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SAN LUIS & DELTA-MENDOTA WATER AUTHORITY; WESTLANDS WATER DISTRICT

UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF CALIFORNIA

THE DELTA SMELT CASES SAN LUIS & DELTA-MENDOTA WATER AUTHORITY, et al. v. SALAZAR, et al. (Case No. 1:09-cv-407) STATE WATER CONTRACTORS v. SALAZAR, et al. (Case No. 1:09-cv-422) COALITION FOR A SUSTAINABLE DELTA, et al. v. UNITED STATES FISH AND WILDLIFE SERVICE, et al. (Case No. 1:09-cv-480) METROPOLITAN WATER DISTRICT v. UNITED STATES FISH & WILDLIFE SERVICE, et al. (Case No. 1:09-cv-631) STEWART & JASPER ORCHARDS, et al. v. UNITED STATES FISH AND WILDLIFE SERVICE, et al. Case No. 1:09-cv-892)	CASE NO. 1:09-cv-407-OWW-DLB 1:09-cv-422-OWW-DLB 1:09-cv-631-OWW-DLB 1:09-cv-892-OWW-GSA PARTIALLY CONSOLIDATED WITH: 1:09-cv-480-OWW-GSA **DECLARATION OF DR. BRYAN MANLY**

I, Bryan F.J. Manly, declare as follows:

1. I am a consultant statistician working for Western EcoSystems Technology Inc., 2003 Central Avenue, Cheyenne, Wyoming. I have been employed by that company since 2000. Before that I was Professor of Statistics and the Director of the Center for Applications of Statistics and Mathematics at the University of Otago, in Dunedin, New Zealand. I have 40 years experience in the application of statistics in environmental and ecological areas. I hold a DSc degree from the City University in London, UK, am a Chartered Statistician of the Royal Statistical Society, and a Fellow of the Royal Society of New Zealand. A copy of my curriculum vitae is attached to this declaration as Exhibit A. I am the author of over 200 papers in refereed scientific journals, and seven books on applied statistics. A list of my publications is attached to this declaration as Exhibit B.

2. I have been involved in various statistical analyses of data from the Sacramento-San Joaquin Delta Estuary since 2003. In the last few years, this has included a number of analyses aimed at better understanding the apparent decline in the numbers of many pelagic fish species since about 2000. I have reviewed the December 15, 2008 biological opinion issued by the United States Fish and Wildlife Service regarding the effects of the coordinated operations of the Central Valley Project and the State Water Project on the delta smelt (*Hypomesus transpacificus*) ("BiOp"). I have been asked to comment upon the statistical analysis in the BiOp. While I have not yet completed a full analysis, based on the results of my review so far, I have identified some important deficiencies in the effects analysis in the BiOp. In particular, the BiOp apparently attributes important long-term population level effects to project operations without any scientifically sound basis. I say "apparently" here because it is often not clear whether the BiOp is referring to a temporary short-term effect that has little influence on the future abundance of delta smelt, or an important long-term effect.

3. In the BiOp, the Service identifies three "seasonally occurring effects" of the projects for specific focus: "entrainment of delta smelt, habitat restriction, and entrainment of *Psuedodiaptomus forbesi,* the primary prey of delta smelt during summer-fall." (BiOp at 203.) The effects analysis in the BiOp "assumes that the proposed CVP/SWP operations affect delta

smelt throughout the year either directly through entrainment or indirectly through influences on its food supply and habitat suitability." (*Id.*) The BiOp further "assumes that any of these three major categories of effects described above will adversely affect delta smelt, either alone or in combination." (*Id.*) The explicit statement that adverse effects from project operations are "assumed" foreshadows the deficiencies I found in the effects analysis in the BiOp. Specifically, rather than providing a scientific basis, the BiOp apparently assumes or surmises without supporting data and analysis that each of the three "major categories of effects" in a year significantly affects the delta smelt population abundance of delta smelt in the following year.

A. There Is No Support For the Service's Conclusion That Entrainment Affects Subsequent Year Abundance Of Delta Smelt Even "Sporadically"

4. The BiOp acknowledges that "currently published analyses of long-term associations between delta smelt salvage and subsequent abundance do not support the hypothesis that entrainment is driving population dynamics year in and year out (Bennett 2005; Manly and Chotkowski 2006; Kimmerer 2008)." (BiOp at 210.) As stated, the available statistical studies do not show a statistically significant, important relationship between the level of entrainment in one year and abundance in the following year, including the 2006 study I authored with Chotkowski.

5. In the same paragraph, however, the BiOp makes the following statement: "[t]he population-level effects of delta smelt entrainment vary; delta smelt entrainment can best be characterized as a sporadically significant influence on population dynamics." (BiOp at 210.) This statement is unclear and confusing. As the BiOp acknowledges, the available studies have not found evidence of important long-term population level effects from entrainment, contradicting the BiOp's statement that the population level effects may "vary," if this means the long-term effects. The BiOp goes on to observe that "Kimmerer (2008) estimated that annual entrainment of the delta smelt population (adults and their progeny combined) ranged from approximately 10 percent to 60 percent per year from 2002-2006." (BiOp at 210.) If the Service meant only that the abundance at a point in time during a single year may vary depending upon entrainment, then Kimmerer's estimates support that statement. But if, as appears more likely,

the Service was relying upon Kimmerer's estimates to support a conclusion that entrainment sometimes causes abundance to vary significantly in the following year, then the statement has no scientific basis.

6. First, it is important to understand that Kimmerer's article, *Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento – San Joaquin Delta* (2008) estimated losses of delta smelt within a single year class of delta smelt, but did not conclude that such losses reduce delta smelt population abundance from one year to the next. To the contrary, Kimmerer concluded that the effects of such entrainment are negligible in comparison to the effect of other factors. For example, in the summer to fall period (after entrainment by the projects has ceased), there has been a 50-fold variation in survival of delta smelt, apparently depending upon the availability of the zooplankton on which delta smelt feed. Therefore, even assuming Kimmerer's estimates of the percentages lost to entrainment are correct, the data and analysis in Kimmerer 2008 do not support a conclusion that entrainment has anything more than a trivial effect on smelt abundance the following year.

7. Second, if the Service wished to test whether high levels of entrainment in some years, such as those estimated by Kimmerer, will "sporadically" reduce abundance the following year, there are relatively simple statistical methods for testing this hypothesis. The BiOp does not report that the Service applied any such statistical methods, so I tried this myself.

8. Using the same years reported in Kimmerer's article, 1995 through 2006, and assuming his estimates of loss to entrainment are correct, I related the logarithm of the summer townet survey abundance index to the logarithm of the previous fall midwater trawl index. The fitted equation accounted for 68% of the variation in the logarithm of the summer townet index, indicating that there is a close relationship between the summer delta smelt abundance and the abundance in the previous fall. I then tried adding Kimmerer's estimated survival rates from entrainment into the equation with the idea that if entrainment has important effects, then the summer abundance should be lower than expected in the years when the entrainment survival rate is low. There was no significant effect of survival when added to the

equation, and the predicted summer townet abundances are almost exactly the same with Kimmerer's entrainment survival estimates either in or out of the equation. Hence, I could find no evidence from this analysis that the entrainment of adults in one generation or juveniles in the next generation of delta smelt affects the number of adults in the next generation in an important way.

9. There are a number of potential explanations for this result. One possibility is that Dr. Kimmerer's estimates of entrainment losses are too high. He acknowledges that there is significant uncertainty in the estimates, and that his extrapolation from salvage to total entrainment could result in an estimate as much as 3 times too high. Thus, the statistical analysis may show no effect on subsequent abundance because actual entrainment is much lower than he calculated. Another possibility, as is stated by Dr. Kimmerer, is that other factors such as limited food availability overwhelm any effect from entrainment.

10. In sum, as the BiOp acknowledges, the available studies do not show that entrainment has any meaningful effect upon abundance from one year to the next. The BiOp's apparent reliance upon Kimmerer 2008 to support a hypothesis that entrainment "sporadically" has effects on long term abundance is misplaced. I do not know whether the Service employed readily available statistical methods to test its hypothesis that such effects do occur; the BiOp reports no such tests. My statistical analyses showed no evidence of such "sporadic" effects. In sum, the available data and statistical analyses do not support a conclusion that entrainment is affecting the long term viability of the population.

B. The Service's Analysis of Fall X2 And Abundance Is Invalid

11. I have reviewed the *Declaration of Dr. Richard B. Deriso in Support of Metropolitan's Motion to Allow Expert Testimony*, dated July 30, 2009. I agree with Dr. Deriso that the Service (and Feyrer et al.) inappropriately used a linear additive model to find a statistically significant relationship between Fall X2 and delta smelt abundance. This is not a matter of judgment. Any competent modeler would understand the inappropriateness of using such a model in these circumstances. To avoid duplication, I will not address this point further.

12. Dr. Deriso reports that he used a standard Ricker stock-recruit model in

order to evaluate whether there is a relationship between Fall X2 and subsequent summer abundance. He reports finding no statistically significant relationship using this model.

13. There are other appropriate statistical methods for investigating whether such a relationship exists. One method of such analysis is described in a letter to the Service dated November 19, 2008, which is in the administrative record at 006367-006392. Regression analyses described in that letter showed that the fit of the regression line using Fall Midwater Trawl data alone was better at predicting the recent low summer townet levels than a regression using both Fall Midwater Trawl and X2. Put another way, adding X2 as a variable worsens the prediction of the recent summer abundance as compared to a simple stock-recruitment relationship. I could more thoroughly explain the method and results of this regression analysis, and other methods the Service could have appropriately used but did not, in a second declaration.

14. In sum, the second theorized effect of project operations, limiting delta smelt abundance through movement of the location of X2, is based on an inappropriate statistical method. In contrast, the statistical analyses described in the November 19, 2008 letter in the administrative record show no evidence that the location of X2 explains recent changes in the summer delta smelt abundance. The Service could have used, but does report, the results of a number of methods that could have been appropriately used to determine whether Fall X2 is related to abundance.

C. There Is No Basis for The Service's Conclusion That Entrainment Of *Pseudodiaptomus* In The Summer Is Limiting Abundance

15. The third and final "major category" of effect attributed to project operations is the entrainment of the *Pseudodiaptomus forbesi*. The BiOp theorizes that summer exports are removing the *Pseudodiaptomus* from the south Delta during the summer, and that these zooplankton would otherwise drift downstream to the western Delta, where delta smelt reside during the summer. The BiOp says this "might" be depriving the delta smelt of an important food source (BiOp at 228), but there is no support for this theory in any data or statistical analyses described in the BiOp.

16. This hypothesis is apparently contradicted in numerous ways by the

available data, as is described in the November 19, 2008 comment letter. (AR 006367-006392.) Among the reasons, as is reported in the letter, the peer review of the draft effects section of the BiOp recommended that the Service reanalyze the supposed relationship between summer export volumes and *Pseudodiaptomus* densities, considering various factors. If the Service did so, the BiOp does not report the results of the reanalysis. The comment letter describes a regression analysis that included factors that the peer review recommended be considered. The analysis found no correlation between export volumes and *Pseudodiaptomus* densities. In a second declaration, I could explain the method and results of this regression analysis, and why it indicates no such effect on summer food availability for delta smelt.

D. Conclusion

17. In sum, the BiOp is fundamentally deficient in its use of the available data and statistical analyses to determine the long-term effects of project operations on the delta smelt. To support the three "major categories" of effects, the BiOp disregards or misuses the studies regarding the effects of entrainment on abundance, uses an inappropriate statistical method to conclude that there is a statistically significant relation between X2 and abundance, and theorizes an effect from entrainment of *Pseudodiaptomus* that is not based on any evidence.

18. While I have not yet completed my full analysis, I expect that if permitted to submit a second declaration, I could and would provide further bases for my conclusions that the effects analysis in the BiOp is not consistent with the best available scientific data, or with competent statistical analysis, and as a result the Service has drawn scientifically unsubstantiated conclusions regarding the long-term effects of project operations on the delta smelt.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct. Executed this 9th day of October, 2009, at Dunedin, New Zealand

BFJ Manly

BRYAN F.J. MANLY

EXHIBIT A

Bryan F.J. Manly
Short Curriculum Vitae

Present Employment

Consultant, Western EcoSystems Technology Inc., Laramie, Wyoming. Telephone: 307-634-1756; e-mail bmanly@west-inc.com. Adjunct Professor of Statistics, University of Wyoming, Laramie, Wyoming.

Qualifications

BSc, DSc (City University, London). Chartered Statistician (Royal Statistical Society).

Distinctions

Awarded the title *Distinguished Statistical Ecologist* at the 6th International Congress of Ecology, Manchester, 1994. Elected *Fellow of the Royal Society of New Zealand* (the national academy of science), 1994.

Other Appointments

Statistician, Fisons Ltd., Felixstowe, UK, 1966-7; Lecturer, Department of Mathematics, University of Salford, UK, 1967-70; Lecturer, Department of Mathematics, University of Papua and New Guinea, Port Moresby, Papua New Guinea, 1970-3. Visiting Associate Professor, Department of Applied Statistics, Louisiana State University, Baton Rouge, USA, 1981; Visiting Professor, Department of Statistics, University of Wyoming, Laramie, USA, 1988; Research Fellow, Max Planck Institute of Limnology, Plon, Germany, 2000; Senior Lecturer (1973-81), Associate Professor (1982-6), Professor (1987-2000), University of Otago; Visiting Professor, Department of Exact Sciences, ESALQ, University of Sao Paulo, Piracicaba, Brazil (May 2004 - April 2006).

Editorial Work

Associate Editor, 1996-98, and then Editor, 1999-02 of the *Journal of Agricultural, Biological and Environmental Statistics*, a journal owned by the American Statistical Association and the International Biometrics Society. Editor, Population and Community Biology Series, Chapman and Hall, London (1993-2000). Editorial Board Member, *Environmental and Ecological Statistics (1991-)*, *Population Ecology (1999-)*; Associate Editor, *Environmetrics* (1996-), *Australian and New Zealand Journal of Statistics* (2004-), *Journal of Animal Ecology* (2005-).

Refereeing of Research Grants, Prizes and Other Awards and Related Service

Panel Member, Mathematical and Information Sciences, for assessing applications to the Marsden Fund for Pure Research (1995-7, 2000). Reviewer for: the Australian Research Grants Committee, the Health Research Council of New Zealand, the International Foundation for Science (Sweden), the John Simon Guggenheim Memorial Foundation (USA), the Lottery Grants Board of New Zealand, the Marsden Fund (New Zealand), the National Science and Engineering Research Council of Australia, the National Science Foundation (USA), the New Zealand Foundation for Research, Science and Technology, and the University of Queensland. Hamilton Prize Committee, Royal Society of New Zealand (1995-7). Fellowship Selection Committee , Mathematics and Information Sciences Panel, Royal Society of New Zealand (1995-98). Author of the Ministry of Research, Science and Technology *Area Profile in Statistics* for the *Profile of New Zealand Science* to be used in making decisions on priorities in science funding (1996), and the *Statistics* section of the Ministry's report on the *New Zealand Knowledge Base for Mathematical Sciences* (1997). Distinguished Statistical Ecologist Award Committee, Statistical Ecology Group, International Association for Ecology (1997-8).

Refereeing for Journals

Anthropology: *American Journal of Physical Anthropology, New Zealand Journal of Archaeology.*

Biology: *Agricultural Systems, American Journal of Physical Anthropology, American Naturalist, Aquaculture, Australian Journal of Ecology, Biological Journal of the Linnean Society, Canadian Journal of Fisheries and Aquatic Science, Ecography, Ecological Entomology, Ecological Modelling, Ecological Applications, Ecological Research. Ecology, Ecology Letters, Entomological Society of America, Fisheries Bulletin, Hydrobiologia, Journal of Animal Ecology, Journal of Applied Ecology, Journal of Biogeography, Journal of Experimental Marine Biology*

and Ecology, Journal of Insect Behaviour, Journal of Vegetation Science, Journal of Wildlife Management, Limnology and Oceanography, Marine Biology, Marine Mammal Science, New Zealand Population Ecology, Journal of Ecology, New Zealand Journal of Marine and Freshwater Research, New Zealand Journal of Zoology, Oecologia, Oikos, San Francisco Estuary and Watershed Science, Scientia Agricola, Theoretical Population Biology, The Wilson Bulletin, The Wilson Journal of Ornithology, Transactions of the American Fisheries Society, Trends in Ecology and Evolution, Wildlife Research.

Environmental: *Archives of Environmental Contamination and Toxicology, CCAMLR Science, Environmental Conservation, Environmental Engineering Science. Environmetrics, Waste Management and Research.*

Medical: *Australian and New Zealand Journal of Surgery, Clinical and Experimental Pharmacology and Physiology, American Journal of Epidemiology.*

Physical Sciences: *Applied Meteorology.*

Psychology: *Psychological Bulletin, Psychological Reports, Perceptual and Motor Skills.*

Statistics: *Australian Journal of Statistics, Biometrics, Environmental and Ecological Statistics, Journal of the American Statistical Association, Journal of Classification, Journal of Agricultural, Biological and Environmental Statistics, Journal of Statistical Education, Journal of Statistical Computation and Simulation, Statistical Papers, Statistics and Computing, The Statistician.*

Government Representation

Represented the New Zealand government at Statistics Subcommittee meetings of the *Commission for the Conservation of Antarctic Marine Living Resources* (CCAMLR), an international organization involving 28 countries that is charged with monitoring and managing the Antarctic marine ecosystem (1996-2000).

Membership of Societies

Fellow: Royal Society of New Zealand, Royal Statistical Society. Member: Environmetrics Society, International Biometric Society, New Zealand Statistical Association, Society for Population Ecology.

Recent Invited Presentations

2000 University of Denver Medical School, Denver, USA; Department of Zoology, University of Toronto, Canada; Department of Zoology, University of Oslo, Finland; Joint Statistical Meetings, Indianapolis, USA (Session Organizer).

2001 The First International Distance Sampling Conference, St Andrews, Scotland; Joint Statistical Meetings, Altanta, Georgia (Session Organizer); Environmetrics Society Conference, Portland, Oregon, USA; Department of Statistics, North Carolina State University, Raleigh, North Carolina, USA.; Australasian Meeting of the International Biometric Society, Christchurch, New Zealand.

2002 University of Florence, Italy; University of Naples, Italy; Colorado State University, Fort Collins, USA.; Western North American meeting of the International Biometric Society; Conference on Statistical Methods for Environmental Surveys, University of Sienna, Italy; Meeting of the Colombian Statistical Society, Bogota.

2003 Waikato University, Hamilton, New Zealand; Auckland University, New Zealand; California Water and Environmental Modelling Forum, Asilomar, Monterey; British Regional Meeting of the International Biometric Society, University of Reading, United Kingdom.

2004 Mathematical Institute, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil; 49th Annual Regional Meeting of the International Biometrics Society, Uberlandia, Brazil (opening talk), 9th Meeting of the Argentinian Scientific Group in Biometry, National University of La Rioja, La Rioja, Argentina (opening talk plus one other), City University of Buenos Aires (two talks).

2005 ComFish conference, Kodiak, Alaska, USA (talk on the assessment of fisheries bycatch of birds and marine mammals). The 11th Symposium on Statistics Applied to Experimental Agronomy, Londrina, Brazil.

2006 Annual meeting of the Ecological Society of America, Memphis, Tennessee; International Conference on Teaching Statistics, Salvador, Brazil; International Workshop on Advances in Statistical Modelling of Faunal Distributions: Global and Local Applications, Castle of Rauischholzhausen, Germany.

2008 California Water and Environmental Modelling Forum Annual Meeting, Asilomar, California; February. Universidad Autonoma de Yucatan, Mexico, April.
2009 Meeting of the German region of the International Biometric Society, Hanover, Germany, March.

Publications

Author of more than 200 refereed research papers in statistical, biological and other journals, and seven books:

The Statistics of Natural Selection on Animal Populations, Chapman and Hall, London (hardback 1985, paperback 1987).

Multivariate Statistical Methods: a Primer, Chapman and Hall, London (1st edition 1986, 2nd edition 1994, 3rd Edition 2004).

Stage-Structured Populations: Sampling, Analysis and Simulation, Chapman and Hall, London (1990).

Randomization, Bootstrap and Monte Carlo Methods in Biology, Chapman and Hall, London (1st edition 1991, 2nd edition 1997, 3rd edition 2006).

The Design and Analysis of Research Studies, Cambridge University Press, Cambridge (1992).

Resource Selection by Animals: Statistical Design and Analysis for Field Studies, Chapman and Hall, London (1st Edition 1993, 2nd Edition 2002), written with L.L. McDonald and others.

Statistics for Environmental Science and Management, Chapman and Hall/CRC, Boca Raton, Florida (2001, 2nd Edition 2009).

Areas of Particular Expertise

(a) Statistical methods in general applied in the areas of ecology and environmental science.
(b) The estimation of animal and plant population sizes through mark-recapture and other specialized methods.
(c) Survey design and analysis in all biological areas including fisheries observer programs to assess accidental bycatch levels of marine mammals and birds.
(d) Computer-intensive statistical methods in general, but particularly with biological applications.
(e) The design and analysis of studies on resource selection by animals.

Bryan F.J. Manly

EXHIBIT B

Bryan F.J. Manly Publications

Refereed Papers and Books (With Books Highlighted)

1. Manly, B.F.J. (1967). An approximate method for calculating the average sample number in certain sequential tests. *Journal of the Royal Statistical Society* A130: 239-43.
2. Manly, B.F.J. and Parr, M.J. (1968). A new method for estimating population size, survivorship, and birth rate from capture-recapture data. *Transactions of the Society for British. Entomology* 18: 81-9.
3. Manly, B.F.J. (1969). Approximations to the characteristics of some sequential tests. *Biometrika* 56: 203-6.
4. Manly, B.F.J. (1969). On a method of estimation using capture-recapture data. *Entomologist* 102: 117-20.
5. Manly, B.F.J. (1969). Some properties of a method for estimating the size of an animal population. *Biometrika* 56: 407-10.
6. Popham, E.J. and Manly, B.F.J. (1969). Geographical distribution of the Dermaptera and the continental drift hypothesis. *Nature* 222: 981-2.
7. Manly, B.F.J. (1970). The choice of a Wald test on the mean of a normal distribution. *Biometrika* 57: 91-5.
8. Manly, B.F.J. (1970). On the distribution of the decisive sample number of certain sequential tests. *Biometrika* 57: 367-76.
9. Manly, B.F.J. (1970). A simulation study of animal population estimation using the capture-recapture method. *Journal of Applied Ecology* 7: 13-39.
10. Manly, B.F.J. (1971). Estimates of a marking effect with capture-recapture sampling. *Journal of Applied Ecology* 8: 181-9.
11. Manly, B.F.J. (1971). A simulation study of Jolly's method for analysing capture-recapture data. *Biometrics* 27: 415-24.
12. Manly, B.F.J. (1972). The application of a Wald-type sequential test with particular reference to acceptance sampling situations. *New Journal of Statistics and Operational Research* 7: 1-12.
13. Manly, B.F.J. (1972). Tables for the analysis of selective predation experiments. *Researches on Population Ecology* 14: 74-81.
14. Manly, B.F.J. , Miller, P. and Cook, L.M. (1972). Analysis of a selective predation experiment. *American Naturalist* 106: 719-36.
15. Manly, B.F.J. (1972). Estimating selective values from field data. *Biometrics* 28: 1115-25.
16. Manly, B.F.J. (1973). A computer program for the method of successive intervals. *Educational and Psychological Measurement* 33: 171-3.
17. Manly, B.F.J. and G.A.F. Seber (1973). Animal life tables from capture-recapture data. *Biometrics* 29: 487-500.
18. Manly, B.F.J. (1973). Estimating survivorship from the recaptures of animals first released at age zero. *Biometrie Praximetrie* 13: 1-14.
19. Manly, B.F.J. (1973). Validity of the quadratic fitness function. *Nature New Biology* 242: 128.
20. Manly, B.F.J. (1973). A linear model for frequency-dependent selection by predators. *Researches on Population Ecology* 14: 137-50.
21. Manly, B.F.J. (1973). A note on the estimation of selective values from recaptures of marked animals when selection pressures remain constant over time. *Researches on Population Ecology* 14: 151-8.
22. Cummings, L.P., Weinand, H.C. and Manly, B.F.J. (1973). Measuring association with link-node problems. *Geoforum* 13: 43-51.
23. Lawson, R. and Manly, B.F.J. (1973). Tooth growth and replacement in *Ctenolucius huieta*, a neotropical Characoid fish. *Journal of Morphology* 141: 383-94.
24. Manly, B.F.J. (1974). Estimating survival from a multi-sample single recapture census where recaptures are not made at release times. *Biometrical Journal* 16: 185-90.

25. Manly, B.F.J. (1974). A discrete analogue of the gamma distribution applied to data on the survival of birds. *Biometrie Praximetrie* 14: 1-14.
26. Manly, B.F.J. (1974). A model for certain types of selection experiment. *Biometrics* 30: 282-94.
27. Manly, B.F.J. (1974). Estimation of stage-specific survival rates and other parameters for insect populations developing through stages. *Oecologia* 15: 277-85.
28. Manly, B.F.J. (1974). A comparison of methods for the analysis of insect stage-frequency data. *Oecologia* 17: 335-48.
29. Cummings, L.P., Weinand, H.C. and Manly, B.F.J. (1974). Measuring association with link-node problems: a reply. *Geoforum* 17: 92-3.
30. Manly, B.F.J., Shannon, A.G. and Allen A. (1974). An analogical replication of a Piagetian experiment on New Guineans. *Malaysian Journal of Education* 11: 77-82.
31. Manly, B.F.J. (1975). Simulation of an agricultural field experiment: a teaching aid. *New Zealand Statistician* 10: 7-8.
32. Manly, B.F.J. (1975). The TINI-TAB programs for the analysis of surveys. *New Zealand Statistician* 10: 72-3.
33. Manly, B.F.J. (1975). Estimating survival from a multi-sample single recapture census - the case of constant survival and recapture probabilities. *Biometrical Journal* 17: 431-5.
34. Manly, B.F.J. (1975). The estimation of a fitness function from two samples taken from a population. *Researches on Population Ecology* 16: 219-30.
35. Manly, B.F.J. (1975). A second look at some data on a cline. *Heredity* 34: 423-6.
36. Manly, B.F.J. (1975). The measurement of the characteristics of natural selection. *Theoretical Population Biology* 7: 288-305.
37. Manly, B.F.J. (1975). A note on the Richards, Waloff and Spradbery method for estimating stage-specific mortality rates for insect populations. *Biometrical Journal* 17: 77-83.
38. Manly, B.F.J. (1976). Exponential data transformations. *Statistician* 25: 37-42.
39. Manly, B.F.J. (1976). Some examples of double exponential fitness functions. *Heredity* 36: 229-34.
40. Manly, B.F.J. (1976). Extensions to Kiritani and Nakasuji's method for the analysis of insect stage-frequency data. *Researches on Population Ecology* 17: 191-9.
41. Manly, B.F.J. (1976). The estimation of a bivariate fitness function from two samples taken from a population. *Researches on Population Ecology* 18: 105-17.
42. Manly, B.F.J. (1977). A further note on Kiritani and Nakasuji's model for stage-frequency data including comments on Tukey's jackknife technique for estimating variances. *Researches on Population Ecology* 18: 177-86.
43. Manly, B.F.J. (1977). Examples of the use of GLIM. *New Zealand Statistician* 12: 26-42.
44. Manly, B.F.J. (1977). A simulation study of the application of the jackknife with Jolly's method for the analysis of capture-recapture data. *Acta Theriologica* 22: 215-23.
45. Manly, B.F.J. (1977). The analysis of trapping records for birds trapped in mist nets. *Biometrics* 33: 404-10.
46. Manly, B.F.J. (1977). The determination of key factors from life table data. *Oecologia* 31: 111-7.
47. Manly, B.F.J. (1977). A model for dispersion experiments. *Oecologia* 31: 119-30.
48. Manly, B.F.J. (1977). The estimation of the fitness function from several samples taken from a population. *Biometrical Journal* 19: 391-401.
49. Manly, B.F.J. (1977). A note on the design of experiments to estimate survival and relative survival. *Biometrical Journal* 19: 687-92.
50. Manly, B.F.J. (1977). A new index for the intensity of natural selection. *Heredity* 38: 321-8.
51. Manly, B.F.J. (1977). A further note on the estimation of a fitness function from two samples from a population. *Researches on Population Ecology* 19: 1-9.
52. Manly, B.F.J. (1978). Regression models for proportions with extraneous variance. *Biometrie Praximetrie* 18: 1-18.
53. Manly, B.F.J. (1978). Comparison of marks on several examination papers. *New Zealand Statistician* 13: 11-20.
54. Manly, B.F.J. (1978). Analysis of differential predation. *Heredity* 40: 315-6.

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