CHARACTERIZATION OF AQUACULTURE EFFLUENTS FROM FOUR TYPES OF PRODUCTION SYSTEMS

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Funding Request: $153,300

Duration: 2 Years (September 1, 1992 to August 31, 1994)

Objectives:

1. Characterize aquaculture effluents from four types of aquaculture production systems: pond culture; flow-through culture (raceway); cage culture, and; recirculating systems.

2. Generate a data base from these four types of production systems, to help promote a reasonable choice of effluent discharge regulations by government agencies.

Proposed Budgets:

Institution	Principal Investigator(s)	Objective(s)	Year 1	Year 2	Total
Illinois State University	Ronald R. Rosati Reginald D. Henry	1 & 2	$9,064	$9,736	$18,800
Iowa State University	Joseph E. Morris	1 & 2	$17,000	$18,500	$35,500
University of Nebraska-Lincoln	Kyle D. Hoagland Terrence B. Kayes	1 & 2	$15,000	$15,000	$30,000
Ohio State University	Konrad Dabrowski James M. Ebeling	1 & 2	$16,000	$13,000	$29,000
University of Wisconsin-Milwaukee	Fred P. Binkowski	1 & 2	$20,000	$20,000	$40,000
		TOTALS	**$77,064**	**$76,236**	**$153,300**

Non-funded Collaborators:

Facility	Collaborator(s)
Kloubec's Fish Farm, Amana, Iowa	Myron Kloubec
Fairport Fish Hatchery	Iowa DNR
Freshwater Farms of Ohio, Inc.	Dave Smith
Sandhills Aquafarm	Michael Wyatt
Glacier Springs Trout Hatchery	John Hyink and John Wolf
Alpine Farms	John Hyink and John Wolf

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JUSTIFICATION

The interest and growth of the aquaculture industry, private as well as public, has heightened awareness and concerns about possible negative impacts upon the aquatic environment.

Aquaculture needs clean, quality water and as such, supports the goals of the Clean Water Act (CWA) of 1977, to protect the nation's waters against further degradation. The aquaculture industry is wholly dependent upon sources of high quality water for current and future production.

As a frequently large water user, aquaculture is perceived by the public and the regulatory community as an industry that has the potential to degrade the nation's waters. To further magnify this concern, aquaculture is more and more recognized as a form of agriculture and agriculture is recognized as the leading source of water pollution in the USA. This includes both point source and non-point source impacts (Weinberg 1991). It is, therefore, important for the aquaculture community to be ahead of the public, the environmental groups, the regulators, in order to avoid unrealistic regulations based on emotions and bad information or poor science. In 1974, the EPA published tentative effluent limitation values for aquaculture systems (USEPA 1974), but these were never promulgated and Harris (1981) pointed out that federal regulations of fish hatchery discharges have been inconsistent because of the lack of a properly prepared guidance document. Additionally, a broad range of state laws and regulations apply to aquaculture and these often constrain the development of aquaculture in the respective states (Ziemann et al. 1990). Indeed, the National Research Council in 1978 reported that the orderly development of aquaculture is constrained due to political and administrative rather than scientific and technological problems.

This demands an awareness of and concern for the problem, but also requires knowledge as to what is occurring and what needs to be done along with an ability and willingness to take proper action. The aquaculture industry must arm itself with solid, reliable facts concerning the nature of its effluent and its impact on receiving waters. Characterization of the effluent is necessary for evaluation of treatment methods and to determine the environmental impact. Such data is also needed in order that permits can be issued and justly written.

The proposed study should provide data that will help the aquaculture industry as well as the regulators better understand the potential impacts on receiving waters. The relationship between aquaculture waste and environmental impact has not been established (Ziemann et al. 1990). Instead, municipal wastes have been used as the standard. Aquaculture wastes may be unique in their character (as opposed to waste from terrestrial animals) and this has not received sufficient attention (Ziemann and Pruder 1990).

Aquaculture in the North Central Region is diverse in nature and is undergoing development. It encompasses a variety of production methods and cultural species.

Historically, most terrestrial animal meat production has evolved from extensive, outdoor production to intensive, indoor production in controlled environments. Aquaculture, on the other hand, has undergone but minimal change and has, generally, remained an extensive, low-technology business. It, therefore, offers many opportunities for exploiting the experience of terrestrial animal husbandry (Fridley et al. 1988).

The North Central Region's traditional aquaculture enterprises range from channel catfish culture in Missouri and Illinois, to trout and salmon culture in Wisconsin and Michigan. The center has funded research projects involving culture techniques for non-traditional species such as walleye, hybrid striped bass, hybrid walleye, yellow perch, as well as trout and salmon. These species are, and will continue to be, reared under a variety of culture techniques, including pond, cage, flow-through (raceway) and recycle systems.

The purpose of this study is to characterize the effluents from a variety of aquaculture systems and to establish a data base. This information will help identify parameters that appear problematic and this may lead to recommending management practices for future research and development studies.

RELATED CURRENT AND PREVIOUS WORK

Characterization of Aquaculture Effluents

According to Liao (1970), there were no articles of any significance concerning hatcheries as a source of pollution in the USA. However, his studies indicated that there are water quality degradation problems associated with salmonid hatchery operations.

In 1972, the Michigan Department of Natural Resources, Environmental Protection Branch, conducted an extensive evaluation of the water quality downstream from nine salmonid fish hatcheries and/or rearing stations. Results of 41 water quality surveys showed that hatchery cultural activities generally resulted in increased effluent loadings of biochemical oxygen demand (BOD), suspended solids, organic nitrogen, ammonia nitrogen, soluble orthophosphate phosphorus, and total phosphorus. Suspended solids appeared to be the most significant problem from discharged hatchery waste water (Michigan DNR 1973).

In 1975, Caufield reported on the water chemistry of five Columbia River basin hatcheries and concluded that the variance for a particular parameter was so high that the analyses were inadequate to provide reliable quantitative information. Also in 1975, Olness et al. studied the effect of a national fish hatchery on a creek and concluded that no degradation of stream water quality occurred due to hatchery discharge, although total phosphorus levels increased.

The European Inland Fisheries Advisory Commission (EIFAC) established a working party on fish farm effluents in 1980. That same year it seems that 15% of fish farms surveyed in England had been implicated in pollution incidents. For the most part, the incidents involved excessive discharge of suspended solids (Solbe 1988).

In 1984, Sumari of Finland stated that waste water discharge is a serious problem for fish farmers in many countries and that the problem will spread to additional countries. About this time the problem was focussed on in the USA in a few isolated cases. The State of Michigan was ordered by the court to reduce the phosphorus contribution from one of it's fish hatcheries to a level below which it was unable to achieve without a substantial cut in production. The State of Vermont was required to spend over $500,000 on data collection and research to obtain a discharge permit for a proposed new state fish hatchery, and the State of Pennsylvania was called to task on a number of their state hatcheries alleged to have violated that state's water quality standards.

In 1989, Hopkins and Manci wrote that the aquaculture industry has failed to realize or come to grips with effluent impacts and that it is not surprising that problems are increasing. Westers (1990) pointed out that a comprehensive approach to waste management based on solid data and a consideration of variables and methodology is needed to describe an important aspect of the problem. He concluded that solids and phosphorus were major effluent problems in salmonid flow-through culture and that waste reduction could be achieved by proper facility design and choice of feeds.

Because of the complexity of fish culture effluents due to differences in culture systems, production rates and timing, quantity and quality of source water, hydraulic retention time, fish species and age, feed types and rates, and management (e.g., cleaning and effluent treatment) aquaculture effluents must be characterized with these variables in mind (Kendra 1991).

A conference, "Water Quality and the Environment - Aquaculture" was convened April 9-10, 1991, in Washington, DC, for the purpose of providing guidance to public agencies and decision-makers concerned with policy and research in water quality as it relates to aquaculture. Forty-three representatives of federal agencies, researchers, farm operators and representatives of aquaculture-related interests attended. Of the six recommendations listed, the characterization of the influent and effluent, needed for evaluation of treatment methods and to estimate environmental impacts, came first. The proposed study will address this particular issue through a well organized collaboration between operators of representative production systems (e.g. pond, flow-through, cage and recycle) and Work Group investigators.

The study must target only those parameters and practices which are most important. However, the issue of what water quality parameters are the most critical to aquaculture systems has not been resolved. Solids, BOD, phosphorus, and nitrogen compounds are usually considered major parameters in effluent monitoring programs.

Pond Culture

There is a paucity of information regarding effluents from pond culture. A majority of the available effluent data is based upon salmonid culture (Beveridge et al. 1991). Much of the available pond information is based on large ponds in the southern United States (Boyd 1990). Currently the Southern Regional Aquarculture Center (SRAC) has proposed to characterize effluents from catfish production ponds in Alabama and Mississippi, crawfish ponds in Louisiana, and hybrid striped bass ponds in Virginia and South Carolina. Variations in pond effluent quality are influenced by rearing practices, by the seasonal cycles of production and by regional climatic factors.

It appears that the amount of solids escaping from ponds is related to the periodicity of seining (Boyd 1978; Tucker and Lloyd 1985; Boyd 1990; Chichra and Shireman 1990). The amount of solids increase with the occurrence of seining and/or movement of fish in bottom sediments. In addition, total suspended solids are often highest in ponds in late summer and fall and less in ponds stocked at lower stocking rates (Chichra and Shireman 1990; Joyner 1990). However, Ellis et al. (1978) and Piper et al. (1982) determined that fish biomass in ponds was not consistently associated with the amounts of settleable or nonsettleable solids.

Murphy and Lipper (1970) noted that, on a daily basis, channel catfish will produce 4.9 grams of BOD per kilogram of live weight, which is higher than chicken or cattle production. The amount of either BOD or chemical oxygen demand (COD) also increased after the ponds were drained (Boyd 1978; Tucker and Lloyd 1985; and Cichra and Shireman 1990). In relation to streams, ponds may have greater COD and total nitrogen (Tucker and Lloyd 1985). The amount of phosphorus increased in ponds as the season increased, but at times it was less in ponds than in streams (Tucker and Lloyd 1985). It was also determined that the amount of phosphorus is high in ponds when the bottom sediments are dislodged during seining. Boyd (1990) has noted that phosphorus readily saturates bottom sediments.

Nitrogen compounds also increased as the culture period progressed. Cichra and Shireman (1990) found that nitrite concentrations were highest during late summer or early fall, while total ammonia nitrogen levels were highest in ponds with the greatest stocking densities. It was also noted that total Kjeldahl nitrogen and fish biomass were not related to each other. The concentration of adsorbed nitrogenous compounds in pond sediments does not vary with season (Shroeder et al. 1991). Beveridge et al. (1991) noted that when aquaculture effluents were standardized on per unit basis or biomass basis, variability still exists. The greatest variability exists in nitrogen and phosphorus data.

Aquaculture effluents appear to have little impact upon the aquatic biota in receiving streams. Ellis et al. (1978) and Olness et al. (1975) suggested that very little pollution would occur resulting from aquaculture effluents. Tucker and Lloyd (1985) indicated that the effluent from channel catfish ponds may have less nutrient load than what the streams located in the agricultural watersheds already experience. Ponds, by their very nature, are complex and dynamic ecological systems. Because of this, it is extremely difficult to create a representative database of pond water quality and effluent characterization.

Better characterization of the variations in pond effluents in relation to rearing practices and climate will provide a more realistic basis for regulatory discussions concerning discharge permitting. Our proposed study would provide information on production ponds from more northern sites in Ohio and Iowa, and provide a useful comparison to those examined in the south by SRAC.

Flow-Through Culture Systems

Stechey and Trudell (1990) conducted a thorough and useful study of flow-through commercial trout hatcheries in Ontario. They focused on solids characterization and management technologies. Production of solid wastes was found to be relatively independent of facility design.

Specific impacts of flow-through systems have to do in part with the high volume of water required. The need to locate these sites near abundant sources of high quality water has resulted in many hatcheries in the North Central Region, being situated on first order streams near headwater spring areas. Such headwaters often support valuable cold water habitat for recreational trout fishing. Even a small hatchery's discharge can potentially have a relatively large impact. For example, the development of hatchery ponds and raceways in the headwaters of the Onion River in Wisconsin has been accused of reducing water quality and eliminating natural reproduction in the brook trout population (Weber et al. 1968; Wisconsin DNR 1981).

Temperature changes, the contribution of solids to sediments and nutrient enrichment from hatchery effluents have sometimes subtle influences on the biota of receiving waters (Hinshaw 1973; Szluhza 1974; Alabaster 1982; Munro et al. 1985; Kendra 1991).

Characterizing effluents from such facilities should take into account the variable scale of production, the species reared, and regional variations in ground water sources and receiving waters.

Flow-through rearing facilities in the North Central region can be small family operations or large scale production facilities similar to government agency hatcheries. Effluent data in combination with corresponding information on variations in a full range of production levels could provide better assessment of potential impact.

Available information on effluent impact often relies on comparison of effluent discharge areas to nearby control areas, usually upstream from the effluent. This approach is necessary for existing facilities where concerns with possible impacts often arise after the aquaculture facility has been brought into production.

Examining changes in water quality characteristics before, during, and after the development of a flow-through production system is an alternative approach which we propose to take for characterizing flow-through system effluents and their possible impacts.

Cage Culture

Environmental issues are of particular concern with respect to open water net cage aquaculture facilities (Weston 1991). Unlike land-based culture sites, the collection and treatment of solid wastes is greatly complicated and at present there are no means available to remove the BOD, nitrogen and phosphorus from the waste stream other than by modification of fish diet and feeding strategy. The BOD of sediments beneath a finfish net cage system in Washington State was approximately six times greater than the BOD of reference sediments (Pamatmat et al. 1973). Sediments beneath a farm in Sweden had a BOD 12 to 15 times greater than normal (Hall et al. 1990). The depletion of pore water oxygen results in a shallowing of the aerobic portion of the sediment column, measurable by both sediment color changes and more negative reduction-oxidation potentials in the sediment (Brown et al. 1987; Weston and Gowen 1988). As a result, a reduction in macrofaunal species richness is a widely reported phenomenon in the vicinity of mariculture operations (Pease 1977; Brown et al. 1987; Ritz et al. 1989; Weston 1990).

Nitrogen is largely released in soluble forms, with only a small fraction in bottom deposits. Conversely, phosphorus is largely associated with solid waste, and the vast majority of phosphorus from net cage culture is initially deposited in the sediments. A large proportion of this phosphorus can later be released to the water column, particularly under anaerobic conditions (Enell et al. 1984).

Recirculating Systems

Of all the methods of fish culture, a recirculating aquaculture system (RAS) most closely follows theoretical predictive models for effluent production from a known quantity of feed input. Such systems offer an opportunity to study some variables that are more reproducible than other operating modes. Responses to variations in feed composition will be quick and obvious (Van Gorder 1991). Chen and Malone (1991a,b) indicate no management guidelines for sludge from recirculating aquaculture systems exist even though such systems have a higher sludge volumetric generation rate than other agricultural animals on a live weight basis. Establishing guidelines for recirculating aquacultural sludge management is an important priority (Chen and Malone 1991a,b).

Total suspended solids (TSS) in a RAS are produced from both feces and bacterial activity in the system. TSS produced from feces vary based on the species fed and the composition of feed. An average TSS production figure is 0.43 kg TSS/kg feed (Chen and Malone 1991a,b).

Sixty-seven percent of TSS are from 1.5 to 30 micron in size (Easter 1992). In a recirculating system producing hybrid striped bass, system average effluent values were 371 mg/L TSS, 320 mg/L COD, 125 mg/L TKN, 85 mg/L total phosphate, 25 mg/L dissolved phosphate, and 178 mg/L nitrate nitrogen (at the end of the grow-out cycle) (Easter 1992).

TSS produced from nitrifying bacteria is slight, from 0.03% to 0.09% of the feeding rate, and is considered "practically negligible" (Chen and Malone 1991a,b). TSS production from heterotrophic bacteria is approximately 9% of the feeding rate (Chen and Malone 1991a,b). Therefore, TSS production from all sources is assumed to be 52% of the feeding rate.

As the water is used in a RAS, the pH of that water tends to decline due to the nitrification of ammonia from NH_3 to NO_3 and due to CO_2 production.

ANTICIPATED BENEFITS

The proposed studies would clarify the nature of aquacultural effluents and their potential impact on receiving waters, and help answer questions as to whether aquacultural wastes are uniquely different or essentially similar to municipal or agricultural wastes generated by terrestrial animals.

Also, these studies would provide a more accurate and complete data base on the variety, quality and scale of wastes produced by the diverse aquaculture production strategies examined. Problematic aspects of the various production techniques will be identified. Through understanding of the relationships of species cultured and production practices to the amount and type of effluent produced aquaculturists will know what approaches can reasonably be used to control effluent. Further research could then be more effectively aimed at solving the identified problem areas, benefiting the advancement of design solutions to the reduction of aquaculture waste loads.

Armed with this information aquaculturists and regional aquaculture federations will be able to take a proactive stance in formulating realistic effluent standards with environmental regulatory agencies. Without this type of information regulators have little choice other than relying on established information which may not be representative of the actual aquaculture situation. The ability to take such a stance could improve the public perception of aquaculture which is now viewed somewhat suspiciously as potential source of water quality degradation.

This will assist the protection of the quality of water resources to the benefit of all users public and private including aquaculturists who will require abundance sources of high quality water to develop and operate their production systems.

OBJECTIVES

1. Characterize aquaculture effluents from four types of aquaculture production systems: pond culture; flow-through culture (raceway); cage culture; and recirculating systems.

2. Generate a data base from these four types of production systems, to help promote a reasonable choice of effluent discharge regulations by government agencies.

PROCEDURES

Pond Culture

With respect to pond culture, Morris (Iowa State University) and Ebeling (Ohio State University) will be responsible for gathering the necessary data.

Through both extension and research activites, two sites for pond culture have been identified in Iowa. The first site is the Fairport Fish Hatchery operated by the Iowa Department of Natural Resources and located near Muscatine. This facility began extensive channel catfish culture in 1991 and will continue to do so in subsequent years through 1995. Through close cooperation with the facility managers it will be possible to obtain firm numbers related to feed level, production and waster usage as they are related to the effluents being generated.

The second Iowa site is Kloubec's Fish Farm, a private fish farm located near Amana, Iowa. This operation has ponds of variable size and age. The wide variety of species cultured at this facility, e.g., hybrid bluegills, walleye, hybrid striped bass, will yield additional effluent data that will be useful to this region. As with the previous site, it will be possible to obtain realistic data regarding effluents as they are related to culture practices.

The following parameters will be measured in accordance to Standard Methods (APHA et al. 1989): temperature; dissolved oxygen (DO); pH; settleable solids, total solids, and total suspended solids; BOD; total Kjeldahl nitrogen, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen; total phosphorus and total reactive phosphorus. Temperature and DO will be measured on site using a Yellow Springs Instrument (YSI) DO meter, model 54. The other water parameters will be done at Iowa State University at either the principal investigator laboratory or at the Analytical Services Laboratory. All samples will be collected in acid-washed polyethylene sample bottles during seining, harvesting and during drawdown. Samples will be collected from mid-depth in ponds and at the point of entry into the receiving stream. At the same time of effluent release from ponds, replicate water samples will be collected and analyzed for the above parameters from a tentative point 1 km above and below the point of entry; actual sampling location will be determined based upon respective flow rates of the receiving stream and effluent.

In Iowa, samples will be collected from two sites, Fairport State Fish Hatchery and Kloubec Fish Hatchery during each culture period. At Fairport, three channel catfish ponds will be sampled randomly at least four times. At Kloubec, three ponds from at least two types of fish, hybrid striped bass fingerlings, hybrid bluegill fingerlings, channel catfish fingerling or channel catfish food fish will be sampled.

In both situations, the amount of feed used, timing and degree of artificial fertilization and type of feed will be noted. The relationship between effluent characteristics and production method will be assessed through appropriate correlation or regression methods. Non-parametric statistical techniques will be employed if the data aren't amenable to a parametric approach.

At the Piketon Research and Extension Center, Ohio, temperature, DO and pH, the parameters of greatest concern in pond management, will be monitored for the two 0.4 ha intensive catfish ponds with a computer based data acquisition system and pump sampler on a half-hour basis, at multiple depths.

In addition, important weather parameters will be monitored: ambient temperature and humidity, wind speed and direction, rainfall and solar radiation. During the cooler months (November-February), pond grab samples will be taken weekly and during the warmer months, twice a week or as often as pond conditions require. The following parameters will be measured in accordance to Standard Methods (APHA et al. 1989): temperature; DO; pH; conductivity; turbidity; settleable solids, total solids, and total suspended solids; BOD; total Kjeldahl nitrogen, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen; total phosphorus and total reactive phosphorus. A water budget will be used to estimate the quantities of effluents that are discharged. All samples will be collected and analyzed in accordance with Standard Methods (APHA et al. 1989).

Flow-Through Culture Systems

Research to characterize effluent from representative regional flow-through production facilities using spring and ground water resources will be studied in Wisconsin (Binkowski) and Nebraska (Hoagland and Kayes).

Through aquaculture extension activities, we have identified private sector producers who are willing to make their production sites available for these investigations. In Wisconsin, the first of these sites is the Glacier Springs Trout Hatchery. This facility has been inactive for over 15 years and the owners intend to renovate this facility and put it back in production. It discharges into the Onion River, a trout water habitat of significant concern to state resource agencies. The same owners have a second flow- through production facility, Alpine farms, which has a recently established indoor tank facility supplied with artesian well water. An earthen raceway and a small pond receive the effluent from the indoor system before it discharges through a small creek into the Sheboygan River. These sites and the production goals of the owners are representative of other small operators using the cold spring and ground water resources in the North Central Region. They are not necessarily interested in rearing only trout, but also have a strong interest in rearing alternative cold- or coolwater species. Currently they are experimenting with whitefish in cooperation with the Leech Lake Indian Reservation in Minnesota. A good working relationship with the owners has been established, which will enable us to control water flows, production levels, food quality, feeding rates and hatchery management practices on an experimental basis.

The Alpine farms site will be used to produce a data set on the effluent quality of flow- through production of whitefish and yellow perch as regional alternative commercial species.

At the Glacier Springs Hatchery, the effluent characterization will be conducted seasonally and coordinated in a stepwise fashion with the renovation of the facility. This work will begin in early 1992, prior to the start of the funding cycle. Then, as the units are renovated and the water supply is redeveloped and improved, we will characterize the effluent generated during the raceway clean-out and rehabilitation efforts. As these rehabilitated rearing units are placed in production, we would characterize the changes in the effluent before and after stocking, and in relation to the increasing level of production within each unit. The contribution of each unit as it comes on line would be described as it contributes to the overall effluent leaving the site.
Glacier Springs discharges to Mill Creek, near its confluence with the Onion river. Further upstream from Glacier Springs a second hatchery (Silver Springs) discharges into Mill Creek. In the past, this hatchery has operated largely as an extensive fee fishing operation, but plans are also underway to renovate this facility and utilize it at a high production level. The final discharge for this facility is accessible at the Glacier Springs site. This will offer another opportunity to characterize the effluent of a second "Before and After" scenario. Discharges and temperature measurements will be recorded to establish the relative size of the hatchery effluent compared to the discharge of Mill Creek. Through cooperative arrangements with the Wisconsin Department of Natural Resources (Wisconsin DNR) and the site owners, we will install temperature recording devices above and below the effluent. During the excavating and clean-out operations of this facility, particular attention will be given to measuring suspended solids and the possible impact of erosion.

Sampling at both sites will be coordinated on an approximately monthly basis (18-24 sampling trips to each site per year) with certain trips arranged to take into account special sampling at the Glacier Springs sites to cover aspects of its redevelopment or of special significance to trout population events, including seasonal low flow and possible trout spawning periods.

Replicate grab samples or composite samples will be taken from the water source and the tank effluents, at approximately monthly intervals over the course of the production cycle. Additionally, samples will be taken representing the effect of specific production operations (e.g. tank cleaning, fish sorting, etc.) on effluent quality. Corresponding production data on species size of the fish, flow rate, density, the loading rate, the quality and quantity of food being used, growth and feed conversion at the time of sampling would be recorded along with the analysis of the effluent water quality parameters. The following parameters will be measured in accordance to Standard Methods (APHA et al. 1989): temperature; DO;

pH; settleable solids, total solids, and total suspended solids; BOD; total Kjeldahl nitrogen, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen; total phosphorus and total reactive phosphorus.

Descriptive statistics describing the central tendency and variation of the above mentioned water quality parameters will be compiled in relation to fish species, fish size, production intensity, hatchery flow and hatchery management practices. When characterizing aquaculture effluents it has been found that most variables examined are not normally distributed and data sets contain values less than the detection limit. The use of non-parametric statistical procedures will be necessary (Gertz 1978; Helsel 1987).

The University of Nebraska-Lincoln investigators (Hoagland and Kayes) will characterize water quality above and below a flow-through trout production facility located on a first order spring-fed stream in the Sandhills Region of western Nebraska. Sandhills AquaFarm, which is located on Whitetail Creek, affords a valuable opportunity to monitor water quality effects related to a modern aquaculture production operation because of the sites excellent upstream water quality and close proximity to the University of Nebraska's Field Station at Cedar Point. The owners offer their full cooperation to study this weel designed facility, which serves as a model system for production and effluent-related studies for all of western Nebraska, as well as the entire North Central Region. They propose to monitor water quality parameters above and below Sandhills Farms, biweekly from June through September and monthly during the remainder of the year (a total of 16 sample dates). Five samples will be collected from each of two sites, one above the facility and one below, to provide for an adequate statistical basis for comparisons. The following parameters will be measured: temperature; DO; pH; settleable solids, total solids, and total suspended solids; BOD; total Kjeldahl nitrogen, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen; total phosphorus and total reactive phosphorus.

All water samples will be collected using a horizontal acrylic Van Dorn bottle and acid- cleaned, amber polyethylene sample jars. Samples collected during the summer months for nutrient assays will be stored on ice in a cooler and returned to the field station laboratory for analysis within 24 hours. Samples to be shipped to the UN-L main campus will be acidified with nitric acid (to pH 2), stored on ice, shipped via next day express mail over dry ice, refrigerated, and analyzed within 48 hours. DO and temperature will be measured at mid-depth in the stream using a YSI DO meter (model 58) and air calibrated probe (model 5775). Nutrient analyses will be performed according to Standard Methods (APHA et al. 1989). The pH determinations will be conducted in the field using a Fisher pH meter (Accumet model 1003).

Cage Culture

The commercial cage culture operation to be studied (Dabrowski and Ebeling) is located in a large, abandoned quarry. It consists of several interconnected ground water fed lakes, and discharges into a cold water stream. The facility is operated by Dr. David Smith of Freshwater Farms of Ohio, Inc., located in Urbana, Ohio. Samples for water quality analyses will be collected at the inflow point of the spring water, in the water column immediately surrounding the cage culture rafts, at the discharge into a small receiving pond, and at the discharge into the receiving stream. The following parameters will be measured in accordance to Standard Methods (APHA et al. 1989): conductivity; turbidity; settleable solids, total solids, and total suspended solids; BOD; total Kjeldahl nitrogen, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen; total phosphorus and total reactive phosphorus. Water flow through the two lake systems will be monitored via an existing weir at the discharge. In addition, a separate neighboring quarry lake will serve as a control and be monitored in order to assess the impact of the cage operation on the quarry lake ecosystem itself. All data will be related to fish culture management practices, feeding levels and schedules, feed composition, growth rates, feed conversions and fish biomass.

Recirculation culture systems will be studied at Illinois State University (Rosati and Henry). Six commercial-style recirculating systems will be constructed and operated under conditions similar to fish farm culture conditions. Two systems were constructed between 1988 and 1991; four systems will be state-of-the-art and constructed between January and June, 1992. System design will be based upon a review of literature and extensive discussion with university and industry engineers, biologists and economists.

All systems will be described according to procedures outlined in the United Nations Food and Agriculture Organization European Inland Fisheries Advisory Committee Technical Paper 49, "Flow-through and Recirculating Systems: Report of the Working Group on Terminology, Format and Units of Measurement." All systems will be economically modeled to determine cost of production. The four most economically-efficient systems will be replicated.

The characterization of the wastewater from the recirculating system will be conducted according to approved practices. All inputs and outflows from the test recirculating systems will be carefully measured. Daily measurements on the following wastewater parameters will be taken: temperature, DO, and pH. Also, daily feed added will be recorded as well as the volume of waste water removed. Three times per week measurements will be made for un-ionized ammonia, ionized ammonia and nitrite nitrogen. Weekly waste water measurements will involve: alkalinity and carbon dioxide; BOD; total Kjeldahl nitrogen and nitrate nitgrogen; total phosphorus and total reactive phosphorus. Of special interest are characteristics of solids generated in A RAS. Accordingly, the following data will be collected: total dried residue, total filterable residue, filterable residue >70 microns, filterable residue 50-70 microns, filterable residue 30-50 microns, filterable residue <30 microns, settleable matter and turbidity. All water quality analyses will be measured in accordance to Standard Methods (APHA et al. 1989). Weekly water replacement (volume) and fish biomass will be determined as well. Data shall be recorded periodically for fish mortality and biomass of fish harvested.

Data Base Generation

The University of Wisconsin-Milwaukee/CGLS will coordinate the generation of the data base with each of the separate workgroup cooperators.

For each of the production systems the separate workgroup cooperators will provide measurements for the following core set of effluent parameters: temperature; DO; pH; settleable solids, total solids, and total suspended solids; BOD; total Kjeldahl nitrogen, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen; total phosphorus and total reactive phosphorus. Standard procedures (APHA et al. 1989) would be used for these core parameters which will facilitate comparison of results of the North Central Region with aquaculture effluent workgroups of the Northeast and Southern regional aquaculture centers.

For evaluation of inter-laboratory quality assurance of nutrient analysis, UW-Milwaukee/CGLS will circulate unknowns and standards (ammonia, nitrate, nitrite, and orthophosphate) quarterly. Depending on their relevance to a particular production system, individual cooperators will include other water quality parameters, but each will provide the above core set of measurements for the effluent characterization data base.

Along with the core parameters the individual investigators will provide information on production system characteristics that are necessary for interpreting effluent quality in relation to the concurrent aquaculture conditions generating the effluent. This description would include the fish species reared, the size distribution of the fish, the biomass on hand, feed types and composition (including N & P levels), feeding rates and enough information on the production system and water use to potentially relate effluent quality to fish production on a per unit or biomass basis.

This information generated concerning effluent quality provided by the separate cooperators will be compiled by UW-Milwaukee into a core parameter data base which could be accessed (as either written tabulations or in electronic formats) to obtain descriptive statistics or further analyses to reveal relationships of effluent quality to aquaculture production strategies.

Analysis, intepretation and reporting of these relationships would be the responsibility of the investigator conducting the analysis of the various production systems, and the centralized data base could be used to provide access and linkage to workgroup cooperators, investigators involved in the other RAC effluent studies, the extension liaison (LaDonn Swan), regional aquaculturists, regulatory agencies or other interested parties.

FACILITIES

Pond Culture Systems

Iowa State University
Kloubec's Fish Farm

Myron Kloubec is owner and operator of the largest fish farm in Iowa and it is located in the east central part of the state near Amana. The earthen ponds empty into one another and ultimately into the Iowa River. Water sources are wells and surface runoff.

This private operation currently has approximately 32 ha of production waters consisting of ponds that range in size from 0.04 to 0.81 ha. These ponds are from 15 years to only a few months in age. This range in both size and age will allow for the effects of time (age of ponds) and pond size influences to be measured. The species being cultured include hybrid striped bass, hybrid bluegill, and channel catfish. Fingerlings of all these species, plus food fish of channel catfish, are currently produced. All species are fed based upon a percentage of body weight or by surface area of the culture pond.

Fairport Hatchery

This former federal hatchery was originally constructed to produce freshwater mussels for the Mississippi River. It has been operated by the Iowa Department of Natural Resources since 1977 and is located along Iowa's eastern border near Muscatine. The source of water is wells and the effluent empties into the Mississippi River. There are seven ponds whose combined area equals 2.4 ha. Artificial feeds are used at 3-5% of total body weight. The major species being cultured is channel catfish. This intensively cultured pond operation produces large numbers of large sized channel catfish for stocking purposes.

Iowa State University Campus

The fisheries section will move into a renovated facility in 1992. This facility will have a Sartorius analytical balance, Turner model 112 fluorometer and a Milton Roy Spectronic 501 spectrophotometer. Also, a Corning model 150 pH/ion meter and YSI model 54 oxygen meter will be available.

Ohio State University
Piketon Research and Extension

This Center's aquaculture program has currently 12 0.10 ha ponds and two 0.8 ha ponds for research and demonstration, a 325 m^2 aquaculture wet lab, and a recently outfitted water quality research laboratory, which includes, besides traditional water quality instrumentation, an Alpkem autoanalyzer, gas chromatograph, and incubation oven.

Flow-through Systems

University of Wisconsin-Milwaukee/Center for Great Lakes Studies (CGLS)

At this facility we have access to both MS-DOS based and MacIntosh microcomputers with appropriate database, spread sheet and statistical software packages to enable us to act as the database coordinator for this proposal.

This facility also has the necessary water analysis equipment and available expertise to perform the required effluent tests and for the role of providing quality assurance standards and unknowns for evaluating interlaboratory performance.

Glacier Springs Hatchery

The Glacier Springs Hatchery site located in Sheboygan County, Wisconsin, and its receiving ecosystem, Mill Creek, will be used as a representative site to examine possible environmental impact of a cold water flow-through culture operation. This trout hatchery was originally established in the late 1940s, but has been inactive for the past 15 years. The new owners, John Hyink and John Wolf, intend to renovate it and return it to operation. They offer their full cooperation. On this site are earthen raceways and existing ponds ranging from small sized ones to several hectares in size.

A second hatchery, Silver Springs, also discharges into Mill Creek a short distance upstream from the Glacier Springs site. Mill Creek has a length of 2.5 km (1.6 mi) and a gradient of 5.0 m/km (26.4 ft/mi) at its confluence with Ben Nutt Creek (length 9.6 km; gradient 9.1 m/km). These two streams form the headwaters of the Onion River. These tributaries along with the 6.4 km stretch of the Onion River above the mill pond at Waldo, support an active trout fishery.

Alpine Farms

Alpine Farms is a recently established indoor fish culture facility supplied with artesian well water. The current operation involves rearing whitefish and yellow perch in eight 2.4 m (8') diameter fiberglass tanks. Additional outdoor ponds are being constructed on this site. The effluent from the indoor facility passes through a recently constructed pond and a small natural pond before entering the Sheboygan River via a small creek. Some analytical facilities could be set up at the indoor facility at Alpine Farms.

Both sites (Glacier Springs and Alpine Farms) are within 80 km of UW-Milwaukee/CGLS, where we possess the necessary water sampling gear and analytical laboratory facilities to conduct the proposed investigations.

University of Nebraska-Lincoln
Sandhills Aquafarm

The effluent characterization studies will be conducted at Sandhills Aquafarm, which is a well designed, modern trout production facility, built in 1989. The primary rearing facility consists of 12 concrete raceways; four side-by-side and three in series. Each raceway is 2.4 m wide x 33.5 m long x 1.2 m wall height (with a 0.9 m water depth) and is equipped with baffles. The water flow through each raceway is 5,867 L/m for a total flow of 23,500 L/m through the facility. Bypass flow around the raceways through a 15.2 cm diameter pipe is 1,893 L/m. In 1990, the raceways were equipped with a low head pure oxygen supplementation system. Production is presently about 36,300 kg/year of Donaldson strain rainbow trout, with a projected maximum of about 77,000 kg/year. The owner/operator has an excellent understanding of loading and other modern production concepts and wants to assist with the project.

Cage Culture System

Ohio State University
Piketon Research and Extension Center
Freshwater Farms of Ohio, Inc.

Freshwater Farms of Ohio, Inc., manages a large commercial cage culture operation in a 65 ha quarry located near Urbana, Ohio. Estimated production from this facility is over 68,000 kg of trout, yellow perch and hybrid bluegills. Dr. Dave Smith, owner and operator, is extremely enthusiastic about the proposed project and the Ohio EPA has expressed an interest in reviewing the results.

Recirculation System

Illinois State University

Facilities available for testing include six commercial-style recirculating systems. University research trials have not yet proven that recirculating systems are economically profitable for the production of food fish when food fish are marketed at standard wholesale prices. However, profitable systems similar to the systems used in this effluent trial are in common use in the aquaculture industry for fingerling production, broodstock holding, ornamental fish production, baitfish holding, and food fish production when the fish are sold into niche markets.

For this study, six commercial-style recirculating systems will be constructed and operated under conditions similar to fish farm culture conditions. Two systems were constructed between 1988 and 1991; four systems will be state-of-the-art and be based on a review of literature and extensive discussions with university and industry engineers, biologists and economists. Component styles employed include:

<u>Tanks</u>: round and rectangular shapes; concrete, PVC, fiberglass, steel construction materials.
<u>Biofiltration</u>: rotating biological contactors, packed columns, submerged media filters, fluidized beds.
<u>Particle filtration</u>: settling tanks, sand filters, screen filters, bead filters.
<u>Oxygen incorporation</u>: oxygen columns, airstone aeration, venturi aerators.
<u>Heat input</u>: electric in-line heaters, electric submersion heaters, infra-red gas heaters.

Four of the six systems employed in this study will be replicated. Three systems will be constructed from January to June, 1992, employing the most economically and mechanically efficient technology available.

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PROJECT LEADERS

State	Name/Institution	Area of Specialization
Illinois	Ronald R. Rosati Illinois State University	Engineering/Recirculating Systems
	Reginald D. Henry Illinois State University	Engineering/Recirculating Systems
Iowa	Joseph E. Morris Iowa State University	Water Quality/Aquaculture
Nebraska	Kyle Hoagland University of Nebraska-Lincoln	Aquatic Ecologist
	Terrence B. Kayes University of Nebraska-Lincoln	Finfish Aquaculture/Physiology/ Endocrinology
Ohio	Konrad Dabrowski Ohio State University	Fish Nutrition and Physiology/Larval Fish Culture
	James E. Ebeling Piketon Research and Extension Center	Water Quality, Computer Monitoring/Control, System Engineering
Wisconsin	Fred P. Binkowski University of Wisconsin-Milwaukee	Finfish Aquaculture/Larval Fish Culture/Ecology/Extension

PARTICIPATING INSTITUTIONS AND PRINCIPAL INVESTIGATORS

Illinois State University
Ronald R. Rosati
Reginald D. Henry

Iowa State University
Joseph E. Morris

University of Nebraska-Lincoln
Kyle D. Hoagland
Terrence B. Kayes

Ohio State University
Konrad Dabrowski
James M. Ebeling

University of Wisconsin-Milwaukee
Fred P. Binkowski

PROPOSED PROJECT BUDGET FOR
ILLINOIS STATE UNIVERSITY

(Rosati and Henry)

Objectives 1 and 2

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)						
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals						
c. Graduate Students	1	0.50	1	0.50	$7,200	$7,800
d. Prebaccalaureate Students						
e. Secretarial-Clerical						
f. Technical, Shop, and Other ...						
Total Salaries and Wages					$7,200	$7,800
B. Fringe Benefits					$864	$936
C. **Total Salaries, Wages and Fringe Benefits**					$8,064	$8,736
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$1,000	$1,000
F. Travel - Domestic (*Including Canada*)					$0	$0
G. Other Direct Costs					$0	$0
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$9,064	$9,736
TOTAL PROJECT COSTS					$18,800	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR ILLINOIS STATE UNIVERSITY

A. Salaries and Wages. A Graduate Student (0.50 FTE) is needed to assist in system construction, fish husbandry, data collection and data statistical manipulation. The PIs will design the study, supervise data collection and statistical analysis, and complie and submit reports.

E. Materials and Supplies. Chemicals, reagents, glassware, filter disks and laboratory supplies are needed for water quality data collection and measurement.

PROPOSED PROJECT BUDGET FOR
IOWA STATE UNIVERSITY (ISU)

(Morris)

Objectives 1 and 2

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	1	0.05	1	0.05	$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals						
c. Graduate Students	1	0.50	1	0.50	$12,600	$13,300
d. Prebaccalaureate Students						
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$12,600	$13,300
B. Fringe Benefits					$300	$350
C. **Total Salaries, Wages and Fringe Benefits**					$12,900	$13,650
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$1,000	$1,200
F. Travel - Domestic (*Including Canada*)					$1,150	$1,200
G. Other Direct Costs					$1,950	$2,450
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$17,000	$18,500
				TOTAL PROJECT COSTS	$35,500	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR IOWA STATE UNIVERSITY

A. Salaries and Wages. A Graduate Student (0.50 FTE) is needed to assist the principal investigator with the collection of samples from the two locations. This individual will also be responsible for coordination of sample collection with the various aquaculture operations.

E. Materials and Supplies. Biochemicals, reagents, field supplies and laboratory supplies (e.g., glassware, buffers, sample bottles, chemical tests) are needed to analyze the water samples for the prescribed water parameters. Fish and fish feeds will be provided by Kloubec Fish Farm and the Iowa Department of Natural Resources.

F. Travel. About $400/year is needed to attend NCRAC Aquaculture Effluent Work Group meeting(s). The remainder of the funds requested is required to partially meet fleet vehicle rental costs, meal costs for four sampling trips per year to each sample location (a distance of approximately 200-350 miles round trip from ISU). The cost of other trips necessary for this project will be covered by other mechanisms.

G. Other Direct Costs. About $150/year is needed for telephone, FAX, postage and photocopying. The remainder of the funds requested is necessary to cover the costs of processing the water samples for biochemical oxygen demand (BOD). Total Kjeldahl nitrogen (TKN), total phosphorus and orthophosphate. These chemical tests will be done by the Analytical Service Laboratory located at ISU. The remaining water parameters will be done using equipment that will be available to the PI from other sources.

PROPOSED PROJECT BUDGET FOR
UNIVERSITY OF NEBRASKA-LINCOLN (UN-L)

(Hoagland and Kayes)

Objectives 1 and 2

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	2	0.08	2	0.08	$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals						
c. Graduate Students						
d. Prebaccalaureate Students	2	0.50	2	0.50	$6,000	$6,000
e. Secretarial-Clerical						
f. Technical, Shop, and Other ...						
Total Salaries and Wages					$6,000	$6,000
B. Fringe Benefits					$0	$0
C. **Total Salaries, Wages and Fringe Benefits**					$6,000	$6,000
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$5,000	$5,000
F. Travel - Domestic (*Including Canada*)					$2,800	$2,800
G. Other Direct Costs					$1,200	$1,200
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$15,000	$15,000
TOTAL PROJECT COSTS					$30,000	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR UNIVERSITY OF NEBRASKA-LINCOLN

A. Salaries and Wages. One or possibly two Prebaccalaureate Student hourly helpers are needed to assist with data collection and water chemistry analyses throughout the study period. Students will be selected based on prior course work in chemistry and limnology, and will be trained in specific collection and analysis methodology relevant to the proposed project.

E. Materials and Supplies. Field collection materials (water bottles, glass jars, hydrochloric acid, fixative, alcohol, nets, coolers) are necessary to obtain the large number of samples required for effluent analyses. water chemistry suppolies (chemicals, glassware, cleaning agents, filters, pipettes, cuvettes) are needed to conduct the proposed water quality analyses. Computer supplies are also required for data entry, statistical analyses, and graphics production.

F. Travel. The funds requested are required to support travel expenses to and from Sandhills Aquafarm (about 600 miles round-trip fromt he UN-L main campus) and from Cedar Point Biological Station (UN-L) to the project site (15 miles round-trip). We anticipate that the proposed project will require a minimum of 12 round-trips per year from the UN-L main campus and 12 round-trips per year from the Cedar Point Station. Part of the total cost for these trips will be supported by funds from other sources. In addition, funds are needed to cover travel costs for the PIs to attend work group meetings.

G. Other Direct Costs. About $1,200 is needed each year for sample shipping (dry ice, coolers, same-day shipping) and routine operating expenses (e.g., telephone, FAX, postage, and photocopying).

PROPOSED PROJECT BUDGET FOR
PIKETON RESEARCH & EXTENSION CENTER, OHIO STATE UNIVERSITY

(Dabrowski and Ebeling)

Objectives 1 and 2

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	1	0.05	1	0.05	$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc	1	0.10	1	0.10	$0	$0
b. Other Professionals						
c. Graduate Students						
d. Prebaccalaureate Students	2	0.50	2	0.50	$8,000	$8,400
e. Secretarial-Clerical						
f. Technical, Shop, and Other ...						
Total Salaries and Wages					$8,000	$8,400
B. Fringe Benefits					$2,240	$2,352
C. **Total Salaries, Wages and Fringe Benefits**					$10,240	$10,752
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$3,260	$748
F. Travel - Domestic (*Including Canada*)					$2,500	$1,500
G. Other Direct Costs					$0	$0
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$16,000	$13,000
TOTAL PROJECT COSTS					$29,000	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR OSU-PIKETON RESEARCH & EXTENSION CENTER

A. **Salaries and Wages.** Field and laboratory studies will be conducted by two research assistants (Prebaccalaureate Students) on 25% appointments. There tasks include sampling at multiple locations at both sites, initial preparation of samples for analysis, transportation to the Piketon Research & Extension Center"s aquaculture and water quality lab, sample analysis and maintenance fo computer based records. Approximately half of the labor and travel associated with the collection of the samples will be supported by monies from the Piketon Center.

Additional responsibilities will include initial set up, weekly downloading of data and maintenance of the continuous water sampling system at both sites. Also preparation of daily, weekly and monthly tables and graphs of water quality parameter and weather data.

E. **Materials and Supplies.** First year general alboratory and field supplies will include: reagents, glassware, sampling bottles, coolers, thermocouples and associated hardware, laboratory apparatus and supplies.

F. **Travel.** These funds will support transportation, meals and if necessary lodging for the collection of samples (round trip distance 240 miles). Travel funds will also be used to attend the annual work group meetings and the NCRAC conference to present initial results.

PROPOSED PROJECT BUDGET FOR
UNIVERSITY OF WISCONSIN-MILWAUKEE (UW-MIL)

(Binkowski)

Objectives 1 and 2

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	1	0.10	1	0.10	$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals	2	0.25	2	0.20	$11,500	$10,000
c. Graduate Students						
d. Prebaccalaureate Students						$1,500
e. Secretarial-Clerical	1	0.08	1	0.08	$1,544	$1,544
f. Technical, Shop, and Other ...						
Total Salaries and Wages					$13,044	$13,044
B. Fringe Benefits (29.5% of 2b and 2e)					$3,848	$3,406
C. **Total Salaries, Wages and Fringe Benefits**					$16,892	$16,450
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$2,000	$2,000
F. Travel - Domestic (*Including Canada*)					$1,108	$1,550
G. Other Direct Costs					$0	$0
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$20,000	$20,000
				TOTAL PROJECT COSTS	$40,000	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR THE UNIVERSITY OF WISCONSIN-MILWAUKEE

A. **Salaries and Wages.** Because of the intensity and complexity of the tasks required, funds are requested for two full-time (25% Year 1 and 20% Year 2) research specialists (Other Professionals). Their tasks include: water sampling according to the production cycle (18-24 times/year) at Alpine Farms and Glacier Springs Hatcheries; chemical analyses of the samples; and compile records at the sampling times relative to hatchery production parameters. Sample Mill Creek and the Onion River relative to the "Before and After" scenario. Daily temperature and flow will be monitored at each effluent site. In addition in cooperation at sites in Mill Creek and the Onion River, along with stream discharge during the monthly sampling periods. We will attempt to coordinate stream survey studies with the Wisconsin DNR to evaluate the utilization of these systems by trout populations.

   In addition, as chair of the Work Group, there will be one of month of secretarial support for each year of the project.

E. **Materials and Supplies.** Water chemistry materials to conduct analytical procedures. Nets for benthos sampling, hardware to construct substrate samplers and general field supplies.

F. **Travel.** To support 18-24 trips per year for sampling at Alpine Farms and Glacier Springs Hatcheries. Approximately 120 miles round trip, with university fleet vehicle at 40 to 50 cents per mile, plus a limited per diem for food and lodging. Remaining funds will be used to attend NCRAC Aquaculture Effluent Work Group meetings.

EFFLUENT PROJECT

Budget Summary for Each Particpating Institution at $77.1K for First Year

	Illinois State	ISU	UN-L	OSU	UW-MIL	TOTALS
Total Salaries and Wages	$7,200	$12,600	$6,000	$8,000	$13,044	$46,844
Fringe Benefits	$864	$300	$0	$2,240	$3,848	$7,252
Total Salaries, Wages and Benefits	$8,064	$12,900	$6,000	$10,240	$16,892	$27,132
Nonexpendable Equipment	$0	$0	$0	$0	$0	$0
Materials and Supplies	$1,000	$1,000	$5,000	$3,260	$2,000	$12,260
Travel	$0	$1,150	$2,800	$2,500	$1,108	$7,558
Other Direct Costs	$0	$1,950	$1,200	$0	$0	$3,150
TOTAL PROJECT COSTS	**$9,064**	**$17,000**	**$15,000**	**$16,000**	**$20,000**	**$77,064**

Budget Summary for Each Particpating Institution at $76.2K for Second Year

	Illinois State	ISU	UN-L	OSU	UW-MIL	TOTALS
Total Salaries and Wages	$7,800	$13,300	$6,000	$8,400	$13,044	$48,544
Fringe Benefits	$936	$350	$0	$2,352	$3,406	$7,044
Total Salaries, Wages and Benefits	$8,736	$13,650	$6,000	$10,752	$16,450	$55,588
Nonexpendable Equipment	$0	$0	$0	$0	$0	$0
Materials and Supplies	$1,000	$1,200	$5,000	$748	$2,000	$9,948
Travel	$0	$1,200	$2,800	$1,500	$1,550	$7,050
Other Direct Costs	$0	$2,450	$1,200	$0	$0	$3,650
TOTAL PROJECT COSTS	**$9,736**	**$18,500**	**$15,000**	**$13,000**	**$20,000**	**$76,236**

RESOURCE COMMITMENT FROM INSTITUTIONS[1]

Institution/Item		Year 1	Year 2
Illinois State University			
Salaries		$17,808	$9,968
Supplies, Expenses and Equipment and Waiver of Overhead		$4,000	$3,000
	Total	$21,808	$12,968
University of Nebraska-Lincoln			
Salaries		$5,200	$5,408
Supplies, Expenses and Equipment and Waiver of Overhead		$6,300	$6,300
	Total	$11,500	$11,708
Ohio State University-Piketon Research and Extension Center			
Salaries and Benefits		$7,945	$8,171
Supplies, Expenses, Equipment, and Waiver of Overhead		$2,000	$2,400
	Total	$9,945	$10,571
University of Wisconsin-Milwaukee			
Salaries and Benefits		$8,674	$9,107
Supplies, Expenses, Equipment		$2,500	$1,500
	Total	$11,174	$10,607
Glacial Springs Hatcheries			
Salaries, Supplies, Expenses, and Equipment		$15,000	$20,000
	Total	$15,000	$20,000
	Total per Year	$69,427	$63,261
	GRAND TOTAL	**$132,688**	

[1]Since cost sharing is not a legal requirement institutions do not need to maintain documentation.

SCHEDULE FOR COMPLETION OF OBJECTIVES

Objective 1: Initiated in Year 1 and completed in Year 2.

Objective 2: Initiated in Year 1 and completed in Year 2.

LIST OF PRINCIPAL INVESTIGATORS

Fred P. Binkowski, University of Wisconsin-Milwaukee

Konrad Dabrowski, Ohio State University

James M. Ebeling, Ohio State University

Reginald D. Henry, Illinois State University

Kyle D. Hoagland, University of Nebraska-Lincoln

Terrence B. Kayes, University of Nebraska-Lincoln

Joseph E. Morris, Iowa State University

Ronald R. Rosati, Illinois State University

LaDon Swann, Purdue University

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EDUCATION

B.S. University of Wisconsin-Milwaukee, 1971
M.S. University of Wisconsin-Milwaukee, 1974

POSITIONS

Senior Scientist, Center for Great Lakes Studies/University of Wisconsin Great Lakes Research Facility (1991-present)
Associate Scientist, Center for Great Lakes Studies/University of Wisconsin Great Lakes Research Facility (1987-1990)
Senior Fisheries Biologist, Center for Great Lakes Studies/University of Wisconsin Great Lakes Research Facility (1984-1986)
Associate Fisheries Biologist, Center for Great Lakes Studies/University of Wisconsin Great Lakes Research Facility (1981-1983)
Assistant Fisheries Biologist, Center for Great Lakes Studies (1978-1980)
Research Specialist, Fisheries, Dept. of Zoology, University of Wisconsin-Milwaukee (1975-1978)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society: Early Life History and Fish Culture Sections
International Association for Great Lakes Research (Associate Editor)
World Aquaculture Society

SELECTED PUBLICATIONS

Luecke, C. J.A. Rice, L.B. Crowder, S.E. Yeo, and F.P. Binkowski. 1990. Recruitment mechanisms of bloater in Lake Michigan: an analysis of the predatory gauntlet. Canadian Journal of Fisheries and Aquatic Sciences 47:524-532.

Rice, J.A., L.B. Crowder, and F.P. Binkowski. 1987. Evaluating potential sources of mortality for larval bloater (*Coregonus hoyi*): Starvation and vulnerability to predation. Canadian Journal of Fisheries and Aquatic Sciences 44:467-472.

Doroshov, S.I., and F.P. Binkowski. 1986. Sturgeon culture: an evolution of the techniques and concepts. Presented at the 1986 Annual Meeting of the World Aquaculture Society, Reno.

Sommer, C.V., F.P. Binkowski, M.A. Schalk, and J.M. Bartos. 1986. Stress factors that can affect studies of drug metabolism in fish. Veterinary and Human Toxicology 28 (Supplement 1):45-54.

Binkowski, F.P., and S.I. Doroshov. 1985. North American sturgeons: biology and aquaculture potential. Kluwer Academic Publications, Dordrecht, Netherlands.

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EDUCATION

M.S. Agriculture and Technical University, Olsztyn, Poland, 1972
Ph.D. Agriculture and Technical University, Olsztyn, Poland, 1976
D.Sc. Agricultural University, Szczecin, Poland, 1984

POSITIONS

Visiting Professor of Aquaculture, Ohio State University (1989-present)
Visiting Professor, University of Innsbruck, Austria (1987-1989)
Visiting Professor, Tokyo University of Fisheries, Japan (1984-1985)
Associate Professor, Agriculture and Technical University, Olsztyn, Poland (1972-1985)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

Fisheries Society of British Isles
Japanese Fisheries Society
World Aquaculture Society

SELECTED PUBLICATIONS

Dabrowski, K., and G. Kock. In Press. Absorption of ascorbic acid and ascorbic sulfate and their interaction with minerals in digestive tract of rainbow trout. Canadian Journal of Fisheries and Aquatic Science 45.

Dabrowski, K. 1989. Formulation of a bioenergetic model for coregonine early life history. Transactions of the American Fisheries Society 118:138-150.

Dabrowski, K., P. Poczyczynski, G. Kock, and B. Berger. 1989. Effect of fish meal protein substitution by soybean protein in diet on growth, diet utilization and proteolytic enzymes activities in rainbow trout. New in vivo test for exocrine pancreatic secretion. Aquaculture 77:29-49.

Dabrowski, K., F. Takashima, and Y.K. Law. 1988. Bioenergetical model of planktivorous fish feeding, growth and metabolism. Theoretical optimum swimming speed in fish larva. Journal of Fish Biology 32:443-458.

Georgopoulou, U., K. Dabrowski, M.F. Sire, and J.M. Vernier. 1988. Absorption of intact proteins by the intestinal epithelium of trout. Demonstration by luminescence enzyme immunoassay and cytochemistry. Cell and Tissue Research 251:145-152.

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EDUCATION

B.A. Albion College, 1971
M.S. Washington State University, 1974
M.S. Washington State University, 1977

POSITIONS

Research and Extension Associate, Piketon Research and Extension Center, The Ohio State University (1991-Present)
Project Manager, Recirculation Aquaculture Demonstration Project, North Carolina State University (1990-1991)
Research Coordinator, Mariculture Research & Training Center, University of Hawaii (1988-1990)
Research Assistant, Department of Agricultural Engineering, University of California-Davis (1983-1988)
Research Technologist II, Department of Agricultural Engineering, Washington State University (1981-1983)
Technical Specialist, Washington Energy Extension Service-Cooperative Extension Service (1979-1981)
Research Technologist II, Department of Agricultural Engineering, Washington State University (1977-1979)
American Peace Corps Volunteer, Secondary Education Program, Ghana (1971-1972)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Society of Agricultural Engineers
World Aquacultural Society
Sigma XI

PUBLICATIONS

Ebeling, J.M. 1991. A computer based water quality monitoring and management system for pond aquaculture. Pages 233-248 *in* Proceedings from the Aquaculture Symposium, Cornell University, Ithaca, NY, NRAES-49.

Ebeling, J.M. and T.M. Losordo. 1989. Continuous environmental Monitoring systems for aquaculture. Pages 54-70 *in* J.A. Wyban and E. Antill, editors. Instrumentation in Aquaculture, Proceedings of the World Aquaculture Society, January, Los Angeles, CA.

Losordo, T.M., R.H. Piedrahita, and J.M. Ebeling. 1988. An automated water quality data acquisition system for use in aquaculture ponds. Aquacultural Engineering 7:265-278.

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EDUCATION

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POSITIONS

Chairperson, Department of Agriculture, Illinois State University
Supervisor, University Farm, Illinois State University
Director, Facilities for Ropp Ag Building and Turner Hall, Illinois State University
Fiacal Agent, Illinois State University, Agriculture Alumni Association

PROFESSIONAL MEMBERSHIPS

Phi Delta Kappa
Alpha Gamma Rho
Bloomington Normal Ag Club
Alpha Zeta
State Aquaculture Association
FFA Alumni Association

SELECTED PUBLICATIONS

Rosati, Ronald and R.D. Henry. In Press. Aquaculture as a Component of the Agriculture Curriculum The Journal of The National Association of College Teachers of Agriculture.

Rosati, Ronald, Patrick O"Rourke, and R.D. Henry. 1990. Preliminary Results of High Density Fish Culture in a Water Recirculating System. Proceedings of the National Symposium on Freshwater Crayfish Aquaculture. Freemantle College of TAFE. Freemantle, West Australia.

Henry, Reginald D. Energy Efficient Alcohol Fuel Plant. Elsevier Science Publishers, B.V. Amsterdam

Henry, Reginard D. A Combination Grain Drier Utilizing Flat Plate Solar Collectors and a Crop Residue Burner. Ann Arbor Science Publishers.

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EDUCATION

B.S. Michigan State University, 1973
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Ph.D. University of Nebraska, 1981

POSITIONS

Associate Professor, Dept. of Forestry, Fisheries, and Wildlife, University of Nebraska-Lincoln (1990-present)
Associate Professor, Department of Biology, Texas Christian University (1983-1990)
Visiting Assistant Professor, Department of Botany, Louisiana State University (1982-1983)
Postdoctoral Research Associate, Department of Botany and Plant Pathology, University of Maine (1981-1982)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Association for the Advancement of Science
American Society of Limnology and Oceanography
Societas Internationalis Limnologiae
Ecological Society of America
Phycological Society of America
International Society for Diatom Research

SELECTED PUBLICATIONS

Hoagland, K.D., and C.G. Peterson. 1990. Effects of light and disturbance on vertical zonation of attached microalagae in a large reservoir. Journal of Phycology 26:450-457.

Mokry, L.E., and K.D. Hoagland. 1990. Acute toxicities of five synthetic pyrethroid insecticides to *Daphnia magna and Ceriodaphnia dubia*. Environmental Toxicology and Chemistry 9:1045-1051.

Peterson, C.G., and K.D. Hoagland. 1990. Autogenic and allogenic factors affecting epilithic diatom succession in Lake McConaughy (Nebraska, USA). Journal of the North American Bethological Society 9:54-67.

Jurgensen, T.A., and K.D. Hoagland. 1990. Effects of short-term pulses of atrazine on attached algal communities in a small stream. Archives of Environmental Contamination and Toxicology 19:617-623.

Swamikannu, X., and K.D. Hoagland. 1989. Effects of snail grazing on diversity and structure of an attached algal community in a eutrophic pond. Canadian Journal of Fisheries and Aquatic Sciences 46:1698-1704.

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EDUCATION

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Ph.D. University of Wisconsin-Madison, 1978

POSITIONS

Associate Professor, Dept. of Forestry, Fisheries and Wildlife, University of Nebraska-Lincoln (1990-present)
Assistant Director and Associate Scientist, University of Wisconsin Aquaculture Program, University of Wisconsin-Madison (1979-1990)
Project Biologist, Aquaculture Research Laboratory, University of Wisconsin-Madison (1974-1979)
EPA Trainee, Laboratory of Limnology, University of Wisconsin-Madison (1970-1972)
Instructor, Department of Biological Sciences, Chico State College (1968-1970)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Society of Zoologists: Divisions of Comparative Endocrinology, Comparative Physiology and Biochemistry, Ecology, and Comparative Immunology
American Fisheries Society: Fish Culture, Bioengineering, Fish Health, Water Quality, and Early Life History Sections
World Aquaculture Society

SELECTED PUBLICATIONS

Malison, J.A., T.B. Kayes, J.A. Held, and C.H. Amundson. 1990. Comparative survival, growth and reproductive development of juvenile walleye (*Stizostedion vitreum*), sauger (*S. canadense*) and their hybrids reared under intensive culture conditions. Progressive Fish-Culturist 52:73-82.

Malison, J.A., T.B. Kayes, B.C. Wentworth, and C.H. Amundson. 1988. Growth and feeding responses of male versus female yellow perch (*Perca flavescens*) treated with estradiol-17β. Canadian Journal of Fisheries and Aquatic Sciences 45:1942-1948.

Kim, K.I., T.B. Kayes, and C.H. Amundson. 1987. Effects of dietary tryptophan levels on growth, feed/gain, carcass composition and liver glutamate dehydrogenase activity in rainbow trout (*Salmo gairdneri*). Comparative Biochemistry and Physiology 88B:737-741.

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EDUCATION

B.S. Iowa State University, 1979
M.S. Texas A&M University, 1982
Ph.D. Mississippi State University, 1988

POSITIONS

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Graduate Research Assistant, Mississippi State University (1986-1988)
Aquaculture manager, Stiles Farm Foundation (1982-1986)
Graduate Research Assistant, Texas A&M University (1981-1982)
Research Technician I, Texas A&M University (1980-1981)
Fisheries Biologist Aide, Indiana Department of Natural Resources (1979)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society, Iowa Chapter
Iowa Fish Farmers Association
Phi Kappa Phi, Iowa State University Chapter
Sigma Xi, Iowa State University Chapter

SELECTED PUBLICATIONS

Morris, J. E. In Press. Supplemental feeding of hybrid striped bass fry. Proceedings South Easteren Association Fish and Wildlife Agencies.

Morris, J.E., L.R. D"Abramo, and R.J. Muncy. In Press. An inexpensive marking technique to assess ingestion of artificial feeds by larval fish. Progressive Fish-Culturist.

Morris, J.E. 1988. Influence of artificial feeds upon striped bass (*Morone saxatilis*) X white bass (*M. chyrsops*) hybrid fry survival. Doctoral dissertation. Mississippi State University, Starkville.

Morris, J.E. 1988. Effect of artificial feeds upon hybrid striped bass fry survival and growth. Mississippi Chapter American Fisheries Society Annual Meeting, Vicksburg.

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EDUCATION

A.A.S. Farmingdale College, 1978
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POSITIONS

Associate Professor, Agricultural Engineering Technology, Illinois State University (1989-1992)
Assistant Professor, Agricultural Engineering Technology, Illinois State University (1986-1989)
Assistant Professor, Agricultural Mechanical/Agricultural Education, Ohio State University (1984-1986)
Instructor, Agricultural Engineering, Iowa State University (1981-1984)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society
American Society of Agricultural Engineers
Society for International Development

SELECTED PUBLICATIONS

Rosati, Ronald and R.D. Henry. In Press. Aquaculture as a Component of the Agriculture Curriculum The Journal of The National Association of College Teachers of Agriculture.

Rosati, Ronald. 1991. Remodeling Existing Farm Structures for Commerical Fish Culture. *in* LaDon Swann, editor. Workshop on Commercial Fish Culture Using Water Recirculating Systems. Illinois-Indiana Sea Grant Extension Publication 91-8.

Rosati, Ronald, Patrick O"Rourke, and R.D. Henry. 1990. Preliminary Results of High Density Fish Culture in a Water Recirculating System. Proceedings of the National Symposium on Freshwater Crayfish Aquaculture. Freemantle College of TAFE. Freemantle, West Australia.

Rosati, Ronald. 1989. Training Trainers - A Consultants Perspective. International Labour Organization. Asian Pacific Skill Development Program Tenth Anniversary Publication. Singapore.

Rosati, Ronald. 1989. Factors Contributing to Radon Contamination in Illinois Houses: Implications for House Construction. National Agricultural Mechanics Professional Development Seminar Blue Ribbon Presentation. Kansas City, MO.

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B.S. Tennessee Technological University, 1982
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POSITIONS HELD:

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Aquaculture Trainer, Peace Corps Stateside Training Program, University of South Carolina (1989)
Farm Technician, Fish Acres Tropical Fish Farm, Lake Worth Florida (1989)
Assistant Project Leader, Non-native Fish Research Lab, Florida Fish and Game, Boca Raton (1988-89)
Aquaculture Extensionist, Tongolese Ministry of Rural Development/U.S. Peace Corps, Togo, West Africa (1985-87)

SELECTED PUBLICATIONS:

Swann, D.L., L.E. Rider, and F.J. In Press. Age, growth and summer foods of four Centrachid species in a Big South Fork National River and Recreation Area stream fish community. Journal Tennessee Academy of Sciences.

Swann, D.L. 1990. A basic overview of aquaculture. Indiana Cooperative Extension Service, Purdue University, AS-457.

Swann, D.L., J.R. Estes, and F. Bulow. 1984. Impacts of rainbow trout introduction on a Big South Fork Stream fishery. Proceedings of Scientific Research in National Parks of the Upland Section of the Southeast Region. (abstract)

Estes, J.R., D.L. Swann, and F.J. Bulow. 1984. Life history of sympatric brown and rainbow trout in a Big South Fork tributary stream. Proceedings of Scientific Research in National Parks of the Upland Section of the Southeast Region. (abstract)

Swann, D.L. and F. Bulow. 1984. Age and growth of centrarchids in a Middle Tennessee mountain stream. Tennessee Academy of Sciences (abstract)

COLLABORATORS AND FACILITIES

State	Name or Location	Facility Type
Iowa	Kloubec"s Fish Farm	Pond
	Fairport Hatchery	Pond
Ohio	Freshwater Farms of Ohio, Inc.	Cage Culture
Nebraska	Sandhills Aquafarm	Flow Through
Wisconsin	Glacier Springs Hatchery	Flow Through
	Alpine Farms	Flow Through