A Field Guide to Wildlife Economic Analyses

John B. Loomis
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
Creekside One Building
2627 Redwing Road
Fort Collins, Colorado 80526-2899

George Peterson and Cindy Sorg
Valuation of Wildland Resource Benefits
Rocky Mountain Forest and Range Experiment Station
U.S. Forest Service
Fort Collins, Colorado 80526[1]

Much unnecessary confusion about the economic value of wildlife is caused by inadequate knowledge of basic economic concepts. This is aggravated by a common failure to identify and separate different policy questions which require different kinds of dollar value-related answers. The information required by questions of national economic efficiency, for example, are different than what is needed to address concerns about local economic impact.

The purpose of this paper is to identify and clarify several major sources of confusion that commonly inhibit effective wildlife valuation. First, economic values in the context of the Public Trust Doctrine are shown to be broader than the financial perspective often taken in practice. This is followed by clarification of concepts of economic efficiency. Common abuse of expenditure information is exposed, and the proper role of expenditures in analysis of economic impact is clarified. Finally, the important relationship between economic value on the one hand and resource quality and price on the other hand are explained.

Public Trust Doctrine

In the United States the Public Trust Doctrine assigns ownership of the nation's wildlife resources to the State or Federal government. The government thus has the incentive and responsibility to manage these resources as trustee for the benefit of the public. The Public Trust Doctrine recognizes that market failures would result in inefficient resource allocation without cooperative intervention. The public agent is expected to pursue broad economic efficiency rather than the more narrow and incomplete financial incentives seen by private firms. In this way wanton resource exploitation and the tragedy of the commons are hopefully avoided.

The Public Trust Doctrine recognizes there are many benefits of wildlife to people in addition to commodity values. Broadly defined, the economic benefits of wildlife go beyond market prices to reflect the benefits to birders, hunters, and citizens who enjoy knowing wildlife exist. Many of the papers which will be presented in this session will be analyzing the nonmarketed values produced by consumptive and nonconsumptive uses of our wildlife resources. In this paper, the notion of the Public Trust Doctrine serves to

[1] Comments by Drs. M. Hay and J. Charbonneau have improved the clarity of this manuscript significantly.

highlight the first pitfall the wildlife biologist often faces in identifying and evaluating wildlife values: the difference between economic values and financial values. Financial values reflect only revenue or sales received by firms or public agencies (i.e., cash changing hands). Economic values are much more general. Financial values may ignore externalities and values which flow in ways that cannot be captured as revenue (Bator 1958). At best, financial values are a subset of economic value and, at worst, may be a serious distortion. In any case for any good or service to have a positive economic value, it must have two properties. It must provide at least some consumers (but not necessarily all) satisfaction or enjoyment. Second, the good or service must be *scarce* in the sense that at a zero price (free) consumers want more than is available. Wildlife certainly meets both of these properties. Some wildlife recreation opportunities are so scarce they are once in a lifetime in nature (e.g., bighorn sheep and mountain goat hunting permits).

Figure 1 illustrates what Randall and Stoll (1983) call a "Total Value Framework." The financial value of wildlife reflects a *portion* of the social benefits (defined in terms of willingness to pay) of recreational and commercial uses of wildlife.

Beside the citizens' economic values of onsite recreation (both consumptive and non-consumptive) and commercial uses of wildlife, there are many off-site user values. These include option, existence, and bequest values. Option value can be thought of as an insurance premium people would pay to insure availability of wildlife recreation opportunities in the future. Existence value is the economic benefit received from simply knowing wildlife exist. Bequest value is the willingness to pay for economic benefits of providing wildlife resources to future generations.

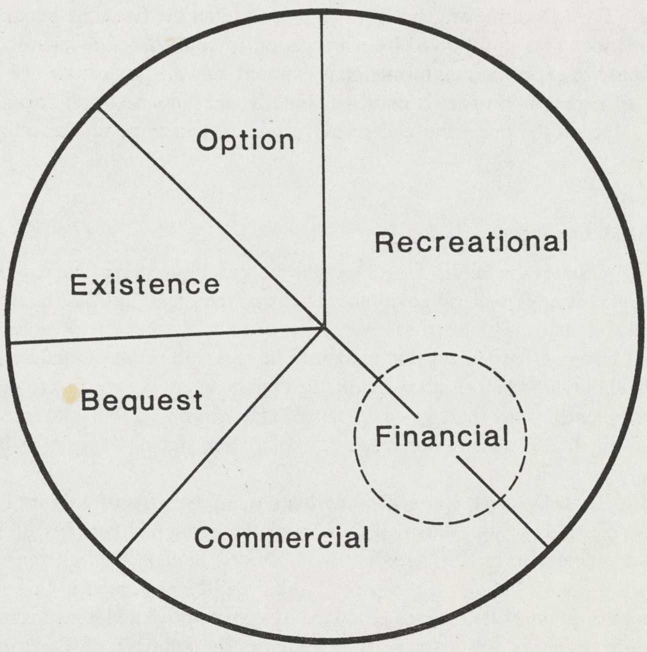

Figure 1. Total value of wildlife.

Uncertainty, Resource Exploitation, and Conservation: Lessons from History

Donald Ludwig, Ray Hilborn, Carl Walters

There are currently many plans for sustainable use or sustainable development that are founded upon scientific information and consensus. Such ideas reflect ignorance of the history of resource exploitation and misunderstanding of the possibility of achieving scientific consensus concerning resources and the environment. Although there is considerable variation in detail, there is remarkable consistency in the history of resource exploitation: resources are inevitably overexploited, often to the point of collapse or extinction. We suggest that such consistency is due to the following common features: (i) Wealth or the prospect of wealth generates political and social power that is used to promote unlimited exploitation of resources. (ii) Scientific understanding and consensus is hampered by the lack of controls and replicates, so that each new problem involves learning about a new system. (iii) The complexity of the underlying biological and physical systems precludes a reductionist approach to management. Optimum levels of exploitation must be determined by trial and error. (iv) Large levels of natural variability mask the effects of overexploitation. Initial overexploitation is not detectable until it is severe and often irreversible.

In such circumstances, assigning causes to past events is problematical, future events cannot be predicted, and even well-meaning attempts to exploit responsibly may lead to disastrous consequences. Legislation concerning the environment often requires environmental or economic impact assessment before action is taken. Such impact assessment is supposed to be based upon scientific consensus. For the reasons given above, such consensus is seldom achieved, even after collapse of the resource.

For some years the concept of maximum sustained yield (MSY) guided efforts at fisheries management. There is now widespread agreement that this concept was unfortunate. Larkin (*1*) concluded that fisheries scientists have been unable to control the technique, distribution, and amount of fishing effort. The consequence has been the elimination of some substocks, such as herring, cod, ocean perch, salmon, and lake trout. He concluded that an MSY based upon the analysis of the historic statistics of a fishery is not attainable on a sustained basis. Support for Larkin's view is provided by a number of reviews of the history of fisheries (*2*). Few fisheries exhibit steady abundance (*3*).

It is more appropriate to think of resources as managing humans than the converse: the larger and the more immediate are prospects for gain, the greater the political power that is used to facilitate unlimited exploitation. The classic illustrations are gold rushes. Where large and immediate gains are in prospect, politicians and governments tend to ally themselves with special interest groups in order to facilitate the exploitation. Forests throughout the world have been destroyed by wasteful and short-sighted forestry practices. In many cases, governments eventually subsidize the export of forest products in order to delay the unemployment that results when local timber supplies run out or become uneconomic to harvest and process (*4*). These practices lead to rapid mining of old-growth forests; they imply that timber supplies must inevitably decrease in the future.

Harvesting of irregular or fluctuating resources is subject to a ratchet effect (*3*): during relatively stable periods, harvesting rates tend to stabilize at positions predicted by steady-state bioeconomic theory. Such levels are often excessive. Then a sequence of good years encourages additional investment in vessels or processing capacity. When conditions return to normal or below normal, the industry appeals to the government for help; often substantial investments and many jobs are at stake. The governmental response typically is direct or indirect subsidies. These may be thought of initially as temporary, but their effect is to encourage overharvesting. The ratchet effect is caused by the lack of inhibition on investments during good periods, but strong pressure not to disinvest during poor periods. The long-term outcome is a heavily subsidized industry that overharvests the resource.

The history of harvests of Pacific salmon provides an interesting contrast to the usual bleak picture. Pacific salmon harvests rose rapidly in the first part of this century as markets were developed and technology improved, but most stocks were eventually overexploited, and many were lost as a result of overharvesting, dams, and habitat loss. However, in the past 30 years more fish have been allowed to spawn and high seas interception has been reduced, allowing for better stock management. Oceanographic conditions appear to have been favorable: Alaska has produced record catches of salmon and British Columbia has had record returns of its most valuable species (*5*).

We propose that we shall never attain scientific consensus concerning the systems that are being exploited. There have been a number of spectacular failures to exploit resources sustainably, but to date there is no agreement about the causes of these failures. Radovitch (*6*) reviewed the case of the California sardine and pointed out that early in the history of exploitation scientists from the (then) California Division of Fish and Game issued warnings that the commercial exploitation of the fishery could not increase without limits and recommended that an annual sardine quota be established to keep the population from being overfished. This recommendation was opposed by the fishing industry, which was able to identify scientists who would state that it was virtually impossible to overfish a pelagic species. The debate persists today.

After the collapse of the Pacific sardine, the Peruvian anchoveta was targeted as a source of fish meal for cattle feed. The result was the most spectacular collapse in the history of fisheries exploitation: the yield decreased from a high of 10 million metric tons to near zero in a few years. The stock, the collapse, and the associated oceanographic events have been the subject of extensive study, both before and after the event. There remains no general agreement about the relative importance of El Niño events and continued exploitation as causes of collapse in this fishery (*7*).

The great difficulty in achieving consensus concerning past events and a fortiori in prediction of future events is that controlled and replicated experiments are impossible to perform in large-scale systems. Therefore there is ample scope for differing interpretations. There are great obstacles to any sort of experimental approach to management because experiments involve reduction in yield (at least for the short term) without any guarantee of increased yields in the future (*8*). Even in the case of Pacific salmon stocks that have been extensively monitored for many years, one cannot assert with any confidence that present levels of exploitation are anywhere near optimal because the requisite experiments would

(*Continued on page 36*)

D. Ludwig is in the Departments of Mathematics and Zoology, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z2. R. Hilborn is in the School of Fisheries, University of Washington, Seattle, WA 98195. C. Walters is in the Department of Zoology, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z4.

(*Continued from page 17*)

involve short-term losses for the industry (*9*). The impossibility of estimating the sustained yield without reducing fishing effort can be demonstrated from statistical arguments (*10*). These results suggest that sustainable exploitation cannot be achieved without first overexploiting the resource.

The difficulties that have been experienced in understanding and prediction in fisheries are compounded for the even larger scales involved in understanding and predicting phenomena of major concern, such as global warming and other possible atmospheric changes. Some of the time scales involved are so long that observational studies are unlikely to provide timely indications of required actions or the consequences of failing to take remedial measures.

Scientific certainty and consensus in itself would not prevent overexploitation and destruction of resources. Many practices continue even in cases where there is abundant scientific evidence that they are ultimately destructive. An outstanding example is the use of irrigation in arid lands. Approximately 3000 years ago in Sumer, the once highly productive wheat crop had to be replaced by barley because barley was more salt-resistant. The salty soil was the result of irrigation (*11*). E. W. Hilgard pointed out in 1899 that the consequences of planned irrigation in California would be similar (*12*). His warnings were not heeded (*13*). Thus 3000 years of experience and a good scientific understanding of the phenomena, their causes, and the appropriate prophylactic measures are not sufficient to prevent the misuse and consequent destruction of resources.

Some Principles of Effective Management

Our lack of understanding and inability to predict mandate a much more cautious approach to resource exploitation than is the norm. Here are some suggestions for management.

1) Include human motivation and responses as part of the system to be studied and managed. The shortsightedness and greed of humans underlie difficulties in management of resources, although the difficulties may manifest themselves as biological problems of the stock under exploitation (*2*).

2) Act before scientific consensus is achieved. We do not require any additional scientific studies before taking action to curb human activities that effect global warming, ozone depletion, pollution, and depletion of fossil fuels. Calls for additional research may be mere delaying tactics (*14*).

3) Rely on scientists to recognize problems, but not to remedy them. The judgment of scientists is often heavily influenced by their training in their respective disciplines, but the most important issues involving resources and the environment involve interactions whose understanding must involve many disciplines. Scientists and their judgments are subject to political pressure (*15*).

4) Distrust claims of sustainability. Because past resource exploitation has seldom been sustainable, any new plan that involves claims of sustainability should be suspect. One should inquire how the difficulties that have been encountered in past resource exploitation are to be overcome. The work of the Brundland Commission (*16*) suffers from continual references to sustainability that is to be achieved in an unspecified way. Recently some of the world's leading ecologists have claimed that the key to a sustainable biosphere is research on a long list of standard research topics in ecology (*17*). Such a claim that basic research will (in an unspecified way) lead to sustainable use of resources in the face of a growing human population may lead to a false complacency: instead of addressing the problems of population growth and excessive use of resources, we may avoid such difficult issues by spending money on basic ecological research.

5) Confront uncertainty. Once we free ourselves from the illusion that science or technology (if lavishly funded) can provide a solution to resource or conservation problems, appropriate action becomes possible. Effective policies are possible under conditions of uncertainty, but they must take uncertainty into account. There is a well-developed theory of decision-making under uncertainty (*18*). In the present context, theoretical niceties are not required. Most principles of decision-making under uncertainty are simply common sense. We must consider a variety of plausible hypotheses about the world; consider a variety of possible strategies; favor actions that are robust to uncertainties; hedge; favor actions that are informative; probe and experiment; monitor results; update assessments and modify policy accordingly; and favor actions that are reversible.

Political leaders at levels ranging from world summits to local communities base their policies upon a misguided view of the dynamics of resource exploitation. Scientists have been active in pointing out environmental degradation and consequent hazards to human life, and possibly to life as we know it on Earth. But by and large the scientific community has helped to perpetuate the illusion of sustainable development through scientific and technological progress. Resource problems are not really environmental problems: They are human problems that we have created at many times and in many places, under a variety of political, social, and economic systems (*19*).

REFERENCES AND NOTES

1. P. Larkin, *Trans. Am. Fish. Soc.* 106, 1 (1977).
2. Pelagic stocks are described by A. Saville, Ed., *Rapports et Procès-Verbaux des Réunions* [*Cons. Int. Explor. Mer* 177 (1980)]. A general survey is given by W. F. Royce, *Fishery Development* (Academic Press, New York, 1987), and tropical fisheries are reviewed by D. Pauly, G. Silvestre, I. R. Smith, *Nat. Res. Model.* 3, 307 (1989).
3. J. Caddy and J. Gulland, *Mar. Policy* 7, 267 (1983).
4. R. Repetto and M. Gillis, Eds., *Public Policies and the Misuse of Forest Resources* (Cambridge Univ. Press, Cambridge, 1988).
5. R. C. Francis and T. H. Sibley, *Northwest Environ. J.* 7, 295 (1991); S. R. Hare and R. C. Francis, in *International Symposium on Climate Change and Northern Fish Populations*, Conference in Victoria, Canada, 13 to 16 October 1992; in preparation.
6. J. Radovitch, in *Resource Management and Environmental Uncertainty. Lessons from Coastal Upwelling Fisheries*, M. R. Glantz and J. D. Thompson, Eds. (Wiley, New York, 1981).
7. R. Hilborn and C. J. Walters, *Quantitative Fisheries Stock Assessment* (Chapman & Hall, New York, 1992).
8. C. J. Walters and J. S. Collie, *Can. J. Fish. Aquat. Sci.* 45, 1848 (1988).
9. C. J. Walters, in *Applied Population Biology*, S. K. Jain and L. W. Botsford, Eds. (Kluwer Academic, Norwell, MA, 1992).
10. R. Hilborn and J. Sibert, *Mar. Policy* 12, 112 (1988); D. Ludwig, in *Springer Lecture Notes in Biomathematics*, vol. 100, S. Levin, Ed. (Springer-Verlag, New York, in press); R. Hilborn, *J. Fish. Res. Board Can.* 33, 1 (1979); D. Ludwig and R. Hilborn, *Can. J. Fish. Aquat. Sci.* 40, 559 (1983).
11. T. Jacobsen and R. M. Adams, *Science* 128, 1251 (1958); M. de Vreede, *Deserts and Men* (Government Printing Office, The Hague, Netherlands, 1977).
12. E. W. Hilgard, *Univ. Calif. Coll. Agricult. Bull.* 86 (1899).
13. W. R. Gardner, in *Arid Lands Today and Tomorrow*, Proceedings of an International Research and Development Conference, E. Whitehead, C. Hutchinson, B. Timmerman, R. Varady, Eds. (Westview Press, Boulder, CO, 1988), p. 167.
14. M. Havas, T. Hutchinson, G. Likens, *Environ. Sci. Technol.* 18, 176A (1984); see comments, *ibid.* 19, 646 (1985); W. B. Innes, *ibid.*, p. 646.
15. D. Cram, in *Resource Management and Environmental Uncertainty. Lessons from Coastal Upwelling Fisheries*, M. R. Glantz and J. D. Thompson, Eds. (Wiley, New York, 1981), p. 145; G. Sætersdahl, in *Rapports et Procès-Verbaux des Réunions*, A. Saville, Ed. [*Cons. Int. Explor. Mer* 177 (1980)]; D. W. Schindler, *Ecol. Appl.* 2, 124 (1992); F. N. Clark and J. C. Marr, *Prog. Rep. Calif. Coop. Ocean Invest.* (July 1953); *ibid.* (March 1955); this was reported in (*6*).
16. World Commission on Environment and Development, *Our Common Future* (Oxford Univ. Press, New York, 1987).
17. Lubchenko *et al.*, *Ecology* 72, 371 (1991).
18. H. Chernoff and L. E. Moses, *Elementary Decision Theory* (Wiley, New York, 1959; reprinted by Dover, New York, 1986); D. V. Lindley, *Making Decisions* (Wiley, New York, ed. 2, 1985); J. O. Berger, *Statistical Decision Theory and Bayesian Analysis* (Springer, New York, 1985).

19. We thank D. Schluter, L. Gass, and L. Rowe for helpful comments. Our research was supported in part by the Natural Sciences and Engineering Research Council of Canada under grants A9239 and A5869 and by a State of Washington Sea Grant.

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
VOL. 34, NO. 5 AMERICAN WATER RESOURCES ASSOCIATION OCTOBER 1998

ESTIMATING THE PUBLIC'S VALUES FOR INSTREAM FLOW: ECONOMIC TECHNIQUES AND DOLLAR VALUES[1]

John B. Loomis[2]

ABSTRACT: Sound water resource management requires comparison of benefits and costs. Many of the perceived benefits of water relate to providing instream flow for recreation and endangered fish. These uses have value but no prices to guide resource allocation. Techniques to estimate the dollar values of environmental benefits are presented and illustrated with several case studies. The results of the case studies show that emphasis on minimum instream flow allocates far less than the economically optimum amount of water to instream uses. Studies in Idaho demonstrated that optimum flows that balance benefits and costs can be ten times greater than minimum flows. The economic benefits of preserving public trust resources outweighed the replacement cost of water and power by a factor of fifty in California. While it is important to incorporate public preferences in water resource management, these economic survey techniques provide water managers with information not just on preference but how much the public is willing to pay for as well. This facilitates comparison of the public costs and benefits of instream flows.
(KEY TERMS: water policy; water management; economics; social.)

ECONOMIC EFFICIENCY GAINS FROM GOING WITH THE FLOW

Reallocating natural resources from old, low-valued uses to new, higher-valued uses in response to changing citizen demand is the hallmark of responsive society. Democratic governments coupled with free enterprise economies have been thriving because of their ability to shift resources from goods in declining demand (e.g., record players and cast-iron skillets) and increase production of goods in increasing demand (e.g., CD players and microwave ovens). A major exception to this principle is the allocation of water, particularly in the western U.S. Despite substantial economic shifts away from an agrarian economy and toward a society that has heightened concerns for outdoor recreation and environmental quality, water largely continues to be allocated as it was in the 1890s or 1920s. Irrigated agriculture diverts upwards of 90 percent of the water in most western states of the U.S. The "first in time, first in right" doctrine of prior appropriation and the reluctance of many irrigation districts to allow water to be traded outside the district to other uses, literally casts in concrete a water use pattern increasingly at variance with current social values. In particular it is at variance with a society that values fishing, rafting and protection of endangered species. Even in the Spring of 1997, one western water district was subsidizing delivery costs of transmountain water to provide water at no cost to its members "to avoid losing excess water down the Colorado River" (NCWCD, 1997). The fact that there are endangered fish on those stretches of the Colorado River, commercial rafting and millions of people living in the lower Colorado Basin suggests the "use it or lose it" mentality continues today. Providing water at "no charge" almost assures water being employed in low valued uses at the expense of higher valued uses elsewhere. As noted by a prominent economist "Dynamic economies require the ability to alter institutional arrangements . . . Economic efficiency demands that the rule structures change in response to new technical opportunities, to new price and cost structures, to new shared perceptions about externalities and other social costs. . .." (Bromley, 1997, pg. 53). Some water managers continue to provide cast-iron skillets despite the fact that people want microwaves.

[1]Paper No. 97148 of the *Journal of the American Water Resources Association*. **Discussions are open until June 1, 1999.**
[2]Professor, Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, Colorado 80523 (E-Mail: jloomis@ceres.agsci.colostate.edu).

ZOOLOGY DEPARTMENT, UNIVERSITY OF OTAGO

Publications in limnology

List No. 1. October 1968. Reprints of papers indicated may be obtained from Dr D. Scott before 1st March 1969 and from Dr S.F. Mitchell after that date, by reference to the number of each publication.

1.* BENHAM, W.B. (1903) A note on the Oligochaeta of the New Zealand Lakes. Trans. Proc. N.Z. Inst. 59, 192-198.

2.* FYFE, M.L. (1929) A new freshwater hydroid from Otago. Trans. Proc. N.Z. Inst. 59, 813-823.

3.* FYFE, M.L. (1943) The anatomy and systematic position of Temnocephala novae-zealandiae Haswell. Trans. roy. Soc. N.Z. 72, 253-267.

4.* JOLLY, V.H. (1957) A review of the Copepod genus Boeckella in New Zealand. Trans. roy. Soc. N.Z. 84, 855-865.

5. MARPLES, B.J. (1960) Some temporary ponds near Sutton, Otago, Proc. N.Z. Ecol. Soc. 7, 22.

6.* BYARS, J. (1960) A freshwater pond in New Zealand. Aust. J.Mar. & Freshwater Res. 11, 222-240.

7. SCOTT, D. (1960) Cover on River Bottoms. Nature, 188, 76-77.

8.* MARPLES, B.J. (1962) An introduction to Freshwater Life in New Zealand. Whitcombe & Tombs, Dunedin.

9. MARPLES, T.G. (1962) An interval plankton sampler for use in ponds. Ecology 43, 323-324.

10. CHAPMAN, M.A. (1963) A review of the Freshwater Ostracods of New Zealand. Hydrobiologia 22, 1-40.

11. SCOTT, D. (1964) The migratory trout (Salmo trutta L.) in New Zealand 1. The introduction of stocks. Trans. roy. Soc. N.Z., Zool., 4, 209-227.

12. SCOTT, D. (1964) Parasitic isopods on trout. Proc. N.Z. Ecol.Soc. 11, 23.

13. WINTER, J.W. (1964) A survey of Lake Roxburgh, a recent hydro-electric dam. Proc. N.Z. Ecol. Soc., 11, 16-23.

14. SCOTT, D. (1966) The Substrate Cover-Fraction Concept. The Pyamatuning Symposia in Ecology. Special Publication No. 4, 75-78.

15. SCOTT, D. & K.W. DUNCAN (1967) The function of freshwater crayfish gastroliths and their occurrence in perch, trout and shag stomachs. N.Z. Jl mar. Freshwat. Res.2: 99-104.

16. DUNCAN, K.W. (1967) The food and population structure of Perch (Perca fluviatilis L.) in Lake Mahinerangi. Trans. roy. Soc. N.Z., Zool., Vol. 9, 45-52.

17. DON, A.W. (1967) Aspects of the biology of Microvelia macgregori Kirkaldy (Heteroptera: Veliidae). Proc.R.ent.Soc. Lond. (A) 42, 171-179.

18. MITCHELL, S.F. (In Press) Phytoplankton Productivity in Tomahawk Lagoon, Lake Waipori and Lake Mahinerangi. N.Z. Marine Department, Fisheries Bulletin.

19. McLAY, C.L. (1968) A study of drift in the Kakanui River, New Zealand. Aust. J. mar. & Freshwat. Res. 19.

* Not available

BY AIR MAIL
PAR AVION

UNIVERSITY OF OTAGO
CENTENARY
AUGUST — 1969

DUNEDIN
6 -PM
24 FEB
1969
N.Z

INVEST IN
THE GOVERNMENT
LOAN

NEW ZEALAND
POSTAGE
0 18
U. 645

Dr. R. Behnke,
Colorado Co-operative Fishery Unit,
Colorado State University,
Fort Collins,
Colorado, 80521,
U.S.A.

UNIVERSITY OF OTAGO
P.O. Box 56
DUNEDIN
N.Z.