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A Conversation with G. A. F. Seber

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Abstract. In a career spanning more than 50 years, George Arthur Frederick Seber has made significant contributions in many areas of statistics as well as foundational work in capture–recapture modeling. Seber was born in 1938 in Australia to New Zealand parents and moved back to New Zealand where he completed almost all of his schooling. After graduating with bachelors and masters degrees from the University of Auckland, Seber studied for his Ph.D. at Manchester on a Commonwealth Scholarship. In his first year, he was supervised by John Darroch with David Silvey taking over supervision for the final 18 months of the degree. Seber's Ph.D. thesis was remarkably fruitful leading to three papers in Biometrika, two in the Annals of Mathematical Statistics and one in the Journal of the Royal Statistical Society B. The topics covered were broad mixing foundational work on linear model theory with capture–recapture problems. His solution to the multi-sample single recapture problem anticipated the general solution to the open population problem that Seber published in 1965 concurrent with the work of George Jolly.

Seber has been a prolific writer of books including classical texts on the linear model and nonlinear regression. His comprehensive book *The Estimation of Animal Abundance* appeared in two editions. He has recently completed four books and is working on a book on open population capture recapture.

Seber took up an invited personal Chair in Biometrics at the University of Otago in 1971, and then the foundational Chair in Statistics at the University of Auckland in 1973. Seber developed a remarkable statistics group built around people such as Jeffrey Hunter, Alan Lee, Alastair Scott, Chris Triggs

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and Chris Wild, all of whom went on to hold Chairs in Statistics and to head Departments of Statistics in New Zealand. Seber was elected a Fellow of the Royal Society of New Zealand (RSNZ) in 1997 and in 1999 was awarded the Hector Medal by the RSNZ.

Key words and phrases: George Seber, Jolly–Seber model.

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1. EARLY LIFE

Barker: Tell me about your early life.

Seber: I was born in April 1938 in the Sydney suburb of Waverly. So I am an Aussie by birth, at least that is what I say when I am in the company of Aussies. My father named me George Arthur Seber. George and Arthur were family names but my father on his way to register my birth thought more about the initials G. A. S. Remembering a girl in his class at school called Fragrance whom the other children called Stinky, he thought he should better change that. So he added his own name Frederick and I became G. A. F. S. I am not sure if that is any better. I have made a few gaffs in my life but I suppose it is better than GAS, which I have problems compressing.

Although I was born in Australia, my family was from New Zealand and temporarily moved to Australia. My mother was a New Zealander from Palmerston North in New Zealand. My father was born in London of German parents, hence the name Seber, and he came to New Zealand when he was six. He was Dux of Wellington College and won a scholarship to attend the university. However, the war was on and before he started they removed his scholarship because of his German background and donated the money to the Belgian Relief Fund. As a result, he went into pharmacy, which in those days did not require university study.

At eight, my family moved back to New Zealand and I was sent to live with my grandparents in Wellington before eventually rejoining my parents in Auckland once they were settled. I attended various schools and I enjoyed life as a kid. I was an expert at marbles and knucklebones, all the kids' things, which have no doubt stood me in great stead for my later life. I had a good academic career at secondary school but I also enjoyed sports including football (soccer), basketball and gymnastics. I was on the school swimming team and was a finalist in the Auckland provincial under-18 table tennis competition.

I was heavily involved in a church youth group as a leader beginning around 18 and I met my first wife Pat there. We enjoyed those early years to the fullest. I taught myself the ukelele and the guitar as well as taking piano lessons. I could play by ear and I regret not starting lessons at a younger age before my interest in sports and girls took over. Music has always been a big part of my life and much later in life I had extensive piano lessons in modern music. I taught myself the bass guitar and played in a church music team for seventeen years. I am now back trying to revitalise my piano playing.

Barker: Where did you attend high school?

Seber: I went to Mt. Albert Grammar School and the teaching was very good. My mathematics teacher was a man named Herbie Towers, a famous athletics administrator. When I was about fourteen, he started to set challenging mathematics problems; about three a week. I got hooked on these and used to spend hours doing them. I think I managed to solve them all. I got no formal credit for them but they switched me on to solving mathematics problems, which was the beginning of my mathematics career. I also liked to do big projects. At age 13, I remember wanting to copy a skeleton out of a textbook into my science notebook. I found a picture of a skeleton and overlaid it with tracing paper, dividing the picture into equal squares. I then drew up the same number of squares in my science book and then copied what was in each square but scaled up. It took several hours. Another example was a project on gold when I was 14. I spent hours on this in the public library and also wrote away for leaflets. I believe that such projects set the stage for the writing of large books in my later career.

Barker: Where did the skill in writing come from?

Seber: In English at school I was hampered by bad handwriting. I sat Scholarship[1] a year early and I totally crashed in English. I decided I needed to tackle English from a more scientific point of view. I have a good memory so I got hold of some essays where

[1]In the 1950s, New Zealand Scholarship examinations were a special set of examinations undertaken by the best final year high school students in order to obtain recognition and monetary reward.

the English teacher had ticked the things he liked and I memorised all of these marked items. Armed with about fifteen essays in my head, and memorising anything in our course that might be useful, I went into the two scholarship English exams with some confidence and I ended up 25th in New Zealand in English. This is one of the proudest things I have achieved in my life; however, it did not indicate that one day I would be an author; far from it. I think that I owe my current writing skill to being able to express things clearly. What helps is that the material has to be very clear to me first before I write about it, and I do not catch on that quickly, and, of course, I have had a lot of writing practice since in several different areas both academically and nonacademically.

2. UNIVERSITY STUDIES

I started at the University of Auckland in 1956, where I studied first year chemistry as well as mathematics, applied mathematics and physics all through until the end of my third year.[2] Because of my success in the school scholarship exams, I was an accelerated student and was pushed into advanced courses early on.

In addition to a BSc, I ended up with a part of a BA, although I did not take it any further. I also included two optional extra papers in statistics but they were not very good courses and totally theoretical; there were only four of us in the course. One paper had Cochran's theorem on quadratics, which was a bit much for a first course. But one thing that the lecturer did was to give us a large collection of problems that he had put together from a variety of sources, often unrelated to the course. We would sign for a problem and if we solved it we had to write out the solution and put it in a folder. Otherwise, it was put back in the pile. It was a bit like the high-school challenge problems and it reinforced my love of tackling problems, even if I received no credit for the solutions. One problem I remember was that if you cut a piece of string at random into three parts, what is the probability you will get a triangle?

Because the course was mathematical it got me interested in statistics, although my Master's degree was all mathematics and there were no advanced statistics courses available. I also completed a three-year Diploma in Theology by correspondence from Moore Theological College in Australia.

Following my Masters degree, I was awarded a Commonwealth Scholarship to pursue a Ph.D. I needed to decide on a topic and I chose statistics instead of topology because I had enjoyed working on statistical problems. Also, there was nobody on the academic staff at Auckland University specialising in statistics and it seemed to have high scarcity value.

I chose the University of Manchester rather than Oxford or Cambridge as Maurice Bartlett, famous for his work in stochastic processes, held the Chair in Mathematical Statistics there. However, when I arrived in Manchester, Bartlett had just left for Oxford, and Peter Whittle, a New Zealander, took over as Head of the Department. It was then called the Statistical Laboratory, and Peter was a very friendly Head of Department.

I had married Pat by then at 22, but I did not get a wife allowance in the first year from the scholarship because I applied before I was married. Nevertheless, it was a very good scholarship and they looked after us very well. Before heading up to Manchester, we spent ten days in London getting used to all the local culture along with other people from all over the Commonwealth. We learned things like etiquette, such as when you are arguing a point you do not wave your fork with a potato on it. Or, you do not put raspberry jam on your cornflakes. We went along for fun. We then took a bus up to Manchester and arrived on a very foggy day. The place was very black because of years of smoke and I thought, what have I let myself in for.

Our years in Manchester were very pleasant. I was heavily involved with the local church in a variety of ways. Also, I joined a table tennis team playing weekly, and I enjoyed trampolining virtually every lunch time in the McDougall sports centre. I played badminton quite frequently and I swam in the pool. I had practically no statistical knowledge even though I had taught some at Auckland as a junior lecturer in mathematics before going overseas.

Barker: I would be interested in hearing about your experiences as a junior lecturer.

Seber: There was just one such appointment and I tended to get the left-overs. I had to teach an evening mathematics course for the first-year arts students. During the day I taught some mechanics and ran a third-year tutorial in matrix theory in which I was only two years ahead of the students. I also had to teach a third-year projective geometry course which was quite theoretical. I followed the notes of the famous mathematician Professor Forder, but I re-wrote them and had to use much of his approach as he taught the follow-up course at the Master's level.

I was really thrown in the deep end, but although I was out of my comfort zone, it was a good thing, looking back. I also taught some probability out of Feller

[2]New Zealand follows the English system of a three year undergraduate BSc degree.

and I even taught some analysis of variance from Mood and Graybill, which I really knew little about; certainly nothing practical. It all interested me and I was quite happy with the minimal statistical experience that I took with me to Manchester. I always believed I could do anything—the arrogance of youth, but I had a positive approach, and I was not afraid of being taken out of my comfort zone.

Barker: Please tell me more about Manchester and your Ph.D.

Seber: I began my Ph.D. in September 1960 and took all the courses I could, even though they were not examinable. I also took a lot of notes in preparation for my eventual return to New Zealand. For example, I had a number of notebooks full of notes from several courses in stochastic processes, linear models and statistical inference. I also studied multivariate analysis out of Ted Anderson's book on my own. In my first year, I had an excellent supervisor in John Darroch who gave me a problem that led to my first paper (Seber, 1962). This was the multi-sample single-recapture problem where the recoveries were from tagged dead animals.

David Silvey took over my supervision in my second year. He was a very helpful and clear thinking man who introduced me to linear models and asymptotic theory. My thesis ended up with some capture–recapture work and then a lot of linear model and asymptotic theory. It took me two and a half years overall to finish. When I came to write up my thesis, mathematical typewriters were not around. The secretary typed the English and I filled in all the mathematics by hand in the three copies that were required. It think it took me about a month working long hours to write the mathematics in, but it looked very neat and much better than my writing now.

I really got hooked on linear and asymptotic theory. I was fortunate that six papers came out of my thesis, three of them in *Biometrika* (Seber, 1962, 1963, 1964a), two of them in *Annals of Mathematical Statistics* (Seber, 1964b, 1964c) and one in *Journal of the Royal Statistical Society B* (Seber, 1964d).

3. THE JOLLY–SEBER MODEL

I graduated with my Ph.D. in 1963, but my first paper published from it was in 1962. My interest in estimating animal numbers from a more practical point of view was stimulated by some research carried out with David Le Cren on Lake Windermere. He was a famous fresh water ecologist and John Darroch sent me up there as a statistical consultant—me, a greenhorn Ph.D. student. It was an interesting research project (electro-fishing to estimate numbers in brooks), and it was the first time that I had ever been exposed to real data, apart from a regular tutorial I was taking with psychology students.

Barker: I would like to hear a little bit more about John Darroch, because when you try to establish a proper foundation for capture/recapture models you inevitably end up at what Darroch was doing in the 1950s which was really quite remarkable work.

Seber: Anything new in science is usually built on the back of somebody else's work. John had published two excellent papers, one of which was on closed population models (Darroch, 1958) and a second (Darroch, 1959) looking at open populations subject to either immigration-only or deaths-only. We needed to put the two together. When I finished at Manchester University, I decided to postpone my return to New Zealand and took up a two-year temporary lectureship at the London School of Economics for some experience in teaching mathematics and statistics. Before I left Manchester, John said that if I took a similar approach to that in my 1962 paper where I transformed the population parameters in a certain way, I might be able to solve the general problem. I will always be very grateful for that advice as it encouraged me to persevere with the problem.

One night in London I set to work on this. As I did not have anywhere to study (and my wife was very understanding), I was sitting in the kitchen in our flat in Lewisham, in South East London (Lee Green). I changed the way John formulated the model and I found an explicit solution. This was a 'Eureka' moment although I was not in the bathtub to leap out of and run out to the street, as it was pretty cold. It was a terrific moment; that sudden realisation that I had actually solved the problem. In a way, it was also a sense of relief. The only other time this happened was when I was writing a paper on allowing catchability to have a random distribution, following an idea due to Cormack. I was flying from Auckland to Dunedin. Part of the previous evening had been spent thinking about the problem and I spent the whole flight working on it. I was sitting next to a student and I was scribbling away. And just before we landed I looked up and I said, "Ah, that's it", and I looked at him and he looked at me. I said "done". That was an 'aha!' moment, just before we landed. I have always used travel and waiting time to work on something, even if just reading. The result became a Biometrics paper (Seber, 1970) and I also used the ideas elsewhere.

Barker: When did you become aware of George Jolly's work?

Seber: After I wrote my 1965 paper and submitted it to Biometrika, I was told that there was a similar submission by George Jolly, and was sent a copy of his paper (Jolly, 1965). We actually saw each other's papers, which was a good idea as George had a different approach to mine. My likelihood was based on the product of multinomial distributions while he focused on a different likelihood and developed intuitive estimators that showed great insight. He expressed his approach in terms of the simple idea that we can estimate a population proportion by a sample proportion, as in the two-sample capture–recapture case. He showed how this basic idea flowed right through his series of estimates. So the two papers together gave the theory and the interpretation, and they were very complementary.

Barker: Were you aware of Richard Cormack's work?

Seber: It was only when I was writing my animal abundance book (Seber, 1973) after returning to New Zealand in 1965 that I became fully aware of Richard's paper (Cormack, 1964), otherwise I would have referred to it in my 1965 paper. One of the things I needed to do was to show that our variance estimates were essentially the same, which I did in my book. I also realised that the models are all connected. I had the pleasure of meeting both George and Richard later. George came to New Zealand to visit a daughter, and I met Richard at a conference. He was using capture–recapture on problems like estimating the number of homeless people and I was very interested in his log-linear model approach.

John Darroch was really the pioneer, as before his papers the development of capture–recapture models was quite limited, especially for open populations. There were some papers by C. N. C. Jackson on open populations applied to tsetse flies, and there was the so-called Schnabel method for closed populations. In the latter case, Doug Chapman, whom I had the privilege of meeting in Seattle, developed this further and also provided some almost-unbiased estimators for the two-sample hypergeometric model. Bailey also published his binomial model.

John Darroch really got open populations going, and following those initial papers there has been a huge amount of work done on the topic. Doug Robson developed his continuous time Poisson model that applied to fisheries. I never actually worked with Doug, but his work features prominently in my animal abundance book and I was very pleased to meet him once at Cornell University.

An interesting digression from my capture–recapture research was my work on line transects and later line intercepts. In the course of writing the chapter on line transects using Charles Gates' work I did something quite trivial that involved reversing a conditional probability. This opened the door for a whole lot of methods, but it was built on Gates' earlier work. Someone told me that Charlie kicked himself that he had not seen it, but I guess that coming at the problem as a mathematician gives one a different point of view.

There has also been some interesting work by other New Zealanders on various models, including yourself Richard. Brian Manly did some important work in the 1960s before he came to Otago via Papua, New Guinea. He is now a well-known figure in statistical ecology and has written many papers and several books. Shirley Pledger did some great work on latent catchability structures, and there are others. It is interesting that so much work has been done from New Zealand. I think New Zealanders have a certain amount of self-confidence as we believe we can do as well as anybody else in the world and have never been overawed by other people. We are quite independent people which probably comes from our physical isolation in the world, and we just work away quite happy in our isolation. Technology and e-mail have made communication much easier and we are now better connected to the rest of the world.

Nowadays, there are a lot of new methods that have appeared on estimating animal numbers and I am well out of date here. One example is the use of random- and mixed-effects models, which are useful when you have many estimates and you want to model them as a time series. Ken Burnham, a very able researcher whom I have had the good fortune to meet with on a number of occasions in different parts of the world, has pioneered some important work in this area.

There has also been work using genetic markers and state-space models which have been particularly useful when you have geographical areas. Carl Schwarz, who has been active in this area, spent some time with me in New Zealand when we wrote our 1999 review on animal abundance (Schwarz and Seber, 1999).

Radio telemetry is another subject that seems to have moved on a lot since I last looked at it seriously. And we have seen the development of computer packages and more general models. Model selection has also become important, especially the ideas that David Anderson and Ken Burnham promoted. I have been interested in this subject from a linear regression point of view.

Anne Chao, a gracious lady I met at a conference, has done some interesting work on closed population models. Her estimators are not particularly precise but they are robust, which is important. In many places, we have robustness versus precision trade-offs. There was also Ken Pollock's work on robust design models that we needed as well. I think we are probably going to need to analyse things several ways and not just stick with one particular model. Capture-recapture methods have also moved into the field of epidemiology, where I have done some research.

One thing I strongly believe in is testing the underlying assumptions in applications. This has sometimes been neglected in the past.

4. LINEAR MODELS

While I was at the London School of Economics, I gave a lot of thought to linear models. The emphasis with my Ph.D. supervisor David Silvey was on using geometry and projections, which was not the way the topic was approached in those days. This came later, and I decided that I could write a whole monograph from that point of view (Seber, 1966). I started off by writing about what I knew rather than starting at the beginning, which is the way I always write books. Then I got into multivariate statistics using my limited knowledge and also included some material about nonlinear models and missing observations.

Large-sample theory published from my Ph.D. thesis (Seber, 1964c) followed. The aim of the monograph was to show that all models and hypotheses were either linear or asymptotically so. Hypothesis tests could be expressed three ways: (i) the usual likelihood ratio statistic, (ii) the Wald statistic or (iii) the score or Lagrange multiplier statistic introduced by Rao. All three are exactly equivalent in the linear model, and consequently are asymptotically equivalent for other models.

I returned to New Zealand in 1965 at the end of my two years at the London School of Economics, and rejoined the Mathematics Department at the University of Auckland. In statistics, there was just me and one other part-time person. I had to do all the statistical consulting. I was the department representative on continuing (adult) education, teaching evening courses to school teachers because the statistics curriculum was changing, and I was the Chairperson of the Auckland Region Syllabus Committee involved with high school curricula. In those days, the Head of the Mathematics Department, which I became for six years, was automatically the Chair of that meeting.

Before I left London, I submitted the manuscript for my first book (Seber, 1966) *The Linear Hypothesis* to Maurice Kendall who was the editor of the Griffin series of monographs, and he was very happy to go ahead with it. Once back in New Zealand, I was very much on my own and I decided it would be very nice to write something on animal abundance, which I did. It took three years and the editor sat on it for a while, but it was eventually published by Griffin, London, as *The Estimation of Animal Abundance* (Seber, 1973) subsequently running to a second edition (Seber, 1982). The editor was a bit slow but very thorough, and as a result there were very few misprints in that book. It was all typed on stencils and I had to calculate all examples on a semi-automatic mechanical calculator. To do long division, I had to take out one place at a time by pressing a button. It was very slow but I was also able to do some quite complicated things like invert a matrix. There were a lot of time-consuming examples, but I thought that they were important to have. I especially tried to find examples where the underlying assumptions were looked at.

5. UNIVERSITY TEACHING

One of my personal priorities when I first started teaching was to teach without notes. I developed that early on. I started off with the notes sitting closed on my lectern while I would give my lecture, and then came the time when I would just walk in with nothing but a piece of chalk. During my whole career, I lectured without notes. To do this, you have got to do your homework, but the more you lecture this way, the better you remember and the more confident you become. It also provided better contact with the students. The main problem I had was remembering theorem numbers. So I would come to class and say "well what theorem are we up to—OK well this is the next one". The rest was straight-forward because mathematics is highly structured. It is the same with music. I remember all my music; it is about 40% by ear and 60% by memory.

Getting to know students was very important to me. I used to set aside a time, which could be done in those days as the course timetable was relatively simple and there were not a lot of optional courses. I would say, "I will be in the student cafe between 10 a.m. and 11 a.m., and if you want to come and talk to me, please do." I had a lot of graduate students come and talk to me over coffee, and got to know them well. It was something I did for quite some time until students had

a lot more options involving courses at different times making the timetable much more complicated. When the university was much smaller (over 40,000 students now), it used to provide a sheet of photographs for those in your course. One of the things I learned to do was when a class had no more than 30 or 40 students I would have the photographs in front of me, and in a tutorial I would put a problem on the board and then spend time looking at the photographs, trying to memorise names and where students were sitting. After the first assignment had been marked, I would just hand it back to them in silence. It really created an impression—"Oh he knows who I am". The university can be a very impersonal place.

6. A BRIEF SOJOURN IN DUNEDIN

In 1971, I was invited to a Chair at the University of Otago in Dunedin. Although I was promoted to Associate Professor at Auckland that year, I accepted the offer of Professor of Biometry at Otago University and went down to Dunedin. Although my main job was to provide a statistical consulting service in statistics, I was basically given a choice of what I did there and I ended up doing quite a lot of teaching, which I enjoyed. I also supervised several projects on quite diverse topics, for example, one of them involved integral equations.

While at Otago, I also wrote a monograph entitled *Elementary Statistics* (Seber, 1974) that partially arose from teaching the medical students elementary statistics. There were about a hundred and fifty of them in my class with their knowledge ranging from nil to a third year statistics level; a very heterogeneous class. I decided that the only way I could do this was to make it absolutely basic. For example, what is a sample, what is something that is random, etc. Some were bored out of their minds but for others it was about right, and every question in a questionnaire evaluating my teaching had a complete range. If I had graded the scores on each question from nought to a hundred, I would have got a uniform distribution. I realised that this class was impossible to teach as a group.

Barker: So you were being evaluated back then?

Seber: No, I evaluated myself to find out how I was doing and I told the Medical School the result. I said it was crazy having this as a compulsory course. It should be an elective and those who have got a statistics background should not need to do it. Apparently, several years later this finally happened. Of course, I was not lecturing only medical students in Dunedin. I also taught linear regression and statistical ecology courses. But what really interested me was Professor Geoff Jowett's service course in statistics for nonmathematical students, which was very popular. It had about 900 students in it. So when I eventually went back to Auckland I started such a course.

7. BACK TO AUCKLAND

I had a good time in Dunedin, but Auckland was where my parents and my wife's family were, and they had decided to create a Chair in Statistics. At the time I left Auckland for Dunedin, there had been an unsuccessful approach to the new Vice-Chancellor by three prominent people to try and offer me something, but it was too late. Auckland had two professors of mathematics at the time: one was pure mathematics and the other was applied mathematics. They were very suspicious of statistics and they thought I had way-out ideas. Well I did not; mine were just normal ideas as seen from today's perspective. So statistics was not going to get an easy foothold. After I left Auckland, the Vice-Chancellor became convinced of the need to strengthen statistics and he created a foundation Chair that I subsequently applied for. When I was interviewed, I was asked what I would like. I said there are too few of us to form a separate department, but we could have some sort of unit, and they ended up creating the Statistics Unit within the Mathematics Department.

Barker: Who were the members of that unit?

Seber: There were six of us with four being very successful past students of mine who had been overseas to obtain PhDs, namely Alan Lee, Chris Triggs, Jeff Hunter and Chris Wild. Also, Alistair Scott joined us after a two-year appointment at the London School of Economics. They are all now professors with established international reputations. I was very fortunate to be part of an excellent team that got on very well together. We had our meetings over a cup of coffee.

The first thing I did at Auckland was to introduce new courses. I started and taught the service course that initially had 99 students in it. (It now has over 4,000 students split into different subject streams.) I also wanted to attract mathematicians into statistics and so I put on a theoretical linear models course using Euclidean vector spaces and projections at the masters level. I was successful in attracting a number of pure mathematicians into that course, and I had to also teach the tail-end of a course in stochastic processes that I had inherited from someone who had left. It was not my field at all, but as usual I got in at the deep end.

I also taught a third course including a variety of new topics like simulation, residual plots, etc.

The Statistics Unit had a certain amount of autonomy. We had a slice of departmental funding for the library and I had a lot of support in buying back issues of the statistics journals. The Economics Department had their own small statistics library; they had been getting *Annals*, *JASA*, *Technometrics* and several of the other mainstream journals. We purchased the back issues and then the whole lot went into the Science Library. In that way, we ended up with a very good statistical journal collection, which has been maintained since. Of course, these days you can get them all online, but it was a good library at the time that I found very useful for my book writing.

There was a strong statistics group in the Economics Department, but we eventually took over their first year course which became compulsory for all commerce students. We also put on a second year applied course in statistics that was computer oriented; it had a compulsory stream for the commerce students. It was very applied and several people, including Alan Lee, wrote computer software for it; it became a very popular course. These days the popular package R developed later by Ross Ihaka in our department is now used. I would grab any statistics teaching that I could, even if it would mean extra work. I ended up teaching a third year course in statistics to engineering students.

When I started back at Auckland, I sent out a questionnaire to every department in the university to let them know the existence of the Statistics Unit and to find out who had statistical interests. Looking back now, it was quite a good marketing strategy as I got to know a lot of people.

8. STATISTICS SPLITS FROM MATHEMATICS

Eventually, the time came when we really needed to split away from mathematics. I was Head of the Mathematics Department from 1975 to 1980 and, as our department was a bit in the doldrums, I worked at us having a reputation of being a reliable and progressive department. We taught pure and applied maths, computing science and statistics, and at one stage we had some long debates over what should be in a Master's programme: pure versus applied (but no statistics). I can remember those difficult discussions very clearly and the long departmental meetings that ensued. A lot of tact was needed all round and we managed to achieve a good balance in the Master's programme. But at that stage I realised we really needed to eventually split up. I started by splitting off computer science which was a natural thing to do at the time.

In 1985, my first wife Pat died aged just 46 after a courageous six-year battle with cancer and I had two young boys to look after. Around 1990, we realised that we needed to split statistics off. I again went around people both within and outside the department to discuss the proposed split with them. In the meantime, I married Jean even though she knew I would soon need to have an aortic heart valve replaced. This was associated with problems I was born with including *ankylosing spondylitis*, a rare genetic form of arthritis (finally properly diagnosed in my forties) that I kept on top of through exercise. However, the arthritis has been catching up with me, and recently I have had both hips and knees replaced as well as three aortic heart valve replacements, the last being due to getting a super bug (MRSA) which nearly killed me five years ago.

It was a very crucial year after my first heart surgery. I went back to work too soon and I got very badly stressed, something that tends to happen after open-heart surgery. Also during that year, the secretary whom I had access to became very ill so I used her sparingly. She eventually died of cancer later in the year. All of this was going on at the same time we were organising to split off statistics. At the end of the year, I set to work to get the whole process going and we got it approved very readily through the faculties. I then spent several months writing the regulations, all forty pages of them because we were introducing a new subject in four faculties. We were also offered six new positions for the fledgling department and so I was involved with recruiting new staff. I then had some well-overdue leave. Before we left overseas, I said that I was not going to be the first Head of the new Statistics Department because I was still recovering from my health issues. Fortunately, Alistair Scott kindly stepped in and he became the inaugural Head of the Department.

I hated the humdrum of administration and sitting in meetings, but if it involved a certain amount of creativity I did not mind. While Head of the Mathematics Department, I had an excellent secretary, and I was able to dictate everything I possibly could to save time, even agendas. I apparently got good appraisals from staff, and I think the main reason was that I did not like doing things by mail or by phone. I preferred face to face because you could shoot someone and smile at the same time. The other important thing was communicating with the university administration, especially dealing with the Deans.

9. ON BOOK WRITING

Usually I sit on an idea for years and then suddenly one day decide that I am going to write a book. The most difficult one was our nonlinear book (Seber and Wild, 1989). The underlying theory was complicated as it involved types of curvature, and the geometry required three-dimensional arrays. I entered into a lot of correspondence trying to clarify things with various authors. Chris [Wild] and I shared the work on a fifty-fifty basis: he did all the practical chapters and the graphs, and I wrestled with the theoretical chapters. Chris is really amazing at using graphical packages. We made a good team and the book was finally 732 pages; a big book, but we had no arguments about the writing.

The technique I would use for writing technical books after roughing out possible chapters was to first carefully choose the notation. Some notation that are entrenched historically often need to change. For example, in multivariate analysis, writers used p for dimension, whereas a lot of people like to use p relating to the dimension of a hypothesis. As I liked a mnemonic notation, I used d for dimension even though at the time there was not a single book that did this. So I thought, "I do not care what the rest of the world uses—I am going to use d". I guess this is that New Zealand attitude again.

My next step would be to start looking up all the journal articles and literature and have a large envelope for each chapter full of this material. I start by writing the chapter that I know best. Before we had word processing, I would write and then literally cut and paste. The books grew outward like topsy. I did not start from Chapter one and then go to Chapter two; I might start at Chapter four as I knew some of Chapter four. I wanted to present something of me rather than just copy other people's work and then I added to it as I read the papers.

Other chapters get added in a similar way. But before all of that, I wrote the preface first. This does three things. First, it forces you to decide clearly on your target audience. Second, you get good ideas as you go along to add to the preface. I might be out walking on the beach, which I used to do, and I would think "Oh yeah that's a good idea—I'll pop that in the preface". Third, when you get to the end of writing your book and you cannot stand it anymore, it is hard to have to go back and write a preface from scratch. When we finished the nonlinear book, we were able to revisit the preface and this gave us something to work on.

Another important aspect of book writing is psychological, namely how will the book look and what will be its visual effect on the reader. For example, it should not look too cluttered with long paragraphs and complex numbering like Section 1.1.2.3.1 and Definition 1.2.3.1. I try to minimise the number of subscripts in the mathematics, for example, instead of x_{i1} and x_{i2} for two samples of random variables I would call them x_i and y_i. To help the reader to find the equations, for example, equation (2.76), I would just label some that I would not refer to. That way you do not go for pages and pages without any numbered equations.

Barker: I recall that you once told me that you did not like writing papers, that it was books that you preferred.

Seber: It is the scope that books allow that I like. Papers are very restricting. I was wary about submitting papers to, for example, Biometrika because the details are usually left out. When you read a paper from some journals you may have to contact the author(s) to fill in the details. A problem is that the statistical articles can be almost unreadable. There is understandably huge pressure on editors to save space and keep articles condensed. But this does make it difficult for book writers who want to refer to articles. So, in the end, I thought I would rather write more extensively and explain things clearly in a book than to have to send off something which I know may cause a lot of fog.

Generally, my papers tended to happen accidentally. I therefore wrote papers on quite diverse topics (e.g., human blood genetics, adaptive sampling) and rarely set out to initially work in a particular topic. Something would come up and I would think "I must have a look at that". I guess this is the way a lot of research happens. I kept a notebook with research topics listed year by year, but ended up throwing it away as the annual lists became longer and longer and few got crossed off.

Barker: What are you working on at the moment?

Seber: I have been continuously authoring or coauthoring books since the beginning of my career on topics such as animal abundance (a second edition of my book), linear and nonlinear regression, multivariate analysis, elementary statistics, matrix theory and adaptive sampling, and at present I have a complete revision of my linear hypothesis monograph in press with Springer, Berlin (Seber, 2015). I am currently completing a book tentatively entitled *We can believe it: Evidence for Christianity* which has involved extensive reading in various branches of science, philosophy and historical documents. I have just started working on my nineteenth book, which is about capture–recapture models for open populations that I am co-authoring with you, Richard, and your colleague

Matthew Schofield. I have some catching up to do in animal abundance. In my early sixties, I began training part-time as a counsellor/psychotherapist and I have been counselling for eleven years since. I ended up writing a large book about it (Seber, 2013a), but I recently came back into statistical writing again (Seber and Salehi, 2013) and (Seber, 2013b). I need counselling for my compulsive writing.

Barker: So when you look back at your career as a mathematician and a statistician have you got a one-liner that can summarise your experiences and your attitude?

Seber: I like a challenge.

REFERENCES

CORMACK, R. M. (1964). Estimates of survival from the sighting of marked animals. *Biometrika* **51** 429–438.

DARROCH, J. N. (1958). The multiple-recapture census. I. Estimation of a closed population. *Biometrika* **45** 343–359. MR0119360

DARROCH, J. N. (1959). The multiple-recapture census. II. Estimation when there is immigration or death. *Biometrika* **46** 336–351. MR0119361

JOLLY, G. M. (1965). Explicit estimates from capture–recapture data with both death and immigration-stochastic model. *Biometrika* **52** 225–247. MR0210227

SCHWARZ, C. J. and SEBER, G. A. F. (1999). A review of estimating animal abundance: Review III. *Statist. Sci.* **14** 427–456.

SEBER, G. A. F. (1962). The multi-sample single recapture census. *Biometrika* **49** 339–350. MR0157458

SEBER, G. A. F. (1963). The non-central chi-squared and beta distributions. *Biometrika* **50** 542–544. MR0162305

SEBER, G. A. F. (1964a). Linear hypotheses and induced tests. *Biometrika* **51** 41–47. MR0175237

SEBER, G. A. F. (1964b). Orthogonality in analysis of variance. *Ann. Math. Stat.* **35** 705–710. MR0161438

SEBER, G. A. F. (1964c). The linear hypothesis and large sample theory. *Ann. Math. Stat.* **35** 773–779. MR0166895

SEBER, G. A. F. (1964d). The linear hypothesis and idempotent matrices. *J. R. Stat. Soc. Ser. B. Stat. Methodol.* **26** 261–266. MR0191040

SEBER, G. A. F. (1966). *The Linear Hypothesis*. Griffin, London.

SEBER, G. A. F. (1970). The effects of trap response on tag-recapture estimates. *Biometrics* **26** 13–22.

SEBER, G. A. F. (1973). *The Estimation of Animal Abundance*. Griffin, London.

SEBER, G. A. F. (1974). *Elementary Statistics*. Jacaranda Wiley, Sydney.

SEBER, G. A. F. (1982). *The Estimation of Animal Abundance and Related Parameters*, 2nd ed. Macmillan, Inc., New York. MR0686755

SEBER, G. A. F. (2013a). *Counseling Issues*: *A Handbook for Counselors and Psychotherapists*. Xlibris, Bloomington, IN.

SEBER, G. A. F. (2013b). *Statistical Models for Proportions and Probabilities*. *Springer Briefs in Statistics*. Springer, Heidelberg. MR3097508

SEBER, G. A. F. (2015). *The Linear Model Hypothesis*. *A General Unifying Theory*. *Springer Series in Statistics*. Springer, Cham. MR3382252

SEBER, G. A. F. and SALEHI, M. M. (2013). *Adaptive Sampling Designs*. *Inference for Sparse and Clustered Populations*. *Springer Briefs in Statistics*. Springer, Heidelberg. MR2986602

SEBER, G. A. F. and WILD, C. J. (1989). *Nonlinear Regression*. *Wiley Series in Probability and Mathematical Statistics*: *Probability and Mathematical Statistics*. Wiley, New York. MR0986070