WHITE STURGEON WORK PLAN

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DISCLAIMER

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PREFACE

This work plan represents the ideas and concepts of many people who participated in a group planning effort during two workshop sessions and subsequent reviews. There is a strong need to implement the plan and to begin research on white sturgeon in the Columbia River system in order to better understand their present status and behavior. This information will serve as the basis from which measures will be developed to protect, mitigate, and enhance white sturgeon.

This plan is only a beginning, and must remain dynamic as new information becomes available. Its implementation should continue to be guided by feedback from ongoing research efforts. In the spirit of adaptive management, research efforts should be initiated and the results carefully evaluated. Such evaluation will likely lead to changes in the objectives and tasks needed to accomplish our mission.

I have attempted to faithfully report the ideas and concepts of many other people representing several agencies, tribes, universities, and the private sector. In many cases the words in the plan are those of small working groups or their reporters. I hope the plan represents the concensus position of the participants and that the spirit of cooperation that guided development of the plan will continue throughout its implementation.

DHF
Portland, Oregon

EXECUTIVE SUMMARY

More information about white sturgeon in the Columbia River system is needed in order to develop specific measures to protect, mitigate, and enhance their populations. The comprehensive research plan presented here was designed by a work group to provide the scientific basis needed to develop these measures. The research program provides goals and expected results in each of the five research areas defined by the Northwest Power Planning Council in its Fish and Wildlife Program. These areas are stock assessment, habitat requirements, migrating potential, potential for artificial propagation, and maintenance of genetic integrity.

Stock assessment activities will provide information on existing stock conditions, including population estimates, mortality rates, and fecundity, which are needed to understand population dynamics. This information will serve to define the need for enhancement or mitigation and provide a basis for evaluating the enhancement measures.

Habitat requirement studies will examine what habitat conditions are required for each life stage. This information will identify the need for mitigation activities that focus on manipulation of habitat.

Research on migration potential will be conducted to determine the extent of white sturgeon movement and the cues that influence movement. The information will help determine whether stocks are reproductively isolated. It will provide input to measures that would supplement existing populations.

Studies of the potential for artificial propagation will provide rationale for assessing ways to supplement depleted populations. The studies will also yield information needed to

evaluate supplementation efforts. Research on genetic integrity will provide a basis for evaluating the need to preserve gene pools, and the risk associated with transplanting or supplementing stocks.

In addition, the work group recommends that special efforts be made to facilitate the exchange of information among white sturgeon researchers and, furthermore, that efforts be made to coordinate development of needed information.

Within each of the topic areas, specific tasks have been developed and assigned a relative priority. The group strongly urges implementation of the research plan to provide information critically needed to manage and protect white sturgeon stocks.

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INTRODUCTION

The white sturgeon (Acipenser transmontanus) represents an important fishery resource in the Columbia River system. Development of hydroelectric dams is believed to have had a significant impact on the species by blocking or inhibiting migration and by altering habitat.

In the lower Columbia River (i.e., from the mouth to Bonneville Dam), white sturgeon populations appear to be healthy and support commercial and sport fisheries. Steve King (Oregon Department of Fish and Wildlife) reports that in 1984 this lower river area supported a record sport catch of white sturgeon (42,000 fish) and a near record commercial catch (17,500 fish). However, in other parts of the system (e.g., parts of the Snake and Kootenai rivers) stocks are severely depleted. These differences in stock condition result in different needs for protection, mitigation, or enhancement.

Despite its importance in the Columbia system and the uniqueness of its large size and extremely long life expectancy, surprisingly little is known about the basic biology of white sturgeon. The published literature on life history and habitat requirements is very limited. Much of the related literature on other species of sturgeon is in Russian and is relatively inaccessible to managers and researchers in the Pacific Northwest.

Recent interest by the private sector has led to hatchery production of white sturgeon for the aquarium market and for export to Italy, where they are raised for the fresh fish market. Researchers at the University of California, Davis, and the University of Washington are investigating hatchery practices. Information on culture and early life history has been recently published. (The author is preparing an annotated bibliography.)

The available information on white sturgeon provides little scientific basis for management of the resource or design of protection and enhancement activities. The Bonneville Power Admin-

istration (BPA) recognized that the lack of information would inhibit development of specific mitigation measures, and sponsored a workshop in November 1983 to identify and evaluate the relative importance of research needs for white sturgeon. The Northwest Power Planning Council (NPPC) is also aware of the lack of information and responded to the mandate to use the "best available scientific information" in developing action plans for protection of fish and wildlife resources. The NPPC included an element in the 1984 amendment of their Fish and Wildlife Program that requires development and implementation of a research program for white sturgeon prior to specific enhancement activities.

The Bonneville Power Administration budgeted funds for research on white sturgeon and supports research at the University of Washington on behavior of juvenile sturgeon and on stock genetics. The planning effort is on-going under BPA's sponsorship. This document is intended to provide a comprehensive approach to developing information as a basis for future mitigation measures. It is BPA's intent to implement specific research projects based on this plan. Projects that address the two top priority research needs (stock assessment and habitat requirements) will be funded in fiscal year 1986.

This document outlines research needed to identify the effects of hydroelectric development on white sturgeon resources. The results will provide information needed to better manage and enhance white sturgeon populations in the Columbia River system. The plan was developed in two workshop sessions attended by representatives of federal and state agencies, tribes, universities, and the private sector who are interested in research and management of white sturgeon (see Appendix A). The work group developed a list of research needs and evaluated them against a set of weighted criteria during the first workshop in November, 1983 (Fickeisen, Neitzel, and Dauble 1984). The NPPC included five specific areas of research on white sturgeon in their 1984 amendment of the Fish and Wildlife Program [(Section 804(e)(8)].

The five areas closely parallel those needs identified by the work group in the first workshop.

A second workshop was held in June 1985. At this workshop, the work group developed specific research objectives for each of the five research areas. Tasks were described to accomplish those objectives with the highest priorities. The objectives and task descriptions form the basis of the research program described in this report. A steering committee provided additional review comments on the draft plan.

This plan responds to the premises of adaptive management as endorsed by the NPPC. It accepts uncertainty and is intended to be flexible in order to respond to emergent information and research needs. Consideration has been given to evaluation and to the need to place high priority on the development of methods that can be used to evaluate the effectiveness of future mitigation and enhancement measures. Elements of the plan that directly relate to evaluation include:

- establishing valid information on existing stock levels,
- reviewing available historical information to determine trends in stocks,
- developing an effective means of marking white sturgeon.

The plan includes research that addresses problems that may arise in the future. For example, identification of genetic stocks is suggested as guidance to developing plans for transplanting stocks or hatchery supplementation of natural stocks. A disease diagnostic center is recommended to help avoid the introduction or spread of disease.

MISSION

This plan is guided by the overall mission to "protect, mitigate, and enhance white sturgeon in the Columbia River system". This mission statement was taken from the Northwest Power Planning Act of 1980 and is responsive to BPA's Congressional authorization. The mitigation anticipated is related to construction and operation of the Federal Columbia River Hydroelectric Power System. Throughout development of the plan, the work group was asked to relate research objectives and task descriptions to this overall mission.

WORK PLAN ORGANIZATION

Elements of this work plan are organized into three research areas. These include each of the five topics identified in section 804(e)(8) of the Fish and Wildlife Program. The research areas are:

- Stock Assessment,
- Habitat Requirements (including Migrating Potential), and
- Potential for Artificial Propagation (including Maintenance of Genetic Integrity).

The stock assessment elements focus on determining present conditions of white sturgeon stocks, including population dynamics (age-structure, age-specific mortality rates due to natural causes and fishing, and age-specific fecundity). Information on current conditions will provide a basis for evaluating the need for actions to protect, enhance, and mitigate white sturgeon populations. It will also serve as the basis for evaluating the effectiveness of such actions.

Research on habitat requirements is designed to explain present stock conditions; assess impacts of hydroelectric development and operations; and develop measures to protect, mitigate, and enhance white sturgeon by protection or manipulation of habitat. This also includes research on migrating potential, i.e., identification of diel and seasonal movements as well as spawning migrations. Knowledge of adult movement patterns of adults may suggest critical spawning and feeding habitats, as well as identifying the degree of reproductive isolation of different stocks. Information on movements of juveniles and sub-adults is expected to help identify likely distribution of pre-recruits, a factor important in managing depleted stocks.

Investigations into the potential for artificial propagation are expected to result in improved methods of rearing white sturgeon and to identify factors to consider in hatchery programming. Artificial propagation measures or transplanting

subadult or adult fish may be necessary to restore stocks in areas where they are depleted. However, supplementation efforts may involve risks associated with disease introduction, disease outbreak in the culture facility, and genetic stock integrity. The proposed work would provide information needed to assess the risks involved, including the degree of reproductive isolation among existing wild stocks and the desirability of maintaining genetically distinct stocks if they exist.

Some research and information needs apply to two or more of these areas. Therefore, an efficient means of information transfer is needed. The work group urged development of a process to facilitate exchange of information. Two examples of common needs are the need to develop new methods of catching early life stages of white sturgeon, and the need to find a tag or mark that would be effective over the long lifetime of sturgeon.

Each of these general topics is developed in the following chapters. Specific objectives and tasks are identified for each topic. Priorities were assigned to the tasks as a guide to implementing the program. The priorities are relative, and consider existing knowledge, available resources, and interrelationships among tasks. The priorities will change over time, and as the most important tasks are completed, the tasks given moderate priority now will likely become more important. Table 1 is a matrix of priorities and reflects different needs by river reach. Priorities for other tasks are indicated in the text.

PRIORITIES

River Reach	Population Abundance	Age Composition, Growth, & Survival	Reproductive Biology	Early Life History	Food Habits	Physical Habitat Require.	Mapping & Modeling Available Habitat	Extent of Movement
Below Bonneville Dam (a)	Low	Low	Low	Low	Low	High	Moderate	Low
Bonneville-McNary	High	High	High	High	Low	High	Moderate	High
McNary-Priest Rapids/ Ice Harbor	High	High	High	High	Low	Moderate *	Low	High
Priest Rapids-Chief Joseph	Moderate*	Moderate*	Moderate*	Moderate*	Low	Moderate *	Low	Moderate *
Columbia Above Chief Joseph	Moderate*	Moderate*	Moderate*	Moderate*	Low	Moderate *	Low	Moderate *
Kootenai River	High	High	High	High	Low	Moderate *	Low	High
Ice Harbor-Lower Granite	Moderate*	Moderate*	Moderate*	Moderate*	Low	Moderate *	Low	Moderate *
Lower Granite-Hell's Canyon	Low	Low	High	High	Low	High	Moderate *	Low
Above Hell's Canyon	Low	Low	High	High	Low	High	Moderate *	Low

(a) A Dingel-Johnson project is in progress in this reach.
* Would be higher in the long term.

STUDY AREAS

The population status of white sturgeon differs remarkably among different reaches of the Columbia River and its tributaries. While the number of sturgeon in the lower Columbia River (from the mouth to Bonneville Dam) has apparently increased in recent years (a record catch was reported in 1984), the numbers in parts of the Snake and Kootenai Rivers are severely depleted. In areas with healthy populations, the major concern is to protect the stocks through wise management of the resource. In areas with depleted stocks, the major concern is to enhance the stocks either with introductions or by habitat manipulation to prevent further losses. In other areas, there is not even enough information to assess the present health of the stocks. The limited studies that have been conducted on sturgeon have not been comprehensive, resulting in an uneven database. The available information (both kind and amount) differs substantially between reaches.

Therefore, the research planning effort must account for differences among reaches and for the specific problems and opportunities for action in different reaches. The work group developed a list of eight areas based on what is known about stock status and on barriers to movement. Management agency jurisdictional boundaries were also considered. Suggested white sturgeon study areas include:

- Columbia River from its mouth to Bonneville Dam
- Columbia River from Bonneville Dam to McNary Dam
- Columbia and Snake Rivers from McNary Dam to Priest Rapids and Ice Harbor Dams
- Columbia River from Priest Rapids Dam to Chief Joseph Dam
- Columbia River above Chief Joseph Dam (primarily Lake Roosevelt)
- Kootenai River
- Snake River from Ice Harbor Dam to Lower Granite Dam
- Snake River from Lower Granite Dam to Hells Canyon Dam

·Snake River above Hells Canyon Dam

The areas are intended to provide guidelines, but not to preclude alternative study areas where they can be justified. The study areas may be further divided or combined to ensure that the research efforts remain comprehensive.

STOCK ASSESSMENT

The overall goal of the suggested stock assessment projects is to determine the existing status of white sturgeon populations in different reaches of the river system. The efforts focus on population dynamics (recruitment, age and growth, age-specific mortality rates, and age-specific fecundity). These efforts will yield a description of existing population conditions and an indication of which populations should be enhanced. In addition, the results will provide an indication of the magnitude of impacts of human activities which can serve as a basis for establishing mitigation goals. Finally, the studies will provide a baseline for evaluating the effectiveness of measures implemented to enhance white sturgeon populations.

Research tasks under stock assessment relate to tag development; population abundance; age composition, growth, and survival; age-specific fecundity; population dynamics modeling; early life history; and food habits.

While not specifically addressed in further detail, the work group suggested use of historical data and comparison of free-flowing and impounded reaches to assess impacts of human activities, including hydroelectric operations. However, such data are scarce, and even free-flowing reaches have been impacted, so caution must be applied to this effort.

TAG DEVELOPMENT

The objective of the tag development studies is to develop a comprehensive tagging methodology for white sturgeon. The method must permit long-term tagging because of sturgeon longevity. It must be size-comprehensive to permit tagging a variety of life stages. The work group recommends that tag development be accomplished by examining the literature to identify existing marking techniques and then to compare tag retention and effects on survival for promising techniques using multiple marking experiments. This development effort has a high priority and is envisioned as a five-year effort. Existing short-term tagging

techniques should be used for stock assessment in the immediate future, while the additional development work is undertaken.

POPULATION ABUNDANCE

The objective of the population abundance studies is to estimate the numbers of subadult and adult white sturgeon in each of the Columbia River study areas. To accomplish this objective, the work group proposes use of multiple mark-recapture methods. The initial task will be to examine the literature to identify appropriate marking techniques and mark-recapture estimators. A limited amount of information is already available (i.e., for sub-sections of the upper Snake River, Bonneville, and John Day pools), and that information will also be reviewed. On the basis of the literature review, priorities will be established for work on different study areas, and experiments will be designed to develop data for estimating both subadult and adult populations in the different study sections. The experimental design will be implemented, and the estimators computed from the resulting data. Finally, the validity of the estimators will be evaluated.

The work group believes this effort will require at least five years. This objective has a high priority in all areas except for the Snake River upstream of Lower Granite Dam, where such information is already available.

AGE COMPOSITION, GROWTH, AND SURVIVAL

The objective of the age composition, growth, and survival studies is to determine the population age structure and rates of growth and survival for subadult and adult white sturgeon in the Columbia River system. The work group recommends that a verifiable technology for aging be developed, for example, by use of oxytetracycline marking. Pectoral fin ray sections have been used for aging, but the technique needs additional verification. An appropriate technique will be used to estimate the age composition of sub-adult and adult white sturgeon. Growth rates will be estimated by back-calculating the lengths-at-age

and by measuring growth between mark and recapture times. The age of recruitment can then be estimated from growth rates. Total annual mortality will be estimated for individual cohorts from catch curves and mark-recapture data to provide estimates of survival within and between years. Fishing mortality will be estimated where applicable from mark-recapture techniques and angler survey data. The work group suggests that this be a five-year study and that it be given high priority in all areas excluding the lower Columbia River (below Bonneville Dam) and the upper Snake River (above Lower Granite Dam).

REPRODUCTIVE BIOLOGY

The objective of these studies is to examine reproductive biology of white sturgeon in the Columbia River system. The work group recommends that spawning areas be located (described further under "Habitat Requirements") and spawning periods be identified. The age at maturity, spawning periodicity, and fecundity will be determined in addition to the sex ratios of the stocks. However, for seriously depleted stocks, caution is needed to avoid further stress from sampling on the remaining fish. This effort will require five years. It has a moderate priority in all Columbia River areas but a high priority in all upriver areas.

POPULATION DYNAMICS MODELING

The objective of the population dynamics modeling study is to develop a population dynamics model for white sturgeon in the Columbia River system, and to apply it to the separate study areas. The work group recommends that existing models (e.g., Cochnauer 1983) be examined to determine whether they can be applied generally to white sturgeon in the Columbia River system. If so, then the next task will be to adapt existing models for this application. If not, then the next task will be to develop new models for specific reaches. The model(s) will then be used to evaluate the effects of hydroeletric development and operations on population abundance using various rates of growth,

recruitment, and mortality. Development of the basic approach to modeling has a high priority as it will drive the data-development tasks. Final results will be dependent on data availability and would not be complete for several years.

EARLY LIFE HISTORY

The objective of the early life history studies is to describe the early life history characteristics of white sturgeon populations in the Columbia River system. The work group recommends development of techniques for sampling white sturgeon eggs, larvae, and juveniles as the first task within this objective, followed by estimates of relative abundance of white sturgeon eggs, larvae, and juveniles in various habitats to identify timing and location of spawning. To date, eggs and larvae have only been collected in the lower Columbia River. These studies will take five years and were given a moderate priority for the lower Columbia River areas and a high priority for all upriver areas.

FOOD HABITS

The objective of the food habit studies is to determine the food habits of various life history stages of white sturgeon in the Columbia River system. The work group recommends that techniques for sampling stomach contents of both juvenile and adult white sturgeon be evaluated, and that selected techniques be used to determine the diet composition and relative importance of ingested food items. Food habit studies will take three years and were given a low priority in all areas.

SUMMARY OF STOCK ASSESSMENT TASKS

The needs for stock assessment and population dynamics data differ from area to area. Previous work in some areas provides useful information that can be applied to the development of research in other areas.

The problem of identifying the impacts of dam construction and operation on white sturgeon populations is confounded by other potential impacts in the system and by the relative lack of

accurate, quantitative data on pre-dam conditions. The closest conditions that may represent a "control reach" are those that exist in free-flowing reaches (i.e., downstreams from Bonneville Dam, Hanford Reach, Upper Snake River).

Information on stocks in free-flowing reaches might be compared with information on stocks in impounded reaches to assess the degree of impact under the assumption that the free-flowing reaches are representative of pre-dam conditions throughout the system. This could provide a basis for establishing goals for mitigation and enhancement measures that might include alterations in dam operation and/or stock restoration through artificial propagation. However, caution must be used in comparing stocks from different reaches to assess impact levels. Nevertheless, comprehensive stock assessment data can provide direction for determining enhancement/protection needs and associated levels of mitigative responsibilities.

HABITAT ASSESSMENT

The goals of this part of the work plan are to determine habitat requirements, identify and map available habitat, and evaluate needs for habitat protection, as well as opportunities for habitat improvement or restoration. The assessment is expected to identify existing habitat conditions and habitat requirements and to provide a basis for explaining existing stock conditions.

Objectives and tasks developed under the habitat assessment area relate to physical habitat requirements, available habitat, and changes in habitat.

PHYSICAL HABITAT REQUIREMENTS

The objective of the physical habitat requirements studies is to define physical habitat requirements for sucessful completion of each life history stage (reproduction, subadult, and adult). To accomplish this objective, the work group recommends establishing habitat preference curves for each life stage that are based on field and laboratory studies of sturgeon behavior. In addition, present habitat use, and acceptable levels and optimum values of several parameters related to habitat use need to be described.

The habitat requirement of eggs, yolk-sac larvae, young-of-the-year and subadults (<75 cm) will be identified in laboratory studies. Laboratory trials will be designed and implemented to determine the acceptable range and optimal values for substrate type and quality (size composition, water depth, water velocity, temperature, turbidity, water quality, salinity, light, and food resources). The laboratory results will be correlated with results of the field survey work to verify their application in the river. Behavioral characteristics may indicate when and where to look for sturgeon in the field. For example, laboratory studies indicate that activity increases just before dawn. Field results have corroborated this information by demonstrating

higher success in collecting in early morning than at other times.

Field sampling methodology needs to be further developed and evaluated for collecting all stages of white sturgeon under different conditions. The work group suggests use of plankton nets, 5-m trawls with 4-mm mesh liners, and epibenthic sleds as standard gear for eggs to young-of-the-year. For young-of-the-year to adults, use of trawls, seines, gill nets, setlines, and hook and line are suggested. These methods will be applied to field sampling in all habitat types to determine presence of the different life stages and to identify diel and seasonal activity. Of particular interest is movement of subadult sturgeon, either upstream or downstream, and its relationship to distribution of the population. Experimental releases of tagged hatchery fish should be considered for this. Spawning sites will be identified and site selection specificity determined through field surveys and radiotelemetry. Spawning displacement will also be examined.

Specific microhabitats within the study areas may be essential to particular life stages. Extensive laboratory studies to determine habitat requirements for eggs through subadults are suggested. Field studies will also be conducted on subadults and adults using radiotelemetry to accurately define the microhabitats. Concurrent field work on juvenile stages is needed to verify spawning sites.

The data collected from literature, laboratory, and field efforts will be analyzed to develop specific habitat preference curves for each life stage. Existing methods for developing habitat preference curves will be adapted for this task. Because habitat preference might differ with season as well as with life stage, the data collection and analysis are expected to be difficult.

This work generally has a high priority, but importance varies with river reach as indicated in Table 1. The effort will require five years to complete.

EXTENT AND TIMING OF MIGRATION

The objective of this part of the study plan is to determine migration patterns (upstream and downstream) of juvenile and adult Columbia River white sturgeon, the reasons that sturgeon migrate (i.e., feeding, spawning), and the influence of environmental cues on migratory behavior. Currently available information will be analyzed to provide a basis for additional research. Subadults and adults will be monitored by radiotelemetry, and movement patterns will be compared with environmental conditions to determine habitat preferences and identify factors stimulating or inhibiting movements. Sexually mature females will be radio- or sonic-tagged, released, and monitored to determine their movements and to identify spawning sites. Other life stages will also be tracked with telemetry to determine habitat selection. Potential factors to be examined include temperature, flow, light, and turbidity. Stomach contents will be logged from sport and commercial catch to relate diet to size in order to determine potential influence of food availability on movement.

A laboratory study will be conducted to assess behavioral response of young-of-the-year to environmental cues in order to examine the influence of environmental factors on movement and to corroborate field data.

The periodicity of movements might suggest particular times of the year when mitigative or protective measures (e.g., operations of hydroelectric dams) would be most effective.

This task will require three to four years. The information will be used to determine extent of adult migration associated with spawning and movement of all ages as a function of distribution for feeding and rearing. This work was assigned a high priority for most river reaches (see Table 1).

MAPPING AND MODELING OF AVAILABLE HABITAT

The objective of these studies is to identify and map available physical habitat by life stage and to assess impacts of hydroelectric operations. Standard techniques will be used

to characterize the physical habitat conditions identified as important to white sturgeon and to evaluate the existing habitat.

For each stage, available habitat will be mapped using the habitat characterization and habitat preference curves. The relative abundance of each life history stage of white sturgeon in each of the identified habitats will be estimated from field survey data. The available habitat may vary seasonally, either with changes in habitat preference or with changes in flow, temperature, or other parameters.

Existing habitat models will be evaluated for their applicability to the Columbia River system. Data collection needs will be defined to establish parameters for the selected model(s), and the model(s) will be applied to evaluate effects of hydroelectric development and operations on existing physical habitat.

Potential enhancement measures will be identified and recommendations developed and evaluated for implementing changes in hydroelectric operations to protect and enhance existing habitat. Measures to mitigate habitat losses will also be identified. This portion of the plan was assigned a moderate to low short-term priority by the work group.

EFFECTS OF HYDROELECTRIC OPERATIONS ON MOVEMENT

The objective of this part of the study is to determine the influence of spill patterns and turbine operations on the attraction and repulsion of juvenile and adult sturgeon. The extent to which migration movement is blocked by hydroelectric operations will be evaluated. Movement of sturgeon past dams and the concentration of fish around dams will be monitored. Field work will be undertaken at hydroelectric facilities to monitor fish movement (e.g., by radiotelemetry, by use of fish locators (echo-sounders), and by traps in the field.

This is envisioned as a three- to four-year study. The information will be used to evaluate the influence of hydroelectric operations and proposed measures to mitigate impacts of the dams, including dam-related mortalities. The extent of juvenile migration and movement over dams may influence mitigation

responsibility and hatchery programming. Diel and seasonal patterns in movement may suggest additional considerations in design of mitigation strategies involving flow manipulation. This effort was assigned a high priority in a few reaches (see Table 1).

SUMMARY OF HABITAT ASSESSMENT

Little information exists on the habitat requirements of each life stage of white sturgeon. Eggs and larval stages have only been collected downstream below Bonneville Dam in the Columbia River system. Because the habitat requirements are not known, the extent of available habitat for white sturgeon is not known, and habitat restoration measures cannot be planned.

Construction and operation of hydroelectric facilities on the Columbia River system has extensively altered existing habitat by impounding free-flowing reaches and by altering of seasonal and diel flow patterns. The extent to which these changes have impacted available white sturgeon habitat is not presently known. The need to protect existing critical habitat, enhance the value of existing marginal habitat, and mitigate habitat losses cannot be determined without the information that would result from the habitat assessment studies.

The best available "control" reaches are the unimpounded areas including downstream of Bonneville Dam, the Hanford Reach, and parts of the Snake River. Sturgeon stocks appear to be healthy and spawning is known to occur at least in the lower Columbia River and portions of the Snake River. Knowledge of habitat use in the lower river may suggest appropriate places to look for each life stage in other study areas. However, caution must be exercised because even the "control" reach has been altered over natural conditions, and present habitat use may not reflect optimum, but only acceptable habitat conditions. In addition, available sampling gear is selective and the efficiency is likely to vary with habitat type, thus biasing the results of field surveys.

Linking the results of this work with the population dynamics information is expected to provide additional guidance for planning mitigation measures on the basis of existing and potential white sturgeon production. The relationship between available habitat and existing populations will indicate whether supplemental stocking (planting hatchery-produced fish or transplanting wild fish), habitat improvement, or a combination of these management practices is the most appropriate means of mitigation for each area.

ARTIFICIAL PROPAGATION/SUPPLEMENTATION

The goal of these studies is to determine whether or not artificial propagation can serve as an effective mitigation strategy. The expected results are guidelines for planning supplementation programs that consider maintenance of wild stock gene pools and prevent the introduction or spread of disease. Additional results will lead to improved diet and better hatchery technology, including effective disease diagnosis and treatment.

Tasks within the artifical propagation area relate to genetic integrity, disease control, release strategies, and husbandry-hatchery practices.

GENETIC INTEGRITY

The objectives of this part of the study are to determine the degree of reproductive isolation of stocks and to evaluate the need to maintain separate stocks if genetic differences are demonstrated. Tasks include determination of the degree of reproductive isolation of stocks (based on isozyme studies and migration information), evaluation of other criteria for determining reproductive isolation, and examination of characteristics of different stocks (e.g., spawning time) to determine the desirability of maintaining genetic differences if they exist.

Information on gene pools is important for evaluating the feasibility of artificial propagation or transplanting as supplementation methods. It will also help determine acceptable sources of broodstock. The degree of genetic and behavioral differences between stocks may not be sufficient to warrant maintenance of separate stocks given the critical nature of some present stock sizes. However, additional research is needed to address this question.

Consideration should be given to taking stocks from several areas to maintain gene pools, through artificial propagation or broodstock maintenance. Information on genetic isolation of stocks is needed to evaluate the need to protect gene pools.

Only a few females would potentially be required to supply all of the eggs needed for annual hatchery production because of the high fecundity of sturgeon. While it would appear desirable to take as few females as possible to avoid further impacts to natural populations, this would seriously limit genetic diversity in the offspring. It is suggested that several females and males be used and multiple crosses be made with each female to provide genetic diversity in hatchery stock. In addition, consideration should be given to limiting the number of fish planted in a given area from an individual female.

Specific tasks were not developed for the accomplishment of these objectives during the workshop because participants chose to work on other areas to the exclusion of genetics. In part this reflects the experience and interest of the participants, and at least one plea was made not to ignore this area of research in further development of the plan. This work was not assigned a priority in the short-term, although it is recognized as having key importance to possible supplementation measures.

DISEASE CONTROL

The objectives of this aspect of the work are to prevent accidental introduction of disease pathogens as a result of transplanting or hatchery supplementation of wild stocks and to provide for diagnosis and treatment of disease in hatcheries. Disease control is necessary for safe and efficient production and movement of artificially propagated stocks and for stock transfers as mitigative techniques. This effort was given a high priority.

A single, centralized disease diagnositic and information center should be established with expertise to diagnose infectious and non-infectious diseases of sturgeon and to conduct fish health surveillance and certification, as needed for stock transfer purposes.

Development and maintenance of appropriate cell lines for investigation of bacterial and viral diseases will be an important function of the center, as will development of appropriate methods of prevention, treatment, and control of diseases under

intensive culture conditions. The center will be well integrated into an established program and could be operating within one year. The work group assigned a high priority to this effort.

RELEASE STRATEGIES

The objective of this work is to determine the optimum conditions for release of hatchery-produced sturgeon. Specific questions to be addressed are when, where, how, and what size to release. In addition, the feasibility of transplanting adults or subadults to restock areas would be evaluated. Concerns which will be addressed include optimal conditions for release, numbers of fish required to establish a breeding stock, ways to prevent accidental introduction of disease, and maintainence of wild genetic stocks.

Developing a long-term mark for sturgeon is a high priority because it will permit the effectiveness of different methods of release and of supplementation strategies to be evaluated. Development of effective marking and tagging technology with acceptable survival, retention, and longevity is needed in many phases of sturgeon research. A mark that can be applied at an early life history stage and remain recognizable until after the fish is recruited to the fishery is desired. Both a mark and a tag that permits individual identification are desired. This work will involve intensive laboratory and field efforts over a relatively long term.

Once an acceptable mark has been developed, experimental research on optimal release conditions can be implemented. This task presents problems with experimental design because of the number of variables involved and the likely interactions among them. Research will determine optimal habitat, time and size of release, and stocking density for planting sturgeon. The experimental work will be based on previous work with other species and on information on habitat requirements, growth rates, dietary requirements, and survival rates for white sturgeon.

Priorities were not assigned for specific tasks with this objective, however, development of release strategy is a key

factor in planning supplementation measures. Because tag development is a long-term project, it should be initiated soon.

HUSBANDRY/HATCHERY PRACTICES

The objective of these studies is to improve hatchery technology to increase the survival of larval stages and to decrease the cost of raising sturgeon. The work group recommends studies of optimum rearing conditions for cultured stocks (e.g., temperature, light intensity and photoperiod, container type, flow rates, loading density).

Basic nutritional studies are needed to determine minimal and optimal dietary requirements for various life stages under intensive production. This will be a laboratory study in a typical aquaculture facility, and results will be compared with carcass and organ composition of wild stocks and with wild stock diets. This work will be a long-term project but will have initial results within one year.

Diets that meet the minimal nutritional requirements will be further evaluated to determine appropriate texture, taste, and water stability criteria. Comparative studies will be conducted on several diets to determine growth, mortality, and cost factors. Methods of packaging, storage, and distribution will also be investigated. Initial results will be available within one year. Finally, feeding behavior will be investigated to determine the timing, periodicity, and amount of feeding.

The work group gave low near-term priority to development of an artificial diet for sturgeon, and to additional work on spawning and incubation methodolgy and broodstock maintenance. Methodology for propagation is already being developed by the private sector and universities. The importance of these tasks will increase in the future if extensive hatchery supplementation was undertaken. In general, the group recommended on-the-job training with an experienced sturgeon culturist to meet the need for husbandry technology transfer. An evaluation of post-caesarean spawning survival was suggested, using radiotelemetry, to evaluate the need for additional work on reduction of the

trauma associated with artificial spawning.

SUMMARY OF ARTIFICIAL PROPAGATION

Artifical propagation of white sturgeon offers a potential means of enhancing stocks in areas were populations are presently depleted. However, the feasibility of using of artificial propagation as a restocking technique for white sturgeon cannot be fully evaluated until additional research is conducted. Husbandry technology is being addressed by the private sector and university research (especially at the University of California, Davis), and should result in improved hatchery techniques. The lack of nutritional information and a specific diet for white sturgeon is a potential problem that would be addressed by the proposed research.

INFORMATION EXCHANGE

A process to enhance communication among researchers and managers interested in white sturgeon would facilitate cooperative use of information and coordinated research efforts. It would also help communicate research results rapidly to those responsible for management of sturgeon stocks and planning protection, enhancement, and mitigation measures.

The suggested means to accomplish information exchange is by distribution and circulation of reports, maintenance of an updated bibliography, and holding an annual project-presentation meeting. This need was given a high priority.

ACKNOWLEDGMENTS

The success of the efforts that lead to this plan are primarily due to the interest and participation of those who attended the two workshops and to the support of the agencies and groups they represent. Members of the Steering Committee (Alex Heindl, Columbia River Inter-Tribal Fish Commission; Jim Lukens, Idaho Department of Fish and Game; Don McIsaac, Washington Department of Fisheries; Bill Nelson, U.S. Fish and Wildlife Service; Tony Nigro, Oregon Department of Fish and Wildlife; Allen Scholz, Upper Columbia United Tribes; and Robert White, Montana Cooperative Fishing Research Unit, Montana State University) provided assistance in revision of the draft plan and helped focus the plan.

Fred Holm of BPA's Fish and Wildlife Division supported the project which had been initiated by Dale Johnson. Fred's interest and commitment to a collaborative plan were instrumental.

Duane Neitzel of the Pacific Northwest Laboratory raised "why" and "how" questions that guided planning for the workshop and "what if..." questions that helped prepare alternative strategies. Cindy Willson assisted with meeting arrangements and did the majority of the word processing required. Carolynn Novich edited the plan and helped clarify its language. Faculty and classmates in the Antioch University Organization Systems Renewal Program reviewed meeting design and suggested useful modifications.

My thanks to all of them.

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APPENDIX A

WORK GROUP COMPOSITION

WORK GROUP COMPOSITION

Habitat Requirements
- Scott Brewer
- Bob Cates
- Tim Cochnauer
- John Elliott
- Gayle Kreitman
- Bob McConnell
- Bill Nelson*
- Bob White

Maintenance of Genetic Integrity
No one selected this topic.

Stock Assessment
- Dennis Dauble
- Jim Lukens*
- Don McIsaac
- Tony Nigro

Potential for Artifical Propagation
- Bob Busch
- Ken Covert
- Jim Galbreath
- Dave Lane*
- Max Woolley

Migrating Potential
- Ernie Brannon*
- N. Kathryn Brigham
- Percy Brigham
- Ivan Donaldson
- Steve King

*Indicates subgroup reporter.

APPENDIX B

WORKSHOP INVITEES

WHITE STURGEON WORKSHOP INVITEES

*Indicates Participation in June 4-5 Workshop

U.S. Fish and Wildlife Service
Bill Nelson*
Brian Cates*

National Marine Fisheries Service
Bob McConnell*

Oregon Department of Fish and Wildlife
Tony Nigro*
Jim Galbraith*
Steve King*
John Elliot*

Washington Department of Fisheries
Gayle Kreitman*
Don McIsaac*

Idaho Department of Fish and Game
Dave Ortmann
Tim Cochnauer*
Jim Lukens*

Montana Department of Fish, Wildlife and Parks
Pat Graham

Northwest Power Planning Council
Mark Schneider*

PNUCC
Mike Erho, Douglas County PUD

Tribes
Alex Heindl, CRITFC
Dan Daley, Sho-Ban Tribes
Allen T. Scholz, U.C.U.T. Fisheries Center
Percy Brigham*, United Indian Fisherman
N. Kathryn Brigham*, CRITFC
Jerry Marco, Colville Confederated Tribes

Universities
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Ernie Brannon*, University of Washington
Scott Brewer*, University of Washington
Bob White*, Montana Coop Fish Research Unit

Terry Patterson, College of Southern Idaho
Dave Lane*, Malaspina College
David Franklin*, Mt. Hood Community College

Industry
Robert Busch*, Clear Springs Trout Co.
Max Wolley*, Clear Springs Trout Co.
Ken Covert*, Covert's Landing
Ed Connolly, Inland Marine Fisheries
Jim Michaels, California Sunshine Fisheries
Donald Campbell, Fish Breeders of Idaho

British Columbia Ministry of Environment
Harvey Andrusak

Consultant
Ivan Donaldson*

Battelle
Dennis Dauble*

Bonneville Power Administration
Fred Holm*