

A LITERATURE REVIEW TO SUPPORT THE INVESTIGATIONAL NEW ANIMAL DRUG EXEMPTION AND NEW ANIMAL DRUG APPLICATION FOR 17-METHYLTESTOSTERONE

Project Termination Report for the Period
December 1, 1996 to November 30, 1997

NCRAC Funding Level: \$5,000 (December 1, 1996 to November 30, 1997)

PARTICIPANTS:

Ronald P. Phelps	Auburn University	Alabama
Bartholomew W. Green	Auburn University	Alabama
<i>Industry Advisory Council Liaison:</i>		
Rosalie A. Schnick		Wisconsin
<i>Extension Liaison:</i>		
Joseph E. Morris	Iowa State University	Iowa

REASON FOR TERMINATION

The objectives of the project have been completed.

PROJECT OBJECTIVES

- (1) Conduct a thorough review of computerized scientific literature data bases.
- (2) Obtain relevant scientific papers and review.
- (3) Prepare the environmental impact statement for submission to the Food and Drug Administration's (FDA) Center for Veterinary Medicine (CVM).

PRINCIPAL ACCOMPLISHMENTS

An environmental impact statement was prepared and submitted to CVM for their review in support of submission of a New Animal Drug Application (NADA) for the use of 17-methyltestosterone (MT) for the sex inversion of newly hatched tilapia. That document described the safe use of MT for sex inversion (sex reversal) of early life stages of tilapia (*Oreochromis* spp.) based on a thorough review of the scientific literature and interpretation of data presented in the cited papers. Specifically, environmental assessment of the proposed use of MT-treated feed for sex inversion of tilapia was addressed.

The quantity of MT-treated feed ordered by participants in the MT Investigational New Animal Drug (INAD) from March 1996 to August 1997 contained 0.48 kg (1.06 lb) of MT. The domestic tilapia production is estimated annually by the American Tilapia Association with assistance from the USDA Agricultural Statistics Center, and data are reported in the Annual Tilapia Situation and Outlook Report. In 1996, it was reported that there was a total of 7,332,396 kg (16,164,894 lb) of live tilapia produced in the United States. Assuming all of the marketable tilapia production was treated with MT, this would require approximately 30,787,000 fry to be sex reversed. The quantity of MT needed to sex reverse this number of fish is 1.3 kg (2.9 lb).

The largest tilapia farms in the United States each sex inverse approximately 4-5 million tilapia per year. Taking a worst case scenario, where all water used to hold fish during treatment is discharged, the following estimate of MT released into the environment was made. For batches of approximately 180,000 fish being treated on a biweekly basis, with an effluent water flow of 63.1 L/min (16.7 gal/min), the quantity of MT released in the effluent would be 4.4 g/L (parts per billion; ppb) soon after feeding and 80 ng/L (parts per trillion; ppt) just before the next feeding.

Fate of MT in the environment is not well documented. One study determined that a 17 g/L (ppb) testosterone dose added to a recirculating system without fish was below detectable levels after 18 h. Environmental impacts of MT on non-target organisms were not documented in the literature. When tilapia with undifferentiated gonads were held in recirculating water where other fish were being fed MT, sex ratios were altered.

It was found that MT use for sex reversal of tilapia represents only a small fraction of MT use in the United States. The majority is used in human and veterinary medicine.

IMPACTS

The direct review submission to FDA is an essential component in preparing a NADA package for the FDA approval of MT. By being able to prepare a literature review on the environmental aspects of MT use with tilapia, much effort and expense may have been avoided. The review identified areas where the literature was weak in documenting environmental aspects regarding the use of MT.

RECOMMENDED FOLLOW-UP ACTIVITIES

The submission of the environmental impact statement for the use of MT for the sex inversion of newly hatched tilapia is a significant step forward towards approval of a NADA for that compound. The impacts that were identified were considered to be minor but that was based on a minimal amount of documentation. Additional studies may be required to answer questions not well documented in the literature. Specific studies regarding the fate of MT in the environment and its effect on non-target animals may be required.

PUBLICATIONS

See the Appendix under Aquaculture Drugs.

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVERSITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
1996-97	\$5,000	\$2,150				\$2,150	\$7,150
TOTAL	\$5,000	\$2,150				\$2,150	\$7,150

APPENDIX

EXTENSION

NCRAC Extension Fact Sheet Series

Garling, D.L. 1992. Making plans for commercial aquaculture in the North Central Region. NCRAC Fact Sheet Series #101, NCRAC Publications Office, Iowa State University, Ames.

Harding, L.M., C.P. Clouse, R.C. Summerfelt, and J.E. Morris. 1992. Pond culture of walleye fingerlings. NCRAC Fact Sheet Series #102, NCRAC Publications Office, Iowa State University, Ames.

Kohler, S.T., and D.A. Selock. 1992. Choosing an organizational structure for your aquaculture business. NCRAC Fact Sheet Series #103, NCRAC Publications Office, Iowa State University, Ames.

Swann, L. 1992. Transportation of fish in bags. NCRAC Fact Sheet Series #104, NCRAC Publications Office, Iowa State University, Ames.

Swann, L. 1992. Use and application of salt in aquaculture. NCRAC Fact Sheet Series #105, NCRAC Publications Office, Iowa State University, Ames.

Morris, J.E. 1993. Pond culture of channel catfish in the North Central Region. NCRAC Fact Sheet Series #106, NCRAC Publications Office, Iowa State University, Ames.

Morris, J.E., and C.C. Kohler. In review. Pond culture of hybrid striped bass fingerlings in the Midwest. NCRAC Fact Sheet Series #107, NCRAC Publications Office, Iowa State University, Ames.

Cain, K., and D. Garling. 1993. Trout culture in the North Central Region. NCRAC Fact Sheet Series #108, NCRAC Publications Office, Iowa State University, Ames.

Mittelmark, J. In review. Fish health management. NCRAC Fact Sheet Series #109, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. In review. Managing feed costs: limiting delivered price paid. NCRAC Fact Sheet Series #110, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1997. Costs for pond production of yellow perch in the North Central Region, 1994-95. NCRAC Fact Sheet Series #111, NCRAC Publications Office, Iowa State University, Ames.

Morris, J.E. In review. Plankton management for fish culture ponds. NCRAC Fact Sheet Series #112, NCRAC Publications Office, Iowa State University, Ames.

NCRAC Technical Bulletin Series

Thomas, S.K., R.M. Sullivan, R.L. Vertrees, and D.W. Floyd. 1992. Aquaculture law in the north central states: a digest of state statutes pertaining to the production and marketing of aquacultural products. NCRAC Technical Bulletin Series #101, NCRAC Publications Office, Iowa State University, Ames.

Swann, L. 1992. A basic overview of aquaculture: history, water quality, types of aquaculture, production methods. NCRAC Technical Bulletin Series #102, NCRAC Publications Office, Iowa State University, Ames.

Kinnunen, R.E. 1992. North Central Region 1990 salmonid egg and fingerling purchases, production, and sales. NCRAC Technical Bulletin Series #103, NCRAC Publications Office, Iowa State University, Ames.

Hushak, L.J., C.F. Cole, and D.P. Gleckler. 1993. Survey of wholesale and retail buyers in the six southern states of the North Central Region. NCRAC Technical Bulletin Series #104, NCRAC Publications Office, Iowa State University, Ames.

Meronek, T., F. Copes, and D. Coble. 1998. The bait industry in Illinois, Michigan, Minnesota, Ohio, South Dakota, and Wisconsin. NCRAC Technical Bulletin Series #105, NCRAC Publications Office, Iowa State University, Ames.

Lichtkoppler, F.P. 1993. Factors to consider in establishing a successful aquaculture business in the North Central Region. NCRAC Technical Bulletin Series #106, NCRAC Publications Office, Iowa State University, Ames.

Swann, L., and J. R. Riepe. 1994. Niche marketing your aquaculture products. NCRAC Technical Bulletin Series #107, NCRAC Publications Office, Iowa State University, Ames.

Swann, L., J. Morris, and D. Selock. 1995. Cage culture of fish in the North Central Region. NCRAC Technical Bulletin Series #110, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1997. Enterprise budgets for yellow perch production in cages and ponds in the North Central Region, 1994/95. NCRAC Technical Bulletin Series #111, NCRAC Publications Office, Iowa State University, Ames.

Brown, P., and J. Gunderson, editors. 1997. Culture potential of selected crayfishes in the North Central Region. NCRAC Technical Bulletin Series #112, NCRAC Publications Office, Iowa State University, Ames.

NCRAC Video Series

Swann, L. 1992. Something fishy: hybrid striped bass in cages. VHS format, 12 min. NCRAC Video Series #101, NCRAC Publications Office, Iowa State University, Ames.

Pierce, R., R. Henderson, and K. Neils. Aquacultural marketing: a practical guide for fish producers. 1995. VHS format, 19 min. NCRAC Video Series #102, NCRAC Publications Office, Iowa State University, Ames.

Swann, L., editor. 1993. Investing in freshwater aquaculture. VHS format, 120 min. NCRAC Video Series #103, NCRAC Publications Office, Iowa State University, Ames.

Kayes, T.B. In production. Spawning and propagating yellow perch. VHS format, 45 min. NCRAC Video Series, NCRAC Publications Office, Iowa State University, Ames.

NCRAC Culture Series

Summerfelt, R., editor. 1996. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Other Videos

Kayes, T.B., and K. Mathiesen, editors. 1994. Investing in freshwater aquaculture: a reprise (part I). VHS format, 38 min. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

Kayes, T.B., and K. Mathiesen, editors. 1994. Investing in freshwater aquaculture: a reprise (part II). VHS format, 41 min. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

Situation and Outlook Report

Hushak, L.J. 1993. North Central Regional aquaculture industry situation and outlook report, volume 1 (revised October 1993). NCRAC Publications Office, Iowa State University, Ames.

Workshops and Conferences

Salmonid Culture, East Lansing, Michigan, March 23-24, 1990. (Donald L. Garling)

Midwest Regional Cage Fish Culture Workshop, Jasper, Indiana, August 24-25, 1990. (LaDon Swann)

Aquaculture Leader Training for Great Lakes Sea Grant Extension Agents, Manitowoc, Wisconsin, October 23, 1990. (David J. Landkamer and LaDon Swann)

Regional Workshop of Commercial Fish Culture Using Water Reuse Systems, Normal, Illinois, November 2-3, 1990. (LaDon Swann)

First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991. (Donald L. Garling, Lead; David J. Landkamer, Joseph E. Morris and Ronald Kinnunen, Steering Committee)

Crayfish Symposium, Carbondale, Illinois, March 23-24, 1991. (Daniel A. Selock and Christopher C. Kohler)

Fish Transportation Workshops, Marion, Illinois, April 6, 1991 and West Lafayette, Indiana, April 20, 1991. (LaDon Swann and Daniel A. Selock)

Regional Workshop on Commercial Fish Culture Using Water Recirculating Systems, Normal, Illinois, November 15-16, 1991. (LaDon Swann)

National Aquaculture Extension Workshop, Ferndale, Arkansas, March 3-7, 1992. (Joseph E. Morris, Steering Committee)

Regional Workshop on Commercial Fish Culture Using Water Recirculating Systems, Normal, Illinois, November 19-20, 1992. (LaDon Swann)

In-Service Training for CES and Sea Grant Personnel, Gretna, Nebraska, February 9, 1993. (Terrence B. Kayes and Joseph E. Morris)

Aquaculture Leader Training, Alexandria, Minnesota, March 6, 1993. (Jeffrey L. Gunderson and Joseph E. Morris)

Investing in Freshwater Aquaculture, Satellite Videoconference, Purdue University, April 10, 1993. (LaDon Swann)

National Extension Wildlife and Fisheries Workshop, Kansas City, Missouri, April 29-May 2, 1993. (Joseph E. Morris)

Commercial Aquaculture Recirculation Systems, Piketon, Ohio, July 10, 1993. (James E. Ebeling)

Yellow Perch and Hybrid Striped Bass Aquaculture Workshop, Piketon, Ohio, July 9, 1994. (James E. Ebeling and Christopher C. Kohler)

Workshop on Getting Started in Commercial Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994. (LaDon Swann)

Aquaculture in the Age of the Information Highway. Special session, World Aquaculture Society, San Diego, California, February 7, 1995. (LaDon Swann)

Second North Central Regional Aquaculture Conference, Minneapolis, Minnesota, February 17-18, 1995. (Jeffrey L. Gunderson, Lead; Fred P. Binkowski, Donald L. Garling, Terrence B. Kayes, Ronald E. Kinnunen, Joseph E. Morris, and LaDon Swann, Steering Committee)

Walleye Culture Workshop, Minneapolis, Minnesota, February 17-18, 1995. (Jeffrey L. Gunderson)

Aquaculture in the Age of the Information Highway. Multimedia session, 18 month meeting of the Sea Grant Great Lakes Network, Niagra Falls, Ontario, May 6, 1995. (LaDon Swann)

AquaNIC. Annual Meeting of the Aquaculture Association of Canada, Nanaimo, British Columbia, June 5, 1995. (LaDon Swann)

Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995. (Donald L. Garling)

Rainbow Trout Production: Indoors/Outdoors, Piketon, Ohio, July 8, 1995. (James E. Ebeling)

North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995. (Christopher C. Kohler, LaDon Swann, and Joseph E. Morris)

Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997. (LaDon Swann)

Proceedings

Garling, D.L., editor. 1991. Proceedings of the North Central Regional Aquaculture Conference. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Gunderson, J., editor. 1995. Proceedings of the Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow. Second North Central Regional Aquaculture Conference, Minneapolis, Minnesota, February 17-18, 1995.

Swann, L., editor. 1997. Proceedings of the 1997 North Central Regional Aquaculture Conference. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana,

February 6-7, 1997. Illinois-Indiana Sea Grant Program, Publication CES-305. (Also available electronically at: <http://ag.ansc.purdue.edu/aquanic/publicat/state/il-in/ces-305.htm>)

ECONOMICS AND MARKETING

Publications in Print

Aubineau, C.M. 1996. Characterization of the supply of walleye fingerlings in the north central region of the U.S. Master's thesis. Illinois State University, Normal.

Brown, G.J. 1994. Cost analysis of trout production in the North Central states. Master's thesis. Ohio State University, Columbus.

Edon, A.M.T. 1994. Economic analysis of an intensive recirculating system for the production of advanced walleye fingerlings in the North Central Region. Master's thesis. Illinois State University, Normal.

Floyd, D.W., and R.M. Sullivan. 1990. Natural resources and aquaculture: the policy environment in the North Central states. Proceedings of the Third Symposium on Social Science and Resource Management, Texas A&M University, College Station, Texas.

Floyd, D.W., R.M. Sullivan, R.L. Vertrees, and C.F. Cole. 1991. Natural resources and aquaculture: emerging policy issues in the North Central states. *Society and Natural Resources* 4:123-131.

Gleckler, D.P. 1991. Distribution channels for wild-caught and farm-raised fish and seafood: a survey of wholesale and retail buyers in six states of the North Central Region. Master's thesis. Ohio State University, Columbus.

Hushak, L.J. 1993. North Central Regional aquaculture industry situation and outlook report, volume 1 (revised October 1993). NCRAC Publications Office, Iowa State University, Ames.

Hushak, L., C. Cole, and D. Gleckler. 1993. Survey of wholesale and retail buyers in the six southern states of the North Central Region. NCRAC Technical Bulletin Series #104, NCRAC Publications Office, Iowa State University, Ames.

Hushak, L.J., D.W. Floyd, and R.L. Vertrees. 1992. Aquaculture: a competitive industry in North Central states? *Ohio's Challenge* 5:3-5.

Makowiecki, E.M.M. 1995. Economic analysis of an intensive recirculating system for the production of walleye from fingerling to food size. Master's thesis. Illinois State University, Normal.

O'Rourke, P.D. 1996. Economic analysis for walleye aquaculture enterprises. Pages 135-145 *in* R.C. Summerfelt, editor. The walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

O'Rourke, P.D. 1996. The economics of recirculating aquaculture systems. *In* Proceedings of successes and failures in commercial recirculating aquaculture, Roanoke, Virginia, July 19-21, 1996.

Riepe, J.R. 1997. Costs for pond production of yellow perch in the North Central Region, 1994-95. NCRAC Fact Sheet Series #111, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1997. Enterprise budgets for yellow perch production in cages and ponds in the North Central Region, 1994/95. NCRAC Technical Bulletin Series #111, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1997. Yellow perch markets in the North Central Region: results of a 1996/97 survey. Office of Agricultural Research Programs, Department of Agricultural Economics, Purdue University, West Lafayette, Indiana.

Thomas, S.K. 1991. Industry association influence upon state aquaculture policy: a comparative analysis in the North Central Region. Master's thesis. Ohio State University, Columbus.

Thomas, S.K., R.M. Sullivan, R.L. Vertrees, and D.W. Floyd. 1992. Aquaculture law in the North Central states: a digest of state statutes pertaining to the production and marketing of aquacultural products. NCRAC Technical Bulletin Series #101, NCRAC Publications Office, Iowa State University, Ames.

Thomas, S.K., R.L. Vertrees, and D.W. Floyd. 1991. Association influence upon state aquaculture policy -- a comparative analysis in the North Central Region. *The Ohio Journal of Science* 91(2):54.

Tudor, K.W., R.R. Rosati, P.D. O'Rourke, Y.V. Wu, D. Sessa, and P. Brown. 1996. Technical and economical feasibility of on-farm fish feed production using fishmeal analogs. *Journal of Aquacultural Engineering* 15(1):53-65.

Manuscripts

Riepe, J.R. In review. Managing feed costs: limiting delivered price paid. NCRAC Fact Sheet Series #110, NCRAC Publications Office, Iowa State University, Ames.

Papers Presented

Brown, G.J., and L.J. Hushak. 1991. The NCRAC producers survey and what we have learned: an interim report. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Foley, P., R. Rosati, P.D. O'Rourke, and K. Tudor. 1994. Combining equipment components into an efficient, reliable, and economical commercial recirculating aquaculture system. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Gleckler, D.P., L.J. Hushak, and M.E. Gerlow. 1991. Distribution channels for wild-caught and farm-raised fish and seafood. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Kohler, S.T. 1995. Hybrid striped bass cost of production. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

O'Rourke, P.D. 1995. Profitability and volume-cost business analysis tools for the aquaculture enterprise. Presented at Illinois-Indiana Aquaculture Conference and North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

O'Rourke, P.D. 1996. The economics of recirculating aquaculture systems. Conference on Successes and Failures in Commercial Recirculating Aquaculture, Roanoke, Virginia, July 19-21, 1996.

O'Rourke, P.D., and A.M.T. Edon. 1995. Economic analysis of advanced walleye fingerling production in an intensive recirculating system. Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995.

O'Rourke, P.D., K. Tudor, and R. Rosati. 1994. The selection and use of economic tools in the aquacultural engineering decision making process to determine the comparative costs of alternate technical solutions. 25th Annual Meeting of the World Aquaculture, New Orleans, Louisiana, January 12-18, 1994.

O'Rourke, P.D., K. Tudor, and R. Rosati. 1994. Economic risk analysis of production of tilapia (*Oreochromis niloticus*) in a modified Red Ewald-style recirculating system operated under commercial conditions. 25th Annual Meeting of the World Aquaculture Society Silver Anniversary Meeting, New Orleans, Louisiana, January 12-18, 1994.

Riepe, J.R. 1994. Production economics of species cultured in the North Central Region. Animal Science, AS-495, one-week summer course "Aquaculture in the Midwest," Purdue University, West Lafayette, Indiana, June 13-17, 1994.

Riepe, J.R. 1994. Getting started in commercial aquaculture: economics. Workshop on Getting Started in Commercial Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994.

Riepe, J.R. 1997. Revisiting retail and wholesale markets (walleye and yellow perch). Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Riepe, J.R., J. Ferris, and D. Garling. 1995. Economic considerations in yellow perch aquaculture. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Robinson, M., D. Zeponi, and B.J. Sherrick. 1991. Assessing market potential for new and existing species in the North Central Region. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Rosati, R., P.D. O'Rourke, K. Tudor, and P. Foley. 1994. Production of tilapia (*Oreochromis niloticus*) in a modified Red Ewald-style recirculating system when operated under commercial conditions. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Rosati, R., P.D. O'Rourke, K. Tudor, and P. Foley. 1994. Technical and economical considerations for the selection of oxygen incorporation devices in a recirculating aquaculture system. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Tudor, K., R. Rosati, P.D. O'Rourke, Y. V. Wu, D. Sessa, and P. Brown. 1994. Technical and economical feasibility of on-farm fish feed production using fishmeal analogs. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

YELLOW PERCH

Publications in Print

Brown, P.B., and K. Dabrowski. 1995. Zootechnical parameters, growth and cannibalism in mass propagation of yellow perch. *In* Kestamont, P., and K. Dabrowski, editors. Workshop on aquaculture of percids. Presses Universitaires de Namur, Namur, Belgium.

Brown, P.B., K. Dabrowski, and D.L. Garling. 1995. Nutritional requirements and commercial diets for yellow perch. *In* Kestamont, P., and K. Dabrowski, editors. Workshop on aquaculture of percids. Presses Universitaires de Namur, Namur, Belgium.

Brown, P.B., K. Dabrowski, and D.L. Garling, 1996. Nutrition and feeding of yellow perch (*Perca flavescens*). *Journal of Applied Ichthyology* 12:171-174.

Dabrowski, K., and D.A. Culver. 1991. The physiology of larval fish: digestive tract and formulation of starter diets. *Aquaculture Magazine* 17:49-61.

Dabrowski, K., D.A. Culver, C.L. Brooks, A.C. Voss, H. Sprecher, F.P. Binkowski, S.E. Yeo, and A.M. Balogun. 1993. Biochemical aspects of the early life history of yellow perch (*Perca flavescens*). Pages 531-539 *in* Proceedings of the International Fish Nutrition Symposium, Biarritz, France, June 25-27, 1991.

Glass, R.J. 1991. The optimum loading and density for yellow perch (*Perca flavescens*) raised in a single pass, flow-through system. Master's thesis. Michigan State University, East Lansing.

Malison, J.A., and M.A.R. Garcia-Abiado. 1996. Sex control and ploidy manipulations in yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*). *Journal of Applied Ichthyology* 12:189-194.

Malison, J.A., and J.A. Held. 1992. Effects of fish size at harvest, initial stocking density and tank lighting conditions on the habituation of pond-reared yellow perch (*Perca flavescens*) to intensive culture conditions. *Aquaculture* 104:67-78.

Malison, J., and J. Held. 1995. Lights can be used to feed, harvest certain fish. *Feedstuffs* 67(2):10.

Malison, J.A., T.B. Kayes, J.A. Held, T.B. Barry, and C.H. Amundson. 1993. Manipulation of ploidy in yellow perch (*Perca flavescens*) by heat shock, hydrostatic pressure shock, and spermatozoa inactivation. *Aquaculture* 110:229-242.

Malison, J.A., L.S. Procarione, J.A. Held, T.B. Kayes, and C.H. Amundson. 1993. The influence of triploidy and heat and hydrostatic pressure shocks on the growth and reproductive development of juvenile yellow perch (*Perca flavescens*). *Aquaculture* 116:121-133.

Twibell, R.G., and P.B. Brown. 1997. Dietary arginine requirement of juvenile yellow perch. *Journal of Nutrition* 127:1838-1841.

Manuscripts

Kolkowski, S., and K. Dabrowski. Accepted. Off-season spawning of yellow perch. *Progressive Fish-Culturist*.

Malison, J.A., J.A. Held, M.A.R. Garcia-Abiado, and L.S. Procarione. In review. The influence of triploidy and heat and hydrostatic pressure shocks on the growth and reproductive development of perch (*Perca flavescens*) reared to adult size under selected environmental conditions. *Aquaculture*.

Malison, J.A., J.A. Held, D.L. Northey, and T.E. Kuczynski. In preparation. Habituation of yellow perch (*Perca flavescens*) fingerlings to formulated feeds in ponds using lights and vibrating feeders. Progressive Fish-Culturist.

Twibell, R.G., K.A. Wilson, and P.B. Brown. In review. Dietary sulfur amino acid requirement and cysteine replacement value for juvenile yellow perch. Journal of Nutrition.

Papers Presented

Batterson, T., R. Craig, and R. Baldwin. 1995. Advancing commercial aquaculture development in the North Central Region. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Binkowski, F. 1995. Intensive yellow perch fry rearing. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Brown, P.B. 1994. Yellow perch culture in the Midwest. Vocational Agriculture Training Workshop, Greencastle, Indiana.

Brown, P.B. 1997. Recent developments in perch nutrition. Martinique '97, Island and Tropical Aquaculture, Les Trois Ilets, Martinique, French West Indies, May 4-9, 1997.

Brown, P.B., and K. Dabrowski. 1995. Zootechnical parameters, growth and cannibalism in mass propagation of yellow perch. Workshop on Aquaculture of Percids, Vaasa, Finland, August 21-25, 1995.

Brown, P.B., K. Dabrowski, and D. Garling. 1995. Nutritional requirements and commercial diets for yellow perch. Workshop on Aquaculture of Percids, Vaasa, Finland, August 21-25, 1995.

Brown, P.B., and R.G. Twibell. 1997. Dietary arginine requirement of juvenile yellow perch. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Brown, P.B., K. Wilson, J. Wetzel, J. Mays, F. Binkowski, and S. Yeo. 1994. Culture characteristics of juvenile yellow perch (*Perca flavescens*) from different geographical locales grown at three temperatures. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Brown, P.B., K. Wilson, J. Wetzel, J. Mays, F. Binkowski, and S. Yeo. 1994. Strain evaluations with yellow perch. Indiana Aquaculture Association Annual Meeting, Indianapolis, Indiana, February 26, 1994.

Crane, P., G. Miller, J. Seeb, and R. Sheehan. 1991. Growth performance of diploid and triploid yellow perch at the onset of sexual maturation. 53rd Midwest Fish and Wildlife Conference, Des Moines, Iowa, November 30 - December 4, 1991.

Garling, D.L. 1991. NCRAC research programs to enhance the potential of yellow perch culture in the North Central Region. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Held, J.A. 1996. Yellow perch fingerling production - Gone is the black magic. Aqua '96, the Tenth Anniversary Minnesota Aquaculture Conference and Trade Show, Alexandria, Minnesota, March 8-9, 1996.

- Held, J.A. 1997. Yellow perch production. Minnesota Aquaculture Association and North American Fish Farmers Cooperative Aquaculture Conference and Tradeshow, Brainerd, Minnesota, March 7-8, 1997.
- Held, J.A. 1997. Advances in yellow perch production. North Central Regional Aquaculture Center Symposium on Yellow Perch Production, Piketon, Ohio, June 21, 1997.
- Held, J.A., and J.A. Malison. 1997. Yellow perch aquaculture. Annual Conference of the Wisconsin Agricultural Teachers Association, Madison, Wisconsin, July 9-10, 1997.
- Kayes, T. 1994. Yellow perch aquaculture. Workshop on Getting Started in Commercial Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994.
- Kayes, T. 1994. Investing in freshwater aquaculture: a reprise. Nebraska Aquaculture Update & Autumn Meeting, North Platte, Nebraska, November 19, 1994.
- Kayes, T. 1995. Yellow perch aquaculture. Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995.
- Kayes, T. 1995. Yellow perch culture studies at Pleasant Valley Fish Farm. Nebraska Aquaculture Update & Spring Meeting, North Platte, Nebraska, March 25, 1995.
- Kayes, T. 1995. Harvesting perch and walleye fingerlings from ponds. Nebraska Aquaculture Update & Spring Meeting, North Platte, Nebraska, March 25, 1995.
- Kayes, T. 1995. Spawning and incubation of yellow perch. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.
- Kayes, T. 1995. Fingerling yellow perch production in ponds. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.
- Kayes, T. 1995. Yellow perch food fish production in ponds and cages. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.
- Kolkowski, S., K. Dabrowski, and C. Yackey. 1997. Larval rearing of yellow perch *Perca flavescens* spawning out of the season. 2nd International Workshop on Aquaculture of Percid Fish, Island Aquaculture and Tropical Aquaculture, Les Trois Ilets, Martinique, French West Indies, May 3-7, 1997.
- Malison, J.A. 1994. Pond production of yellow perch fingerlings. Wisconsin Aquaculture '94, Stevens Point, Wisconsin, February 18-19, 1994.
- Malison, J.A. 1995. Production methods for yellow perch. Wisconsin Aquaculture '95, Stevens Point, Wisconsin, March 17-19, 1995.
- Malison, J.A. 1997. Reproduction and sex reversal in yellow perch and walleye. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.
- Malison, J.A. 1997. Factors promoting and constraining the commercial culture of yellow perch, *Perca flavescens*. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Malison, J.A., and J.A. Held. 1995. Sex control and ploidy manipulations in yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*). Percid II, the Second International Percid Fish Symposium and the Workshop on Aquaculture of Percids, Vaasa, Finland, August 21-25, 1995.

Malison, J.A., and J.A. Held. 1996. Pond design, construction and management. Wisconsin Aquaculture Conference '96, Wausau, Wisconsin, February 16-17, 1996.

Malison, J.A., and J.A. Held. 1997. Pond design and construction for aquaculture. Wisconsin Aquaculture '97, Stevens Point, Wisconsin, March 14-15, 1997.

Malison, J.A., J.A. Held, and C.H. Amundson. 1991. Factors affecting the habituation of pond-reared yellow perch (*Perca flavescens*), walleye (*Stizostedion vitreum*), and walleye-sauger hybrids (*S. vitreum* female x *S. canadense* male) to intensive culture conditions. 22nd Annual Meeting of the World Aquaculture Society, San Juan, Puerto Rico, June 16-20, 1991.

Malison, J.A., J.A. Held, M.A.R. Garcia-Abiado, and L.S. Procarione. 1996. The influence of triploidy and heat and hydrostatic pressure shocks on the growth and reproductive development of perch (*Perca flavescens*) reared to adult size under selected environmental conditions. International Congress on the Biology of Fishes, San Francisco, California, July 14-18, 1996 and Midwest Endocrinology Conference, Madison, Wisconsin, June 22-23, 1996.

Malison, J.A., J.A. Held, L.S. Procarione, T.B. Kayes, and C.H. Amundson. 1991. The influence on juvenile growth of heat and hydrostatic pressure shocks used to induce triploidy in yellow perch. 121st Annual Meeting of the American Fisheries Society, San Antonio, Texas, September 8-12, 1991.

Malison, J.A., J. Mellenthin, L.S. Procarione, T.P. Barry, and J.A. Held. 1997. The effects of handling on the physiological stress responses of yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*) at different temperatures. Martinique '97, Martinique, French West Indies, May 4-9, 1997.

Malison, J.A., D.L. Northey, J.A. Held, and T.E. Kuczynski. 1994. Habituation of yellow perch (*Perca flavescens*) fingerlings to formulated feed in ponds using lights and vibrating feeders. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Oetker, M., and D.L. Garling. 1997. The effects of maternal size on growth and survivorship of larval yellow perch. 127th Annual Meeting of the American Fisheries Society, Monterey, California, August 24-18, 1997.

Riepe, J.R., J. Ferris, and D. Garling. 1995. Economic considerations in yellow perch aquaculture. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Selock, D. 1995. Floating raceways for yellow perch culture. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Starr, C. 1995. Yellow perch food fish production in flowing water systems. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Williams, F. 1995. Federal grant opportunities? Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Williams, F., and C. Starr. 1991. The path to yellow perch profit through planned development. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Yackey, C., S. Kolkowski, and K. Dabrowski. 1997. Weaning diets for yellow perch (*Perca flavescens*)--suitability of commercial, semi-commercial, and experimental dry formulations. Fish Feed and Nutrition Workshop, Frankfort, Kentucky, September 21, 1997.

HYBRID STRIPED BASS

Publications in Print

Brown, P.B., R. Twibell, Y. Jonker, and K.A. Wilson. 1997. Evaluation of three soybean products in diets fed to juvenile hybrid striped bass *Morone saxatilis* × *M. chrysops*. Journal of the World Aquaculture Society 28:215-223.

Kelly, A.M., and C.C. Kohler. 1996. Sunshine bass performance in ponds, cages, and indoor tanks. Progressive Fish-Culturist 58:55-58.

Kohler, C.C. 1997. White bass production and broodstock development. Pages 169-185 in R.M. Harrell, editor. Striped bass and other *Morone* culture. Elsevier Press, Amsterdam.

Kohler, C.C., R.J. Sheehan, C. Habicht, J.A. Malison, and T.B. Kayes. 1994. Habituation to captivity and controlled spawning of white bass. Transactions of the American Fisheries Society 123:964-974.

Woods, L.C., C.C. Kohler, R.J. Sheehan, and C.V. Sullivan. 1995. Volitional tank spawning of female striped bass with male white bass produces hybrid offspring. Transactions of the American Fisheries Society 124:628-632.

Manuscripts

Brown, G.G., R.J. Sheehan, C.C. Kohler, C. Habicht, L. Koutnik, L. Ellis, and L.D. Brown. In preparation. Short-term and long-term storage of striped bass *Morone saxatilis* semen. Journal of the World Aquaculture Society.

Morris, J.E., and C.C. Kohler. In review. Pond culture of hybrid striped bass fingerlings in the Midwest. NCRAC Fact Sheet Series #107, NCRAC Publications Office, Iowa State University, Ames.

Suresh, A.V., J.B. Rudacille, M.L. Allyn, V. Sheehan, R.J. Sheehan, and C.C. Kohler. In review. Induction of ovulation in white bass (*Morone chrysops*) using hCG and LHRHa. Aquaculture.

Papers Presented

Brown, G.G., L.D. Brown, K. Dunbar, C. Habicht, R.J. Sheehan, C.C. Kohler, and L. Koutnik. 1991. Evaluation of white bass semen with ³¹P-NMR for the improvement of transportation, storage, and fertility methods. 53rd Midwest Fish and Wildlife Conference, Des Moines, Iowa, November 30-December 4, 1991.

Brown, G.G., R.J. Sheehan, C.C. Kohler, C. Habicht, L. Koutnik, L. Ellis, and L.D. Brown. 1995. Use of cryopreservatives. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

Brown, P.B., Y. Hodgin, R. Twibell, and K.A. Wilson. 1996. Use of three soybean products in diets fed to hybrid striped bass. 27th Annual Meeting of the World Aquaculture Society, January 29-February 2, 1996, Bangkok, Thailand.

Brown, P.B., R. Twibell, Y. Hodgins, and K. Wilson. 1995. Soybeans in diets fed to hybrid striped bass. 24th Annual Fish Feed and Nutrition Workshop, October 19-21, 1995, Columbus, Ohio.

Habicht, C., R.J. Sheehan, C.C. Kohler, G.G. Brown, and L. Koutnik. 1991. Routine collection, storage, and shipping of white bass sperm. 29th Annual Meeting Illinois Chapter of the American Fisheries Society, Champaign, Illinois, March 5-7, 1991.

Kohler, C.C. 1993. The farm fish of the future: hybrid stripers. Aqua '93: 7th Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 5-6, 1993. (Invited paper)

Kohler, C.C. 1994. Hybrid striped bass aquaculture. Yellow Perch and Hybrid Striped Bass Production: From Fry to Frying Pan, Piketon, Ohio, July 3, 1994. (Invited speaker)

Kohler, C.C. 1995. Broodstock management of white bass. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, November 2-4, 1995, Champaign, Illinois.

Kohler, C.C. 1996. Induced out-of-season spawning of fishes. Missouri Aquaculture Industry Association Annual Meeting, February 3-4, 1996, Jefferson City, Missouri.

Kohler, C.C. 1996. Advancing hybrid striped bass culture in the North Central Region and elsewhere. U.S. Chapter of the World Aquaculture Society, Arlington, Texas, February 14-17, 1996.

Kohler, C.C. 1997. Induced spawning of fishes. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Kohler, C.C., and R.J. Sheehan. 1991. Hybrid striped bass culture in the North Central Region. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Kohler, C.C., R.J. Sheehan, M.L. Allyn, J.B. Rudacille, and A. Suresh. 1996. Controlled spawning of white bass. U.S. Chapter of the World Aquaculture Society, Arlington, Texas, February 14-17, 1996.

Kohler, C.C., R.J. Sheehan, C. Habicht, J.A. Malison, and T.B. Kayes. 1992. Acclimation to captivity and out-of-season spawning of white bass. 23rd Annual Meeting of the World Aquaculture Society, Orlando, Florida, May 21-25, 1992.

Kohler, C.C., R.J. Sheehan, C. Habicht, V. Sanchez, J. Finck, J.A. Malison, and T.B. Kayes. 1991. Domestication and out-of-season spawning of white bass. 53rd Midwest Fish and Wildlife Conference, Des Moines, Iowa, November 30-December 4, 1991.

Kohler, C.C., R.J. Sheehan, C. Habicht, V. Sanchez, J.A. Malison, and T.B. Kayes. 1992. Collection, acclimation to captivity, and out-of-season spawning of white bass. 122nd Annual Meeting of the American Fisheries Society, Rapid City, South Dakota, September 14-17, 1992.

Kohler, C.C., R.J. Sheehan, C. Habicht, V. Sanchez, J.A. Malison, and T.B. Kayes. 1993. Development of white bass brood stock and spawning protocol. U.S. Chapter of the World Aquaculture Society, Hilton Head Island, South Carolina, January 27-30, 1993. (Invited paper)

Kohler, C.C., R.J. Sheehan, and T.B. Kayes. 1989. Advancing hybrid striped bass culture in the Midwestern United States. 51st Midwest Fish and Wildlife Conference, Springfield, Illinois, December 5-6, 1989.

Kohler, C.C., R.J. Sheehan, V. Sanchez, and A. Suresh. 1994. Evaluation of various dosages of hCG to induce final oocyte maturation and ovulation in white bass. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Kohler, C.C., R.J. Sheehan, A. Suresh, L. Allyn, and J. Rudacliffe. 1996. Effect of hCG dosage on hatching success in white bass. International Congress on the Biology of Fishes, July 15-18, 1996, San Francisco, California.

Kohler, S.T. 1995. Cost of production. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, November 2-4, 1995, Champaign, Illinois.

Koutnik, L.A., R.J. Sheehan, C.C. Kohler, C. Habicht, and G.G. Brown. 1992. Motility and fertility of extended and cryopreserved *Morone* sperm: when is cryopreservation the best option? Annual Meeting, Illinois/Wisconsin Chapters of the American Fisheries Society, Waukegan, Illinois, February 10-13, 1992. (Awarded Best Student Paper)

Morris, J. 1995. Pond preparation for larval fish. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, November 2-4, 1995, Champaign, Illinois.

Rudacille, J.B., and C.C. Kohler. 1996. Relative performance of white bass, sunshine bass, and palmetto bass fed a commercial diet. U.S. Chapter of the World Aquaculture Society, Arlington, Texas, February 14-17, 1996. (Awarded Best Student Presentation)

Rudacille, J.B., and C.C. Kohler. 1997. Performance of Phase III palmetto bass, sunshine bass and white in a recirculating water system. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Rudacille, J.B., and C.C. Kohler. 1997. Relative performance of Phase III sunshine bass, palmetto bass, and white bass in an indoor recirculating system. 35th Annual Meeting of the Illinois Chapter of the American Fisheries Society, Collinsville, Illinois, March 4-6, 1997. (Awarded Lewis L. Osborne Best Student Paper)

Sheehan, R.J. 1995. Use of sperm extenders. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, November 2-4, 1995, Champaign, Illinois.

Swann, L. 1995. Cage culture. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, November 2-4, 1995, Champaign, Illinois.

WALLEYE

Publications in Print

Aubineau, C.M. 1996. Characterization of the supply of walleye fingerlings in the North Central Region of the U.S. Master's thesis. Illinois State University, Normal.

Barry, T.P., A.F. Lapp, L.S. Procarione, and J.A. Malison. 1995. Effects of selected hormones and male cohorts on final oocyte maturation, ovulation, and steroid production in walleye (*Stizostedion vitreum*). *Aquaculture* 138:331-347.

Billington, N., R.J. Barrette, and P.D.N. Hebert. 1992. Management implications of mitochondrial DNA variation in walleye stocks. *North American Journal of Fisheries Management* 12:276-284.

Bristow, B.T. 1993. Comparison of larval walleye stocks in intensive culture. Master's thesis. Iowa State University, Ames.

Bristow, B.T., and R.C. Summerfelt. 1994. Performance of larval walleye cultured intensively in clear and turbid water. *Journal of the World Aquaculture Society* 25:454-464.

Bristow, B.T., and R.C. Summerfelt. 1996. Comparative performance of intensively cultured larval walleye in clear, turbid, and colored water. *Progressive Fish-Culturist* 58:1-10.

Clouse, C.P. 1991. Evaluation of zooplankton inoculation and organic fertilization for pond-rearing walleye fry to fingerlings. Master's thesis. Iowa State University, Ames.

DiStefano, R.J., T.P. Barry, and J.A. Malison. 1997. Correlation of blood parameters with reproductive problems in walleye in a Missouri impoundment. *Journal of Aquatic Animal Health* 9:223-229.

Harder, T., and R.C. Summerfelt. 1996. Effects of tank color and size on the success of training walleye fingerlings to formulated feed. Pages 631-636 *in* G.S. Libey and M.B. Timmons, editors. *Successes and failures in commercial recirculating aquaculture*. Northeast Regional Agricultural Engineering Service (NRAES), NRAES-98, volume 2. Cornell University, Ithaca, New York.

Harding, L.M., C.P. Clouse, R.C. Summerfelt, and J.E. Morris. 1992. Pond culture of walleye fingerlings. NCRAC Fact Sheet Series #102, NCRAC Publications Office, Iowa State University, Ames.

Harding, L.M., and R.C. Summerfelt. 1993. Effects of fertilization and of fry stocking density on pond production of fingerling walleye. *Journal of Applied Aquaculture* 2(3/4):59-79.

Held, J.A., and J.A. Malison. 1996. Culture of walleye to food size. Pages 231-232 *in* R.C. Summerfelt, editor. *Walleye culture manual*. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Held, J.A., and J.A. Malison. 1996. Pond culture of hybrid walleye fingerlings. Pages 311-313 *in* R.C. Summerfelt, editor. *Walleye culture manual*. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Kapuscinski, A.R., chair. 1995. Performance standards for safely conducting research with genetically modified fish and shellfish. Part I. Introduction and supporting text for flowcharts. *In* USDA, Agricultural Biotechnology Research Advisory Committee, Working Group on Aquatic Biotechnology and Environmental Safety. Office of Agricultural Biotechnology, Document No. 95-04.

Kapuscinski, A.R., chair. 1995. Performance standards for safely conducting research with genetically modified fish and shellfish. Part II. Flowcharts and accompanying worksheets. *In* USDA, Agricultural Biotechnology Research Advisory Committee, Working Group on Aquatic Biotechnology and Environmental Safety. Office of Agricultural Biotechnology, Document No. 95-05.

Kapuscinski, A.R. 1996. Selective breeding of walleye: building block for indoor aquaculture. Pages 331-338 *in* R.C. Summerfelt, editor. *The walleye culture manual*. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Luzier, J.M. 1993. The ecology of clam shrimp in fish culture ponds. Master's thesis. Iowa State University, Ames.

Luzier, J.M., and R.C. Summerfelt. 1993. A review of the ecology and life history of clam shrimp (Order Spinicaudata, Laevicaudata, Formerly Order Conchostraca: Branchiopoda). *Prairie Naturalist* 25:55-64.

Luzier, J.M., and R.C. Summerfelt. 1996. Effects of clam shrimp on production of walleye and northern pike and a review of clam shrimp control strategies. *Journal of Applied Aquaculture* 6(4):25-38.

Luzier, J.M., and R.C. Summerfelt. 1996. Experimental demonstration of the effects of clam shrimp on turbidity of microcosms. *Progressive Fish-Culturist* 58:68-70.

Malison, J.A., and M.A.R. Garcia-Abiado. 1996. Sex control and ploidy manipulations in yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*). *Journal of Applied Ichthyology* 12:189-194.

Malison, J.A., and J.A. Held. 1996. Reproductive biology and spawning. Pages 11-18 in R.C. Summerfelt, editor. The walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Malison, J.A., and J.A. Held. 1996. Habituating pond-reared fingerlings to formulated feed. Pages 199-204 in R.C. Summerfelt, editor. The walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Malison, J.A., and J.A. Held. 1996. Reproduction and spawning in walleye. *Journal of Applied Ichthyology* 12: 153-156.

Malison, J.A., L.S. Procarione, A.R. Kapuscinski, T.P. Barry, and T.B. Kayes. 1994. Endocrine and gonadal changes during the annual reproductive cycle of the freshwater teleost, *Stizostedion vitreum*. *Fish Physiology and Biochemistry* 13:473-484.

Marty, G.D., D.E. Hinton, R.C. Summerfelt. 1995. Histopathology of swimbladder noninflation in walleye (*Stizostedion vitreum*) larvae: role of development and inflammation. *Aquaculture* 138:35-48.

Rieger, P.W. 1995. Behavior of larval walleye. Doctoral dissertation. Iowa State University, Ames.

Summerfelt, R.C. 1991. Non-inflation of the gas bladder of larval walleye (*Stizostedion vitreum*): experimental evidence for alternative hypotheses of its etiology. Pages 290-293 in P. Lavens, P. Sorgeloos, E. Jaspers, and F. Ollevier, editors. LARVI '91 - Fish & Crustacean Larviculture Symposium. European Aquaculture Society, Special Publication No. 15, Gent, Belgium.

Summerfelt, R.C. 1995. Pond- and tank-culture of fingerling walleyes: A review of North American practices. Pages 31-33 in P. Kestemont and K. Dabrowski, editors. Workshop on aquaculture of percids. First meeting of the European Workgroup on Aquaculture of Percids, Vaasa, Finland, August 23-24, 1995.

Summerfelt, R.C. 1995. Production of advanced fingerling to food size walleye. Pages 48-52 in P. Kestemont and K. Dabrowski, editors. Workshop on aquaculture of percids. First meeting of the European Workgroup on Aquaculture of Percids, Vaasa, Finland, August 23-24, 1995.

Summerfelt, R.C., editor. 1996. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C. 1996. Walleye culture manual: Preface. Pages xiii-xiv in R.C. Summerfelt, editor. Walleye Culture Manual. NCRAC Culture Series #101. NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C. 1996. Introduction. Pages 1-10 in R.C. Summerfelt, editor. Walleye Culture Manual. NCRAC Culture Series #101. NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C. 1996. Intensive culture of walleye fry. Pages 161-185 in R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Summerfelt, R.C., R.C. Clayton, T.K. Yager, S.T. Summerfelt, and K.L. Kuipers. 1996. Live weight-dressed weight relationships of walleye and hybrid walleye. Pages 241-250 in R.C. Summerfelt, editor. Walleye Culture Manual. NCRAC Culture Series #101. NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C., C.P. Clouse, L.M. Harding, and J.M. Luzier. 1996. Walleye fingerling culture in drainable ponds. Pages 89-108 in R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Summerfelt, R.C., C.P. Clouse, and L.M. Harding. 1993. Pond production of fingerling walleye, *Stizostedion vitreum*, in the northern Great Plains. *Journal of Applied Aquaculture* 2(3/4):33-58.

Summerfelt, S.T., and R.C. Summerfelt. 1996. Aquaculture of walleye as a food fish. Pages 215-230 in R.C. Summerfelt, editor. Walleye Culture Manual. NCRAC Culture Series #101. NCRAC Publications Office, Iowa State University, Ames.

Vargas, G. 1994. A behavioral study of feeding aggression in walleye (*Stizostedion vitreum*). Report for the Minnesota Biological Sciences Summer Research Program, University of Minnesota, Department of Fisheries and Wildlife, St. Paul.

Manuscripts

Bielik, I., and T.B. Kayes. In preparation. Effects of aeration, fertilization, and sac-fry stocking rate on the large-scale pond production of fingerling walleye. *Progressive Fish-Culturist*.

Clayton, R.D., T.L. Stevenson, and R.C. Summerfelt. In press. Fin erosion in intensively cultured walleye and hybrid walleye. *Progressive Fish-Culturist*.

Malison, J.A., and J.A. Held. In press. Juvenile and adult performance characteristics and sexually related dimorphic growth in walleye (*Stizostedion vitreum*) and hybrids (*S. vitreum* × *S. canadense*) produced from several geographic stocks. *Aquaculture*.

Malison, J.A., and J.A. Held. In preparation. Organoleptic and carcass characteristics of purebred walleye (*Stizostedion vitreum*) and hybrids (*S. Vitreum* × *S. canadense*) produced from several geographic stocks. *Aquaculture*.

Malison, J.A., J.A. Held, L.S. Procarione, and M.A.R. Garcia-Abiado. In press. The production of monosex female populations of walleye (*Stizostedion vitreum*) using intersex broodstock. Progressive Fish-Culturist.

Malison, J.A., T.B. Kayes, L.S. Procarione, J. Hansen, and J.A. Held. In press. Induction of out-of-season spawning in walleye (*Stizostedion vitreum*). Aquaculture.

Rieger, P.W., and R.C. Summerfelt. In press. The influence of turbidity on larval walleye, *Stizostedion vitreum*, behavior and development in tank culture. Aquaculture.

Papers Presented

Barry, T.P., L.S. Procarione, A.F. Lapp, and J.A. Malison. 1992. Induced final oocyte maturation and spawning in walleye (*Stizostedion vitreum*). 23rd Annual Meeting of the World Aquaculture Society, Orlando, Florida, May 21-25, 1992. Also presented at the Midwestern Regional Endocrinology Conference, Illinois State University, Normal, May 15-16, 1992, and the Endocrinology Reproductive Physiology Program Research Symposium, Madison, Wisconsin, September 10, 1992.

Bielik, I., and T.B. Kayes. 1995. Effects of aeration, fertilization, and sac-fry stocking rate on the large-scale production of fingerling walleye, *Stizostedion vitreum*, in earthen ponds. 26th Annual Meeting of the World Aquaculture Society, San Diego, California, February 1-4, 1995.

Bristow, B., and R.C. Summerfelt. 1993. The timing of critical events in the early development of larval walleye reared on formulated feed. Joint meeting, 31st annual meeting of the Illinois Chapter and 25th Annual Meeting of the Iowa Chapter of the American Fisheries Society, Bettendorf, Iowa, February 16-18, 1993.

Bristow, B.T., and R.C. Summerfelt. 1995. A production-scale evaluation of training and grower diets for the extensive-intensive production of advanced fingerling walleyes. 1995 Coolwater Fish Culture Workshop, State College, Pennsylvania, January 8-10, 1995.

Bristow, B.T., R.C. Summerfelt, and R. Clayton. 1995. Culture of larval walleye in clear, turbid, and colored water. Mid-Continent Fish Culture Workshop. Kansas City, Kansas, February 14-15, 1995.

Bristow, B.T., R.C. Summerfelt, and R. Clayton. 1995. Culture of larval walleye in clear, turbid, and colored water. Iowa-Minnesota State Chapters, American Fisheries Society, February 21-23, 1995, Okoboji, Iowa.

Bushman, R.P., and R.C. Summerfelt. 1991. Effects of tank design on intensive culture of walleye fry. Coolwater Fish Culture Workshop, Springfield, Missouri, January 7-9, 1991.

Bushman, R.P., and R.C. Summerfelt. 1992. The effect of pH on gas bladder inflation of larval walleye. Coolwater Fish Culture Workshop, Carbondale, Illinois, January 6-8, 1992.

Clayton, R., and R.C. Summerfelt. 1995. Toxicity of hydrogen peroxide to juvenile walleye. 1995 Coolwater Fish Culture Workshop, State College, Pennsylvania, January 8-10, 1995.

Clayton, R., and R.C. Summerfelt. 1995. Toxicity of hydrogen peroxide to juvenile walleye. Mid-Continent Fish Culture Workshop Kansas City, Kansas, February 14-15, 1995.

Clouse, C., and R.C. Summerfelt. 1991. Evaluation of zooplankton inoculation and organic fertilization as management strategies for pond-rearing walleye fry to fingerlings. Coolwater Fish Culture Workshop, Springfield, Missouri, January 7-9, 1991.

Held, J.A. 1996. Hybrid walleye - A candidate for intensive aquaculture? Aqua '96, Tenth Anniversary Minnesota Aquaculture Conference and Trade Show, Alexandria, Minnesota, March 8-9, 1996.

Kapuscinski, A.R. 1995. The role of selective breeding in sustainable aquaculture. University of Minnesota, Lake Itasca Summer Program, Course on Sustainable Fisheries and Aquaculture.

Kapuscinski, A.R., R.C. Summerfelt, B. Bristow, and M.C. Hove. 1994. Genetic components of early performance traits of intensively cultured walleye. Fifth International Symposium on Genetics in Aquaculture, Halifax, Nova Scotia, June 19-25, 1994.

Kayes, T.B. 1995. Harvesting perch and walleye fingerlings from ponds. Nebraska Aquaculture Update & Spring Meeting, North Platte, Nebraska, March 25, 1995.

Malison, J.A. 1995. Reproductive biology and control of spawning in walleye. Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995.

Malison, J.A. 1997. Reproduction and sex reversal in yellow perch and walleye. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Malison, J. A., and J.A. Held. 1995. Reproduction and spawning in walleye. PERCIS II, the Second International Percid Fish Symposium and the Workshop on Aquaculture of Percids, Vaasa, Finland, August 21-25, 1995.

Malison, J.A., J.A. Held, and L.S. Procarione. 1994. The production of all-female populations of walleye (*Stizostedion vitreum*) using partially sex-inverted broodstock. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Malison, J.A., T.B. Kayes, L.S. Procarione, J.F. Hansen, and J.A. Held. 1994. Induction of out-of-season spawning in walleye (*Stizostedion vitreum*). 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Malison, J.A., J. Mellenthin, L.S. Procarione, T.P. Barry, and J.A. Held. 1997. The effects of handling on the physiological stress responses of yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*) at different temperatures. Martinique '97, Martinique, French West Indies, May 4-9, 1997.

Malison, J.A., L.S. Procarione, A.R. Kapuscinski, and T.B. Kayes. 1992. Endocrine and gonadal changes during the annual reproductive cycle of walleye (*Stizostedion vitreum*). 23rd Annual Meeting of the World Aquaculture Society, Orlando, Florida, May 21-25, 1992. Also presented at the Endocrinology Reproductive Physiology Program Research Symposium, Madison, Wisconsin, September 10, 1992.

Marty, G.D., D.E. Hinton, and R.C. Summerfelt. 1994. Histopathology of swimbladder noninflation in walleye (*Stizostedion vitreum*) larvae: role of development and inflammation. International Symposium on Aquatic Animal Health, September 4-8, 1994.

Moore, A., M. Prange, R.C. Summerfelt, B.T. Bristow, and R.P. Bushman. 1995. Culture of larval walleye, *Stizostedion vitreum*, fed formulated feed. 26th Annual Meeting of the World Aquaculture Society, San Diego, California, February 1-4, 1995.

Phillips, T.A., and R.C. Summerfelt. 1995. Effects of feeding frequency on metabolism and growth of fingerling walleye in intensive culture. 1995 Coolwater Fish Culture Workshop, State College, Pennsylvania, January 8-10, 1995.

Phillips, T.A., and R.C. Summerfelt. 1995. Effects of feeding frequency on metabolism and growth of fingerling walleye in intensive culture. Iowa-Minnesota State Chapters, American Fisheries Society, Okoboji, Iowa, February 21-23, 1995.

Riepe, J.R. 1997. Revisiting retail and wholesale markets (walleye and yellow perch). Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Summerfelt, R.C. 1989. Research of activities of the NCRAC Walleye Work Group on pond and intensive culture of walleye. Symposium on Aquaculture: Current Developments and Issues. 51st Midwest Fish & Wildlife Conference, Springfield, Illinois, December 5-6, 1989.

Summerfelt, R.C. 1991. Pond production of fingerling walleye in the northern Great Plains. Symposium on Strategies and Tactics for Management of Fertilized Hatchery Ponds, 121st Annual Meeting of the American Fisheries Society, San Antonio, Texas, September 12, 1991.

Summerfelt, R.C. 1991. Non-inflation of the gas bladder of larval walleye (*Stizostedion vitreum*): experimental evidence for alternative hypotheses of its etiology. Larvi '91: International Symposium on Fish and Crustacean Larviculture, Ghent, Belgium, August 27-30, 1991.

Summerfelt, R.C. 1991. Walleye culture research sponsored by the North Central Regional Aquaculture Center (NCRAC). Walleye Technical Committee, North Central Division, American Fisheries Society, Work Group Meeting, Dubuque, Iowa, July 15-17, 1991.

Summerfelt, R.C. 1991. Culture of walleye for food: a status report. 5th Annual Minnesota Aquaculture Conference, St. Paul, Minnesota, March 8-9, 1991.

Summerfelt, R.C. 1992. Intensive walleye fry production. Aqua '92, 6th Annual Minnesota Aquaculture Conference, Duluth, Minnesota, March 6-7, 1992. (Invited speaker)

Summerfelt, R.C. 1992. Intensive culture of walleye fry on formulated feeds: status report on problem of non-inflation of the gas bladder. Iowa Department of Natural Resources, Fisheries Bureau Statewide Meeting, Springbrook, March 3, 1992.

Summerfelt, R.C. 1993. Production of fingerling walleye in drainable ponds. Aqua '93, 7th Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 5-6, 1993. (Invited speaker)

Summerfelt, R.C. 1994. Fish biology: a problem-solving tool for aquaculture. 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994. (Invited speaker)

Summerfelt, R.C. 1994. Intensive culture of walleye from fry to food fish. Wisconsin Aquaculture '94, Wisconsin Aquaculture Conference, Stevens Point, Wisconsin, February 18-19, 1994.

Summerfelt, R.C. 1995. Status report on the walleye culture manual. North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995. (Invited speaker)

Summerfelt, R.C. 1995. Pond culture of walleyes. Aquaculture Conference '95. Wisconsin Aquaculture Association, Stevens Point, Wisconsin March 17-18, 1995. (Invited speaker)

Summerfelt, R.C. 1997. Water quality considerations for aquaculture. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7.

Summerfelt, R.C., and B.T. Bristow. 1995. Culture of larval walleye in clear, turbid, and colored water. 1995. Coolwater Fish Culture Workshop, State College, Pennsylvania, January 8-10, 1995.

SUNFISH

Publications in Print

Bryan, M.D., J.E. Morris, and G.J. Atchison. 1994. Methods for culturing bluegill in the laboratory. *Progressive Fish-Culturist* 56:217-221.

Miller, S. 1995. Tetraploid induction protocols for bluegill sunfish, *Lepomis macrochirus*, using cold and pressure shocks. Master's thesis. Michigan State University, East Lansing.

Mischke, C.C. 1995. Larval bluegill culture in the laboratory. Master's thesis. Iowa State University, Ames.

Montes-Brunner, Y. 1992. Study of the developmental stages of bluegill (*Lepomis macrochirus*) eggs using selected histological techniques. Master's thesis. Michigan State University, East Lansing.

Read, E.R. 1994. Cage culture of black, white and F₁ hybrid crappie (*Pomoxis* species). Master's thesis. Pittsburg State University, Pittsburg, Kansas.

Thomas, G.L. 1995. Culture of white crappie (*Pomoxis annularis*) in a Recirculating System. Master's thesis, Pittsburg State University, Pittsburg, Kansas.

Westmaas, A.R. 1992. Polyploidy induction in bluegill sunfish (*Lepomis macrochirus*) using cold and pressure shocks. Master's thesis. Michigan State University, East Lansing.

Wills, P.S., J.P. Paret, and R.J. Sheehan. 1994. Induced triploidy in *Lepomis* sunfish and hybrids. *Journal of the World Aquaculture Society* 25(4):47-60.

Manuscripts

Mischke, C.C., and J.E. Morris. In press. Out-of-season spawning of sunfish in the laboratory. *Progressive Fish-Culturist*.

Mischke, C.C., and J.E. Morris. Submitted. Comparison of growth and survival of larval bluegill in the laboratory under different feeding protocols. *Progressive Fish-Culturist*.

Wang, N., R.S. Hayward, and D.B. Noltie. Submitted. Variation in food consumption, growth, and growth efficiency among juvenile hybrid sunfish held in isolation. *Aquaculture*.

Wang, N., R.S. Hayward, and D.B. Noltie. Submitted. Effect of feeding frequency on food consumption, growth, size variation, and feeding pattern of age-0 hybrid sunfish. *Aquaculture*.

Papers Presented

Brown, P.B., and K. Wilson. 1994. Experimental and practical diet evaluations with hybrid bluegill. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-16, 1994.

Mischke, C.C., and J.E. Morris. 1996. Growth and survival of larval bluegill (*Lepomis macrochirus*) and hybrid sunfish (green sunfish, *L. cyanellus* x bluegill) in the laboratory under different feeding regimes. Iowa-Nebraska American Fisheries Society Meeting, Council Bluffs, Iowa, January 29-31, 1996.

Mischke, C.C., and J.E. Morris. 1996. Early spawning of bluegill. Midcontinent Warmwater Fish Culture Workshop, Council Bluffs, Iowa, February 7, 1996.

Mischke, C.C., and J.E. Morris. 1996. Growth and survival of larval bluegill, *Lepomis macrochirus*, in the laboratory under different feeding regimes. U.S. Chapter of the World Aquaculture Society, Arlington, Texas, February 14-17, 1996. (Awarded Best Student Poster)

Morris, J.E. 1995. Hybrid bluegill culture update. Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995.

Morris, J.E. 1995. Culture of bluegills under laboratory conditions. Nebraska Aquaculture Conference, North Platte, Nebraska, March 25, 1995.

Morris, J.E., C.C. Mischke, and G. Dike. 1997. Overview of *Lepomis* spp. culture in the U.S. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Paret, J.M., R.J. Sheehan and S.D. Cherck. 1993. Growth performance of *Lepomis* diploid hybrids, triploid hybrids and parental species at five temperatures. Meeting of the Illinois and Iowa Chapters of the American Fisheries Society, Bettendorf, Iowa, February 16-18, 1993.

Read, E.R., and J.R. Triplett. 1994. Cage culture of crappie. 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994.

Read, E.R., and J.R. Triplett. 1995. Cage culture of black, white and F₁ hybrid crappie (*Pomoxis* species). Kansas Commercial Fish Growers Association, McPherson, Kansas, February 2, 1995.

Sheehan, R.J., J.P. Paret, P.S. Wills, and J.E. Seeb. 1993. Induced triploidy and growth of *Lepomis* parental species, hybrid, and triploid hybrid at five temperatures, 8 to 28C. Prospects for Polyploid Fish in Fisheries Management Symposium, 123rd Annual Meeting of the American Fisheries Society, Portland, Oregon, August 29 - September 2, 1993. (Invited paper)

Tetzlaff, B., and P. Wills. 1991. Current trends in the culture of hybrid sunfish. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Thomas, G.L., and J.R. Triplett. 1994-1995. Close-loop white crappie (*Pomoxis annularis*) culture. 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994. Also presented at the Kansas Commercial Fish Growers Association Meeting, McPherson, Kansas, February 2, 1995 and Kansas Academy of Science Annual Meeting, Pittsburg State University, Pittsburg, Kansas, April 7, 1995.

Wang, N., R.S. Hayward, and D.B. Noltie. 1997. Individual variation in growth, food consumption, and growth efficiency of hybrid sunfish due to genetic differences. 127th Annual Meeting of the American Fisheries Society, Monterey, California, August 24-28, 1997.

Westmaas, A.R., W. Young, and D. Garling. 1991. Induction of polyploids in bluegills and chinook salmon. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

SALMONIDS

Publications in Print

Cain, K.D., and D.L. Garling. 1995. Pretreatment of soy bean meal for salmonid diets with phytase to reduce phosphorus concentration in hatchery effluents. *Progressive Fish-Culturist* 57:114-119.

Finck, J.L. 1994. Activity of all-female and mixed-sex rainbow trout (*Oncorhynchus mykiss*) and their early growth and survival in comparison to all-female triploids. Master's thesis, Southern Illinois University-Carbondale.

Pan, J.Z., K. Dabrowski, L. Liu, and A. Ciereszko. 1995. Characteristics of semen and ovary in rainbow trout (*Oncorhynchus mykiss*) fed fish meal and/or animal by-product based diets. Proceedings of the 5th International Symposium on the Reproductive Physiology of Fish, Austin, Texas, July 2-8, 1995.

Ramseyer, L.J. 1995. Total length to fork length relationships of juvenile hatchery-reared coho and chinook salmon. *Progressive Fish-Culturist* 57:250-251.

Riche, M. 1993. Phosphorus absorption coefficients for rainbow trout (*Oncorhynchus mykiss*) fed commercial sources of protein. Master's thesis. Purdue University, West Lafayette, Indiana.

Riche, M., and P.B. Brown. 1996. Absorption of phosphorus from feedstuffs fed to rainbow trout. *Aquaculture* 142:269-282.

Riche, M., M.R. White, and P.B. Brown. 1995. Barium carbonate as an alternative indicator to chromic oxide for use in digestibility experiments with rainbow trout. *Nutrition Research* 15:1323-1331.

Shasteen, S.P. 1995. Benefits of artificial swimbladder deflation for depressurized largemouth bass, walleye, and rainbow trout in catch and release fisheries. Master's thesis. Southern Illinois University-Carbondale.

Suresh, A.V. 1996. Fiber growth and DNA, RNA, and protein concentrations in white muscle tissue as indicators of growth in diploid and triploid rainbow trout, *Oncorhynchus mykiss*. Doctoral dissertation. Southern Illinois University-Carbondale.

Manuscripts

Barry, T.P., T.B. Kayes, T.E. Kuczynski, A.F. Lapp, L.S. Procarione, and J.A. Malison. Submitted. Effects of high rearing density and low-level gas supersaturation on the growth and stress responses of rainbow and lake trout. *Transactions of the American Fisheries Society*.

Procarione, L.S., T.P. Barry, and J.A. Malison. In preparation. A rapid corticosteroid stress response is correlated with superior growth in rainbow trout. *Aquaculture*.

Procarione, L.S., and J.A. Malison. In preparation. Effects of rearing density and loading on the growth and stress response of rainbow trout. *Aquaculture*.

Ramseyer, L.J., D.L. Garling, and G. Hill. In preparation. Effect of dietary zinc supplementation and phytase pre-treatment of soybean meal or corn gluten meal on growth, zinc status and protein utilization in rainbow trout, *Oncorhynchus mykiss*. *Comparative Biochemistry and Physiology*.

Sheehan, R.J., C. Habicht, and J.E. Seeb. In preparation. Tolerance of diploid and triploid chinook Salmon, coho salmon, and rainbow trout during simulated transportation. *Transactions of the American Fisheries Society*.

Sheehan, R.J., S.P. Shasteen, A.V. Suresh, A.R. Kapuscinski, and J.E. Seeb. Accepted. All-female triploids and diploids outgrow mixed-sex diploid rainbow trout. *Transactions of the American Fisheries Society*.

Suresh, A.V., and R.J. Sheehan. In press. Muscle fiber growth dynamics in diploid and triploid rainbow trout. *Journal of Fish Biology*.

Suresh, A.V., and R.J. Sheehan. In press. Biochemical and morphological correlates of growth in diploid and triploid rainbow trout. *Journal of Fish Biology*.

Papers Presented

Adelizi, P., P. Brown, V. Wu, and R. Rosati. 1995. Fish meal-free diets for rainbow trout. 24th Annual Fish Feed and Nutrition Workshop, Columbus, Ohio, October 19-21, 1995.

Adelizi, P., P. Brown, V. Wu, K. Warner, and R. Rosati. 1996. Alternative feed ingredients in diets fed to rainbow trout. *Aquaculture America*, Dallas, Texas, February 14-17, 1996.

Barry, T.P., T.B. Kayes, T.E. Kuczynski, A.F. Lapp, L.S. Procarione, and J.A. Malison. 1993. Effects of high rearing density and low-level gas supersaturation on the growth and stress responses of lake trout (*Salvelinus namaycush*). 123rd Annual Meeting of the American Fisheries Society, Portland, Oregon, August 28-September 3, 1993.

Brown, P.B. 1993. Salmonid aquaculture in the North Central Region. Seventh Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 5-6, 1993.

Brown, P.B., Y. Hodgins, K. Wilson, and J. Stanley. 1996. Review of lecithin in aquaculture and evaluation of three commercial lecithin products in diets fed to coho and Atlantic salmon. 87th Annual Meeting of the American Oil Chemists' Society, Indianapolis, Indiana, June 22-24, 1996.

Finck, J.L., and R.J. Sheehan. 1993. Daily activity patterns of mixed-gender and all-female rainbow trout in raceways. Presented at the 55th Midwest Fish & Wildlife Conference, Annual Meeting of the North-Central Division of the American Fisheries Society, St. Louis, Missouri, December 11-15, 1993. (Invited paper)

Finck, J.L., and R.J. Sheehan. 1993. Daily activity patterns of mixed-sex and all-female rainbow trout in raceways. Presented at the Joint Meeting of the Illinois and Iowa Chapters of the American Fisheries Society, Bettendorf, Iowa, February 16-18. (Awarded Best Student Paper)

Procarione, L.S., T.P. Barry, and J.A. Malison. 1996. A rapid corticosteroid stress response is correlated with superior growth in rainbow trout. Midwest Endocrinology Conference, The Society of Integrative and Comparative Biology, Madison, Wisconsin, June 22-23, 1996.

Ramseyer, L.J., and D.L. Garling. 1997. Fish nutrition and aquaculture waste management. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Riche, M., and P.B. Brown. 1993. Apparent phosphorus absorption coefficients for rainbow trout fed common feedstuffs. 24th Annual Meeting of the World Aquaculture Society, Torremolinos, Spain, May 26-28, 1993.

Riche, M., M.E. Griffin, and P.B. Brown. 1994. Effect of dietary phytase pretreatment on phosphorus leaching from rainbow trout feces. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-16, 1994.

Sheehan, R.J. 1995. Applications of chromosome set manipulation to fisheries resource management. Presented at the University of Peru, Amazonia, Iquitos, Peru, August 17, 1995. (Invited paper)

Sheehan, R.J., C. Habicht, and J.E. Seeb. 1994. Tolerance of triploid *Oncorhynchus* (coho, chinook, and rainbow trout) to aquaculture stressors. Presented at the 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994.

NORTH CENTRAL REGIONAL AQUACULTURE CONFERENCE

Publication in Print

Proceedings of the North Central Regional Aquaculture Conference. 1991. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

NATIONAL AQUACULTURE EXTENSION WORKSHOP/CONFERENCE

Publications in Print

Proceedings of the National Extension Aquaculture Workshop. 1992. National Extension Aquaculture Workshop, Ferndale, Arkansas, March 3-7, 1992.

National Aquaculture Extension Conference: A Program Summary of Presentations, Posters and Aquaculture Short Courses. 1997. National Extension Aquaculture Conference, Annapolis, Maryland, April 8-12, 1997. Maryland Sea Grant Extension Publication Number UM-SG-MAP-97-01, College Park, Maryland. (Also available electronically at: <http://www.mdsg.umd.edu:80/extensionconf/summary.html>)

CRAYFISH

Publications in Print

Brown, P., and J. Gunderson, editors. 1997. Culture potential of selected crayfishes in the North Central Region. NCRAC Technical Bulletin Series #112, NCRAC Publications Office, Iowa State University, Ames.

Fetzner, J.W., Jr., R.J. Sheehan, and L.W. Seeb. 1997. Genetic implications of broodstock selection for crayfish aquaculture in the Midwestern United States. *Aquaculture* 154:39-55.

Gunderson, J.L. 1995. Rusty crayfish: a nasty invader, the biology, identification, and impacts of the rusty crayfish. Minnesota Sea Grant Extension Publication, University of Minnesota, Duluth.

Richards, C., J.L. Gunderson, P. Tucker, and M. McDonald. 1995. Crayfish and baitfish culture in wild rice paddies. Technical Report No. NRRI/TR-95/39. Natural Resources Research Institute, Duluth, Minnesota.

Papers Presented

Brown, P.B. 1994. Pond production of crayfish. Workshop on Getting Started in Commercial Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994.

Brown, P.B. 1994. Crayfish and aquatics: raising fish for profit. Indiana Horticultural Congress, Indianapolis, Indiana.

Brown, P.B. 1995. Crayfish aquaculture in the north. Nebraska Aquaculture Conference, North Platte, Nebraska, March 25, 1995.

Gunderson, J.L. 1994. Raising crayfish commercially. Development 94, Detroit Lakes, Minnesota, February 18, 1994.

Gunderson, J.L. 1994. Softshell crayfish production. Aqua '94, 8th Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 4, 1994.

Gunderson, J.L. 1994. Outdoor culture systems and crayfish production. Minnesota Extension Service Aquaculture Seminar, Thief River Falls, Minnesota, April 25, 1994.

Gunderson, J.L. 1994. Softshell crayfish production. Workshop on Getting Started in Commercial Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994.

Gunderson, J.L. 1995. Diversity in aquaculture -- crawfish. Wisconsin Aquaculture '95, Stevens Point, Wisconsin, March 17, 1995.

BAITFISH

Publication in Print

Meronek, T.G. 1994. Status of the bait industry in the North Central Region of the United States. Master's thesis. University of Wisconsin, Stevens Point.

Meronek, T.G., F.A. Copes, and D.W. Coble. 1995. A summary of bait regulations in the north central United States. *Fisheries* 20(11):16-23.

Papers Presented

Copes, F.A. 1993. Aquaculture shortcourse. Sponsored by University of Wisconsin-Sea Grant and Wisconsin Department of Agriculture, Greenwood, Wisconsin, March 1993.

Copes, F.A. 1995. Baitfish aquaculture. North Central Regional Aquaculture Conference/Ninth Annual Minnesota Aquaculture Conference, Minneapolis, Minnesota, February 1995.

Meronek, T.G. 1993. Survey of the bait industry in the north central United States. Annual Meeting of the Michigan Fish Farmers Association, Cadillac, Michigan, February 1993.

Meronek, T.G. 1993. Survey of the bait industry in the north Central United States. Seventh Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 1993.

Meronek, T.G. 1993. Survey of the bait industry in the north central United States. Illinois Fish Farmers Association, Pana, Illinois, March 1993.

Meronek, T.G. 1994. Status of the bait industry in the North Central Region. Annual Meeting of the Wisconsin Chapter of the American Fisheries Society, Marinette, Wisconsin, January 1994.

Meronek, T.G. 1994. Baitfish aquaculture and production. Governor's Conference: Wisconsin Aquaculture '94. University of Wisconsin, Stevens Point, February 1994.

WASTES/EFFLUENTS

Publication in Print

Rosati, R., P.D. O'Rourke, K. Tudor, and R.D. Henry. 1993. Performance of a raceway and vertical screen filter while growing *Tilapia nilotica* under commercial conditions. Pages 303-214 in J-K. Wang, editor. Techniques for modern aquaculture. Publication No. P-0293, American Society of Agricultural Engineering, St. Joseph, Michigan.

Papers Presented

Hinrichs, D., J. Webb, R. Rosati, and P. Foley. 1994. Effluent characterization from the production of *Oreochromis niloticus* in a modified Red Ewald-style recirculating system. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-16, 1994.

Rosati, R., D. Hinrichs, and J. Webb. 1994. Biofilter performance during the production of *Oreochromis niloticus* in a modified Red Ewald-style recirculating system. 124th Annual Meeting of the American Fisheries Society, Halifax, Nova Scotia, August 21-25, 1994.

Rosati, R., P.D. O'Rourke, K. Tudor, and R.D. Henry. 1993. Performance of a raceway and vertical screen filter while growing *Tilapia nilotica* under commercial conditions. Techniques for Modern Aquaculture, Special Session at the Annual Meeting of the American Society of Agricultural Engineering, Spokane, Washington, June 21-23, 1993.

Rosati, R., J. Webb, D. Hinrichs, and P. Foley. 1993. Characteristics of the effluent from a recirculating aquaculture system. U.S. Chapter of the World Aquaculture Society, Hilton Head, South Carolina, January 27-30, 1993.

Smydra, T.M., and J.E. Morris. 1994. Characterization of aquaculture effluents from two Iowa hatcheries. Iowa Chapter, American Fisheries Society, Council Bluffs, Iowa, February 15-16, 1994.

Smydra, T.M., and J.E. Morris. 1994. Characterization of aquaculture effluents. 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994.

NATIONAL AQUACULTURE INAD/NADA COORDINATOR

Publications in Print

Schnick, R.A. 1996. Chemicals and drugs. Pages 347-354 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series # 101, North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Schnick, R.A. 1996. Cooperative fish therapeutic funding initiative: States in partnership with federal agencies to ensure the future of public fish culture. Transactions of the 61st North American Wildlife and Natural Resources Conference 61:6-10.

Schnick, R.A. 1997. International regulatory aspects of chemical and drug residues. Pages 186-194 *in* R.E. Martin, R.L. Collette, and J.W. Slavin, editors. Fish inspection, quality control, and HACCP: a global focus. Technomic Publishing Company, Inc., Lancaster, Pennsylvania.

Schnick, R.A. and R.D. Armstrong. 1997. Aquaculture drug approval progress in the United States. Northern Aquaculture Supplement (Salmon Health Report):22-28.

Schnick, R.A., W.H. Gingerich, and K.H. Koltes. 1996. Federal-state aquaculture drug registration partnership: A success in the making. Fisheries 21(5):4.

Manuscript

Schnick, R.A. In press. Approval of drugs and chemicals for use by the aquaculture industry. Veterinary and Human Toxicology.

Papers Presented

Gingerich, W.H. and R.A. Schnick. 1997. Federal-state aquaculture drug approval partnership program. World Aquaculture '97, Seattle, Washington, February 19-23, 1997.

Gingerich, W.H. and R.A. Schnick. 1997. Aquaculture drug registration study progress report. Meeting of the International Association of Fish and Wildlife Agencies, Inland Fisheries Committee, Washington, D.C. March 16, 1997.

Ringer, R.K. 1993. Workshop on INADs, NADAs, and the IR-4 Project. California Aquaculture Association, Oakland, October 11, 1993.

Ringer, R.K. 1993. INAD workshop: proper drug and chemical use in aquaculture. 9th Annual Florida Aquaculture Association Conference, Fort Pierce, November 6, 1993.

Ringer, R.K. 1994. National INAD Coordinator's role in aquaculture. 25th Annual Meeting of the World Aquaculture Society, New Orleans, January 12-18, 1994.

Ringer, R.K. 1994. State of current USDA regulations on drug, therapeutic, and chemical use. North Carolina Aquaculture Development Conference, New Bern, February 5, 1994.

Ringer, R.K. 1994. Investigational New Animal Drugs Workshop. Tropical and Subtropical Regional Aquaculture Center Industry Advisory Council Meeting, Honolulu, Hawaii, March 14, 1994.

Schnick, R.A. 1995. Idaho Aquaculture Association Annual Meeting, Twin Falls, Idaho, May 19-22, 1995.

Schnick, R.A. 1995. Chemistry in Aquaculture Symposium. Convener and presenter, Cullowhee, North Carolina, May 31-June 2, 1995.

Schnick, R.A. 1995. FWS/INAD Coordination Workshop. Presenter and coordinator, Bozeman, Montana, August 1-4, 1995.

Schnick, R.A. 1995. Funding crisis for drugs/therapeutants and coordination of aquaculture INADs/NADAs. Annual meeting of the U.S. Trout Farmers Association, Twin Falls, Idaho, September 27-30, 1995.

Schnick, R.A. 1995. Activities of the National Coordinator for Aquaculture New Animal Drug Applications. Annual meeting of the National Research Support Program Number 7 (NRSP-7), Rockville, Maryland, October 2, 1995.

Schnick, R.A. 1995. INAD/NADA Coordinators workshop under the sponsorship of CVM. Organizer and presenter, Rockville, Maryland, November 1-2, 1995.

Schnick, R.A. 1996. Status of aquaculture INADs and NADAs. Presenter and coordinator, Midcontinent Warmwater Fish Culture Workshop and INAD/NADA Coordination Meetings, Council Bluffs, Iowa, February 6-8, 1996.

Schnick, R.A. 1996. INAD/NADA update. Western Regional Aquaculture Expo '96, Sacramento, California, February 7-9, 1996.

Schnick, R.A. 1996. National Aquaculture NADA Coordinator update. Working Group on Quality Assurance in Aquaculture Production, Arlington, Texas, February 14, 1996.

Schnick, R.A. 1996. Proper use of fish therapeutants based on legal requirements-gill lice, bacterial gill disease, furunculosis, etc. Annual Meeting of the Michigan Aquaculture Association, East Lansing, Michigan, February 23, 1996.

Schnick, R.A. 1996. Status of aquaculture drug development. Great Lakes Fish Disease Workshop, La Crosse, Wisconsin, February 28, 1996.

Schnick, R.A. 1996. Advances in therapeutants. Southeastern Fish Diagnosticians' Workshop, Mississippi State, Mississippi, March 13-14, 1996.

Schnick, R.A. 1996. Report on progress and research study objectives of the Federal-State Drug Registration Partnership. Meeting of the International Association of Fish and Wildlife Agencies, *ad hoc* Committee on Aquaculture, Tulsa, Oklahoma, March 24, 1996.

Schnick, R.A. 1996. Cooperative fish therapeutic funding initiative--States in partnership with Federal agencies to ensure the future of public fish culture. 61st North American Conference on Wildlife and Natural Resources, Tulsa, Oklahoma, March 24-28, 1996.

Schnick, R.A. 1996. International regulatory aspects of chemical and drug residues. International Conference on Fish Inspection and Quality, Arlington, Virginia, May 19-24, 1996.

Schnick, R.A. 1996. Aquaculture drug approval progress in the United States. Aquaculture Canada '96, 13th Annual Meeting of the Aquaculture Association of Canada, Ottawa, Ontario, June 2-5, 1996.

Schnick, R.A. 1996. Summary of activities of the National Coordinator for Aquaculture New Animal Drug Applications (NADAs): (May 15, 1995 to May 14, 1996). Meeting of the Aquatic Remedies Steering Committee, American Pet Products Manufacturers Association, Minneapolis, Minnesota, June 18-19, 1996.

Schnick, R.A. 1996. Overview of NADA Coordinator activities, International Project update, short-term INAD/NADA needs. FWS INAD Coordination Workshop, Bozeman, Montana. August 14-15, 1996.

Schnick, R.A. 1996. The procedures and responsibilities related to the amoxicillin INAD. Meeting of the Fish Growers of America, Memphis, Tennessee. October 2, 1996.

Schnick, R.A. 1996. Overview of pivotal study protocol requirements. Chloramine-T Pivotal Efficacy Protocol Development Workshop, Kansas City, Missouri. November 7-8, 1996.

Schnick, R.A. 1997. INAD and drug clearance update. Midcontinent Warmwater Fish Culture Workshop, Springfield, Missouri. February 3-5, 1997.

Schnick, R.A. 1997. Overview of partnerships for aquaculture drug approvals. Partnerships for Aquaculture Drug Approvals: Models for Success. Chair of Special Session at 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington. February 19-23, 1997.

Schnick, R.A. 1997. Current status and future needs for drugs in aquaculture: regional needs. Workshop on International Harmonization for Drugs and Biologics, Seattle, Washington. February 24, 1997.

Schnick, R.A. 1997. Aquaculture drug approval progress for the catfish industry. Catfish Farmers of America 1997 National Convention, Nashville, Tennessee. February 27-March 1, 1997.

Schnick, R.A. 1997. Aquaculture drugs and chemicals approvals. Wisconsin Aquaculture Conference '97, Stevens Point, Wisconsin. March 14-15, 1997.

Schnick, R.A. 1997. History of the IAFWA drug approval project; review of FDA's decisions on drug use in aquaculture; and negotiations by NADA coordinator. First Meeting of the IAFWA Drug Approval Oversight Subcommittee, Hot Springs, Arkansas. May 5, 1997.

Schnick, R.A. 1997. Review of the November 1996 chloramine-T data requirements; Data call-in. Chloramine-T INAD Coordination Workshop, Bozeman, Montana. August 5, 1997.

Schnick, R.A. 1997. Overview of NADA Coordinator activities. FWS-INAD Coordination Workshop, Bozeman, Montana. August 7, 1997.

TILAPIA

Publications in Print

Fiumera, A.C. 1997. Use of microsatellite DNA to estimate the loss of genetic diversity in the Lake Victoria cichlid Species Survival Plan captive breeding program. Master's thesis. Ohio State University, Columbus.

Fiumera, A.C., and P.A. Fuerst. 1997. Use of DNA microsatellite loci to estimate the effective population size of a captive-bred Lake Victoria cichlid managed within the Species Survival Plan (SSP). *Ohio Journal of Science* 97 (2):A-31.

Fiumera, A.C., and P.A. Fuerst. 1997. Use of DNA microsatellite loci to study the maintenance of genetic variation in the captive managed populations of the Lake Victoria cichlid Species Survival Plan. Contribution No. 1 (1997), Museum of Zoology, Fish Division, Ohio State University, Columbus.

Mwanja, W.W., L. Kaufman, and P.A. Fuerst. 1997. Genetic population structure and meristic characterization of populations of *Oreochromis niloticus* (Pisces: Cichlidae) of Lake Victoria Region and Lake Edward-Albert System (Uganda - E. Africa). *Proceedings of the 7th International Aquaculture Symposium*, Swansea.

Wu, L., L. Kaufman, B. Porter, and P. Fuerst. 1997. Genetic variability and inter-population gene flow of *Astatoreochromis alluaudi* revealed by microsatellite data. Pages 316-317 *in* *Proceedings of the 77th Annual Meeting of the American Society of Ichthyologists and Herpetologists*.

Manuscripts

Fiumera, A.C., P.G. Parker, and P.A. Fuerst. Submitted. Effective population size and loss of genetic diversity in captive bred populations of the Lake Victoria cichlid *Prognathochromis perrieri*. *Conservation Biology*.

Fiumera, A.C., P.G. Parker, and P.A. Fuerst. Submitted. Small effective population size contributes to the loss of genetic diversity in the Lake Victoria cichlid SSP species *Paralabidochromis chilotes*. *Zoo Biology*.

Fuerst, P., W. Mwanja, L. Kaufman, and G. C. Booton. In press. Genetic Phylogeography of introduced *Oreochromis niloticus* (Pisces: Cichlidae) in Uganda. *Proceedings of the IV International Symposium on Tilapia Aquaculture*.

Riche, M., M. Oetker, D. Haley, T. Smith, and D. Garling. In preparation. Effects of feeding frequency on intake, growth efficiency and body composition of Nile Tilapia (*Oreochromis niloticus*). *Aquaculture Research*.

Twibell, R.G., and P.B. Brown. In Press. Optimum dietary crude protein for hybrid tilapia (*Oreochromis niloticus* × *O. aureus*) fed all-plant diet. *Journal of the World Aquaculture Society*.

Papers Presented

Brown, P.B., R.G. Twibell, and J. Weigel. 1997. Minimum dietary crude protein for tilapia fed diets free of fish meal. 28th Annual Meeting of the World Aquaculture Society, Seattle, February 19-23, 1997.

Mbahinzireki, G., and Dabrowski, K. 1997. Production of male tilapia by heat-treatment of embryos and growth on different diets in recirculation systems. 28th Annual Meeting of the World Aquaculture Society, Seattle, February 19-23, 1997.

AQUACULTURE DRUGS

Report

Green, B.W. 1996. Direct review submission to Division of Toxicology and Environmental Science, Center for Veterinary Medicine, U.S. Food and Drug Administration in support of the Tilapia 17 -Methyltestosterone INAD (INAD #9647 A0000, January 24, 1996).

Paper Presented

Kohler, C.C., A.M. Kelly, E.M. Carnivale, and W.L. Muhlach. 1997. Target animal safety studies for aquaculture. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

APPENDIX

1. NCRAC has funded five Extension projects, the first three of which were chaired by Donald L. Garling. The fourth project was chaired by Fred P. Binkowski. A fifth 2-year project, which began September 1, 1995 and ended August 31, 1997, was chaired by Joseph E. Morris.
2. NCRAC has funded three Economics and Marketing projects. This termination report is for the third project that was chaired by Patrick D. O'Rourke.
3. This progress report is for the fourth and fifth Yellow Perch projects funded by NCRAC. Both projects chaired by Jeffrey A. Malison. The fifth project continues and expands upon work undertaken in the fourth project. It is a 2-year study that began September 1, 1995 and concluded on August 31, 1997.
4. NCRAC has funded five Hybrid Striped Bass projects. This progress report is for the fifth project which is chaired by Christopher C. Kohler. The project continues and expands upon the first four projects. It began on September 1, 1995 and was scheduled to end on August 31, 1997.
5. NCRAC has funded six Walleye projects. This project component termination report covers all of the second Walleye project and Objective 2 of the fourth project. Objective 2 of the fourth project expanded upon the work of the second project. Robert C. Summerfelt chaired the second Walleye project, a 2-year study, and Jeffrey A. Malison chaired the fourth Walleye project, a 1-year study.
6. NCRAC has funded six Walleye projects. This project component termination report covers two of the three objectives (Objectives 1 and 3) contained in the project outline for the fifth Walleye project. The third objective (Objective 2 in the project outline) was continued and completed in the sixth Walleye Project. The fifth Walleye project was a 2-year project that was chaired by Robert C. Summerfelt.
7. NCRAC has funded six Walleye projects. This project component termination report covers Objective 2 of the fifth project and all of the sixth project. Objective 2 of the fifth project was continued in the sixth project (Objective 4) where it was completed. Both the fifth and sixth projects were 2-year projects. The fifth project began September 1, 1993; the sixth project began September 1, 1995. Robert C. Summerfelt chaired the fifth project and the last three months of the sixth project; Terrence B. Kayes chaired the first 21 months of the sixth project.
8. NCRAC has funded four Sunfish projects. This progress report is for the third and fourth projects. These projects continue and build upon the first two projects. Donald L. Garling chaired the third project and Robert J. Sheehan chairs the fourth project. Charlie Stevens was appointed to serve as the Industry Advisory Council Liaison for the fourth project.

9. NCRAC has funded three Salmonid projects with the first beginning June 1, 1990. The first project initiated work on developing less-polluting diets. That work continued in the second and third projects. Work on using high rearing densities began in the second project and continued in the third. Paul B. Brown chaired the first and second projects; Ronald R. Rosati chaired the third project until he left Illinois State University after which Terence B. Barry became chair.

10. NCRAC has provided funding along with the four other Regional Aquaculture Centers for two national aquaculture extension meetings; the first was called a National Aquaculture Extension Workshop whereas the second was called a National Aquaculture Extension Conference. This termination report is for the second meeting which was held April 8-12, 1997 in Annapolis, Maryland.

11. NCRAC has funded two Wastes/Effluents Projects. This progress report is for the second project which is a 2-year study that began September 1, 1996 and is chaired by Fred P. Binkowski.

12. Ted R. Batterson serves as the facilitator for this multi-year project interacting with a steering committee in overseeing the Coordinator's activities.

13. NCRAC has funded only one Tilapia project to date. This is a 2-year project that began September 1, 1996 and is chaired by Donald L. Garling.

14. NCRAC has funded several projects on "Aquaculture Drugs," this being one of them. This project is chaired by Christopher C. Kohler.

15. NCRAC has funded several projects on "Aquaculture Drugs," this being one of them. This project was co-chaired by Ronald P. Phelps and Bartholomew W. Green.

