Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

White Sturgeon Mitigation And Restoration In The Columbia And Snake Rivers

Bonneville project number, if an ongoing project 8605000

Business name of agency, institution or organization requesting funding
Oregon Department of Fish and Wildlife

Business acronym (if appropriate) ODFW

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Subcontractors.

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U.S.G.S. Biological Resources Division	Columbia River Research Laboratory 5501A Cook-Underwood Road	Cook, WA 98605	Michael Parsley
U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office	9317 Highway 99, Suite 1	Vancouver, Washington 98665	Don Anglin
Columbia River Inter Tribal Fish Commission	729 N.E. Oregon Street, Suite 200	729 N.E. Oregon Street, Suite 200	Blaine L. Parker

NPPC Program Measure Number(s) which this project addresses.
10.4A.1, 10.4A.3, 10.4A.5

NMFS Biological Opinion Number(s) which this project addresses.

Other planning document references.
"Columbia River Fish Management Plan" (US v. Oregon), "Wy-Kan-Ush-Mi Wa-Kish-Wit", "Multi-Year Implementation Plan" (Columbia Basin Fish and Wildlife Authority 1997 Draft). Recommended actions from earlier work are described in "A Review of Alternatives for the Restoration and Management of White Sturgeon Populations and Fisheries in the Columbia River Between Bonneville and McNary Dams (Zone 6)" (DeVore et al 1997 Draft). "White Sturgeon Research Program Implementation Plan" developed by the Bonneville Power Administration in cooperation with state and federal fishery agencies, tribes, universities, and the private sector, and approved by the Northwest Power Planning Council in 1985. The earlier phases of the study focused on high priority information needs conducted in high priority areas, as designated in this plan. The study also addresses research priorities described in the White Sturgeon Management Framework completed by the Pacific States Marine Fisheries Commission

Subbasin.
Columbia River mainstem reaches: Bonneville, The Dalles, John Day, and McNary reservoirs, Hanford Reach, lakes Rufous Woods, and Roosevelt; Snake River mainstem reaches: Ice Harbor, Lower Monumental, and Little Goose reservoirs.

Short description.
Restore and mitigate for documented lost white sturgeon productivity caused by development and operation of the hydropwer system through intensive fisheries management and modified hydrosystem operation. Assess lost productivity in unstudied areas

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
	Anadromous fish		Construction		Watershed
X	Resident fish		O & M	+	Biodiversity/genetics
	Wildlife	+	Production	+	Population dynamics
	Oceans/estuaries	+	Research		Ecosystems
	Climate	X	Monitoring/eval.	+	Flow/survival
	Other	+	Resource mgmt		Fish disease
		+	Planning/admin.	X	Supplementation

_____		_____	
_____	Enforcement	_____	Wildlife habitat en-
_____	Acquisitions		hancement/restoration

Other keywords.
Master planning, Genetic stock structure, Population status, Distribution, Flow/recruitment, Loss assessment

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Develop and implement mitigation actions that do not involve changes to hydrosystem operation and configuration.	a	To guide restoration, mitigation, and production activities, develop a comprehensive Master Plan. Provide information to BPA for NEPA records of decision prior to specific mitigation or restoration actions.
1		b	Describe the genetic stock structure of white sturgeon in the Columbia River Basin. Determine if unique stocks exist and describe their geographic range.
1		c	Begin releasing transplants in impoundments where disease and genetic risks associated with transplanting fish are low and where recruitment failures due to low flow and hydrosystem operations have reduced sturgeon productivity and harvest opportunies.
1		d	Develop artificial propagation

			techniques and protocols in preparation for supplementing white sturgeon populations.
1		e	Manage affected sturgeon populations by monitoring and planning for optimal harvest.
2	Develop and implement mitigation actions that involve changes to hydrosystem operation and configuration.	a	Describe the relationship between specific daily dam operations and the onset of spawning.
2		b	Determine the relationship between river discharge and the location and quantity of spawning and rearing habitat for sturgeon in the Columbia River between McNary and Priest Rapids dams, and in the Snake River downstream from Lower Granite Dam.
3	Monitor and evaluate actions to mitigate for lost white sturgeon production due to development, operation, and configuration of the hydropower system..	a	Monitor the status of populations between Bonneville and Priest Rapids dams in the Columbia River and between the Snake River mouth and Lower Granite Dam through periodic updates of population status
3		b	Describe annual variation in white sturgeon recruitment between Bonneville and Priest Rapids dams on the Columbia River and downstream from Lower Granite Dam on the Snake River through annual indexing of young of the year.
4	Assess losses to white sturgeon productivity caused by development and operation of the hydrosystem.	a	Determine the status of white sturgeon populations between Priest Rapids and Grand Coulee dams, and in Lake Roosevelt.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	10/1997		40.00%

2	10/1997		25.00%
3	10/1997		20.00%
4	10/1997	9/1999	15.00%
			TOTAL 100.00%

Schedule constraints.

Completion date.
Some mitigation actions continue indefinitely, loss assessments to be reviewed in 2002

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		$325,000
Fringe benefits		$133,250
Supplies, materials, non-expendable property		$45,000
Operations & maintenance		$22,000
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		$3,000
PIT tags	# of tags: 5500	$15,950
Travel		$35,000
Indirect costs		$128,300
Subcontracts		$2,192,500
Other		$ 0
TOTAL		$2,900,000

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$3,200,000	$3,500,000	$3,500,000	$3,500,000
O&M as % of total	1.00%	1.00%	1.00%	1.00%

Section 6. Abstract

Concern for white sturgeon populations is documented in measures 10.4A.1, 10.4A.2, 10.4A.3, and 10.4A.5 of the 1994 Columbia Basin Fish and Wildlife Program. Goals of this project are to 1) implement and evaluate measures to protect and enhance white

sturgeon populations and mitigate for effects of the hydropower system downstream from McNary Dam, and 2) determine the need and identify potential measures for protecting and enhancing white sturgeon populations and mitigate for effects of the hydropower system upstream from McNary Dam. Objectives are (1) develop and implement mitigation actions that do not involve changes to hydrosystem operation and configuration, (2) develop and implement mitigation actions that involve changes to hydrosystem operation and configuration, (3) monitor and evaluate response of white sturgeon populations to mitigation actions by reassessing stock status in Bonneville Reservoir, and (4) assess losses to white sturgeon productivity caused by development and operation of the hydrosystem in lakes Rufus Woods and Roosevelt.

We will undertake a master planning process to guide decisions regarding white sturgeon mitigation, restoration, and production activities above Bonneville Dam. We will continue development of a plan for operating the hydropower system to provide flows that maximize spawning and recruitment in The Dalles and John Day reservoirs, and evaluate effects of these flows on white sturgeon production. We will describe the relationship between daily dam operations and the onset of spawning, develop specific recommendations for in-season water management; determine the location and quantity of spawning and rearing habitat and the timing and duration of spawning upstream from McNary Dam; describe annual variation in white sturgeon recruitment between Bonneville and McNary Dam dams and in the lower Snake River; describe the potential effect of proposed reservoir drawdown on white sturgeon productivity, and update relationships between river flow, available habitat, and recruitment.

Section 7. Project description

a. Technical and/or scientific background.

The Problem: Development of the Columbia River Basin hydroelectric system has created impoundments throughout the basin, severely restricted movements of white sturgeon and two of their principal food sources (eulachon and lamprey), and degraded or destroyed white sturgeon spawning and rearing habitat. As a result, many impounded white sturgeon populations are not as productive as they were before development of the hydropower system. In some upper Columbia River Basin reaches, the isolated populations may face extirpation or extinction (Beamesderfer et al. 1995, North et al. 1993, Parsley and Beckman 1994, Parsley et al. 1993).

Relationship to the Columbia River Basin Fish and Wildlife Program

This study addresses Northwest Power Planning Council sturgeon mitigation measures 10.4A.1, 10.4A.2, 10.4A.3, and 10.4A.5 of the 1994 Fish and Wildlife Program (as amended) that state “The Council believes that studies and evaluations should be undertaken and completed quickly, and on-the-ground projects identified and completed as soon as possible to address the needs of this species. In addition, these studies should be coordinated to avoid redundant work and to increase the potential for learning.” The measures further state that "Specific recommendations for the protection, mitigation, and

enhancement of sturgeon may be submitted to the Council upon completion of these studies." In the study area downstream from McNary Dam, work to determine the impact of development and operation of the hydropower system on sturgeon is nearly complete. Work is therefore turning to mitigating for these impacts.

Another element of the program has been incorporated into this project as a result of a recent review by the Northwest Power Planning Council. Measure 7.4B calls for the development of detailed master plans to address potential conflicts among increased production, mixed-stock harvest, gene conservation, consistency with other plans, and other objectives. Future mitigation and management planning activities for this white sturgeon project will be closely coordinated, and will include appropriate elements from the Council's suggested list of factors to be considered in the master planning process.

Actions to protect and restore populations and mitigate for effects of the hydropower system on productivity of white sturgeon have been called for in the "Columbia River Fish Management Plan" (US v. Oregon), in "Wy-Kan-Ush-Mi Wa-Kish-Wit" (the anadromous fish restoration plan of the Nez Perce, Umatilla, Warm Springs and Yakama tribes), and in the "Multi-Year Implementation Plan" (Columbia Basin Fish and Wildlife Authority 1997 Draft). Recommended actions from earlier work are described in "A Review of Alternatives for the Restoration and Management of White Sturgeon Populations and Fisheries in the Columbia River Between Bonneville and McNary Dams (Zone 6)". (DeVore et al 1997 Draft). These recommendations are being implemented and assessed under this project as specific measures that can protect and restore populations and mitigate for effects of the hydropower system on productivity of white sturgeon in the three-pool area between Bonneville and McNary dams. In the study area upstream from McNary Dam, efforts focus on assessing the current status of white sturgeon populations and determining the need for protection, mitigation, and restoration measures and implementing recommendations "as soon as possible". Much of the field work has been completed on the Columbia River reach between McNary and Priest Rapids dams, and on the Snake River between the mouth and Lower Granite Dam.

The study goals correspond to those of the "White Sturgeon Research Program Implementation Plan" (Plan) developed by the Bonneville Power Administration (BPA) in cooperation with state and federal fishery agencies, tribes, universities, and the private sector, and approved by the Northwest Power Planning Council in 1985. The earlier phases of the study focused on high priority information needs conducted in high priority areas, as designated in this plan. The study also addresses research priorities described in the White Sturgeon Management Framework completed by the Pacific States Marine Fisheries Commission in 1992.

Coordination:

The study proposal was reviewed and approved by the Resident Fish Caucus of the Columbia Basin Fish and Wildlife Authority. The approach to restoration and enhancement was reviewed and approved by the Columbia River Compact's Sturgeon Management Task Force, which is comprised of fishery managers and researchers representing the states of Oregon and Washington, the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation, the Nez Perce Tribe of Idaho, and Columbia River Inter-

Tribal Fish Commission. The overall study design and approach for restoration and enhancement were reviewed by the Northwest Power Planning Council in 1997. The study plan for 1999 involves the Oregon Department of Fish and Wildlife (ODFW), the Washington Department of Fish and Wildlife (WDFW), the Biological Research Division of the US Geologic Survey (BRD), the US Fish and Wildlife Service (USFWS), and the Columbia River Inter-Tribal Fish Commission (CRITFC).

Additional cooperators in white sturgeon research, who are also located within the Columbia River Basin, and who have been or may be involved with research on this project, include the Nez Perce Tribe, Yakama Indian Nation, the mid-Columbia Public Utility Districts (PUDs), the Kootenai Tribe, and others. One or more of the tribal entities may elect to participate in this project, possibly as subcontractors to CRITFC. Sturgeon researchers throughout the region are invited to periodic workshops and informal discussion sessions where ideas, information, and research findings can be shared among the participants. The most recent of these, December 18 and 19, 1997, was attended by over 50 white sturgeon researchers and managers from Oregon, Washington, Idaho, and British Columbia.

Results and plans of the white sturgeon project have been reviewed by the Council before each phase of the project: the current phase was reviewed at the April 2, 1997 Council meeting. The Council in their review of the FY98 program recommendations by the Agencies and Tribes, recommended continued funding for this project, with two caveats: (1) project is to be presented in the FY99 review process in clearly-defined components, and (2) supplementation and aquaculture projects should not expand without prior Council review. The format of this year's work statement had already been reorganized from past years to more clearly define the corresponding mitigation application (supplementation, hydro operations, monitoring/evaluation, etc.). Project implementers will continue to work with Council and Bonneville staff to develop clear descriptions of project components and to explain their interrelationships. In response to Council recommendations, supplementation-related activities planned for FY98 have been dropped, contingent upon completion of appropriate reviews (including a formal master plan).

The accomplishment of effective mitigation in the future will depend on specific alternatives and their rationales and priorities that are identified in the study plan and which are subsequently approved through the master planning process. Implications of lack of action on supplementation investigations in FY98 range from the short-term (deferral) to long-term (termination) of efforts designed to implement mitigative actions called for in the plan. The same concerns hold true for the entire range of mitigation measures identified in the planning documents cited earlier. The inability to engage priority actions in a timely manner will increase risks for stocks already in need of more intensive management.

b. Proposal objectives.

The Goals: The goals of this project are to 1) implement and evaluate selected measures to protect and enhance populations and to mitigate for effects of the hydropower system on production of white sturgeon in Columbia River impoundments downstream from McNary Dam and 2) determine the need and identify potential measures for protecting and enhancing populations and mitigating for effects of the hydropower system on production of white sturgeon in the Columbia and Snake rivers upstream from McNary Dam by employing the experience and technologies developed through this study.

The Objectives: The following objectives are structured such that findings will result in a mitigation plan designed to offset losses to white sturgeon stocks and their productivity caused by the hydropower system. The first three address a mitigation planning process designed to identify and evaluate specific mitigation measures, whereas the fourth objective is to describe the extent of losses:

1. Develop and implement mitigation actions that do not involve changes to hydrosystem operation and configuration.
2. Develop and implement mitigation actions that involve changes to hydrosystem operation and configuration.
3. Monitor and evaluate response of white sturgeon populations to mitigation actions.
4. Assess losses to white sturgeon productivity caused by development and operation of the hydrosystem.

[Note to reviewer: please refer to 7e. for products by objective.]

The Approach: All study objectives will be addressed concurrently. ODFW will be the prime contractor with BPA and will subcontract portions of the study to WDFW, BRD, USFWS, NMFS, and CRITFC, and others as appropriate.

As part of the first objective, a master planning process is being undertaken to guide future decisions regarding white sturgeon mitigation, restoration, and production activities. A guiding framework will be developed that documents and prioritizes steps leading toward restoring productive white sturgeon populations and fisheries above Bonneville Dam. The process will include public and peer reviews of all proposed mitigation and restoration actions before they are approved for implementation. We will utilize guidelines and procedures acquired from the master planning process to develop artificial propagation protocols in preparation for future supplementation of white sturgeon in selected areas above Bonneville Dam that lack capacity for natural spawning and recruitment.

As part of that process, we are proceeding with genetic analyses for developing guidelines on stock structures and to document geographic boundaries and gene types that define unique stocks, and annual harvest management planning and monitoring. Actions to refine supplementation and propagation techniques will be developed under guidelines developed and reviewed in the master planning process.

The second objective addresses recommendations for mitigation actions that involve changes to hydrosystem operation and configuration to optimize physical habitat

conditions for white sturgeon production. We will continue development of a flow-optimization plan that describes specific strategies for operating the hydropower system to provide flows in the tailraces of John Day and McNary dams that maximize spawning and recruitment in The Dalles and John Day reservoirs. We will work with hydropower operators and fish managers to develop and implement these plans and will evaluate their effects on white sturgeon production.

The final objectives of the FY98 work plan are to continue to monitor and evaluate actions that mitigate for lost white sturgeon production due to the development, operation, and configuration of the hydropower system, and to assess losses to white sturgeon due to development, operation, and configuration of the hydropower system, specifically between Priest Rapids and Grand Coulee dams.

c. Rationale and significance to Regional Programs.

Development of the Columbia River Basin hydroelectric system has severely restricted movements of white sturgeon and their principal food sources, and degraded or destroyed white sturgeon spawning and rearing habitat. As a result, many impounded white sturgeon populations are not as productive as they were before development of the hydropower system. In some upper Columbia River Basin reaches, the isolated populations may face extirpation or extinction.

Measures 10.4A.1, 10.4A.2, 10.4A.3, and 10.4A.5 of the 1994 Fish and Wildlife Program call for studies and evaluations to be undertaken and completed quickly, and on-the-ground projects identified and completed as soon as possible to address the needs of this species. The measures further call for specific recommendations for the protection, mitigation, and enhancement of sturgeon to be submitted to the Council upon completion of these studies. In addition, Measure 7.4B calls for the development of detailed master plans to address potential conflicts among increased production, mixed-stock harvest, gene conservation, consistency with other plans, and other objectives.

Our study objectives are structured such that findings will result in a mitigation plan designed to offset losses to white sturgeon stocks and their productivity caused by the hydropower system. The first three address a mitigation planning process designed to identify and evaluate specific mitigation measures, whereas the fourth objective is to describe the extent of losses.

The project has demonstrated a high level of cooperation with other projects. Specific examples include:

Kootenai White Sturgeon Investigations 8806500. Findings from project 860500 were the justification for flows sought for Kootenai River sturgeon restoration. Project 860500 continues to provide assistance in egg and larval sampling. Laboratory work to describe timing of larval development will provide direct benefits.

Nez Perce Tribe white sturgeon investigations. Project 860500 will continue to provide assistance in work to restore white sturgeon productivity in Lower Granite Reservoir and Hells Canyon.

Yakama Indian Nation K-Ponds. Personnel from project 860500 will serve on a technical advisory group to develop a plan for K-Ponds located on the Hanford Site.

d. Project history

PROJECT REPORTS AND TECHNICAL PAPERS:

Annual Reports

Status and habitat requirements of the white sturgeon populations downstream from McNary Dam: Annual Reports for 1988-DOE/BP-63584-2, 1989-DOE/BP-63584-3, 1990-DOE/BP-63584-4, 1991-DOE/BP-63584-5, 1993-DOE/BP-63584-6, 1993-DOE/BP-63584-7; and Effects of Mitigative Measures on Productivity of White Sturgeon Populations in the Columbia River Downstream from McNary Dam 1994-DOE/BP-63584-8, and 1995-DOE/BP-63584-9 are available. The 1996 Annual report is in press and the 1997 annual report is in preparation.

Technical Papers

Beamesderfer, R.C. 1991. MOCPOP 2.0: A flexible system for simulation of age-structured populations and stock related functions. Oregon Department of Fish and Wildlife Information Report 91-4.

Beamesderfer, R.C. 1993. A standard weight (Ws) equation for white sturgeon. California Fish and Game 79(2):63-69}

Beamesderfer, R.C.P., T.A. Rien, and A.A. Nigro. 1995. Dynamics and potential production of white sturgeon populations in three Columbia River reservoirs Transactions of the American Fisheries Society 124:857-872.

DeVore, J.D., B.W. James, C.A. Tracy, and D.A. Hale. 1995. Dynamics and potential production of white sturgeon in the Columbia River downstream from Bonneville Dam. Transactions of the American Fisheries Society 124:845-856.

Elliott J.C. and R.C. Beamesderfer. 1990. Comparison of efficiency and selectivity of three gears used to sample white sturgeon in a Columbia River reservoir. California Fish and Game 76(3):174-180.

McCabe, G.T., Jr. 1993. Prevalence of the parasite *Cystoopsis acipenseri* (Nematoda) in juvenile white sturgeons in the lower Columbia River. Journal of Aquatic Animal Health 5(4):313-316.

McCabe, G.T., Jr. and L.G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Fish and Game 76(4):248-250.

McCabe, G.T., Jr., R.L. Emmett, and S.A. Hinton. 1993. Feeding ecology of juvenile white sturgeon (*Acipenser transmontanus*) in the Lower Columbia River. Northwest Science 67(3):170-180.

North, J.A., R.C. Beamesderfer, and T.A. Rien. 1993. Distribution and movements of white sturgeon in three lower Columbia River reservoirs. Northwest Science 67(2):105-111.

Parsley, M.J., and L.G. Beckman. 1994. White Sturgeon spawning and rearing habitat in the Lower Columbia River. North American Journal of Fisheries Management 14:812-827.

Parsley, M.J., L.G. Beckman, and G.T. McCabe, Jr. 1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. Transactions of the American Fisheries Society 122(2):217-227.

Rien, T.A. and R.C. Beamesderfer. 1994. Accuracy and precision in age estimates of white sturgeon from pectoral fin rays. Transactions of the American Fisheries Society 123(2):255-265.

Rien, T.A., R.C.P. Beamesderfer, and C.A. Foster. 1994. Retention, recognition, and effects on survival of several tags and marks on white sturgeon. California Fish and Game 80(4):161-170.

Warren, J.J. and L.G. Beckman. 1993. Fishway use by white sturgeon to bypass mainstem Columbia River dams. U.S. Fish and Wildlife Service Sea Grant Extension Project, Columbia River Series WSG-AG 93-02.

SUMMARY OF MAJOR RESULTS ACHIEVED

Documented an 85% reduction in sturgeon productivity between Bonneville and McNary dams because of impoundment and operations (measured in harvestable pounds / acre/ year). Identified spawning habitat and access as the key limiting factor. Determined low spring flows decrease spawning habitat and sturgeon recruitment. Identified the importance of protecting spawner broodstock (females > 6 feet). Arrested declining trends and started rebuilding sturgeon populations. Preserved limited harvest and fishing opportunities for reservoir sturgeon populations. Project results were the justification for flows for Kootenai River sturgeon restoration. Results provide a sound quantitative basis for predicting the benefits of flow measures and reservoir drawdown on sturgeon production. Results have been used to develop models for application in management strategies.

Key findings and recommendations based on this projects findings are summarized on pages 9-16 in Volume 1 of our 1993 Final Report for phase 1 work. The management implications of research to date are now being compiled in a document with the working title: "A review of alternatives for the restoration and management of white sturgeon populations and fisheries in the Columbia River between Bonneville and McNary dams (Zone 6)".

The top three recommendations are: 1) A 250 Kcfs minimum instantaneous discharge at McNary Dam when water temperatures are 13-15 °C will provide white sturgeon spawning habitat in all three Zone 6 pools. Reduced flows limit spawning habitat and recruitment of white sturgeon. Lesser discharges do not provide spawning habitat in John Day Reservoir. Greater discharges provide more spawning habitat. Detailed recommendations for operation of the hydropower system are one of the objectives for current research. 2) Supplementing recruitment through transplantation or hatchery releases should be initiated and evaluated. Supplementation evaluation or implementation should continue until increased flows restore recruitment, because the density and potential harvest for populations in The Dalles and John Day reservoirs are limited by poor recruitment. 3) Management strategies should be tailored to optimize production and offset effects of impoundment based on the unique attributes of each impounded population and each population must be closely monitored to maintain optimum

exploitation rates. This intensive management is called for because sturgeon are isolated in each reservoir, and no individual reservoir fully meets the life history needs of the sturgeon isolated there and the dynamics of each reservoir population are unique.

Stock status updates have been completed for Bonneville (1994), The Dalles (1994), and John Day (1996) reservoirs. Initial descriptions of stock status were completed for McNary Reservoir and Hanford Reach (1993,1995), Ice Harbor (1996), Lower Monumental (1997), and Little Goose (1997) reservoirs. Fisheries monitoring in Bonneville, The Dalles, and John Day reservoirs (1994-1997) has allowed recreational and treaty fisheries to continue, and allowed sturgeon population numbers to increase. About 8,500 sturgeon collected downstream from Bonneville Dam were transplanted to The Dalles Reservoir (1995 and 1996). In 1997 these fish were recaptured to estimate survival, growth, and condition, and the feasibility of transplanting juvenile white sturgeon from productive populations to areas limited by low recruitment. Young-of-the-year white sturgeon were captured annually in Bonneville Reservoir (1994-1997); this provides an index of recruitment which is correlated with flow. Spawning and rearing habitat were quantified under a range of flow conditions in McNary Reservoir and Hanford Reach (1995-1997). We investigated the feasibility of describing daily hydro-operation effects on spawning by intensive sampling of eggs and larvae downstream from The Dalles Dam (1995). We conducted laboratory experiments on the susceptibility of sturgeon fry to gas bubble trauma (1996 and 1997). We conducted laboratory experiments to determine effects of temperature and egg source (stock?) on the timing of egg development and the precision of back-calculated hatch dates. These findings will be used in describing the effects of daily hydro-operations on spawning (1996-1997). Using telemetry, we described habitat use by white sturgeon in McNary Reservoir and Hanford Reach (1996-1997).

ADAPTIVE MANAGEMENT IMPLICATIONS

Annual indexes of recruitment, periodic updates of population status, and monitoring of recreational and treaty fisheries are essential to assessment of population responses to hydro-operations, flow, and fisheries restrictions.

YEARS UNDERWAY

10

PAST COSTS

$14,157,915

e. Methods.

Objective 1. Mitigate for lost white sturgeon productivity in impoundments where development and operation the hydropower system has reduced production by developing, recommending, and implementing actions that do not involve changes to hydrosystem operation and configuration of that system.

Supplementation of populations with hatchery reared and/or transplanted white sturgeon will be reviewed by Columbia Basin fisheries management entities prior to implementation. Intensive management of white sturgeon fisheries in impoundments to optimize production is being implemented.

Task 1.1 Planning and review of restoration and mitigation activities. Develop a comprehensive master plan (as outlined under in measure 7.4B of the 1994 Columbia River Basin Fish and Wildlife Program) to guide white sturgeon restoration, mitigation, and production activities in the Columbia and Snake rivers upstream from Bonneville Dam. Provide information to Bonneville Power Administration (BPA) that is needed for National Environmental Policy Act (NEPA) records of decision prior to initiating specific restoration or mitigation actions.

Rationale: *White sturgeon populations upstream from Bonneville Dam are substantially less productive than the population downstream from Bonneville Dam. Isolation between hydroelectric facilities and poor recruitment associated with low flows are the primary causes of reduced productivity. A guiding framework that documents and prioritizes steps to restoring productive populations and fisheries will ensure an orderly public and peer reviewed process for taking action. The NEPA records of decision will ensure potential effects of restoration/mitigation actions on other species and the environment have been addressed and reviewed in a public forum and by peer scientists.*

Products: A comprehensive master plan that summarizes information and production goals for transplant and hatchery supplementation of white sturgeon. Records of decision (NEPA documentation) for specific actions identified and approved by the Northwest Power Planning Council.

Task 1.2 Describe the genetic stock structure of white sturgeon in the Columbia River Basin. Determine if genetic differences present today represent the stock structure prior to development of the hydropower system or if differences among geographic areas are an artifact of hydroelectric development. Determine if unique stocks exist and describe their geographic range.

Rationale: *An understanding of white sturgeon stock structure prior to hydrosytem development will allow managers to determine the limits to mitigation actions intended to restore population productivity. The current stock structure may be different from that prior to hydrosystem development due to small population size effects resulting when widely migrating individuals were trapped in impoundments. Stock identification will allow restoration actions to be shaped to ensure genetic diversity is not lost.*

Products: Guidelines for white sturgeon stock transfers in the Columbia Basin based on pre-impoundment stock structure and intended to preserve stock identity. A description of the genetic markers used to identify unique stocks. Documentation of the geographic boundaries, and gene types that define unique stocks.

Task 1.3 Following guidelines and procedures developed under Task 1.1 and if 1997 field work in The Dalles Reservoir demonstrates transplant supplementation (trawl & haul) is effective, begin releasing transplants in nearby impoundments where disease and genetic risks associated with transplanting fish are low and where recruitment failures due to low flow and hydrosystem operations have reduced white sturgeon productivity and harvest opportunities. Transplant fish to more distant impoundments if allowed by guidelines developed under Task 1.1.

Rationale: *Results of research to date have demonstrated that recruitment to white sturgeon populations in The Dalles and John Day reservoirs was low during the decade 1986-1995. However, growth of subadult white sturgeon in these reservoirs has been good. In contrast, recruitment in areas downstream from The Dalles Dam has been much greater, and growth of subadults in Bonneville Reservoir has been relatively poor. Transplanting subadult white sturgeon from apparently fully-seeded habitat downstream from The Dalles Dam to apparently under-seeded habitat in The Dalles and John Day reservoirs may increase yield from all impoundments downstream from McNary Dam.*

Products: Transplanted white sturgeon from areas downstream from The Dalles Dam into The Dalles and John Day Reservoirs. All sturgeon will be counted, measured, and uniquely marked. A description of anticipated benefits (harvest and brood-stock recruitment) given different numbers of transplants. Documentation of methods and procedures used. An assessment of whether available or new gear and techniques can be used to collect, transport, and release adequate numbers of subadult white sturgeon from Bonneville Reservoir to under-seeded habitats upstream. (Estimates of relative abundance of transplanted fish will be developed as part of periodic updates of population status; see Task 3.1).

Task 1.4 Following guidelines and procedures developed under Task 1.1, coordinate with the Yakama Indian Nation and other appropriate agencies to develop artificial propagation techniques and protocols in preparation for supplementing white sturgeon populations in areas of the Columbia and Snake rivers where recruitment has been lost due to the development and operation of the hydrosystem. If transplant supplementation is not effective, or is not appropriate, artificial propagation may also be used to supplement white sturgeon populations in areas of the Columbia and Snake rivers where low recruitment limits population productivity. We will seek opportunities for cost sharing with Public Utility Districts that operate hydroelectric facilitates between Priest Rapids and Chief Joseph dams. Index sampling will be used to verify lost recruitment; see Task 3.1. We will also conduct literature surveys and interviews to determine and document historical white sturgeon use in these areas.

Rationale: *White sturgeon populations between Priest Rapids and Grand Coulee dams are believed to have little or no natural recruitment under the current hydropower configuration, and there is little potential for providing flows that will allow spawning and recruitment. Initiating hatchery release programs, in areas of the Columbia and Snake rivers where production has been severely reduced or lost, will allow establishment or re-establishment of white sturgeon fisheries. Techniques and strategies for rearing and release of white sturgeon developed for these reservoirs may be used in other areas as well.*

Products: Hatchery-reared white sturgeon released into impoundments where recruitment has been lost or severely reduced. A description of anticipated harvest benefits given different release numbers. Documentation of methods and procedures used. Recommendations for densities and lighting conditions in rearing facilities necessary to optimize growth, feed utilization, health, and survival of juvenile white sturgeon. Designs for effective water recycling and reclamation systems for use in white sturgeon rearing facilities.

Task 1.5 Annual harvest management planning and monitoring. Coordinate Council mitigation planning process with U.S. v. Oregon Columbia River Fish Management Plan process and regulate harvest consistent with mitigation efforts to optimize harvest in white sturgeon fisheries where population productivity and resilience have been reduced by hydropower development and operation. Provide recommendations for hydrosystem operations that will provide sturgeon spawning habitat given anticipated water conditions. Monitor white sturgeon fisheries where population productivity and resilience have been reduced by hydropower development and operation.

Rationale: *Reduced productivity of white sturgeon populations in impounded reaches of the Columbia River downstream from McNary Dam has complicated fisheries management. Sustainable harvest levels have been reduced by low productivity of white sturgeon caused by poor recruitment and slow growth. Recruitment and growth have been reduced by altered flow regimes and degraded spawning and rearing habitat due to hydropower development and operation. Through intensive fisheries management we can provide for limited fisheries and ensure population recovery. In 1995, sampling in John Day Reservoir demonstrated the beginnings of population recovery, brought about by severe harvest restrictions which were enabled by closely coordinated monitoring of all fisheries.*

Products: A process involving the interagency-tribal Sturgeon Management Task Force for review and adoption of an annual management plan designed to protect and enhance white sturgeon populations in Bonneville, The Dalles, and John Day reservoirs. A set

of near-term and long-term fish and hydropower system management objectives. A set of specific fish management and hydropower management strategies (see also Objective 2), including, but not necessarily limited to:

Annual harvest objectives based on optimum sustainable yields, and the regulations necessary to achieve harvest objectives.

Annual operational criteria for hydroelectric projects that optimize spawning and rearing conditions and habitat.

Annual assessment of recreational angling effort, catch rate, and harvest; and treaty commercial fishing effort, harvest rate, and harvest.

Objective 2. Mitigate for effects of hydropower-system configuration by developing and recommending actions that involve changes to hydrosystem operation and configuration to optimize physical habitat conditions for white sturgeon production.

Task 2.1 Describe the relationship between specific daily dam operations and the onset of spawning.

Rationale: *We currently have a broad recommendation for sturgeon spawning flows that will provide at least some spawning habitat in Bonneville, The Dalles, and John Day reservoirs (250 Kcfs minimum instantaneous discharge at McNary Dam when water temperatures are 13-15 °C in May and June). We do not know which specific hydro-facility operations may stimulate spawning in tailrace areas (peaking, ramping, spill versus turbine discharge, etc.) and we cannot currently make recommendations about those operations.*

Products: Specific recommendations for in-season water management at hydropower facilities that will stimulate white sturgeon spawning. Criteria and associated error bounds for estimating age (in hours) of white sturgeon eggs from different reaches within the Columbia Basin incubated at a range of water temperatures.

Task 2.2 Determine the relationship between river discharge and the location and quantity of spawning and rearing habitat for white sturgeons in the Columbia River between McNary and Priest Rapids dams, and in the Snake River downstream from Lower Granite Dam.

Update descriptions of the relationship between river flow, available habitat, and recruitment of white sturgeon as new information becomes available.

Rationale: *Available habitat for spawning is the key factor limiting production of white sturgeon in impoundments downstream from McNary Dam. Work conducted in the Columbia and Snake rivers upstream from McNary Dam will determine the extent to which white sturgeon recruitment has been affected by hydropower system operations.*

Products: Habitat suitability index curves describing the suitability of depths, water velocities, and substrates for spawning and rearing white sturgeon in these reservoirs. Estimates of the quantity of spawning and rearing habitat available at various river discharges. A time series analysis of available habitat developed from past discharge records. A description of physical habitat parameters associated with "rearing" white sturgeon in McNary Reservoir, and an estimate of the quantity of suitable microhabitat available.

Revised suitability index curves, water velocities, water temperatures and substrates associated with spawning and rearing white sturgeon, and updated estimates of available spawning habitat.

Task 2.3 Describe the potential effect of proposed reservoir drawdowns on white sturgeon productivity in John Day, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite reservoirs based on an assimilation of existing data. Use geospatial data and modeling to simulate the physical environment, and thus enable comparisons of the habitat for white sturgeons under current and post-drawdown conditions. Use existing information on the habitat, abundance and productivity of white sturgeon populations in various free-flowing environments to speculate about changes in productivity that may occur if drawdowns are implemented. Develop and implement a monitoring program to determine the effect of the drawdowns, if implemented, on white sturgeon movements, abundance, and productivity.

Rationale: *Reservoir drawdowns have been proposed for John Day Reservoir and the four lower Snake River reservoirs to assist the migration of anadromous salmonids. Fisheries managers need an assessment of the effect proposed drawdown actions will have on white sturgeon habitat or productivity in those areas.*

Products: Estimates of the change in quantity of habitat available for spawning and rearing if drawdowns are implemented. Estimates of the potential production that may be expected from reservoirs that are drawn down to more riverine conditions. A statistically robust sampling design that will enable changes in population productivity to be detected if changes occur.

Objective 3. Monitor and evaluate actions to mitigate for lost white sturgeon production due to development, operation, and configuration of the hydropower system.

Task 3.1 Periodic updates of population status. Monitor the status of populations between Bonneville and Priest Rapids dams in the Columbia River and between the Snake River mouth and Lower Granite Dam.

Rationale: *Periodic updates of population status will allow us to assess if mitigation actions are working as expected and modify our management approach when they are not.*

Products: A sensitivity analysis using data collected to date to describe expected precision given various levels of field effort. Field sampling will provide data to describe catch per unit effort, length frequency, age and growth, as well as tagged white sturgeon to monitor harvest (see task 1.5).

Task 3.2 Annual young-of-year indexing. Describe annual variation in white sturgeon recruitment between Bonneville and Priest Rapids dams on the Columbia River and downstream from Lower Granite Dam on the Snake River.

Rationale: *Research conducted to date has demonstrated a direct relationship between river velocity during late April through early July and densities of young-of-the-year white sturgeon. Continued investigations at established sites and expansion into new reservoirs will provide additional data to determine if the relationship is consistent through time, among geographic areas, and outside the range of flow conditions observed to date. Previous stock assessments in Bonneville, The Dalles, and John Day reservoirs have demonstrated that there are adequate numbers of spawners to provide some recruitment, and brood-stock abundance does not change dramatically among years. Development of criteria for operating projects to optimize physical conditions (water velocity, temperature, etc.) during periods of spawning and rearing may increase production.*

Products: A sampling strategy and protocols for fishing trawl nets and gill nets to develop indices of relative abundance of young-of-the-year white sturgeon. A comparison of the trends in abundance among years as seen in trawl catches and gill net catches. The assessment will include annual estimates of distribution and abundance of young-of-year, and estimates of year class strength and time-series analyses of the relationships between flows, project operations, spawning success, and recruitment.

Objective 4. Assess losses to white sturgeon production due to development, operation, and configuration of the hydropower system.

Task 4.1 Population assessment & indexing. Determine the status of white sturgeon populations between Priest Rapids and Grand Coulee dams, and in Lake Roosevelt.

Rationale: *Initial indexing will provide information on the distribution, size, recruitment of young-of-the-year, and age composition in unsampled populations. This will allow us to identify and expedite management actions to restore and/or mitigate for lost potential production (see Task 1.1). More intensive sampling may be necessary to describe population characteristics needed to estimate optimum exploitation rates and ensure success of restoration and enhancement measures. We will seek opportunities for cost sharing with Public Utility Districts that operate hydroelectric facilitates*

between Priest Rapids and Grand Coulee dams. We will look for opportunities to cooperate with the Spokane Tribe of Indians on Lake Roosevelt work.

Products: Initial descriptions of white sturgeon distribution, length frequency, and age structure. Recommendations for management actions and associated information needs for each reservoir sampled.

f. Facilities and equipment.

Most major facilities and equipment to be used in the project currently exist and are being used. The project is headquartered in existing offices of the lead and cooperating agencies. Staff and facilities associated with the Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, Columbia River Inter-Tribal Fish Commission, U.S. Geological Survey Biological Resources Division, and U.S. Fish and Wildlife Service collectively provide a long history of white sturgeon research and management expertise in the Columbia River basin.

A variety of boats and sampling gear designed to collect various life stages of white sturgeon are currently used on the project. Design and use of experimental production facilities will be determined as part of the master planning process under Objective 1.

g. References.

Beamesderfer, R.C. and T.A. Nigro. 1993. "Status & Habitat Requirements of the White Sturgeon Populations in the Columbia River Downstream from NcNary Dam." Final Report of Research, Volume I (Project 86-50, Contract DE-AI79-86BP63584) to the Bonneville Power Administration, Portland, OR.

Beamesderfer, R.C.P., T.A. Rien, and A.A. Nigro. 1995. Dynamics and potential production of white sturgeon populations in three Columbia River reservoirs Transactions of the American Fisheries Society 124:857-872.

Bonneville Power Administration. 1985. "White Sturgeon Program Implementation Plan." Portland, OR.

Columbia Basin Fish and Wildlife Authority. 1997. "Multi-Year Implementation Plan for the Protection, Restoration, and Enhancement of Columbia River Basin Fish and Wildlife Resources." Presented to the Northwest Power Planning Council, Portland, OR.

Columbia River Fish Management Plan. 1988. (an Agreement ordered by the Unites States District Court for the District of Oregon in the case of United States et al v. Oregon et al, Civ. 68-153), as amended by the Court, Portland, OR.

Columbia River Inter-Tribal Fish Commission. 1996. "Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon." The Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes, Volume 1., Portland, OR.

DeVore, J.D., B. Parker, R.C. Beamesderfer, and T.A. Rien. 1997. "A Review of Alternatives for the Restoration and Management of White Sturgeon Populations and Fisheries in the Columbia River Between Bonneville and McNary Dams (Zone 6)." (March 13, 1997 Draft). Washington Department of Fish and Wildlife, Battle Ground, WA.

North, J.A., R.C. Beamesderfer, and T.A. Rien. 1993. Distribution and movements of white sturgeon in three lower Columbia River reservoirs. Northwest Science 67(2):105-111.

Northwest Power Planning Council. 1994. Amendments to the Columbia Basin Fish and Wildlife Program 98-48, Portland, OR.

Pacific States Marine Fisheries Commission. 1992. White Sturgeon Management Framework Plan, Portland, OR.

Parsley, M.J., and L.G. Beckman. 1994. White Sturgeon spawning and rearing habitat in the Lower Columbia River. North American Journal of Fisheries Management 14:812-827.

Parsley, M.J., L.G. Beckman, and G.T. McCabe, Jr. 1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. Transactions of the American Fisheries Society 122(2):217-227.

Section 8. Relationships to other projects

From its inception this project has been a cooperative effort among many agencies. Our past performance demonstrates a high level of cooperation. We expect this level of cooperation will continue. Some specific examples are:

Kootenai White Sturgeon Investigations 8806500. Findings from project 860500 were the justification for flows sought for Kootenai River sturgeon restoration. Project 860500 continues to provide assistance in egg and larval sampling. Laboratory work to describe timing of larval development will provide direct benefits.

Nez Perce Tribe white sturgeon investigations. Project 860500 will continue to provide assistance in work to restore white sturgeon productivity in Lower Granite Reservoir and Hells Canyon.

Yakama Indian Nation K-Ponds. Personnel from project 860500 will serve on a technical advisory group to develop a plan for K-Ponds located on the Hanford Site.

Section 9. Key personnel

Resume for David Ward

Experience

1984-Present Oregon Department of Fish and Wildlife, 17330 S.E. Evelyn St., Clackamas, OR. (1) Program Leader for Columbia Region Research Program (6 months). Current responsibilities: Coordinate activities of ongoing departmental and interagency projects, identify needs for and develop future projects, provide technical oversight to project leaders, and supervise project leaders and other program staff. (2) Project Leader on evaluation of the Northern Squawfish Management Program (7 years); (3) Project Leader on Portland Harbor Study (3 years); (4) Project Biologist and Technician on various studies (3 years).

Education:	Degree and Date Received
Humboldt State University, Arcata, CA	M.S. Fisheries, 1985
Humboldt State University, Arcata, CA	B.A. Zoology, 1978

Duties as Project Manager on Proposed Study: Coordinate and integrate activities of cooperating agencies; supervise project leader; review and edit project summary reports; provide technical oversight for data analysis and report preparation. FTE: 4 months.

Expertise: Coordinated and integrated activities of cooperating agencies, hired and supervised staff of project leaders, project biologists, and seasonal workers, designed field and laboratory sampling plans, analyzed wide variety of biological data, authored, edited, and reviewed scientific reports and peer-review articles. Organized personnel from cooperating agencies to give symposia at fisheries conferences. Developed and submitted proposals for numerous research projects to various funding sources. Direct experience with methods and gears associated with habitat and fish surveys in streams, rivers, lakes, and reservoirs.

Publications and Reports

Ward, D.L., R.R. Boyce, F.R. Young, and F.E. Olney. 1997. A review and assessment of transportation studies for juvenile chinook salmon in the Snake River. North American Journal of Fisheries Management 17:652-662.

Beamesderfer, R.C., D.L. Ward, and A.A. Nigro. 1996. Evaluation of the biological basis for a predator control program on northern squawfish in the Columbia and Snake rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908.

Ward, D.L., J.H. Petersen, and J.J. Loch. 1995. Index of predation on juvenile salmonids by northern squawfish in the lower and middle Columbia River and in the lower Snake River. Transactions of the American Fisheries Society 124:321-334.

Ward, D.L. 1995. Distribution of fish and crayfish, and measurement of available habitat in the Tualatin River basin. Final Report by the Oregon Department of Fish and Wildlife to the Unified Sewerage Agency, Hillsboro, Oregon.

Resume for Tom Rien

Experience

1984-Present Oregon Department of Fish and Wildlife, 17330 S.E. Evelyn St., Clackamas, OR. (1) Project Leader for White Sturgeon Research (1.5 years). Current responsibilities: Principal Investigator for studies on the early life history and habitat use of white sturgeons in the Columbia River. Coordinate research activities on white sturgeons with the activities and needs of the tribes, states, and other governmental agencies. Oversee the work of two biologists and several seasonal employees. (2) Project Biologist for studies on the early life history and habitat use of white sturgeons in the Columbia River (6.5 years); (3) Sub-Basin Planner for Clackamas and Lower Willamette rivers (1.5 years); (4) Project Technician and Biology Aide on various studies (4 years).

Education:	Degree and Date Received
Oregon State University, Corvallis, OR	B.S. Wildlife Biology, 1981

Duties as Principal Investigator. Coordinate research activities on white sturgeons with the activities and needs of the tribes, states, and other governmental agencies. Oversee the work of two biologists and several seasonal employees. FTE - 12 months

Expertise: Considered expert at aging and age evaluations of several fish species including white sturgeon; devloping and implementing sampling designs to describe population parameters; interpretting and applying findings in population models. Coordinated and integrated activities of cooperating agencies, hired and supervised staff of project biologists, and seasonal workers.

Publications and Reports

Beamesderfer, R.C.P., T.A. Rien, and A.A. Nigro. 1995. Dynamics and potential production of white sturgeon populations in three Columbia River reservoirs Transactions of the American Fisheries Society 124:857-872.

North, J.A., R.C. Beamesderfer, and T.A. Rien. 1993. Distribution and movements of white sturgeon in three lower Columbia River reservoirs. Northwest Science 67(2):105-111.

Rien, T.A. and R.C. Beamesderfer. 1994. Accuracy and precision in age estimates of white sturgeon from pectoral fin rays. Transactions of the American Fisheries Society 123(2):255-265.

Rien, T.A., R.C.P. Beamesderfer, and C.A. Foster. 1994. Retention, recognition, and effects on survival of several tags and marks on white sturgeon. California Fish and Game 80(4):161-170.

Resume for Michael J. Parsley

Experience

1984-Present U.S. Geological Survey - Biological Resources Division. (1) Project Leader on White Sturgeon Study. Current responsibilities. Principal Investigator for studies on the early life history and habitat use of white sturgeons in the Columbia River. Coordinate research activities on white sturgeons with the activities and needs of the tribes, states, and other governmental agencies. Oversee the work of several biologists and technicians. Geospatial technology coordinator for the Western Fisheries Research Center. (2) Project Biologist, U.S. Geological Survey - Biological Resources Division.

Education:	Degree and Date Received
Iowa State University	B.S. Fish & Wildlife Biology, 1982
University of Wisconsin at Stevens Point	M. S. Fisheries, 1984

Duties as Principal Investigator. Coordinate research activities on white sturgeons with the activities and needs of the tribes, states, and other governmental agencies. Oversee the work of several biologists and technicians. FTE - 11 months.

Expertise. Considered an expert on the ecology and biology of white sturgeons. Use of biotelemetry to ascertain habitat use by juvenile and adult white sturgeons, laboratory experiments to determine the effects of gas supersaturation on developing embryos, and trawls to estimate recruitment to young of the year. In 1993, organized and co-chaired a day-long symposium called "Biology and Management of North American Sturgeons" that was held at the Annual Meeting of the American Fisheries Society, Portland, Oregon, Knowledgeable in methods to quantify habitat in large rivers using remote sensing and geographic information systems.

Publications and Reports

Counihan, T.D., A.I. Miller, M.G. Mesa, and M.J. Parsley. In press. The effects of dissolved gas supersaturation on white sturgeon larvae. Transactions of the American Fisheries Society.

Counihan, T.D., A.I. Miller, and M.J Parsley. In press. Indexing the relative abundance of young-of-the-year white sturgeon in an impoundment of the lower Columbia River from highly skewed trawling data. North American Journal of Fisheries Management.

Parsley, M. J., and L. G. Beckman. 1994. White sturgeon spawning and rearing habitat in the lower Columbia River. North American Journal of Fisheries Management 14:812-827.

Parsley, M. J., L. G. Beckman, and G. T. McCabe. 1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. Transactions of the American Fisheries Society 122:217-227.

Section 10. Information/technology transfer

Information collected from the project is shared with fishery managers and is used to help develop or revise the management of white sturgeon fisheries. One example is information on population status of white sturgeon gathered as part of the project is used to set maximum harvest limits.

Numerous manuscripts based on findings from the project have been published in peer-review journals. A list of these publications is given in Section 7 above, under "Project Reports and Technical Papers". Publication in peer-review journals will continue as the project progresses.

The project has also shared information through workshops. A workshop organized by project cooperators in December 1997 was attended by sturgeon biologists from throughout the Pacific Northwest.