Collecting data to the database and processing data from it are pre-requisites for improving automatic processing. Modifying the location program was, of course, merely the first stage of preparing for the potentially momentous step of changing the way that the ISC computes hypocentres, which is our most closely watched function.

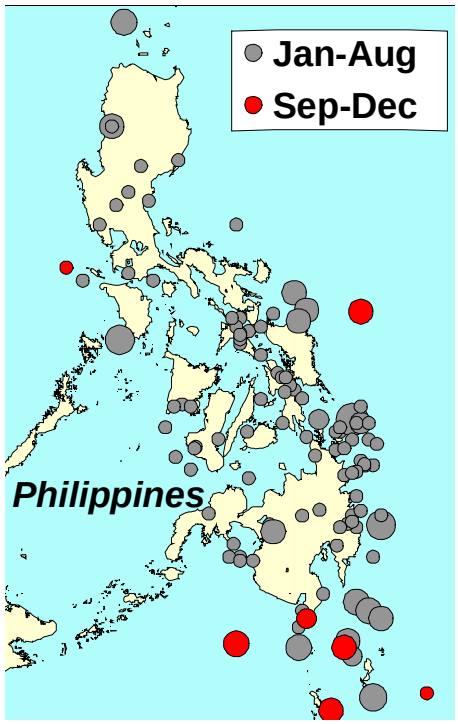
Even in the coming year not all of this preparation will reach fruition. But over the course of 2001 we plan to use a new scheme to select events for manual review and put new programs into use for automatically grouping reported hypocentres, identifying duplicate phase readings, and associating phase readings with events. Late in the year we hope to begin using a new system for editing that will fundamentally change how we work within the Centre. Finally, subject to the approval of the Governing Council at its meeting in August, we hope to begin using *S* and *PKP* arrival times with appropriate travel time tables to significantly improve the accuracy of hypocentres in the Bulletin.

Data Collection

In recent years ISC has received data of the Philippine Institute of Volcanology and Seismology only through NEIC. PHIVOLCS resumed reporting both station readings and hypocentre solutions directly to the ISC from 1998. The hypocentres were introduced to the Bulletin from September 1998, with an obvious improvement in the Bulletin, as shown at right.

New Delhi and Pretoria replaced printed contributions with electronic versions, while JMA added fault plane solutions to its electronic contributions. In each case we previously keyed only selected data, and we are now able to re-publish more. Readings for large events from GSN quality control procedures, which are especially complete in later phases and amplitudes, started contributing to the Bulletin.

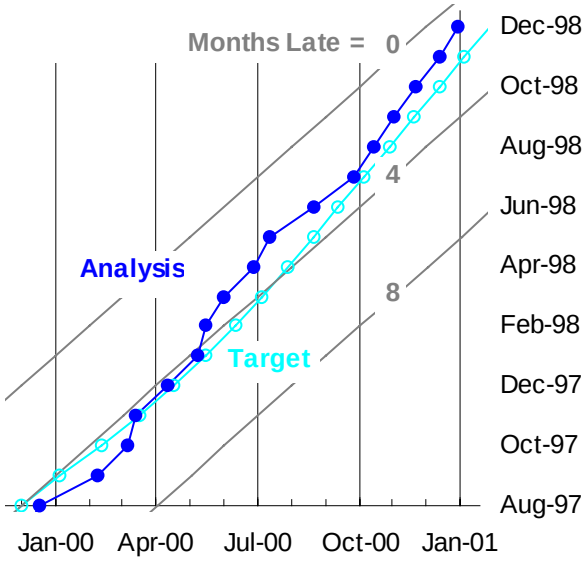
We wound down use of the Data Collection File and planned no further use it in 2001, instead analysing data inserted in our relational database directly from contributions. One advantage is that all contributed data can be inserted, leaving thresholds to be applied only in selecting events for re-analysis.



The 1998 Bulletin includes 111 events that are near the Philippines but lack a PHIVOLCS hypocentre. Only 7, all in the periphery, are from the last four months.

Bulletin Editing

Sixteen months of the Bulletin were edited during 2000. These months included even more events (88,100), hypocentres (201,126), readings (1,637,364) and phases (2,485,473) than the record-setting numbers of 1999. Early in the year the editing staff invested time familiarising a new seismologist with ISC practices and standards, which slowed production in line with expectations, as shown at right. The pace of editing fluctuated during the middle part of the year over a typical range partly as a result of variations in seismicity. Late in the year the ISC benefited from a full complement of experienced editors, data input clerk and supporting programmers. Over the year the team exceeded the ambitious goal established in 1998 of averaging just 40 “seismologist days” to edit each month after allowing for training.



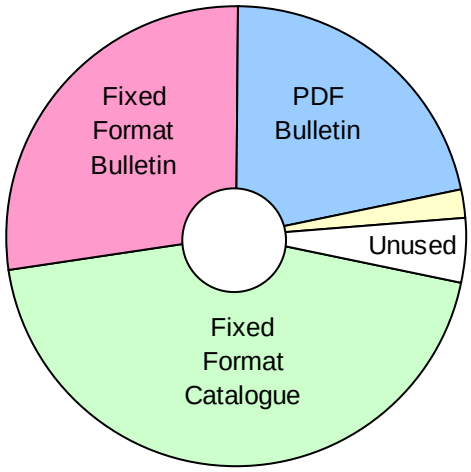
Grey lines show delay behind ISC’s nominal schedule, which is to complete analysis within 23 months of events so that the printed Bulletin can be despatched within 2 years. The target is re-computed when new editors join the staff, using parameters established in 1998.

Production and Distribution

In 1999 the ISC distributed seven bimonthly issues of the Bulletin averaging 181 pages per month and three semi-annual issues of the Catalogue averaging 576 pages per half year. The time between despatching master copies and receiving product from the printer varied between 5 and 6 weeks. Print runs were held at 350 for the Bulletin (215 are required for members and subscriptions) and 350 for the Catalogue (310 are required).

Product	Issue	Distributed
97 Bulletin	Jul/Aug	22-Feb
	Sep/Oct	14-Apr
	Nov/Dec	26-May
	CD-ROM	8-May
98 Bulletin	Jan/Feb	27-Jun
	Mar/Apr	15-Aug
	May/Jun	2-Oct
	Jul/Aug	23-Nov
Catalogue	1997/A	15-Feb
	1997/B	12-Jun
	CD-ROM	31-Jul
	1998/A	30-Oct

The 1997 Bulletin CD was distributed within a few weeks of completing analysis for the year and included Fixed-Format Bulletin files for the current year, Fixed Format Catalogue files for earlier years and PDF files of the long version of the typeset current year Bulletin, averaging 433 pages per month. As shown at right, more than 95% of the 668 Mbytes available on a CD were used. We produced the ISC's first Catalogue CD a few months later, with the data in Fixed Format Catalogue files and IASPEI Seismic Format files, and the typeset catalogue as PDF files. The Catalogue CD was offered to agencies receiving the printed Catalogue without charge as part of data exchange agreements; most indicated that the CD will be acceptable, indeed preferable, to the printed Catalogue in the future.



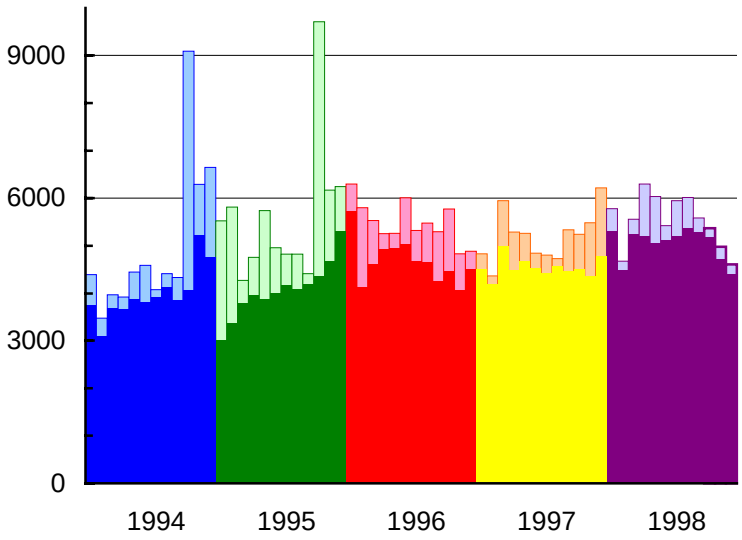
About half of the 1997 Bulletin CD was required for the Bulletin in two formats. Most of the remainder of the disk was used for 1964–1996 Catalogue data.

While the ISC has been posting data to its web since 1998, only shortly before the start of 2000 was the web server's data source changed from a collection of files to the relational database. This enabled the Centre to remove the restriction on queries to a single calendar month, which results in new usage patterns. Over the year, the average rate of database searches grew from 20 per day through the first ten weeks to more than 80 per day during the last twenty weeks of the year. But usage varies sharply from week to week, and averaged more than 1000 per day over each of three separate weeks. Such peaks appear to be due to users making use of the ISC web site as an on-line database and retrieving data for one earthquake after another, which has only a small load on the database server.

The breadth of the community using the ISC web site grew moderately during the year, averaging 60 distinct users per day during the first quarter of the year and 80 per day during the last quarter. Nearly 40% of web site users have IP addresses that we cannot identify with an IP name. About 35% of users are from domains without a country code (.com, .net, .edu, .gov, .org), which are often registered by sites in the United States. The countries occurring most frequently among users with domain names indicating a particular country are Great Britain, Japan and Germany.

1997 and 1998 Seismicity

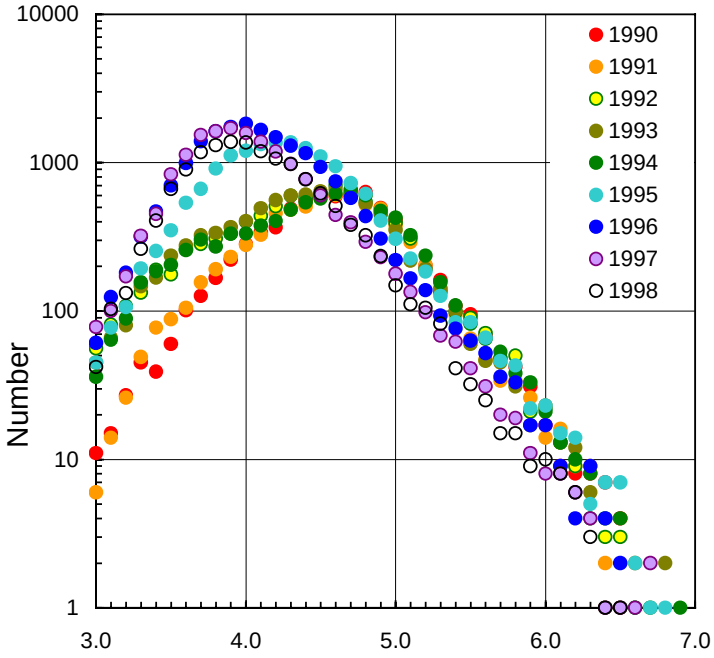
There were fewer great earthquakes during 1997 and 1998 than in other recent years. Since the most prolific aftershock sequences usually follow great earthquakes, we would expect relatively few aftershocks in the Bulletin for these years. There is disagreement about methods for identifying aftershocks from catalogues but the results from one approach, shown at right, seem to confirm expectations.



The numbers of aftershocks and independent events in the Bulletin each month, estimated from ratios of intervals between preceding and following events within a distance that depends on mainshock M_W. *If independent events are a Poisson process then their number varies randomly in a narrow range.*

Despite the recent scarcity of aftershocks, progressively more inclusive data collection resulted in a 1998 Catalogue with more than 98% as many events as 1995, which has the largest annual count of total events to date. With few great earthquakes of late and more small events, the average number of associated readings has fallen from 23 per event in 1995 and 1996, to 21 in 1997, and 18 in 1998. This still exceeds the 16 readings per event of 1993, when the Bulletin included numerous smaller earthquakes in Japan.

The ISC computed its own hypocentre for 47,078 of the 66,031 events of 1998, but teleseismic amplitudes required for the ISC to compute its own m_b were reported for only 14,500 of the ISC hypocentres. In the m_b/frequency relations at right the true relationship is presumed to be log-linear. Roll-off at small m_b results from missing data for some earthquakes. Thus, roll-off at progressively smaller m_b suggests improvement of the completeness threshold. For 1997 and 1998 the linear portions of the observed relations are offset from previous years, partly because of fewer aftershocks. But changes in the stations or procedures used to measure amplitudes that are reported to the ISC might also contribute to the offset.

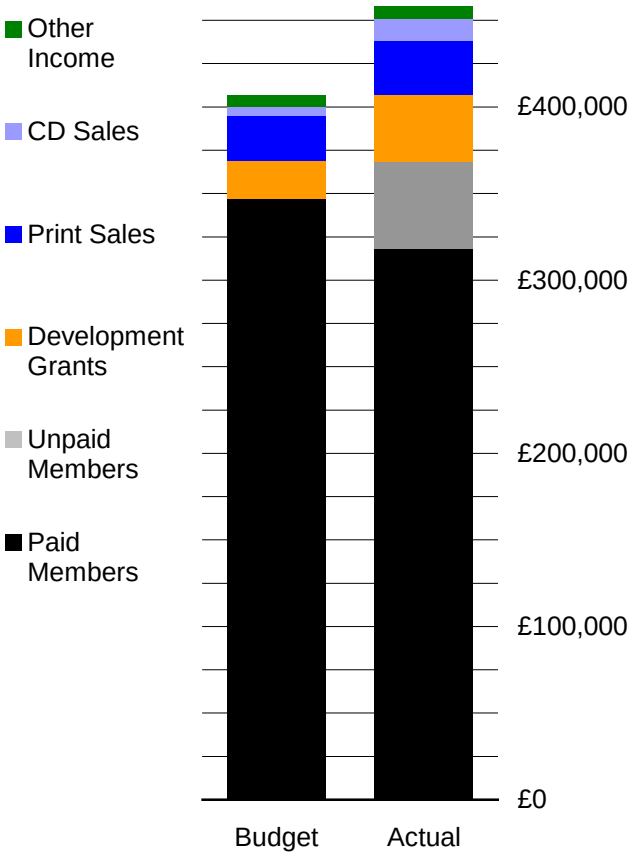


The number of earthquakes to which the ISC assigned each m_b *value, rounded to the nearest 0.1 magnitude unit.*

Income

Member contributions (black and grey) exceeded expectations in the budget from last year's report. This is principally because of exchange rate changes; member invoices, which are almost all in US Dollars, had a higher value when expressed in British Pounds at the end of year rate.

At year-end, nearly 15% of year 2000 membership contribution invoices were unpaid (grey), which is somewhat more than last year. ISC staff members are working with Governing Council members representing organisations that failed to make their contributions to arrange for payments. Some unpaid contributions have been written off, and so appear also as expenditures. Eventual payment of the other contributions is anticipated, but the delays may require the Centre to pay bank charges maintaining and using a line of credit.

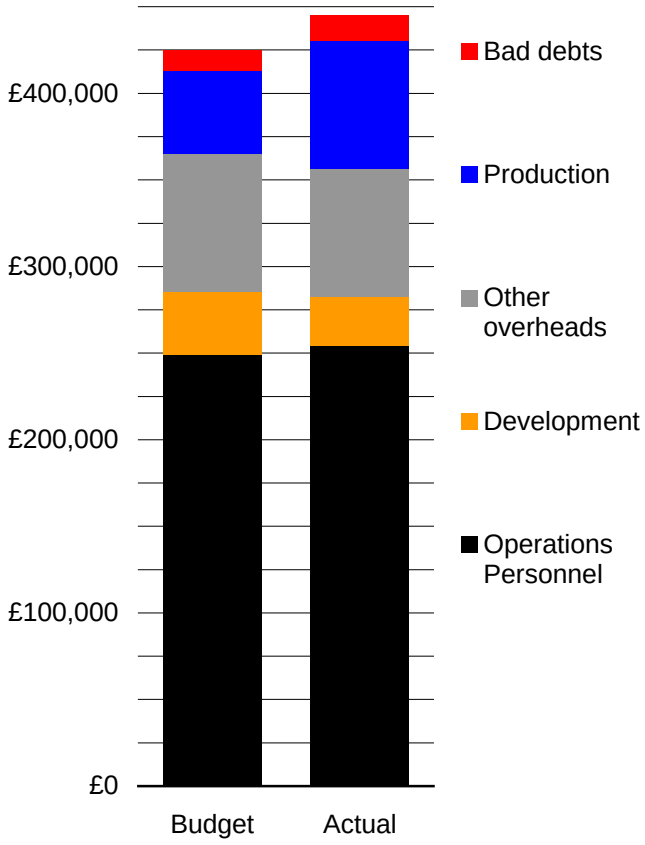


Development grants (orange) were received from the US National Science Foundation to support integration further data into the ISC database, from the Royal Society for a visiting fellowship to study the effect of 3-dimensional earth models in locating ISC earthquakes, and from the European Commission for participation in the EPSI project led by EMSC.

Income from printed products (dark blue) somewhat exceeded expectations, a further improvement on last year that was made possible by nearly complete recovery of the publication schedule, providing an opportunity for sales from earlier in the year. Income from CD sales (light blue) remained strong, once again exceeding budget projections.

Other income (green) consists principally of interest on bank deposits, with minor amounts from associate member contributions and sales of services. This income slightly exceeded expectations due to an increase in associate member contributions.

Total income for the year exceeded the budget by more than 12%. The difference is due to a combination of exchange rate changes, development grants, and robust sales of CDs.



Expenditures

Personnel expenditures (black and orange) are comprised of salaries, pension contributions, recruiting and repatriation expenses. These costs were close to expectations because there were no unanticipated personnel changes. A slight savings arose because hiring for development of an on-line editing system occurred later in the year than planned.

Other overheads (grey) include building expenses, computing expenses, travel by the committee and staff, and exchange rate gains or losses. Building expenses include mortgage payments, which were larger than expected due to changes in the Dollar/Sterling exchange rate. Computing expenses include service contracts, supply purchases, training, and additions to the computer replacement fund. They were less than budgeted because no further training was required. Staff travel costs include participation by ISC seismologists in EGS and AGU annual meetings and the ESC bi-annual assembly, and were slightly less than budgeted. Exchange rate gains and losses are not budgeted and were nearly offsetting because the ISC mortgage debt in US Dollars is comparable to the balance in its US Dollar bank accounts.

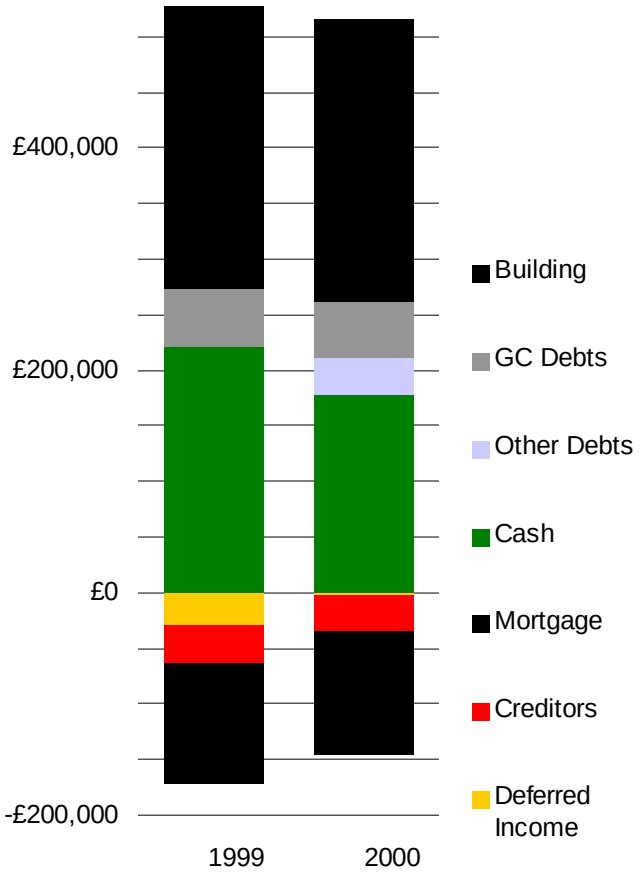
Production costs (blue) are almost entirely for printing and distributing the Bulletin and Catalogue of 1998 events, for which subscribers received invoices during 2000. These costs are partly estimated since several issues were yet to be printed and distributed at the end of 2000. Production costs are larger than anticipated because of a combination of an increased charge per page printed, an increased number of pages per issue of both the Bulletin and the Catalogue, and production of one more issue of the Catalogue than budgeted for.

Unpaid contributions that are not likely to be paid within another year are provided for as bad debts (red) and appear as expenditures to remove them from the ISC list of assets. This year, bad debt provisions were larger than allowed for in the budget as the result of receiving a statement from the CSB that their contributions for 1999 and 2000 will be at a lower level than previously, withdrawals by Thailand and the Philippines, and the backlog of unpaid contributions by Yemen reaching three years.

Operating costs are expenditures exclusive of bad debt provisions and special charges, of which there were none this year. Operating costs were 4.2% more than budgeted, despite modest savings on overheads, primarily due to production costs in excess of expectations.

Assets

The net value of the ISC's liquid assets is the difference between cash and creditors, shown in green, red and yellow at the right. This includes bank balances required for the exchange rate stabilisation and computer replacement funds. The net liquid assets of the Centre decreased during 2000 from £158,000 to £143,000. Ongoing lateness of some member contributions limits the ISC's liquidity, but the decline is principally due to expenditure related to an NSF development grant, for which payment is expected in early 2001. Liquid assets provide the ISC with the cash flow required to operate without drawing on committed reserves. Setting aside the exchange rate stabilisation and computer replacement fund balances, at year-end the ISC's unencumbered liquid assets stood at £77,000, which is sufficient to continue operations for three months.



Current debts owed to the ISC (grey and blue) consist of unpaid membership invoices, including, at year-end, the 1999 ING (Italy) and 2000 ING, French, and New Zealand invoices. The net value of the ISC's current assets is the sum of its liquid assets and current debts, shown in colours other than black. Net current assets increased during 2000 from £209,000 to £230,000, partly because assets in US Dollars grew more valuable when expressed in British Pounds due changes in the exchange rate. With these net current assets, the ISC could continue operating without 2001 contributions for approximately seven months, but only if all contributions due by 31 December were paid and the Executive Committee authorised use of funds that are normally reserved.

The ISC's net tangible assets are the difference between the assets (above the "0" line) and liabilities (below the "0" line) shown in black in the figure above. A decrease in net tangible assets from £146,000 to £142,000 arose due to an increase in the mortgage balance. The ISC paid 4% of the original principal of the mortgage, as set out in the terms of the loan, but the remaining balance in British Pounds grew due to the increase in the relative value of US Dollars. The ISC plans to continue paying down its mortgage debt leading to long term growth of net tangible assets, but in the short run fluctuations in the Dollar/Sterling exchange rate might lead to further increases or faster than expected decreases.

The net value of the ISC's total assets, represented by the difference between all assets and liabilities in the figure above, increased from £355,000 to £372,000 during 2000. This is well within British guidelines for assets of charitable organisations, which suggest that net total assets should not normally be much more than twice the annual operating expenditures, over £800,000 in the ISC's case.

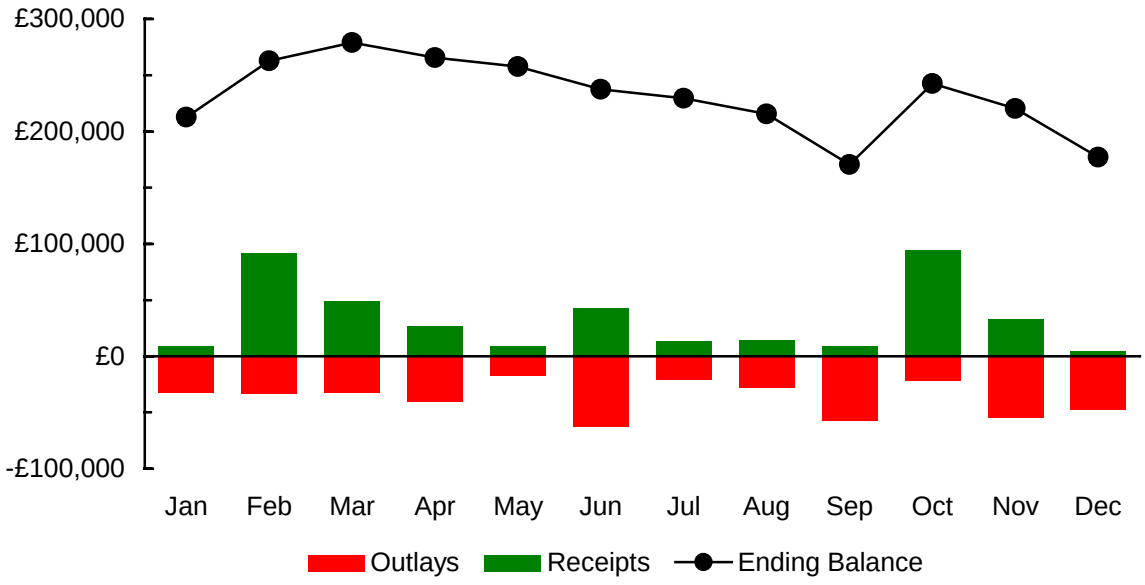
Excess Income and Net Assets

The ISC recognises income from capital-purchase grants only when the capital purchases are made, so that capital-purchase grant income and grant-funded capital expenditures are exactly offsetting. In conformance with generally accepted accounting principles, grant income and capital purchases treated in this way are not shown as income or expenditures, and the value of purchased equipment is not shown as an asset.

If capital grants are received and purchases made in different years, however, there will be an effect in the financial statements. During 1999, the ISC received no capital purchase grants but transferred £5,000 to the computer replacement fund for future capital purchases. Consequently, the increase in net assets of £18,000 exceeded the surplus income of £13,000.

Cash Flow

The cash flow figure below shows receipts and outlays using dates when transactions were recorded at the bank, and bank balances with US Dollars converted to British Pounds using the exchange rate as of 1 January 2000. Cash flow does not show credit extended to the ISC, debts owed to the ISC, or commitment of assets, such as the exchange rate and computer replacement funds. Receipts were large in February and October, when contributions of the Royal Society and the National Science Foundation were recorded. Outlays were large in June, September and November when the bank delayed recording salary payments from the preceding month. Other outlay fluctuations result from quarterly mortgage payments and invoices to print the Bulletin and Catalogue.



During 2000 ISC bank balances never fell to a level that suggests the ISC might need to use short-term credit. Nevertheless, the ISC maintained a £40,000 line of credit at Lloyds Bank, using the net value of its land and building as collateral. The NSF development grant provides an example of why short-term credit might be needed. NSF's award letter in early 2000 was a commitment to reimburse the ISC for costs related to the purposes of the grant, and on this basis the ISC started to spend. But NSF actually made payment in early 2001 after the ISC submitted a report documenting expenditures already made.

Computing Infrastructure

Computing infrastructure is comprised of computers, disk systems, printers and other computer hardware, plus purchased software including operating systems, data management systems, and business applications.

As a result of investment during 1997-1999, spending required for computing infrastructure during 2000 was limited. Thanks to high-capacity Ethernet cards purchased with all recent computers, the ISC was able to alleviate a LAN bottleneck with an inexpensive 100 Mbit/s hub. The PC used by the Honorary Secretary was ceded to him on his retirement.

Operating system upgrades and patches for the Suns were provided as part of service contracts. The contract with Rutherford-Appleton Laboratory for Internet service and a British Telephone 64 kbit/s leased-line was renewed for one year at a rate comparable to that for the past three years. The ISC's Oracle 8 license was re-negotiated as a result of an increased number of users and changes in pricing, resulting in a change in the annual fee from £1000 to £1300. The most expensive hardware service contract is for the line printer, which requires service regularly.

ISC Computing Equipment
as of 1 January 2001

CPUs:

- Sun 250, and internal disks. Sun service contract.
- 2 Sun Ultra 1's (1997) and 5 Sun Ultra 10's (1998), Sun service contract.
- 4 desktop PCs (1998), no service contract.
- 1 laptop PC (1999), no service contract.

Peripherals:

- Line printer (1990), Compaq service contract.
- PostScript Printers: 2 Ethernet laser printers (1995, 1998); PC laser printer (1998); Ethernet colour ink-jet printer (1998).
- Scanner (1998) and CD writer for PC (1999).
- Sun disk multipack and disks (1997, 1998, 1999) and Sun DLT (1997) and DAT (1998) drives, Sun service contract.

Commitment of £5,000 to the computer modernisation fund was complemented by interest of £3,000 earned on the bank account for the computer modernisation and exchange rate stabilisation funds, increasing the computer fund balance from £28,000 to £36,000.

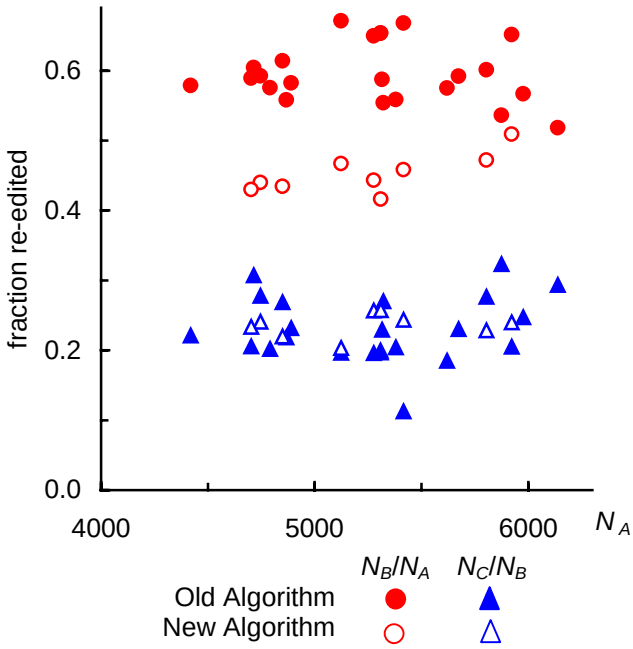
Software Development

Major Software Development Completed

Collect data directly to the database: One reason for updating ISC's data management is to allow storing new types of data without modification of unrelated software. Thus, collecting data to the relational database was an important step forward. Because data are received in many different formats, dozens of programs had to be written. Data that were formerly embedded in strings with typesetting sequences are now stored numerically, benefiting users who can more easily parse data from ISC products. The new type of data most important within the ISC is reported associations, which will be used soon in automatic processing.

Write Working Tape Format (WTF) files from the database: The overall strategy in updating data management is to generate WTF files from the relational database until programs are modified to query and update the database directly. Thus, completing "RDB-to-WTF" was essential for allowing us to use data collected to the database. This data extraction program is complex because the WTF files it writes incorporate complex data structures that support editing. In addition, the program was developed to meet requirements that evolved as database schema was modified based on initial experience in data collection.

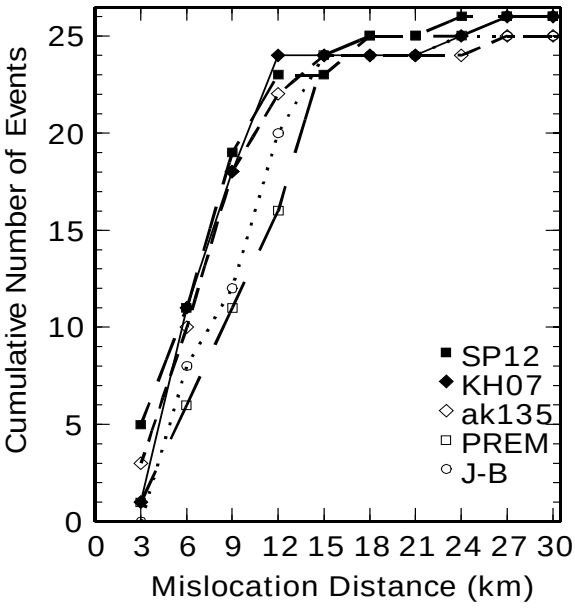
Improved phase association: The figure at right shows that after we implemented a new association algorithm for events from April, the proportion of events requiring a second review in B-pass fell by about a quarter. We have analysed no extraordinary aftershock sequences in the nine months edited since the new algorithm was implemented, but otherwise the number of A-pass events spans the range that we normally encounter. The proportion of events re-edited was greatest in the month with the most A-pass events, but this was also just the second month the algorithm was used. It is not yet clear whether or not very many events in a month might affect the performance of the new association algorithm. The proportion of B-pass events that are edited yet again is unchanged. Many later pass edits are unrelated to association, *e.g.* imposing different location constraints, and changes in automatic association will not reduce their number much.



The ratios of numbers of events printed in listing files for different passes of the last 15 months before implementing a new association algorithm and the first 9 months after. Edited events are printed in the next pass, so the fraction of events re-printed is the fraction in which an editor recognised an error in the earlier pass.

Other Significant Computer-Related Projects

Compute hypocentres using alternative travel-times: To prepare for updating ISC hypocentres, the ISC location program was modified to be more easily linked with new travel time functions. In one test, the modified program was linked with travel time functions for several different tomographic mantle models and epicentres were re-computed for explosions with known locations. The tests barely recovered the accuracy of Bulletin locations, which are based partly on local and regional arrival times. As shown at right, however, when teleseismic times alone are used, accuracy of the ISC location program is better with modern 1-D travel time models than with J.-B. travel times, and slightly better still with 3-D tomographic models.



For 26 explosions relocated using 3-D earth models, mislocation is the difference between the known and the computed epicentres. Models that lead to more accurate epicentres plot further to the left.

Compute hypocentres using additional arrival times: To further prepare for updating ISC hypocentres, the ISC location program was modified to use arrival times from additional phases. In a test using J.-B. *P* and *S* travel times, the proportion of events from 1997 October for which ISC an hypocentre could not be

computed was reduced from 30% to 15%. Among events for which the ISC had been able to compute a hypocentre from *P* times alone, fewer than 10% of the hypocentres were changed by as much as 20 km as a result of introducing *S* arrival times.

Waveform retrieval to the ISC: Programs were developed to retrieve waveform data for events in the ISC database. The programs allow users to select events and stations, compose and despatch e-mail requests based on locations in the ISC database and computed travel-times, and alerts the user who made the request when a response is received. Users can then use Geotool or SAC, which have been installed on ISC computers, to view the waveforms.

Post recently-collected readings and waveform links to the web site: Improving user services by making collected data available sooner after earthquakes occur is an important goal, and began this year when the ISC started posting recently collected arrival times to its web site. Other improvements to user services this year include posting links to data sets assembled for important events at other waveform archive centres and implementing an AutoDRM server that allows users to retrieve Bulletin selections by e-mail.

Personnel Changes

ISC Staff as of 1 January 2001

Dr Raymond J Willemann, Director
Dr Dmitry Storchak, Senior Seismologist
Mrs Maureen Aspinwall, Fin & Admin Officer
Mr James Harris, System & DB Administrator
Mr Mamy Andrianirina, Seismologist
Ms Esmeralda Banganan, Seismologist
Dr Peter Dawson, Applications Manager
Dr Richard Luckett, Applications Developer
Mr Cliff Allen, Data Preparation Assistant
Mr Tom Bayliss, TCS Associate

Dr Noureddine Beghoul left the ISC in February after completing the bulk of development of a new association algorithm.

Ms Esmeralda Banganan joined the ISC on a two-year appointment in January. Ms Banganan earned her B.Sc. and M.Sc. degrees in physics and engineering at the University of the Philippines and brings 7 years of experience working in regional seismology and hazard analysis with the Philippine Institute of Volcanology and Seismology. She has had training in global seismology in Tsukuba, Japan, in instrumentation and siting with the CTBT Preparatory Commission in Vienna, Austria, and in seismic hazard analysis sponsored by Kanto Gakuin University and GeoForschungsZentrum, Potsdam.

Dr Richard Luckett joined the ISC in March. Dr Luckett holds a B.Sc. in physics from Bath University and a 1996 Ph.D. in seismology from Leeds University, where he worked with Dr Jurgen Neuberg. Dr Luckett has experience in seismic operations from a survey in Africa and from working at the Montserrat Volcano Observatory since completing his Ph.D. and he is an accomplished programmer, with years of experience in Unix software development.

Mr Matt Evans, a student in the University of Leeds M.Sc. geophysics programme, worked at the ISC during his summer break to create a waveform retrieval system for the ISC.

Mr Mamy Andrianirina agreed to a one-year extension of his appointment at the ISC that runs until 2001 November.

Mr Thomas Bayliss started working at the ISC in December as an employee of the University of Reading. Mr Bayliss earned an M.Sc. from Keele University in computational geophysics, a programme that trains geophysicists software development. He concentrated on seismology in his B.Sc. and M.Sc. programmes and has experience developing graphical user interfaces (GUI), including for an EU-funded project to map seismic hazard in Greece.

User Survey

The ISC conducted a survey of users during 2000 that consisted mostly of questions to which respondents could select any number of several choices, with an option to indicate their most important selection. The web-site form was used by most, but responses were received also by way of e-mail and the post. The most common uses of ISC data among respondents are seismic hazard analysis (45% of respondents), seismotectonics (41%) arrival-time tomography (31%), and earthquake physics (24%). One-quarter of respondents use ISC data to select waveforms for further study. Half of all respondents report that they use ISC data at least monthly, and 55% of them that they often use the web site to obtain the data. The most often used other sources of ISC data are the CD (35%) and the printed Bulletin (31%). Two-thirds of respondents use ISC epicentres and magnitudes, while arrival times, epicentres and magnitudes reported by other agencies were each used by about half of all respondents. Intensity values and macroseismic reports are used by 40% of respondents. The least frequently used data are phase amplitudes and source parameters other than moment tensors.

The most frequently selected answer in the survey came in response to a question about the printed Bulletin: given that phase data are printed for only some earthquakes, 73% of respondents answered that they should be included for large earthquakes. Just 43% selected the second most common choice for this question, that phases should be printed for events unusually far from other earthquakes. Slightly more than half of respondents indicated their most important choice for this question, and of these 57% chose large earthquakes and 25% chose unusually isolated events.

A printed summary and a monthly CD could meet the needs of 39% of respondents with the full set of phase data. The most important features of a summary would be statistics of initial phase types, arrival time residuals, and station magnitudes. If an enhanced CD were developed however, 63% of respondents answered that a program with a graphical interface for selecting events would help to satisfy needs now met by the printed Bulletin. Of respondents seeking a graphical interface, 68% indicated that Microsoft Windows was their preferred platform, while 19% preferred X-windows, 6% Macintosh, and 6% expressed no preference. Other widely sought enhancements included separate PDF files for various subsets of events (47%) a program to produce maps (41%) and Fortran or C subroutines for reading ISC data that are more easily linked into users' own programs (31%).

Scientific Liaisons

ISC staff members analyse the Bulletin in order to plan or evaluate improvements to the Bulletin, and to help users take full advantage of ISC data. Analyses of broad interest are presented in conferences or seminars, and sometimes published in peer-reviewed journals. The status of papers by ISC staff that were published in or submitted to journals during 2000 are tabulated at right.

Peer-Reviewed Publications by ISC Staff

D A Storchak, A L Bird & R D Adams (2000). Discrepancies in earthquake location between ISC and other agencies, *J. Seis., 4*, 321-331.

R J Willemann and D A Storchak (2001). Data collection at the ISC, *Seis. Res. Lett*. (*in press*).

Q-f Chen and R J Willemann (2001). Earthquake locations using 3-D earth models, *Bull. Seis. Soc. Amer.* (*submitted*).

During 2000 ISC staff made a total of 8 presentations with published abstracts at conferences of the European Geophysical Society, the European Seismological Commission, the American Geophysical Union, and CO-DATA, and gave lectures at the the Universities of Cambridge and Leeds, and at the British Geological Survey, Edinburgh. We also visited AWE Blacknest, attended seminars at the University of Oxford, and participated regularly in London meetings of the Royal Society, the Royal Astronomical Society, and the Society of Earthquake and Civil Engineering Dynamics. The ISC participated in the kick-off and first regular meeting of EPSI, a project co-ordinated by the EMSC to develop a Europe-wide bulletin. ISC staff members continue subscriptions to Nature, the Journal of Geophysical Research, and Geophysical Journal International.

2000 Visitors to ISC

James Anderson, U. Reading
Chris Argent
Eric Bergman, Global Seis. Serv.
Jackie Bott, Brit. Geol. Surv.
Chris Browitt, Brit. Geol. Surv.
Neal Cryer, Teaching Co. Direc.
Adam Dziewonski, Harvard U.
Jens Havskov, U. of Bergen
Rachel McCrindle, U. Reading
Deiter Mayer-Rosa, ETH Zurich
Bernard Minster, U. California
Patrick Smit, Imperial College
Oleg Starovoit, Rus. Acad. Sci.
Graham Sutton, Reading U.
Gordon Woo, Risk Mgmt. Solns.
John Woodhouse, Oxford U.
Akio Yoshida, Japan Met. Agcy.
John Young, AWE

Citations of ISC Data in 2000

The ISC has only a limited knowledge of how its data are used. Users often do not inform the ISC when they publish research that uses of ISC data. Unfortunately, therefore, the list below of papers using ISC data is incomplete.

Ambraseys, N., and J. Douglas, Reappraisal of surface wave magnitudes in the Eastern Mediterranean region and the Middle East, *Geophys. J. Int.*, *141*, 357-373, 2000.

Antolik, M., G. Ekström, A.M. Dziewonski, and L. Boschi, Utilizing three-dimensional seismic velocity models in regional and teleseismic event location, in *21st Seismic Research Symposium*, pp. 346-351d, Las Vegas, Nevada, 2000.

Berberian, M., J.A. Jackson, M. Qorashi, M. Talebian, M. Khatib, and K. Priestly, The 1994 Sefidabeh earthquakes in eastern Iran: blind thrusting and bedding-plane slip on a growing anticline, and active tectonics of the Sistan suture zone, *Geophys. J. Int.*, *142*, 283-299, 2000.

Bernard, M., D. Reiter, Shirley Rieven, W. Rodi, and C. Vincent, Development of a 3-D model for improved seismic event location in the Pakistan/India region, in *21st Seismic Research Symposium*, pp. 374-382, Las Vegas, Nevada, 2000.

Bijwaard, H., and W. Spakman, Non-linear global P-wave tomography by iterated linearized inversion, *Geophys. J. Int.*, *141*, 71-82, 2000.

Boschi, L., and A.M. Dziewonski, Whole Earth tomography from delay times of P, PcP, and PKP phases: Lateral heterogeneities in the outer core or radial anisotropy in the mantle?, *J. Geophys. Res.*, *105*, 13675-13696, 2000.

Bowers, D., D.A. McCormack, and D.S. Sharrock, Observations of PKP(DF) and PKP(BC) across the United Kingdom: implications for studies of attenuation in the Earth's core, *Geophys. J. Int.*, *140*, 374-384, 2000a.

Bowers, D., R.G. Pearce, and A. Douglas, Using regional geophysical databases to facilitate the identification of surface reflections on P seismograms, *Geophys. J. Int.*, *142*, 915-924, 2000b.

Bunge, H.-P., and S.P. Grand, Mesozoic plate-motion history below the northeast Pacific Ocean from seismic images of the subducted Farallon slab, *Nature*, *405*, 337-340, 2000.

Castle, J.C., K.C. Creager, J.P. Winchester, and R.D.v.d. Hilst, Shear wave speeds at the base of the mantle, *J. Geophys. Res.*, *105*, 21543-21557, 2000.

Engdahl, E.R., S.H. Kirby, and A. Villasenor, New results of a global investigation of slab morphology and seismicity using arc-centric projections of reprocessed hypocenters with a high-resolution tomographic model, *Eos*, *81*, F1080, 2000.

Engdahl, E.R., and M.H. Ritzwoller, Use of Teleseismic P and S Station Corrections to Constrain and Validate a 3-D P- and S-wave Velocity Model of the Eurasian Upper Mantle, *Eos*, *81*, S, 2000.

Font, Y., H. Kao, C. Liu, and S. Lallemand, Seismogenic patterns near the interplate thrust zone in the Ryukyu Arc-Taiwan junction area: preliminary results from 3-D earthquake relocation, *Eos*, *81*, F1080, 2000.

Garcia, R., and A. Souriau, Amplitude of the core-mantle boundary topography estimated by stochastic analysis of core phases, *Phys. Earth Planet. Int.*, *117*, 345-359, 2000.

Garcia-Castellanos, D., M. Torne, and M. Fernandez, Slab pull effects from a flexural analysis of the Tonga and Kermadec trenches (Pacific Plate), *Geophys. J. Int.*, *141*, 479-784, 2000.

Goes, S., R. Govers, and P. Vacher, Shallow mantle temperatures under Europe from P and S wave tomography, *J. Geophys. Res.*, *105*, 11153-11169, 2000.

Gorbatov, A., S. Widiyantoro, Y. Fukao, and E. Gordeev, Signature of remnant slabs in the North Pacific from P-wave tomography, *Geophys. J. Int.*, *142*, 27-36, 2000.

Henry, C., S. Das, and J.H. Woodhouse, The great March 25, 1998 Antarctic Plate earthquake: Moment tensor and rupture history, *J. Geophys. Res.*, *105*, 16097-16118, 2000.

Kaiho, Y., and B.L.N. Kennett, Three-dimensional seismic structure beneath the Australasian region from refracted wave observations, *Geophys. J. Int.*, *142*, 651-668, 2000.

Lees, J.M., Implications of slab tear on geodynamics, seismology and volcano geochemistry, *Eos*, *81*, F1080, 2000.

Maggi, A., J.A. Jackson, K. Priestley, and C. Baker, A re-assessment of focal depth distributions in southern Iran, the Tien Shan and northern India: do earthquakes rally occur in the continental mantle?, *Geophys. J. Int.*, *143*, 629-661, 2000.

Maus, S., Is there an observable lack of reciprocity in PKP(DF) traveltimes?, *Geophys. J. Int.*, *143*, 274-277, 2000.

Moore, M.A., H.J. Anderson, and C. Pearson, Seismic and geodetic constraints on plate boundary deformation across the northern Macquarie Ridge and southern South Island of New Zealand, *Geophys. J. Int.*, *143*, 847-880, 2000.

Morikawa, N., and T. Sasatani, The 1994 Hokkaido Toho-oki earthquake sequence: the complex activity of intra-slab and plate-boundary earthquakes, *Phys. Earth Planet. Int.*, *121*, 39-58, 2000.

Myers, S.C., and C.A. Schultz, Improving sparse network seismic location with Bayesian Kriging and teleseismically constrained calibration events, *Bull. Seis. Soc. Amer.*, *90*, 199-211, 2000.

Nicholson, T., M. Sambridge, and O. Gudmundsson, On entropy and clustering in earthquake hypocentre distributions, *Geophys. J. Int.*, *142*, 37-51, 2000.

Okal, E.A., and A.R. Langenhorst, Seismic properties of the Eltanin Transform System, South Pacific, *Phys. Earth Planet. Int.*, *119*, 185-208, 2000.

Reif, C., and G. Masters, A comparison of long and short period travel times, *Eos*, *81*, F289, 2000.

Röhm, A.H.E., h. Bijwaard, W. Spakman, and J. Trampert, Effects of arrival time errors on traveltime tomography, *Geophys. J. Int.*, *142*, 270-276, 2000.

Schoeffel, H.J., and S. Das, Seismological constraints on dynamics of subducting slabs, *Eos*, *81*, F1080, 2000.

Shearer, P., Relocation of global events using the L1 norm and source specific station corrections, in *21st Seismic Research Symposium*, pp. 633-638, Las Vegas, Nevada, 2000.

Slancova, A., A. Spicak, V. Hanus, and J. Vanek, Delimitation of domains with uniform stress in the subducted Nazca plate, *Tectonophysics*, *319*, 339-364, 2000a.

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Souriau, A., and G. Poupinet, Inner core rotation: a test at the worldwide scale, *Phys. Earth Planet. Int.*, *118*, 13-27, 2000.

Thurber, C., F. Haslinger, and C. Trabant, Testing event location capability with ground truth events in Kazakstan, in *21st Seismic Research Symposium*, pp. 283-293, Las Vegas, 2000.

Vanek, J., A. Spicak, and V. Hanus, Position of the disastrous 1999 Puebla earthquake in the seismotectonic pattern of Mexico, *Bull. Seis. Soc. Amer.*, *90*, 786-789, 2000.

Widiyantoro, S., A. Gorbatov, B.L.N. Kennett, and Y. Fukao, Improving global shear wave traveltime tomography using three-dimensional ray tracing and iterative inversion, *Geophys. J. Int.*, *141*, 747-758, 2000.

Zhao, D., A New Model of Whole Mantle Seismic Tomography, *WPGM Meeting*, 2000a.

Zhao, D., A Plume-Like Slow Anomaly Under the Subducting Pacific Slab Beneath Central Japan, *Western Pacific Geophysics Meeting*, 2000b.

Status of Earlier Plans

The table at right, derived from the 1999 Director's report, shows that the ISC successfully carried out nearly all of its plans for 2000. Even while training a new editor and introducing a new association algorithm, two more months were edited than planned. Bulletins, Catalogues and CDs were all despatched promptly. We made progress establishing a new standard for data exchange and encouraging contributors to replace printed bulletins with Internet versions. In our own data services, we added an e-mail server and new content. Only minor computing infrastructure improvements were required, but we modified our own applications to prepare for changes in operations. Spending nearly matched expected income, as planned, and further funding for development was obtained.

JAN 2000 STATUS	PLANS FOR 2000		JAN 2001 STATUS
Data Analysis			
• Five months behind	• Edit 14 months	☑	• One month behind
• 2 full-time editors	• Train new seismologist	☑	• 3 experienced editors
• Marginal auto assoc.	• Implement new algorithm	☑	• Clear improvement
• Edits require data entry	• Develop an alternative	☒	• Personnel on hand
Data Exchange			
• No standard format	• Complete ISF with NEIC	☑	• NEIC sends in ISF
• 1 wk. entry / mo.	• Solicit Internet contrib.	☑	• 1 day entry / mo.
Internet Data Services			
• Web is only method	• AutoDRM e-mail	☑	• Working reliably
• Bulletin is only content	• Post collected data	☑	• 1999 readings on-line
	• Rescue unassoc. readings	☒	• Code mostly ready
	• Integrate EHB Bulletin	☒	• Awaiting release
Computing			
• LAN bottleneck	• Upgrade to 100 Mbit/s	☑	• No LAN problems
• Losing reported assoc.	• Collect data to database	☑	• All data collected
• Locate with only JB P	• Modify locn. program	☑	• Options available
Finances			
• Surplus from 1997-99	• Spend current income	☑	• General reserve stable
• Develop. funds avail.	• Seek further	☑	• DTI funding secured

We set ambitious goals and made substantial progress towards each of them. Challenges in co-ordinating different aspects of internal development and work with other organisations characterise the tasks on which we were did not get as far as planned:

Alternative Editing System: Start of this work was postponed from mid-year due while taking time to identify the best outside experts to help plan the system, securing funding, and seeking an appropriate developer to carry out the work. By December all of these components were in place and detailed requirements were being prepared.

Rescue Unassociated Readings: We developed software to read ISC binary-format data files and insert unassociated readings in the relational database. The software was adapted to read different varieties of ISC data files used as long ago as 1980 but transcribing large amounts of data was postponed pending a re-organisation of the database during 2001.

Integrate the EHB Bulletin: Release of an updated EHB bulletin was postponed while the authors refined their processing; a definitive release incorporating the 1998 ISC Bulletin was planned for the first quarter of 2001. Most of the software required for integration, which also supports similar aspects of ISC operations, will be ready before the release.

Plans for Data Collection

The prototype IDC has not released their bulletin, the REB, since 20 February 2000, while the CTBTO Preparatory Commission has yet to approve release of the REB produced by their own IDC. ISC staff members continue to make the case for the importance of this bulletin to global seismic monitoring. We hope that release of the REB will be recommended by Working Group B at its meeting in June 2001 and that the Preparatory Commission will adopt the recommendation at its first meeting thereafter.

Contributions from Africa and South America remain more sparse than is desirable, and we continue contacting agencies from those regions to encourage contribution of further catalogues and bulletins. The ISC has continued to increase the sources proportion of data that are sent electronically rather than in print; during 2000 we will continue working with Albania, Saudi Arabia, and others to replace printed bulletins with e-mail contributions.

ISC staff hope to see extensions of IMS1.0 formally adopted by the Commission on Practice as IASPEI Seismic Format (ISF) at the IASPEI Assembly in August 2001. Wide use of ISF for exchanging parametric data would reduce the level of effort required to parse contributions. We have urged authors of software such as SeisAn, to adapt their systems to both read and write ISF bulletins and other data centres to make their data publicly available in ISF. ISF is the default format for ISC data on the Internet, and the Catalogue CD includes events in ISF. For earthquakes from 1999 nearly all earthquake parameters and macroseismic data will be fully ISF formatted.

Plans for Data Processing

During the earliest part of 2001 ISC developers will concentrate on supporting the transition from analysis of data taken from the Data Collect File collected to analysis of data parsed directly to the relational database. Thresholding and formatting of some data into comments have been deliberately removed from data collection and the replacement procedures used in preparing the analysis files from the database require a shakedown period during their first few months of use in operations.

After this shakedown period, ISC developers will implement database procedures to automatically group hypocentres into events, identify duplicate readings, and associate readings with events. We expect database procedures to be more accurate than the program currently used in operations because more complete information is available in the database on the reporter and relations between data. An additional benefit is that the database procedures can be re-run promptly when each contribution is received. In effect, this creates a preliminary ISC bulletin that can be offered to users of the ISC web site and e-mail service using the same programs that we have written to provide the final Bulletin on the Internet.

Pending approval by the Governing Council in August, later during 2001 ISC developers plan to concentrate on programming and testing related to use of additional phases and a new travel time model to compute hypocentres to be used in analysis and printed in the Bulletin.

Plans for Data Analysis

Ms Banganan is contracted to work at the ISC through January 2002, and may work in the UK legally through January 2003. The ISC is likely to offer Ms Banganan an extension, but she might may not accept it if her permanent employer declines to extend a leave of absence. Mr Andrianirina works at the ISC under an extension to his contract, but may work in the UK legally only through November 2001. To avoid replacing two editors within a short time, we might hire a new seismologist several months before either departs, operate with just two editors until a replacement is trained, or seek an extension of Mr Andrianirina's work permit.

Since we are now collecting all data from contributed reports, we will now select data to be re-analysed just before analysis begins. At this point we have complete knowledge of data contributed by all agencies and results from initial processing, avoiding the possibility of excluding some data for an event while including others. With less risk of inconsistencies, we plan to use thresholds in more areas rather than only where they are essential. Initially only events with contributed magnitudes the largest of which is less than 3 will be excluded.

By the end of 2001 we hope to be using the first part a replacement for the editing system now used by ISC seismologists. A University of Reading employee contracted to work at the ISC in close co-operation with ISC staff is developing the system. University computer scientists recommend adding bar codes to printouts, which will allow seismologists to create edit files using scanners, rather than requiring manual keying from marks in the printouts. During 2002 we plan to continue working with Reading University to develop an entirely on-line system that will be useful in later passes of editing.

Plans for Data Distribution

As a result of catching up to the publication schedule, during 2001 we expect to produce the 1998 Bulletin and Catalogue CDs in January and the 1999 Bulletin and Catalogue CDs in December. For 1999 files in recent Bulletin CDs will exceed the capacity of a CD so we will produce a 2-disk set from which the second can be offered on its own as a Catalogue CD.

By mid-2001 we anticipate that locations from the Engdahl, van der Hilst and Buland (EHB) catalogue will be inserted in the database, grouped with ISC events, and posted as non-prime hypocentres in the on-line Bulletin. By mid-2001 we expect to insert unassociated readings from the ISC tape back to about 1970 in the database and make them available on-line.

During 2001 we plan to complete parsing of all contributed reports and to develop automatic mechanisms for removing deprecated data when contributors replace preliminary releases. Based on this and developments in automatic processing, we plan a preliminary on-line Bulletin in advance of the ISC's own analysis. Any part of the preliminary Bulletin will be subject to change at any time, based on re-processing or receipt of further contributions.

With the database we can offer users access to a bulletin that includes events smaller than our analysis thresholds or with corrections based partly on comments about the published Bulletin. We plan to spend time designing these new features of the web site carefully. We may be able to adapt a system developed to make maps for internal purposes to generate on-line maps for events selected by users. We will continue supplementing the on-line Bulletin with links to sets of waveforms and other products for particular earthquakes.

Plans for Computing Infrastructure

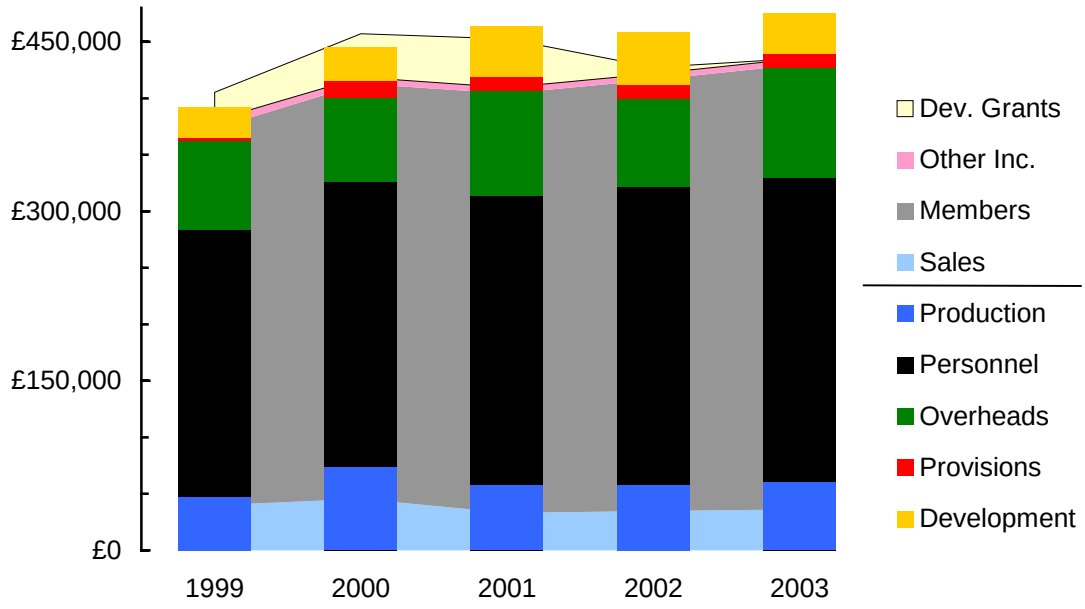
During 2001 we plan to replace the PC and printer used by the administration and finance officer. The new PC will be configured with the latest versions of Windows NT and Microsoft Office applications, and a DVD reader. The existing PC will be used to replace the aging helicorder with an exhibit of seismic data that are available on the Internet, including waveforms and near real-time maps. The exhibit could be upgraded in future when large-format displays become more affordable.

The ISC's 56 kbit/s Internet connection is slow enough to require consideration in certain decisions. But requirements have not yet risen dramatically nor have prices fallen much, so we plan a further one-year extension of our contract with Rutherford-Appleton Laboratory.

Storage requirements have grown with comprehensive parsing of data from contributed bulletins and catalogues, creation of more database indexes to support operations, and plans to insert the EHB bulletin and unassociated readings from the ISC tapes into our database. We plan to purchase two 18 GB disks and install them in the file server this year, satisfying requirements expected through 2002. We do not plan to purchase larger disks to meet requirements for much longer because computer disk capacity is growing quickly and costs are falling. The two new disks will fill the slots available in the server, and further expansion in 2003 should be planned during 2002, with regard for a growing load on the server as editors begin working on-line while the ISC continues expanding its Internet data services.

Plans for Finances

The budget projection figure below illustrates the evolution of the ISC's income and expenditures over the last two years and projected for this year and the next two years. Grant-funded capital spending is excluded. The projections are based on the membership rates agreed by the Governing Council in 1999 and write-offs estimated at £12,000 annually. Details of planned expenditures are given in the appendix.



Apart from development grants, income grows as the result of annual indexing of member contributions, modified by fluctuations in exchange rates. The actual and projected increases of member contributions are less than the agreed rate of increase in the unit membership rate because some members fail to increase their contributions and withdrawals occur as often as new members join. While ISC staff members continue seeking opportunities for sales of commercial services, other income remains very small compared with member contributions.

Expenditure grows principally as the result of salary rises, which are based on inflation indexing of university salary scales plus step increases for employees hired recently. Indexing has been 3% or more in each recent year, which is less than salary rises in the UK generally, and much less than 6% rises agreed for many UK public sector employees lately. Full employment and shortages of qualified candidates continue in Britain, and the ISC is unlikely to attract or retain good employees without salary rises. It is unrealistic to foresee ISC performance continuing to meet expectations if income in support of operations rises at a lower rate than the prevailing rate of salary rises in Britain.

A modest shortfall of income is projected for 2001, and a somewhat larger deficit for 2002. This represents investment of about 23% of cumulative excess income during 1997 to 2000. Nevertheless, the staffing level during 2000, which enabled significant progress in development, requires ongoing efforts to obtain support beyond member contributions. We continue to seek grants for development projects, but it is important that funding for operations does not decline in real terms. Even development projects undertaken by staff hired with supplementary funding require time from both the Director and the Senior Seismologist, who are necessarily involved in projects with a potential to affect the Bulletin. As shown at right, the ISC has applied or intends to apply for special grants from agencies of the governments of the US, the UK, the European Union and Japan. If all were successful, the ISC would be challenged to implement each with full effect. As in the past, however, it is likely that some will succeed only if re-submitted in the future.

ISC Development Support

NSF: Separate grant during 2000-2002 to support an extra staff member for nearly 2 years to make more data available from ISC.

RS: Funded a fellowship for Dr Chen Qi-fu of the CSB to investigate earthquake locations using 3-D earth models at the ISC during 2000.

EC: ISC has joined the EC-funded EPSI project to develop a fully integrated European-wide bulletin.

DTI: Funded 60% of Reading University costs during 2001–2002 to develop an interactive Bulletin editing system for the ISC.

RS: Contributed 50% of the ISC's share of first-year costs for the DTI-funded project.

DTRA: ISC has proposed to employ a seismologist for three years to implement maximum-likelihood magnitudes in operations.

NERC: ISC intends joint proposals with Oxford and Leeds Universities to develop new location methods and procedures for routinely measuring shear wave splitting.

STA: Request for ¥100,000,000 over five years to support development of new products is pending, but prospects remain uncertain.

This year will see critical developments in regard to ISC finances because it is the last of a four-year NSF grant supporting operations and the Royal Society is also planning a review this year to establish its ISC contributions for the next several years. ISC staff plan to submit a proposal to NSF for 20% of the expected cost of operations over the four-year period 2002–2005, which is in-line with level of support in the recent past. Traditionally the Royal Society has funded an equally large fraction of ISC operations, but Royal Society staff have asked the ISC only to keep them informed about the status of the NSF proposal and to stand ready to respond to enquiries from the Society's review panel.

APPENDIX

SUMMARY OF BUDGET FOR 2001, 2002 AND 2003

	2001	2002	2003
EXPENDITURE	**£**	**£**	**£**
Publications	57,570	57,780	60,090
Personnel Costs	255,690	263,450	269,490
Buildings	31,780	25,690	28,720
Travel	20,750	12,750	27,170
Computing	19,870	17,550	18,250
Other costs	21,100	21,940	22,820
Provision for write-offs	12,000	12,000	12,000
Development	45,408	47,571	36,350
	£464,168	£458,731	£474,890
INCOME	@ $2100/unit	@ $2160/unit	@ $2230/unit
National Contributions	370,830	381,340	393,610
Sale of Publications inc. CDs	33,210	34,870	36,260
Bank Deposit Interest	5,500	5,500	5,500
Grant from NSF	30,904	5,569	
Grant from RoySoc + EPSI	12,000		
	£452,444	£427,279	£435,370
(LOSS)/GAIN	(11,724)	(31,452)	(39,520)