1. Silvex will control *Myriophyllum brasiliense* at the rate of 3 pound acid per acre sprayed.
2. Silvex will control *Myriophyllum heterophyllum* at the rate of 0.5 p.p.m. and indications are lower amounts will be successful.
3. Silvex will control most water lilies at the rate of 3 pounds per acre if application is made early in the year.
4. No degree of control has been achieved using silvex on *Lemna sp.* at rates up to 2 p.p.m.
5. Silvex has eradicated *Eleocharis acicularis* at 0.25 p.p.m. This was in a small shallow pond with a high water temperature. Higher concentrations also have given satisfactory results. At rates of 3 p.p.m. fish were killed but it is not known if oxygen depletion due to weed decomposition or silvex caused the kill.
6. No indications of control has been achieved using silvex for control of grasses.
7. Silvex probably has a wider range of control than other hormonal type herbicides.
8. Dalapon will not consistently control *Glyceria sp., Hydrochloa caroliniensis,* and *Paspalum sp.* Although it is the best herbicide for these grasses, available results are inconsistent and apparently dependent on the degree of plant exposed to the chemical application.
9. Dalapon will successfully control cattails and *Leersia sp.* at rates of 20 pounds per acre and probably lower with indications of control at 10 to 15 pounds per acre.
10. No synergistic effects have been noted using other herbicides mixed with dalapon.
11. Apparently, although sufficient data is not available, Granular 2, 4-D will control water lilies, *Myriophyllum brasiliense, Myriophyllum heterphyllum,* and *Utricularia sp.* at rates of 100 pounds per acre (20 lbs. acid).
12. Comparisons should be made using silvex, dalapon and 2, 4-D and 2, 4, 5-T.

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COMMENTS ON THE NEED FOR CRITICAL FISHERY RESEARCH PLANNING AND ELECTRONIC DATA PROCESSING *

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ABSTRACT

Two great problems facing fishery scientists who must improve and rapidly complete research projects involving large amounts of data are: (a) Improvement in the statistical design of projects; and (b) electronic data processing (EDP) with the aid of punch cards, paper and magnetic tape. Good statistical design of a project is usually achieved by a well-trained fishery scientist work-

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ing in conjunction with a biostatistician. With EDP, the fishery scientist consults with a specially trained biostatistician associated with EDP procedure.

Demands for more rapid, accurate and reliable results of fishery work are increasing. EDP is becoming a necessary adjunct to fishery research programs where workloads are increasing and data processing facilities are inadequate to handle the burgeoning data characteristic of fishery programs in a short time. Coupled with these points is a shortage of trained fishery workers. Some other factors that strongly suggest the need for EDP are: Expansion of fishery research programs; improvement of research standards; need for greater efficiency of the individual fishery scientist; and, greater accuracy of the results of data analysis.

EDP applications in fisheries are few and largely in the pioneering stages of research. A few workers have reached the stage of advancement with EDP where creel census, fish sampling, age and growth, and sex and condition data can be programmed on electronic computors, such as Univac 120 or IBM 704, and multiple correlation and regression analysis are possible. The cost of EDP equipment is too great for many fishery research agencies, so that cooperative EDP centers are a partial solution for many organizations Advantages of cooperative EDP centers must be weighed against the disadvantages; in general, the former overshadows the latter. The challenge of educating fishery scientists, administrators, and associated persons about the methods and practical aspects of EDP continues.

I. *Problems Are Good Design and Automatic Processing of Data:* Two of the greatest related, yet separate, problems facing fishery scientists who are confronted with the need for improvement and rapid completion of projects involving large amounts of data are: (a) improvement in the design and analysis of projects, surveys, and experiments; and (b) the automatic processing of data by machine manipulation in the form of punch cards, paper tape and magnetic tape.

A. *Improvement in Design* of projects and experiments must precede any large-scale electronic data processing (EDP; also referred to as ADP—automatic data processing). This broad and necessary aspect of fishery science may be achieved by:

1. Exposure of all fishery science students to principles and methodology of biostatistics and design of experiments during the normal schooling, or in the form of in-service training.
2. Close cooperation between professional biostatisticians and fishery scientists, whether the latter are well-schooled or not in the subject of statistics, is necessary in fishery research planning and design.
3. Consultation with biostatisticians associated with EDP organizations before projects, involving large amounts of data, are undertaken is a primary step for fishery scientists. This approach can sometimes be efficiently reached through a cooperative biostatistical and EDP center.
4. Seeking out competent biostatistical advice, whether or not an important fishery project is facilitated by EDP.
5. Striving for efficiency and high standards in fishery research programs by consideration of proper biostatistical design and techniques.

B. *The Need for EDP Applications to Fishery Problems* are more urgent today than ever before. Lambou (1959A: 1-2) and others have highlighted this need by citing many of the obvious advantages.

1. Workloads of the average fishery research agency are increasing all out of proportion to its staff and data-processing facilities. The demands for more rapid, accurate, and reliable analyses and results are also increasing.
2. The expansion of fishery research programs and the rising level of research standards, both of which necessitate more detailed and complex analyses of data, have recently been associated with a shortage of trained fishery workers.
3. An increase in the efficiency of the individual fishery scientist is necessary, and can partly be achieved by removing the burden of data proces-

sing in the form of routine and tedious calculating and computing work by transferring the task to machines.

4. Machine methods result in great accuracy in handling masses of data, dependent, of course, on the quality of original data. Extraordinary advantages accrue from EDP:
   a. Exploratory studies of large amounts of data, otherwise prohibitively expensive, can be made with relative ease by machine methods.
   b. Retrieval of data accumulated many years before is greatly facilitated and provide a rapid and efficient way of quickly comparing present with past data.
5. The integration of closely related data into one system is an advantage, which in turn makes possible information processing, retrieval of past data, forecasting, and other analysis operations on a large scale.
6. Progress may be such in the future that automatic interchange of fishery data on magnetic tapes between one investigator and another, one state and another, etc., will be possible.
7. Although the types of data-processing that are possible are quite variable, some highly simplified aspects are:
   a. Fish species, individual fish and number, time of capture, place, gear, length, weight, scale measurements, age, meristic and morphometric characters, etc., can be punched into a card and with appropriate directions, such information as length-weight relationships, body-scale relationships, growth rates, mortality rates, etc., can be obtained rapidly.
   b. Appropriate tests of significance can be worked in where needed. Thus, length and weight measurements for groups of collections for a species could be tested with an analysis of covariance, and meristic or morphometric characters of different subpopulations can be tested by an analysis of variance.
   c. Programming is flexible enough so that new types of data that had not been anticipated in the original planning can be processed. Optimum programming is obtained by sending the proposed project to an IBM, Remington Rand, or other technical testing centers, to clear out the difficulties.

II. *EDP Applications in Fisheries and Related Natural Resources:* EDP applications in these fields are few and largely in the pioneering stage. Past history indicates meagre use of EDP except in work with commerical fishery catch records and game kill records.

A. The California Bureau of Marine Fisheries (1952: 40-49) was apparently one of the first natural resource organizations to apply machine methods to large amounts of fishery data. A good description of all the steps in the punch card processing of records is given in this paper.
   1. California first installed IBM equipment in 1931 to process catch records from the commercial fisheries. The system was elaborated in 1947 with the procurement of two IBM-405 accounting machines. Since then, it has further expanded.
   2. California Bureau of Marine Fisheries (1952: 50-58) also processed marine angling catches by machine methods.

B. The game division of the Michigan Department of Conservation (1940: 1-5) also pioneered in the use of IBM punch cards for game kill and trapping reports, beginning some time in 1937. Eberhardt and Hayne (1958: 10) provided an example of a specialized use of punch card techniques in wildlife work.

C. The U. S. Fish and Wildlife Service has processed commercial catch records by punch cards for well over two decades.
   1. Currently the Maryland Department of Research and Education at the Chesapeake Biological Laboratory, in cooperation with the Maryland Department of Tidewater Fisheries, collects and provides detailed licensed catch records of the fin-fisheries by species, area, gear, etc. In an agreement with the U. S. Fish and Wildlife Service (1959, MS: 1-2),

the records are tabulated and punched on IBM cards by federal facilities. Hammer, Hensel and Tiller (1948: 3-5) tell how the system was set up.

2. The commercial catch records of many other states and waters are also so processed.

D. Various data-processing methods, ranging from relatively simple to complex techniques, have served to facilitate the analyses of large amounts of data in fishery research and related fields.

1. Notch-card systems, notably the relatively simple and inexpensive McBee keysort punch card system, have been used successfully with small biological samples. Thus:
   a. Adams (1950: 1-7) evaluated the use of a notch-card system in working with small wildlife samples with the Hollerith punch card system.
   b. Adams (1955: 472-476) also described a punch card bibliographic file for vertebrate ecologists. See also Levine (1955: 343-352).
   c. Hicks (1955: 1-5) provided an application of the keysort system to hydrographic data. See also Schwabe and Davis (1957: 634-638), and Wood (1957: 65-69).
   d. Byer, Cantlon and Wetmore (1959: 323-324) utilized it in ecological work.
2. Punch card methods somewhat more complex and elaborate EDP applications are few in the natural resource field.
   a. Cottam and Curtis (1948: 516-519) pioneered in the use of the Hollerith punch card system in phytosociological research.
   b. Schultz (1954: 48-51) described the problems of editing, coding, tabulating, and evaluating data when utilizing EDP techniques.
   c. Greenhalgh, Clifton and Nielson (1951: 131-134) applied punch card techniques to game bird work.
   d. Davis (1954, MS: 1-4) is an example of the successful application of punch cards for a single species, the brown rat, with the result of many significant biological papers.
   e. Benson (1957: 1-9) mentioned the IBM equipment used to analyze hunter reports: IBM-026 printing punch; IBM-075 counting sorter; IBM-077 collator; and IBM-402 accounting machine.
   f. Other specialized studies include: Clem, Mosier and Sprague (1956: 319-320), Schmid (1954: 159), and Wood and Welt (1956: 886-888).

E. Although EDP of fishery research data is being undertaken by a number of agencies in North America, few have reported upon their experiences. The extensive use of EDP of fishery research data in Louisiana exemplifies the new approach to the rapid and efficient processing of large amounts of data.

1. Leeper, Stern and Lambou (1958: 226-232) described in some detail how creel census, fish sampling, age and growth, sex and condition data, were tabulated and analyzed on the Remington-Rand punch card system.
   a. After the cards were punched and verified, the electronic computor, Univac 120, was programmed and calculations were made to answer specific questions. Such analyses proceeded much more rapidly than if an electronic sorter or printing tabulator, both useful in modest projects, had been used.
   b. The Louisiana Wildlife and Fisheries Commission found it necessary to borrow the use of such machines as the verifier, interpreter, and Univac 120 computor, from other state agencies.
2. El-Zarka (1959: 366) provided a good example of the benefits to be derived by using EDP equipment. His studies of yellow perch populations were programmed so that multiple correlation and regression analysis of many years of biological and environmental data were possible.
3. Lambou (1959A: 1-7) and (1959B: 1-6) presents at this meeting: (a) some constructive suggestions, based on several years of experience, on the use of machine methods in processing fishery research, data; and (b) a simplified creel census program for punch card tabulation.

4. Although fishery scientists are making increasing use of EDP facilities, few specific examples are publicized because EDP is a means to achieving results rather than the end. Two examples, however, that may be mentioned:
   a. Modest computor facilities have been acquired by fishery scientists at the University of Rhode Island. The computor laboratory is equipped with an IBM-610 computor; IBM-026 printing card punch; IBM-514 reproducing machine; IBM-402 accounting machine; and IBM-101 statistical machine. In addition, an IBM-704 data processing system is available at a nearby institution.
   b. Fishery scientists at the University of Delaware indicated the possible use of an IBM 650 magnetic drum data-processing machine. With a memory capacity of over 10,000 digits, depending on the model, it has a maximum input rate of 200 cards or 16,000 digits per minute and a maximum output speed of 100 cards per minute. It uses the standard 80 digit IBM punch card.

F. The epitome of EDP application to fishery research data is exemplified by an example in forest science as given by Grosenbaugh (1958). A similar program in fisheries would allow a multiple regression program to be processed (possible with IBM-704 EDP machine). This would provide for the automatic handling of up to 500 observations of fish lengths or weights (Y's) which could be correlated with observations of up to 9 associated variables of environmental and biological origin (X's).

III. There are many problems, in addition to costs and personnel, associated with the purchase or renting of EDP equipment by a single fishery research agency. Although many articles and books provide insight into this problem, the report on the use of EDP equipment in federal agencies is especially illuminating. Thus the Subcommittee on Census and Government Statistics of the 86th Congress (1959: 1-142) point out that:

A. In order to make the most effective use of EDP systems, planning for their development and use should be undertaken long in advance of procurement of the equipment.

B. In view of the costly nature of these facilities, it is worthwhile to analyze existing procedures and try to streamline or improve operations before action is taken to procure EDP equipment.

C. In view of the usually small financial resources of most fishery agencies, participation in cooperative EDP and biostatistical agencies may be strongly advantageous.

IV. *Cooperative EDP Programs Are Characterized by Many Advantages and Some Disadvantages:*

A. Advantages result largely in substantial professional gains and financial savings in fishery research, especially after several years participation.
   1. Planned operational use on a sharing basis will preclude the need for purchase or rental of equipment in individual agencies. A central agency can afford EDP equipment that a small single agency cannot sustain.
   2. Emergency use can be made by agencies where their normal operations cannot afford a specialized or separate electronic facility.
   3. EDP programs can be tested at a center prior to the installation of new EDP equipment in a single agency. The center can also be used for training programs.
   4. Experimental uses of certain data can be undertaken at a center prior to the development of advanced systems.
   5. The center will set relatively high standards of data collection and reporting, and may provide consultation for basic statistical design of the project that might otherwise never be considered. Thus, some uniformity will result between participating agencies, especially for similar fishery research agency.
   6. Data between investigators, between states, or on a national basis can be compared rapidly and reliably.

B. Disadvantages are few but important and must be seriously considered by investigators embarking on a cooperative venture.

1. Participation may preclude the procurement of EDP equipment in a single agency, where they may very well be necessary in order to carry out special studies. Once a commitment is made to the cooperative center, where costs will be relatively low, it may be difficult to convince administrators of the necessity of an independent facility.
2. Individual ownership of machines allows close control and supervision to be maintained over the equipment and personnel. Better scheduling of the workload results. Where one must depend on a center or another agency, it is necessary to fit the work into schedules at their convenience.
3. The standards set, the inflexibility of certain aspects of a system once adopted, and the uniformity of data collecting and reporting, may well impede other more critical workers who desire to try new ideas and want to analyze their data differently than the system that is adopted.

V. *The EDP of Fishery Data is in Its Infancy:* Pioneering is still the rule rather than the exception. Possibilities seem unlimited.

A. Electronic equipment speeds up enormously each of the fundamental steps of recording, transferring, processing, storing and reporting. Although some obsolescence of EDP equipment takes place with time, machines of today and those of a few years ago have prodigious capacities in fishery research work that have not been adequately tapped just because human ingenuity has not yet figured how to do it.

B. EDP systems are producing trends that fishery scientists must recognize, i. e.:

1. More centralized processing of data.
2. Consolidation of related data previously contained or filed separately.
3. More effective analysis of the relationships between biological and ecological phenomena.
4. Reduction of the time cycle required for the processing of data and report preparation, especially for data spread over a long time period.
5. Higher standards of design and analysis of data.

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