



## A Practical Guide to Mark-Recapture Analysis using *SURGE* - 2nd Edition

### Background & Motivation

Welcome to the second edition of our guide for using program **SURGE** (**SUR**vival **GEN**eralized **EST**imation), one of the most widely used software applications for analysis of mark-recapture data.

*SURGE* is a very flexible and powerful program. However, program *SURGE* is not one of those programs that you can learn to use without some instruction (although, in fairness, we suspect that as most software applications fall victim to “feature-creep”, such that simple word processing applications can now occupy >20 megabytes of drive space, the days of “learning by doing” may be drawing to a close in general). Unfortunately, existing documentation which accompanies *SURGE* was not written for a broad audience - it was written by the people who developed *SURGE*, primarily for people with strong motivation to analyze capture-recapture data, and some significant background in the theory of these approaches. It was generally not written to serve as a comprehensive introduction on how to use *SURGE*.

In short, it was with this latter aim that we wrote the first edition of this guide. Motivated by both our experiences trying to teach *SURGE* to neophytes, as well as the success of the “software for dummies”-type guidebooks currently flooding the market (e.g., “UNIX for Dummies”, “Big Idiots Guide to the Internet”...), we decided to write a comprehensive guide on the mechanics and logic for using *SURGE*.

Why a second edition? Two primary reasons: first, feedback from users of the first edition has helped us improve the clarity (we hope!) of the text in several places. Second, and perhaps most notably, there have been several recent advances, both in terms of the software itself, and the mechanics and philosophy of model selection, which have necessitated modifying the text in several places.

*SURGE* is not the only program available for analysis of mark-

recapture data (see <http://www.biol.sfu.ca/cmr> on the World Wide Web for pointers to other applications), you may wonder “why bother with *SURGE*?”. The short answer is that *SURGE* offers, on the one hand, **far** more flexibility and power in statistical modelling and hypothesis testing than other widely available and frequently used programs (e.g., *JOLLY*, *JOLLYAGE* and *RELEASE*), but at the same time is **much** easier to use (with some instruction) than some others (e.g., *SURVIV*). However, despite its considerable strengths, *SURGE* does have some limitations, at least in its present form. We mention these to help you decide if it is the right software for your needs, or if you should consider one of the other packages available.

In its current form, *SURGE*

- cannot directly handle unequal intervals between marking or capture occasions.
- does not provide abundance estimates
- it has no “built-in” goodness-of-fit capabilities.
- cannot easily handle recovery data (recoveries from harvested individuals)
- cannot handle more than the two primary parameters (survival and recapture rate)

Those of you familiar with the previous version of *SURGE*, and the first edition of this guide, may notice one very important change in this list - previously, *SURGE* did not automatically count the number of estimable model parameters, and did not provide any level of diagnostics to help you determine when some of the parameters were inestimable. You had to count parameters ‘by hand’.

No longer! The new version of *SURGE* counts parameters, calculates the model AIC (discussed in detail in later chapters), and alerts the user when some parameters may not be estimable.

Clearly, this change represents a major advance. We anticipate that many of the remaining “limitations” will be addressed in future releases of *SURGE*. Some of these changes and innovations are discussed in Chapter 9.

## Which version of SURGE?

This guide is written around the “official, supported” versions of SURGE - version 4.2, both the older DOS version (‘non-AIC’), and the newer Windows-version (‘AIC’). Superficially, the two versions are identical, and most of the text in this Guide applies **equally** to either version - the only major difference between the two versions is that the newer Windows-based version counts parameters and calculates the model AIC, whereas the older DOS-based version does not.

We use the word “supported”, as opposed to “common”, quite intentionally. SURGE has tripped, stumbled and fallen out of various people’s hands into the larger research community, where it has multiplied into a great many copies of different versions in a great many places. This history owes its lineage to the fact that SURGE was developed to be used as a research tool, and was given away to interested researchers. Without some formal structure to control distribution (which almost by definition means “going commercial”) there were few controls on “who had which versions” of SURGE.

Currently, the “official” version of SURGE (both the DOS and Windows version) is available free-of-charge through the Web at

**<http://www.biol.sfu.ca/cmr/surge>**

Previously, SURGE was distributed with a rudimentary menuing interface (CR). In the first edition, we did not discuss CR at all - our view was that CR was potentially useful if you only used SURGE intermittently, or are particularly uncomfortable with software run from the “command line (SURGE is a DOS-based, command-line driven application). However, the CR interface is not compatible with the new Windows-version of SURGE, and is no longer distributed. It has been our experience that once a user becomes familiar with how SURGE works, there is little need for CR - in fact, most experienced users find anything other than the command-line interface more of a hindrance than help. Thus, we doubt CR’s demise will pose any significant problems for users.

However, while CR may be of limited appeal to most users, several of

the “utilities” which CR “calls” are particularly useful. One of them (RELTOSUR) we make considerable use of in Chapter 2. Several of the component utilities that comprised CR (especially RELTOSUR) are available through the SURGE Web site.

## About the guide

This guide has been written to be used (in effect) to teach yourself how to use SURGE. It is NOT a tutorial on how to get SURGE running on your machine - that is left to the installation documentation that comes with the software. We have included much of the material we normally cover in the classroom or during workshops, placing as much emphasis on “why things work the way they do” as on “now..press this button”. Our basic view of learning to use software is that the only way to really master an application is to understand what it is doing.

Having said that, it is worth letting you know right from the beginning that this is NOT a book on the theory of capture-recapture analysis. At least, not strictly speaking. It is intended to be a means by which you can learn how to use SURGE to do capture-recapture analyses. In the process, we do cover a lot of the basics of the methodology, so if it has been a while since you last delved into this area, you might find it reassuring to have some of the text devoted to the underlying logic of how the analyses are approached. If you’re an experienced analyst of these sort of data, you’ll quickly find which parts you can skip, and which you can’t. Regardless, we commend you to read the current literature - it is the only way to keep up with recent developments in the analysis. In particular, we suggest you have a copy of the following paper handy:

Lebreton, J-D., Burnham, K.P., Clobert, J., & Anderson, D.R.  
(1992) Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. *Ecological Monographs*, **62**, 67-118.

This paper synthesises many of the current ideas concerning analysis of capture-recapture data, from both the statistical and biological perspective. As you’ll see, we refer to this paper with considerable frequency (in fact,

we will re-visit the analysis of some of the data sets described in this paper).

## The Structure of the Guide

There are 9 chapters and 1 appendix, which cover the basics of CMR analysis using SURGE (the Appendix covers GOF testing using program RELEASE). The Chapters have been written in such a way that each builds on the material covered in the preceding chapters. Thus, unless you have some level of background with SURGE (or equivalent programs), we strongly suggest you resist the temptation to leap directly into a chapter you think might be of interest. A few days of working steadily through each chapter, in order, will be more fruitful, and far less trying, than jumping back and forth among chapters.

Beginning with Chapter 2 (“Getting Ready...”), we will take you, step-by-step, through the process of using SURGE, working for the most part with “practice” data sets, starting with the basic rudiments, and ending with some fairly sophisticated examples. Our goal is to provide you with enough understanding of how SURGE works so that even if we don’t explicitly cover the particular problem you’re working on, you should be able to figure out how to approach the problem with SURGE, on your own. In fact, we measure the success of this guide by how little you’ll need to refer to it again, once you’ve gone through all of the chapters.

- One of the things you’ll notice is that we make a rather overwhelming use of bullet lists. This is not because we’re overly fascinated by the ability to create such lists - rather, we find it provides a nice logical structure to the text .
- We also make periodic use of icons in the margins, to highlight sections with particular importance. In particular, we use a pointing hand icon to indicate sections or ideas of particular importance. We use a screwdriver icon to highlight various “tips” for using SURGE more effectively (including pointers to several “time-saving tricks”).



Finally, we also make periodic uses of “question boxes” (for lack of a better description), to highlight text of special note - either points for discussion, or more detailed explanation of points covered in the main body of the text.

## Where to get additional copies of the guide

Additional copies of the guide (and the practice data sets) are available free of charge in print-to-disk format, via the World Wide Web

[http://www.biol.sfu.ca/cmr/surge/surge\\_guide.html](http://www.biol.sfu.ca/cmr/surge/surge_guide.html)

Updates to chapters and other developments will be posted on the Web.

## Acknowledgements

The danger with trying to acknowledge the people who have contributed to the writing of this guide, either directly or indirectly, is that we will both understate the importance of their contributions, as well as run the risk (P → 1.0) of unwittingly omitting some people. However, we would be remiss if we didn’t acknowledge some individuals, without whose guidance and support this guide would not have come into being.

First, and foremost, Jean Clobert, and Jean-Dominique Lebreton, who together have taken both the software and the methodology from the beginning to its current state. EGC and RP also acknowledge the contributions of the staff at the Patuxent Wildlife Research Centre (yes, we know it probably isn’t the current name...), especially Jim Nichols and programming *sensei* Jim Hines. They provided a superb atmosphere in which many of the ideas in this guide germinated, and unintentionally demonstrated that SURGE has at least one advantage over a “certain other” application - it can be used by mere mortals! We’d also like to thank our respective employers for indulging the time it has taken us to put this together. We also thank Anne Viallefont (CEFE/CNRS) for contributing Chapter 9. We would also like to thank Gary White, Carl Schwarz and

Neil Arnason for many comments on the first edition.

Finally, we owe perhaps the deepest debt to the many students and colleagues who have asked us questions about using SURGE. We believe in earnest that the only truly 'dumb' question is one never asked - hopefully, most of your queries over the years are answered in this book.

1997

*Burnaby, British Columbia*

*Montpellier, France*

*Point Reyes, California*

EGC

RP

NN

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