SPECIAL PUBLICATION SJ 90-SP9

APPENDICES
TO THE
FINAL REPORT

ENVIRONMENTAL AND ECOLOGICAL EFFECTS OF DRAWDOWN AND ENHANCED FLUCTUATION FOR LAKE APOPKA, FLORIDA

SEPTEMBER, 1990

APPENDIX A:

INTERVIEW DATABASE

Aquatic Control, Inc.
P.O. Box 100
Seymour, IN 47274
(812) 497-2410

WHEN AND HOW CONTACTED: Letter sent in November 1989

SUMMARY: This company has been involved in several small scale drawdown projects for their clients; however, no documentation or information is available from these projects. Different aquatic plants react differently to drawdowns, with some showing a reduction in coverage, and some showing an increase in coverage. They would be interested in receiving a copy of this review, if it is for general distribution.

Arruda, Joe
Department of Biology
Pittsburgh State University
Pittsburgh, KS 66762

WHEN AND HOW CONTACTED: Letter followed by telephone conversation

SUMMARY: Dr. Arruda has not been directly involved with drawdown; however, he suggested talking to the Kansas Department of Wildlife and Parks. The Wildlife and Parks Department manages 24 Federal reservoirs in Kansas using fall drawdowns for fisheries and waterfowl management.
A letter was sent to the Wildlife and Parks Department requesting information regarding their drawdown program.

Carr, Jerome B.
Carr Research Laboratory, Inc.
17 Waban Street
Wellesley, MA 02181

WHEN AND HOW CONTACTED: Letter sent November, 1989

STUDY LOCATION: New England lakes

LAKE SIZE: Variable, small ponds

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Dr. Carr writes that the drawdown work in New England is usually done by small pond associations that have limited funds. Thus, they do not do detailed follow-up studies. The drawdowns in New England are done during the winter months, and the freezing action on the exposed sediments is an important aspect of the benefits for macrophyte control.

Cooke, G. Dennis
Department of Biological Science
Kent State University
Kent, OH 44017

WHEN AND HOW CONTACTED: Letter sent November, 1989

SUMMARY: Dr. Cooke sent a copy of his paper entitled "Lake level drawdown as a macrophyte control technique" Water Resources Bulletin 16: 317-322 (1980), which is included in the Literature Review Database. He also referred to Lake and Reservoir Management (1986), also included in the Literature Review Database.

Couch, Richard
Aquatic Management Services
Oral Roberts University
Tulsa, OK 74171

WHEN AND HOW CONTACTED: Letter sent November, 1989

STUDY LOCATION: Lakes in Oklahoma

OBJECTIVES OF DRAWDOWN:

SUMMARY: Oklahoma has a lot of aquatic habitats and a wide variety of aquatic plant species, including Eurasian water milfoil which has been in State waters since the 1950's. Aquatic plants have never become serious weeds for two reasons. Most the water waters of Oklahoma are turbid most of the time which confines macrophyte growth to shallow water. When natural drawdowns are brought on by frequent periodic droughts, plants growing in these shallow waters are killed from desiccation. Mr. Couch knows of no one in Oklahoma who uses drawdown as a management technique.

Courtemanch, David L.
Maine Department of Environmental Protection
Division of Environmental Evaluation and Lake Studies
State House #17
Augusta, ME 04333

SUMMARY: Dr. Courtemanch sent two lake restoration reports from the Maine Department of Environmental Protection which are included in the Literature Review Database. These are "The Restoration of Sebasticook Lake" and "Sabattus Pond Restoration Project".

Filbin, Jerry
Technical Resources, Inc.
3202 Monroe Street
Rockville, MD 20852
(301) 231-5250

WHEN AND HOW CONTACTED: Letter followed by telephone conversation; November 3, 1989

STUDY LOCATION: Eau Gallie Reservoir, Wisconsin

DRAWDOWN TIMING/DURATION: Overwinter, 1985

LAKE SIZE: 125 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Eau Gallie Reservoir is a shallow reservoir with problems with Ceratophyllum (coontail) overabundance. An overwinter drawdown lowered water 3', which resulted in volumes of about half the full lake volume. Drawdown and freezing to the ice level resulted in the reduction of coontail in the littoral zone by 50% in the first two years after drawdown; however, pond weed (Potamogeton) proliferated above the ice line. Apparently, the Potamogeton was overshadowed by the coontail, and, upon being exposed to sunlight and space after the coontail was frozen, became as much a nuisance plant as the coontail. Coontail was not affected below the ice line, and became reestablished after 2 years. This work was conducted for the U.S. Army Corps of Engineers Cold Regions Lab.

POSITIVE EFFECTS: Ceratophyllum control for 2 years. Observed increase in large bass numbers.

NEGATIVE EFFECTS: Potamogeton proliferation with release from Ceratophyllum overshadowing.

KEYWORDS: Wisconsin, macrophyte control, winter drawdown, freezing

AVAILABLE PRINTED INFORMATION: Reports from the Army Corps of Engineers; reviewed in the Literature Review Database.

OTHER SUGGESTED CONTACTS: John Barko, Army Corps of Engineers; Dennis Cook

Groves, Anthony F.
Progressive Architects Engineers Planners
2942 Fuller N.E.
Grand Rapids, MI 49505
(616) 361-2664

WHEN AND HOW CONTACTED: Letter sent November 1989

STUDY LOCATION: Wolverine Lake, Michigan

DRAWDOWN TIMING/DURATION: winter 1987-1988

LAKE SIZE: 241 acres

OBJECTIVES OF DRAWDOWN: macrophyte control

SUMMARY: A 2.5 foot drawdown was conducted to control growth of milfoil (Myriophyllum spp.). A macrophyte study conducted after refilling in spring indicated that the drawdown-resistant Chara and Najas has an early season competitive advantage over milfoil which cannot withstand the freezing and desiccating effects of winter drawdown exposure. However, milfoil growth was observed late in the growing season along much of the littoral zone exposed during drawdown. Drawdown and freezing appears to mitigate early season milfoil growth, but not later in the season. Sufficient dissolved oxygen levels were maintained during drawdowns to protect fish populations.

POSITIVE EFFECTS: Milfoil control for early season,

NEGATIVE EFFECTS: Short-term (2-3 months) macrophyte control.

KEYWORDS: Michigan lake, macrophyte control

AVAILABLE PRINTED INFORMATION: "Wolverine Lake 1988 Post-Drawdown aquatic vegetation monitoring program. Final Report", prepared for the Village of Wolverine Lake and Michigan Department of Natural Resources; by Progressive Architects Engineers Planners. November 1988.

OTHER SUGGESTED CONTACTS: none

Hudson, Daniel M.
15 Aaron St.
Berea, OH 44017

WHEN AND HOW CONTACTED: Letter sent November 1989

SUMMARY: Mr. Hudson does not have direct experience with lake or reservoir drawdown techniques. However, he would like to receive a copy of the final report of this review, when available.

Jacoby, Jean M.
Kramer, Chin & Mayo, Inc.
1917 First Avenue
Seattle, WA 98101
(206) 443-5300

WHEN AND HOW CONTACTED: Letter sent November 1989

SUMMARY: Dr. Jacoby sent three published papers, which are included in the Literature Review Database:

Welch, E.B. et al. 1988. Sources for internal loading in a shallow lake. Verh. Internat. Verein. Limnol. 23: 307-314.

Jacoby, J.M., et al. 1982. Internal Phosphorus Loading in a shallow eutrophic lake. Water Res. 16: 911-919.

Jacoby, J.M. et al. 1984. Control of internal phosphorus loading in a shallow lake by drawdown and alum.

Johnson, Bill and John Benton
Florida Game and Freshwater Fish Commission
P.O. Box 1903
Research Laboratory, Eustis, FL 32727
(904) 357-6631

WHEN AND HOW CONTACTED: personal interview on November 8, 1989

STUDY LOCATION: Central Florida lakes, including Lake Tohopekaliga, Lake Griffin, East Lake Tohopekaliga

DRAWDOWN TIMING/DURATION: Most drawdowns are conducted at the end of the dry season in Florida (late spring) and are planned for a 60 to 90 day duration. In practice, the drawdown typically lasts until the start of the rainy season, when the lakes refill.

LAKE SIZE: Variable

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: The FGFWFC is generally pleased with the results of their various drawdown management projects, and feel that drawdown is one of the most (if not the most) effective fisheries management technique available to them. They have not observed significant changes in water quality or sediment consolidation with the 2-3 month drawdowns conducted for fishery management.

POSITIVE EFFECTS: Improved sport fisheries (due to growth and reinundation of shoreline vegetation, concentration of forage fish; "new lake effect"), some success with Hydrilla control, reestablishment of littoral and shallow water vegetation (such as water lily, Vallisneria) which had not been observed for many years.

NEGATIVE EFFECTS: Observed some settling and cracks in houses, seawalls, and other lakeside structures which had been originally built on fill or muck; trees along the bank (especially maples) may be affected during extended drawdown; fishkills observed in downstream canals (anoxic conditions) during no-flow conditions, large growth of littoral zone vegetation (especially cattails) which can cause problems after reinundation; some lakes may need hyacinth and floating islands removed after reinundation; potential water supply or frost protection concerns for agriculture around the lakes.

KEYWORDS: Florida lakes, fisheries management, spring drawdown

Johnson, Bill and John Denton (con't)

AVAILABLE PRINTED INFORMATION: Many annual and final reports concerning drawdown as a fishery management technique in Florida, including Lake Tohopekaliga, Lake Carlton, Lake Griffin, and other Central Florida lakes. All reports and publications available from the FGFWFC office and from the personal collections of Bill Johnson are included in the Literature Review Database.

OTHER COMMENTS: The FGFWFC has found that public relations before drawdown is a very important part of their program, especially in areas (such as around Apopka) of agricultural and residential concerns. Issues such as what the lake will look like during the drawdown and the effects of reinundation (floating islands, cattail and other littoral zone growth) are important to explain before the drawdown begins.

General succession of plant species in exposed areas: Eleocharis, then cattails, pigweed, willows, primrose willows, Scirpus.

OTHER SUGGESTED CONTACTS: Vince Williams, Kissimmee FGFWFC; Georgia Game and Fish Division

Jude, David J.
University of Michigan
31161 S.T. Building
Ann Arbor, MI 49505

WHEN AND HOW CONTACTED: Letter sent November 1989

STUDY LOCATIONS: Three Michigan lakes

DRAWDOWN TIMING/DURATION: Winter drawdowns

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: A four-foot drawdown was conducted in Woodland Lake to control Eurasian watermilfoil. Aquatic weeds were killed back to the sediment surface, but by July, pioneering species (usually Vallisneria and Chara) began to grow and by August the growth appeared as if no drawdown had occurred. Drawdown on this lake was effective for a few months and did not cost anything. This is the fifth year of winter drawdown; there has been a noticeable consolidation of sediments and drawdown allowed homeowners a chance to clean their beaches.

Sanford Reservoir was drawn down in winter 1978 to control heavy growths of Eurasian watermilfoil. Biomass was reduced and sediments were consolidated. However, refilling was conducted too early in the spring and ice brought up logs from the bottom of the reservoir which were a navigational problem. Some wells around the Reservoir also went dry.

Thompson Lake also had large growths of aquatic plants, especially watermilfoil. A drawdown was conducted which killed some plants, allowing better access to the lake and resulting in some consolidation of sediments. Dr. Jude implies that drawdown needs to be conducted on a regular (probably annual) basis to get adequate macrophyte control.

POSITIVE EFFECTS: Macrophyte control for several months, no costs in some cases, sediment consolidation, improved access

NEGATIVE EFFECTS: Macrophyte control short-lived, wells dewatered, logs from the bottom a navigational hazard.

KEYWORDS: Michigan lakes, macrophyte control

AVAILABLE PRINTED INFORMATION: none

OTHER SUGGESTED CONTACTS: none

Layher, William G.
Environmental Services Section
Kansas Department of Wildlife and Parks
RR 2, Box 54A
Pratt, Kansas 67124
(316) 672-5911

WHEN AND HOW CONTACTED: Letter sent December 1989

STUDY LOCATION: Reservoirs in Kansas

WATER LEVEL FLUCTUATION TIMING/DURATION: rising water level in spring to improve fish spawning and nursery conditions, followed by mid-summer drawdown for revegetation of the fluctuation zone and to increase forage availability for piscivorous fish.

LAKE SIZE: variable

OBJECTIVES OF WATER LEVEL MANIPULATION: fisheries enhancement, waterfowl attraction, facilities protection, water clarity

SUMMARY: The Kansas Department of Wildlife and Parks annually recommends lake and reservoir water level management plans for select reservoirs in Kansas. Benefits can be categorized as: 1.) improved fish populations: increase prey fish production and reproduction, recruitment and growth of sportfish; 2.)improved waterfowl attraction: increase waterfowl habitat through the timely flooding of natural and planted vegetation; 3.) facility protection:

pool drawdowns prevent flooding of facilities by providing a buffer for spring inflows, and protect shoreline from ice damage; and 4.) improved water clarity: pool drawdowns allow the compaction of silt deposits and the re-establishment of vegetation on exposed mud flats resulting in reduced wave action turbidity. The decomposition of vegetation causes settling of suspended silt particles.

POSITIVE EFFECTS: improved fish populations, waterfowl attraction, facility protection, water clarity

NEGATIVE EFFECTS: Due to uncontrollable weather conditions, a plan may have to be implemented for several years to achieve the desired results.

KEYWORDS: Kansas reservoirs, water level fluctuations, fishery management

AVAILABLE PRINTED INFORMATION: (included in Review Database) -Groen, C.L. and T.A. Schroeder, 1978. Effects of Water Level Management on Walleye and Other Coolwater Fishes in Kansas

Reservoirs. Am. Fish. Soc. Spec. Publ. 11:278-283.
-Kansas Department of Wildlife and Parks publications (4).

McCune, Mac
Lake Management Services, Inc.
P.O. Box 923/708 Highway 90A
Richmond, TX 77469

SUMMARY: This consulting firm has been involved with several drawdown projects and would be available for consulting.

McNabb, Thomas J.
President
Aquatics Unlimited
2150 Franklin Canyon Road
Martinez, CA 94553
(415) 370-9179

WHEN AND HOW CONTACTED: Letter sent November 1989

STUDY LOCATIONS: Michigan

DRAWDOWN TIMING/DURATION: winter, early 1980's

LAKE SIZE: unknown

OBJECTIVES OF DRAWDOWN: macrophyte control

SUMMARY: Dr. McNabb writes that Aquatics Unlimited was involved with the control of watermilfoil via drawdown techniques in the State of Michigan in the early 1980's, but is unable to locate any publications or information on these projects. They were successful in reducing milfoil growths in areas where the hydrosoil was exposed to freezing conditions throughout the winter months.

POSITIVE EFFECTS: milfoil growth reduced

NEGATIVE EFFECTS:

KEYWORDS: Michigan lakes, macrophyte control

AVAILABLE PRINTED INFORMATION: none

OTHER SUGGESTED CONTACTS: none

Moxley, Danon
Florida Game and Freshwater Fish Commission
Lakeland, Florida

WHEN AND HOW CONTACTED: Telephone on January 10, 1990

STUDY LOCATION: Hunter Lake, Florida

DRAWDOWN TIMIMG/DURATION: winter drawdown, 1983

LAKE SIZE: 103 acres

OBJECTIVES OF DRAWDOWN: reestablish desirable plant species, fishery enhancement

SUMMARY: Hunter Lake is an urban lake subject to stormwater runoff and watershed nutrient loading. A drastic drawdown was conducted in 1983 to set back the aging process, remove some sediments, dry and compact remaining sediments, establish plant growth in littoral zones, and improve fishery resources. During drawdown, the lake bottom was physically sculpted to create a littoral zone which future limited annual water level fluctuations would expose for plant maintenance. Grass carp were stocked to control anticipated hydrilla growth; however, carp were overstocked and other plant species were also consumed.

Game and Fish does not recommend drawdown as a technique to control or improve water quality, but states that drawdown is a very powerful tool for fishery management and establishment and maintenance of desirable plant species. Sediment consolidation and compaction are also results of drawdown to below the littoral zone in Lake Hunter.

Moxley recommends that a three step process for lake management be applied in many Florida urban lakes. 1) conduct a drastic drawdown to oxidize sediments, dredge (if necessary and practical), and sculpt lake bottom to create a littoral zone. 2) conduct annual water level fluctuations, never allowing water level to remain constant for long periods of time. 3) Approximately every 6 years, drawdown the lake water level to expose the created littoral zone; this procedure encourages desirable plant species to become reestablished.

During drawdown of Lake Talquin (northern Florida), millet was seeded in the exposed areas to help the drying process and to help prevent establishment of undesirable vegetation species.

POSITIVE EFFECTS: Desirable plant establishment, fishery management, sediment consolidation and compaction

Moxley, Danon (continued)

NEGATIVE EFFECTS: No water quality improvements, but water quality is not a goal for the G&F.

AVAILABLE PRINTED INFORMATION: Annual Reports

Muench, Bruce
Illinois Lake Management Service
19121 Beck Road
Marengo, IL 60152

WHEN ANT HOW CONTACTED: Letter sent November, 1989

SUMMARY: Mr. Muench sent several references of general interest which are included in the Literature Review Database.

Snow, Phillip D.
Civil Engineering Department
Union College
Schenectady, NY 12308

SUMMARY: Dr. Snow recommends contacting the New York State Department of Environmental Conservation regarding Saratoga Lake drawdown.

Tazik, Pamela P.
Illinois Natural History Survey
607 East Peabody Drive
Champaign, IL 61820

SUMMARY: Ms. Tazik sent a copy of her publication "Effects of Overwinter Drawdown on Bushy Pondweed" J. Aquatic Plant Management 20: 19-21, which is included in the Literature Review Database.

Williams, Vince
Biological Administrator
Florida Game and Fresh Water Fish Commission
207 West Carroll Street
Kissimmee, FL 32741
(407) 847-7293

WHEN AND HOW CONTACTED: Personal interview on December 4, 1989

STUDY LOCATION: Central Florida lakes

DRAWDOWN TIMING/DURATION: Drawdowns in the lakes are scheduled to occur during the dry season (spring), with a optimal duration sediment exposure of 90 days.

OBJECTIVES OF DRAWDOWN: Fisheries habitat management and enhancement

SUMMARY: The FGFWFC has conducted lake drawdowns for fisheries management since the early 1970's. Early spring drawdowns result in sediment exposure and germination of many species of aquatic plants. This results in improved food supply for young-of-the-year game fish species, as well as forage fish. The FGFWFC has found that a 7-year drawdown cycle is usually necessary in poor water quality lakes to maintain the game fishery. For Lakes Toho and Kissimmee, no improvements in water quality was observed during or after drawdown. Several lakes have had to implement an aquatic plant eradication program for extensive floating mats of cattail which germinated during drawdown and floated to the surface after refill. Dr. Williams believes that Apopka would need to be dewatered (using pumps) to below the muck level (about 6 feet to be effective)- this would probably require 12 months of pumping or more. He also expects that a weed control or eradication program (such as aerial spraying) would be necessary to remove mats of cattails and other species. The FWGFC believes that an extensive drawdown in Lake Apopka is the only lake restoration technique which will result in any improvement in the Lake, but that external loadings (especially from the muck farms) will have to be halted before any lasting improvement is possible.

POSITIVE EFFECTS: Fisheries improvement, littoral zone revegetated

NEGATIVE EFFECTS: Floating mats of vegetation need to be controlled

KEYWORDS: Florida lakes, fishery management

AVAILABLE PRINTED INFORMATION: Many reports available; reviewed in the Literature Review Database.

APPENDIX B:

LITERATURE REVIEW DATABASE

Aggus, L. R. 1971. Summer benthos in newly flooded areas of Beaver Reservoir during the second and third years of filling 1965-1966. Reservoir Fisheries and Limnology, Special Publications No. 8, American Fisheries Society. pp. 139-152.

STUDY LOCATION: Beaver Reservoir, Arkansas

DRAWDOWN TIMING/DURATION: n/a; reservoir filling

LAKE SIZE: 28,219 acres

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Multiple plate samplers showed that areas of recently flooded herbaceous vegetation contained greater numbers and biomass of benthos than did cleared areas or those with woody vegetation. Recently inundated herbaceous plants presumably provide space for attachment, food, and refuge from predators. Cleared areas were less productive than areas with vegetation and were subjected to greater and more rapid erosion. The typical summer decline in the number of organisms was more rapid after the breakup or decomposition of herbaceous vegetation, and decreases in chironomid abundance coincided with conspicuous increase in the rate of shoreline erosion and sediment redeposition.

POSITIVE EFFECTS: Recently inundated herbaceous vegetation provides habitat and forage for greater numbers of benthos; the "new reservoir" effect.

NEGATIVE EFFECTS:

KEYWORDS: Reservoir filling, benthos, Arkansas

COPY OBTAINED: Yes

Aggus, L.R. and S.A. Lewis. 1976. Environmental conditions and standing crops of fishes in predator-stocking-evaluation reservoirs. Proceedings of the Annual Conference of Southeastern Association of Fish Wildlife Agencies 30:131-140.

STUDY LOCATION: Variable reservoirs

DRAWDOWN TIMING/DURATION: Variable

LAKE SIZE: Variable

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: Of eleven environmental variables tested (from 23 reservoirs) by multiple regression analysis, only storage ratios (i.e., reservoir volume divided by the annual outflow volume), outflow volume, growing season, and total dissolved solids were consistently related to the standing crop of fish. Total standing crops and crops of sunfishes, clupeids, and small fishes were larger in impoundments with rapid rates of water exchange (storage ratio < 0.165, as in mainstream reservoirs) than in storage reservoirs with slow rates of water exchange. During periods of high inflow, storage reservoirs may become similar to mainstream reservoirs in terms of hydrology, fish standing crops, and fish community structure. Standing crops of all fishes increased more in storage reservoirs than in mainstream reservoirs after the high inflows of 1973. During 1973, flooded shoreline vegetation in the 23 fluctuating reservoirs added a new source of detritus, but the effects of water-level fluctuation (in vertical feet) were not significant, although relations were generally positive. Combinations of environmental variables explained 41-67% of the variation in the standing crops of selected taxa.

POSITIVE EFFECTS: Increased standing crop of all fishes, increased detrital input

NEGATIVE EFFECTS:

KEYWORDS: Reservoirs, fisheries

COPY OBTAINED: Abstract in Ploskey (1982)

Anderson, W. and G. H. Hughes. 1977. Hydrologic considerations in dewatering and refilling Lake Carlton, Orange and Lake Counties, Florida. U. S. Geological Survey, Water Resources Investigation 76-131.

STUDY LOCATION: Lake Carlton, Florida

DRAWDOWN TIMING/DURATION: n/a; feasibility study

LAKE SIZE: 382 acres

OBJECTIVES OF DRAWDOWN: Sediment consolidation

SUMMARY: Lake Carlton, a 382-acre (155 hectare) lake in Lake and Orange Counties in central Florida is highly eutrophicated and subject to algal blooms. It is proposed to correct this problem by dewatering the lake long enough to allow the muck on its bottom to dry and compact, which will allow seed believed to exist in the muck on the lake bottom to germinate. The predicted time required to dewater the lake at a pumping rate of 50,000 gallons (190 cubic meters) per minute is 21 days. The average pumping rate required to maintain the lake in a dewatered condition is computed to be 2,400 gallons (9.08 cubic meters) per minute. The natural average rate of input between May 31 and October 31 is enough to cause the lake to rise from 48 feet (15 meters) to 56 ft (17 meters) above mean sea level. Supplementing the natural input between May 31 and October 31 at a rate of 4,800 gallons (18.4 cubic meters) per minute will cause the lake level to rise from 48 feet (15 meters) to 63 feet (19 meters).

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Carlton; feasibility study; sediment consolidation

COPY OBTAINED: Yes

Anderson, W. 1971. Hydrologic considerations in draining Lake Apopka- A preliminary analysis, 1970. Open-file Report 71004; United States Department of the Interior Geological Survey, Water Resources Division.

STUDY LOCATION: Lake Apopka, FL

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: A muck layer covered 90 percent of the lake bottom to thicknesses that averaged 5 feet and ranged up to 40 feet by 1968. Probable effects of drawdown to consolidate sediments were examined using a water budget model. Draining the lake is contingent on adequate capacity downstream to convey water at the rate required. The capacities of Apopka-Beauclair Canal and Dora Canal are marginal and may well be the limiting factor in evaluating the feasibility of the project. The design of the upstream lock-gate sill dictates that the lowest level to which Lake Apopka could be drained by gravity is 62.0 ft MSL, and this is possible only if the levels of Lakes Dora, Harris, and Eustis were more than a foot below their average levels for January through March. Assuming inputs to the lake and outputs from the lake (other than canal discharge) are equal, the time required to lower the lake by gravity alone to 62 ft MSL exceeds 7 years. Pumping would be required for faster drainage. Refilling the lake without pumpage would take over 450 days. If pumpage is used, the downstream lakes could be allowed to rise to a foot above normal during the drainage period to provide makeup water for backpumping during the refill stage.

POSITIVE EFFECTS: Potential sediment consolidation

NEGATIVE EFFECTS: Maintenance of the water balance to muck farms will not be possible when lake levels are lowered to below 64 ft MSL because the normal input to the farms by gravity flow and seepage through the dike will be eliminated. The canals and lakes downstream of Lake Apopka may not have the capacity to handle the amounts of water necessary to drain the lake in a timely manner.

KEYWORDS: Lake Apopka, hydrologic study

COPY OBTAINED: Yes

Arner, D.H., W.J. Lorio, B.M. Teels and E.D. Norwood. 1971. The effects of age and water fluctuations on the limnological factors of impounded waters. Mississippi Water Resources Research Institute, Mississippi State University Completion Report A-047-Miss.

STUDY LOCATION: Bluff Lake and Oktibbeha County Lake, Mississippi - reservoirs

DRAWDOWN TIMING/DURATION: Fall drawdown, 5-6 feet

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Water supply

SUMMARY: Effects of reservoir age and drawdown were studied by comparing the plankton, chlorophyll levels, benthos, fish, and water chemistry of Bluff Lake, Mississippi (an old lake subjected to drawdown), to that of Oktibbeha County Lake, Mississippi (a new lake with stable water levels). Drawdown had no obvious effect on the populations of phytoplankton and zooplankton, which reached peak abundance in the fall in both lakes. Bluff Lake did exhibit a strong spring algal bloom that was lacking in the new non-fluctuating lake. Chlorophyll concentrations were significantly higher in Bluff Lake than in Oktibbeha Co. Lake during the fall drawdown period. Indications are that Bluff Lake is more productive than the other lake. Because no significant difference was noted in the numbers or weights of benthic taxa in the two lakes, the authors concluded that the 5- to 6-foot drawdown of Bluff Lake had no effect on benthos. However, all of the sampling stations in Bluff Lake were below the drawdown limit. Largemouth bass and bluegills collected from Bluff Lake had better condition factors than those from Oktibbeha Co. Lake. Rotenone sampling indicated that the sport-fish populations were low in both lakes but that there were more harvestable-sized fish in the drawdown lake. Drawdown apparently increased the amount of prey fish available to piscivores.

POSITIVE EFFECTS: Increase in harvestable-sized fish

NEGATIVE EFFECTS: No effect on benthos

KEYWORDS: Mississippi reservoirs, fall drawdown, fisheries management

COPY OBTAINED: Abstract in Ploskey (1982)

Baker, L. A., P. L. Brezonik, and C. R. Kratzer. 1985. Nutrient loading models for Florida lakes. Lake and Reservoir Management: Practical Applications, Proceedings of the Fourth Annual Conference and International Symposium of the North American Lake Management Society.

STUDY LOCATION: Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: Input/output (I/O) models to predict lake trophic state have been developed primarily for phosphorus-limited, temperate lakes. These models tend to overestimate chlorophyll a in N-limited lakes, and have not been evaluated for subtropical lakes. Data from 101 Florida lakes were used to evaluate chlorophyll a-total phosphorus (Chl. a-TP) relationships; a subset of 40 National Eutrophication Survey (NES) lakes was used to examine and modify P-loading models and to develop analogous models for N-limited lakes. Most lakes in the data set are well-mixed and do not exhibit major seasonal trends in chl. a or major nutrients characteristic of temperate lakes. Forty-five percent of the lakes - including nearly all the most eutrophic lakes - are N-limited. The chl. a-TP relationship for 33 P-limited lakes shows that there is less chl. a per unit TP in these lakes than in temperate lakes. Existing phosphorus loading models were modified and used with the observed chl. a-TP relationship to develop revised P loading criteria for Florida lakes. Statistical relationships and I/O modeling concepts were used to develop N-loading models. Nitrogen loading criteria based on Dillon's (1975) approach were successful in classifying trophic status of the NES lakes. For lakes with known nutrient limitation, the appropriate models (N or P) should be used to evaluate trophic status. For lakes in which nutrient status may be altered by perturbations (e.g., addition of sewage), both N and P models should be used; the correct model is the one that produces the lower estimate of chlorophyll a or trophic status.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Florida lakes; nutrient loading models

COPY OBTAINED: Yes

Barman, E.H., Jr. and Baarka, David G. 1978. An evaluation of the effects of drawdown on the trophic status of a small reservoir. Prepared by the Georgia College Center for Environmental Study and Planning in cooperation with Environmental Resources Center, Georgia Institute of Technology. ERC 01-78.

STUDY LOCATION: Lake Laurel, central Georgia

DRAWDOWN TIMING/DURATION: October 1975 to March 1976. Six months.

LAKE SIZE: 13.3 acres

OBJECTIVES OF DRAWDOWN: Water quality improvement

SUMMARY: Lake Laurel is a small eutrophic lake which was drained in 1975-76 and the sediments allowed to dry for six months. Post-drawdown data showed that total phosphorus, total soluble phosphorus, and orthophosphorus concentrations in the water column were significantly lower after drawdown. Significant reductions in phytoplankton biomass and periphyton production were observed during the summer following drawdown, but were near those observed before the lake was drained by the summer of 1977. High levels of iron were observed in the water column just above the sediment surface after drawdown. Increases in organic compounds near the sediment surface and decreases in the amounts of oxalate extractable iron in the sediments were observed after drawdown. No changes were observed in DO, BOD, turbidity, sulfide, nitrate, or nitrite concentrations.

POSITIVE EFFECTS: Decreased TP, total soluble P, and ortho-P in water column after drawdown. Reductions in phytoplankton and periphyton for one year.

NEGATIVE EFFECTS: Elimination of benthic invertebrates from the exposed sediment areas. Low dissolved oxygen levels remained after drawdown and refill. Reductions in phosphorus concentrations and phytoplankton populations appear to be temporary, lasting only 1 year after drawdown.

KEYWORDS: Georgia reservoir, water quality, phytoplankton, benthos, drawdown

COPY OBTAINED: Yes

Bayley, S. E., J. Zoltek, Jr., A. J. Hermann, T. J. Dolan, and L. Tortora. 1985. Experimental manipulation of nutrients and water in a freshwater marsh: effects on biomass, decomposition, and nutrient accumulation. Limnology and Oceanography, 30:500-512.

STUDY LOCATION: Clermont, Florida, freshwater marsh

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Experimental freshwater marsh plots (2,000 m^2) received 9.6, 3.7, and 1.5 cm wk^{-1} of treated sewage effluent and the control plot received 4.4 cm wk^{-1} potable water during a 2-year study. Surface water elevation above the peat substrate average 0.2 m in the second year. During the first year the marsh surface remained dry. Application of treated effluent increased net primary production only during the dry year. During the wet year there was no significant difference between the highest effluent plot and the control plot in aboveground biomass, or in phosphorus content in the aboveground live or dead vegetation and in the belowground vegetation. Based on the 2 years of study, a natural increase in water level above the marsh surface had the same effect on the marsh production and nutrient accumulation as did application of 42 g P m^{-2} yr^{-1} in treated effluent. This was presumably due to the release of P from the peat substrate under flooded conditions.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Release of phosphorus under flooded conditions

KEYWORDS: Freshwater marsh, phosphorus release

COPY OBTAINED: Yes

Beard, T. D. 1973. Overwinter drawdown. Impact on the aquatic vegetation in Murphy Flowage, Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin #61.

STUDY LOCATION: Murphy Flowage, Wisconsin

DRAWDOWN TIMING/DURATION: Winter, 1967-68 and 1968-69; 70% reduction in water volume

LAKE SIZE: 180 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: A lowering of water levels on 180-acre Murphy Flowage during the winters of 1967-68 and 1968-69 significantly reduced the relative abundance and acreage of aquatic vegetation. Before the drawdown, about 75 acres (42% of the flowage) were covered by plants, to the extent that fishing was almost impossible from June through the summer. After two over-winter drawdowns, 60 of the 75 acres were open to fishing. Five of the six plant species that dominated the flowage before drawdown were most affected, and densities of these five species were reduced greatly after two drawdowns. Management implications involving the use of an over-winter drawdown to control aquatic vegetation are discussed.

Considerations when using an overwinter drawdown for macrophyte control include: 1) type of vegetation; some are susceptible and some aren't; 2) invasion of aquatic vegetation after drawdown; 3) phytoplankton bloom; 4) wells may go dry; 5) severity of drawdown; 6) timing and number of drawdowns; 7) winter kill of fish; 8) increase in fishing pressure on concentrated number of fish; 9) other uses, such as fish, waterfowl or wildlife use must be considered.

POSITIVE EFFECTS: Significant reduction in aquatic vegetation after two winter drawdowns.

NEGATIVE EFFECTS: Invasion of aquatic vegetation species; shallow well went dry; muskrat and beaver use curtailed.

KEYWORDS: Wisconsin, winter drawdown, macrophyte control

COPY OBTAINED: Yes

Beard, T. D. 1969. Impact of an overwinter drawdown on the aquatic vegetation in Murphy Flowage, Wisconsin. Wisconsin Department of Natural Resources, 16 p.

STUDY LOCATION: Murphy Flowage, Rusk County, Wisconsin

DRAWDOWN TIMING/DURATION: 3 consecutive years; winter, 6 months

LAKE SIZE: 180 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control, lake access

SUMMARY: Drawdowns occurred in 1967, 1968, and 1969. Usually the water level was dropped in late October and maintained 1.5 m below normal until the next March. The surface area and total water volume were reduced by 45 and 70%, respectively. There was little or no direct cost. Before drawdown 32 ha were choked with vegetation. Two summers later this was reduced to only 4 ha. Some species were resistant to drawdown and others reinvaded quickly. Planktonic algal blooms were experienced one year after reduction of the macrophytes. The primary predator species, northern pike (Esox lucius), increased their feeding activities during each drawdown. However, based on data extrapolations the small bluegills apparently outnumbered the northern pike by about 415 to 1 and the increased predation probably had no effect on the dynamics of the bluegill population. After drawdown the consumption of bluegills by largemouth bass increased greatly, apparently due to an increased accessibility of and preference for bluegills (macrophyte densities were reduced by drawdown) and to a reduction in other foods. There was a drastic reduction in the young bluegills in two out of the three years of drawdown. There was also a slight increase in the abundance of larger bluegills.

POSITIVE EFFECTS: Increased bluegill consumption by largemouth bass; macrophyte biomass reduction.

NEGATIVE EFFECTS: Drastic reduction in young bluegills.

KEYWORDS: Wisconsin, macrophyte control, winter drawdown

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Bennett, G. W. 1954. The effects of a late-summer drawdown on the fish population of Ridge Lake, Coles County, Illinois. Transactions of 19th North American Wildlife Conference, 259-270.

STUDY LOCATION: Ridge Lake, Illinois

DRAWDOWN TIMING/DURATION: Consecutive years for an overall period of 10 years; September - December (4 months)

LAKE SIZE: 17 acres

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: At two-year intervals for 10 years, Ridge Lake was drained in March to facilitate census of fish populations. In 1951 and 1952, the area of the lake was reduced by drawdown from 17 acres in early September to 5 acres in December, when runoff began to refill it. Fishery data collected during and after the drawdown were compared with data collected in the preceding 10 years (primarily 1947, 1949, and 1951), when water levels were relatively stable. From the standpoint of individual fish, no loss of bass resulted from drawdown. In years when the lake was drained in March and small fish were culled, production of bass fry was relatively heavy - suggesting that survival of young bass was largely controlled by predation. Drawdowns probably greatly reduced the benthos of Ridge Lake, because some invertebrates were trapped in macrophytes or depressions as water receded. The concentration of aquatic animals in a reduced volume of water exposed them to predators, which probably accounted for the greatly reduced number of fish-food animals. Numbers of bluegills, especially the smaller ones, were severely reduced by drawdown. The extent of drawdown probably was too severe (especially with respect to its effect on bluegills). A more nearly optimum amount of drawdown probably could be determined by further study. This preliminary experiment suggests that there may be a considerable difference in the effect of severe drawdown on various segments of a fish population. The drawdown had almost no effect on bass numbers, while bluegill numbers were drastically reduced due to being trapped under drying vegetation during drawdown and predation in small lake volume remaining.

POSITIVE EFFECTS: No reduction in bass population resulted from drawdown.

NEGATIVE EFFECTS: Reduction in benthos, fish-food animals, and bluegills as a result of the drawdown.

KEYWORDS: Severe drawdown, Illinois, fisheries management

COPY OBTAINED: Yes

Bennett, G. W. 1962. Theories and techniques of management. Chapter 6 in Management of Artificial Lakes and Ponds. 283 pp.

STUDY LOCATION: Variable

DRAWDOWN TIMING/DURATION: Variable

LAKE SIZE: Variable

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: Techniques for fish sampling, removal (draining and poisoning), and population adjustment, as well as lake fertilization, vegetation control, and water-level manipulation are discussed in this chapter. Drawdown is viewed as a means of changing the relative abundance of fishes to favor the species important to man. Exposure of sediments to the atmosphere during drawdown increases decomposition and soil pH. Under these conditions greater quantities of potassium and phosphorus are available. Exposure of bottom sediments to the air is considered more important to fish production than is the growth of terrestrial vegetation after drawdown. Drawdown does not greatly affect most macrophytes and is not considered to be an effective method of control. In fact, Potomogeton crispus expanded its habitat lakeward as drawdown occurred. On reflooding, it was established at greater depths. Drawdown strands and kills invertebrates or exposes them to new environmental conditions that decrease their chances for survival. Many small fishes also become stranded and perish. Those that migrate must leave the protection of vegetation and are exposed to increased predation. The net result is a selective culling action, which reduces the number of small sunfishes and thereby improves the changes for a successful bass spawn in the spring after the basin is reflooded. Drawdown to cull fish must reduce the surface area by 50% and force small fish from beds of aquatic plants. Predation will be significant only as long as prey is concentrated and temperatures are above 55° F. Annual cycles of water-level fluctuation have a great impact on fish populations, but even droughts that cause water levels to slowly recede can have an effect. Timing of annual drawdowns to benefit fish and waterfowl often conflict.

POSITIVE EFFECTS: Expansion of habitat and fish food source when lake is reflooded.

NEGATIVE EFFECTS: Drawdown does not control macrophytes; drawdown is detrimental to invertebrates.

KEYWORDS: Reservoirs, fisheries management review

COPY OBTAINED: Abstract in Ploskey (1982)

Benson, N. G. and P. L. Hudson. 1975. Effects of a reduced fall drawdown on benthos abundance in Lake Francis Case. Transactions of American Fisheries Society, 104:526-528.

STUDY LOCATION: Lake Francis Case Reservoir

DRAWDOWN TIMING/DURATION: Annual fall drawdown

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Water storage for winter snowmelt

SUMMARY: Water levels of Lake Francis Case, which are normally drawn down 10-12 m in the fall to make room for inflowing water in the winter, were lowered only 6-7 m in 1971-73. Benthos samples collected in May from 1966 to 1973 showed more than a threefold increase in the density of bottom organisms during the period of reduced drawdown. Increased abundance was most evident in five burrowing taxa (chironomids, Hexagenia, Caenis, oligochaetes, and ceratopogonids). The abundance of benthos in September was similar under both drawdown regimes, except that Hexagonia was very abundant in September 1973. Reduced drawdown in the fall apparently allowed silt deposits to form at higher elevations and increased the amount of habitat for organisms requiring soft substrates.

POSITIVE EFFECTS: Increased benthos abundance following drawdown.

NEGATIVE EFFECTS:

KEYWORDS: Reservoir, fall drawdown, invertebrates

COPY OBTAINED: Abstract in Ploskey (1982)

Borkowski, W. K., L. E. Snyder. 1982. Evaluation of white bass X striped bass hybrids in a hypereutrophic Florida lake. Proceedings of Annual Conference of Southeastern Association of Fish and Wildlife Agencies. 36:74-82.

STUDY LOCATION: Lake Apopka, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Fingerling Morone hybrids were stocked in Lake Apopka, Florida, in an attempt to create a sportfishery in the hypereutrophic lake. The lake was stocked with 635,000 original hybrids (8 fish/ha) in May, 1980 and 315,000 original hybrids (4 fish/ha) in May, 1981. Growth during their first year (age 0) was not rapid for either year class, however, by 23 months the mean total length of the 1980 year class was comparable to that of other hybrids in Florida and the southeast. Analysis of stomach contents indicated extensive use of shad (Dorosoma spp.), although grass shrimp (Palaemonidae) comprised a large part of the stomach contents of hybrids 292 mm total length and smaller. Enthusiastically accepted by anglers, a successful but localized put-grow-and-take sportfishery was created.

POSITIVE EFFECTS: Increased sportfishery

NEGATIVE EFFECTS:

KEYWORDS: Lake Apopka, Florida; fishery management; hybrids; hypereutrophic lake

COPY OBTAINED: no

Boyter, C. J. and M. P. Wanielista. 1973. Review of lake restoration procedures. Water Resources Bulletin, Vol. 9:499-511.

STUDY LOCATION: Varies

DRAWDOWN TIMING/DURATION: Varies

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Results are reported of a search to find what restoration procedure to use for a given lake condition. The restoration procedures considered are applicable to water, the bottom sediments, and aquatic plant improvement. Thirteen suggested methods of restoration are reviewed. The techniques which apply to water include: 1) the elimination of pollutants entering the water from controllable sources, 2) replacing the water with high quality water; and 3) direct treatment of the existing water. Methods to control pollutional releases from the bottom sediments have been divided into three categories: sediment covering, oxygenation, and dredging. Techniques for the removal or control of undesirable plants or plant productivity with the goal of restoring the natural balance are categorized as chemical, mechanical, biological, and physical. Discussion of these procedures and methods should provide pollution control and water management agencies with some additional information for making the choice of the appropriate restoration technique.

Drawdown and water level fluctuation is included as a macrophyte control technique, with the added benefit of increasing sport fish populations.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Lakes, restoration procedures, water quality, bottom sediments, aquatic plants

COPY OBTAINED: Yes

Brezonik, P.L., S.D. Preston, and T.L. Crisman. 1981. Limnological studies on Lake Apopka and the Oklawaha Chain of Lakes 1-4. Water quality and a summary of the four-year data base. Prepared by the Department of Environmental Engineering Sciences for Florida Department of Environmental Regulation. Report No. ENV-07-81-02.

STUDY LOCATION: Lake Apopka and Oklawaha Chain of Lakes, FL

LAKE SIZE: 33,000 acres

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: Data on water quality, biology, and trophic state collected during 1977-1980 in Lakes Apopka, Beauclair, Dora, Eustis, and Griffin in the Oklawaha Chain of Lakes are described. The upstream lakes (Apopka and Beauclair) were the most eutrophic and had the poorest water quality. The five-lake system appears to be in a dynamic steady-state, with considerable year-to-year variability. Peak concentrations of nutrients occurred during different years in the five lakes, with no apparent temporal trends. Spatial patterns are better defined, and a gradual improvement downstream typically was observed. Seasonal patterns in biologically-affected parameters become more obvious in the downstream lakes, whereas water quality variations in Lake Apopka are especially random and largely unrelated to season. This trend reflects the profound influence of the flocculent sediments that cover this large, shallow lake on water chemistry and quality.

KEYWORDS: Lake Apopka background water quality, Oklawaha Chain of Lakes

COPY OBTAINED: yes

Brezonik, P. L. Eutrophication in Florida lakes.

STUDY LOCATION: Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a; background information on Lake Apopka

SUMMARY: Florida has a vast and valuable resource of fresh water in its many springs and thousands of lakes. Practically all these surface waters are useful for recreational purposes; indeed the appeal of Florida to tourists throughout this country results from its abundance of water resources as well as its warm climate. Fishing, boating, and water contact sports are among the year-round attractions of Florida lakes for both residents and out-of-state visitors. Preservation of these lakes in attractive, unpolluted states is thus of vital economic concern. However, many Florida lakes are susceptible to water quality degradation (e.g., proliferation of algal blooms and nuisance aquatic weeds) as a result of what is commonly known as cultural eutrophication. The term "eutrophication" has come into popular use only in the last 5-10 years, and the meaning of the term and the effects of eutrophication on water quality are commonly misunderstood. The purposes of this discussion are to attempt clarification of the nature of the eutrophication problem, to indicate the magnitude of the problem in Florida, and to suggest avenues of remedy.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Apopka; background information

COPY OBTAINED: Yes

Busch, W. N. and L. M. Lewis. 1984. Responses of wetland vegetation to water level variations in Lake Ontario. International Symposium on Lake and Reservoir Management, Third Annual Conference of North American Lake Management Society, USEPA 440/5/84-001.

STUDY LOCATION: Lake Ontario

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Water level fluctuations, a naturally occurring phenomena in the Great Lakes, cause a continuing rejuvenation of lake-influenced wetlands. Two Lake Ontario wetlands (Campbell and Sage Creek Marshes) were mapped for 1 ft. contour intervals and habitat-vegetation type. Historical habitat/vegetation conditions were evaluated through interpretation of aerial photography. The photography was selected to represent water levels different from the current. Habitat types defined at Campbell Marsh and their most important herbaceous species include: 1) narrow-leaved persistent emergents, Typha glauca; 2) aquatic bed, Ceratophyllum demersum; 3) grass sedge, Calamagrostis canadensis; 4) scrub/shrub, Cornus spp., and 5) flooded deciduous forest, Fraxinus spp. Habitat types defined at Sage Creek Marsh and their most important herbaceous species include: 1) narrow-leaved nonpersistent emergent, Sparganium eurycarpum; 2) broad-leaved nonpersistent emergent, Pontederia cordata; 3) aquatic bed, Elodea canadensis and 4) grass sedge, Calamagrostis candensis. Computerized data analysis showed that vegetation types occurred within rather distinctive elevational ranges. As water levels changed, the area of the various habitat types changed, adjusting to both the new water depth and to the size of the area at that depth. In Sage Creek Marsh a large area of narrow-leaved nonpersistent emergents was lost as water levels increased. The greatest loss in Campbell Marsh occurred to persistent emergents; however, this loss did not have a linear relationship to annual mean water depth.

POSITIVE EFFECTS: Wetland vegetation species adjust to changes in water levels.

NEGATIVE EFFECTS:

KEYWORDS: marsh, water level fluctuation, vegetation response

COPY OBTAINED: Yes

Clugston, J. P. 1963. Lake Apopka, Florida, a changing lake and its vegetation. Quarterly Journal of the Florida Academy of Sciences. 26:168-174.

STUDY LOCATION: Lake Apopka, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: Ecological changes have been observed in many Florida lakes over a period of years. Many of these changes have been attributed either directly or indirectly to man. With regard to its plan and animal life, Lake Apopka, Florida, is an example of a changing lake which has been affected by man and his activities. The following paragraphs are a brief description of how Lake Apopka appeared fifteen years ago, a few of the basic changes that have occurred during this interval of time, and a description of the plant life in 1959. Undoubtedly in another fifteen years additional changes will occur in Lake Apopka's ecology. Possibly this report will be useful in determining the changes that may occur in the plant succession and physical changes in the next fifteen year cycle of this lake, and will serve as a clue to the future for this and other lakes in Florida.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Apopka, Florida; aquatic vegetation

COPY OBTAINED: Yes

Conner, J. R., J. E. Reynolds and K. C. Gibbs. 1973. Activities, characteristics, and opinions of lakefront residents: Kissimmee River Basin, Florida. University of Florida, Institute of Food and Agricultural Sciences.

STUDY LOCATION: Kissimmee River, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Water in the Kissimmee River Basin can be controlled by the Central and Southern Florida Flood Control District. Both fluctuating and excessively low water levels have adverse impacts on the residents adjacent to the lakes and streams. In order to assess these impacts on the lakefront property and on aesthetic values held by the residents, studies are needed to identify the population of persons affected, to ascertain their opinions concerning various qualities of the lakes, and to determine the amount of lake use by these residents. The recreational users of the Kissimmee River Basin are of two types: 1) recreational visitors and 2) waterfront residents. This study was concerned with recreational data from a sample of waterfront residents in the Kissimmee River Basin. It was designed to obtain information regarding property values, recreational activities of the residents, effects of different water levels on the participation in different recreational activities, and opinions of the residents regarding the value of lakefront property as compared to other types of property. It was also concerned with the analysis and interpretation of the data obtained from this survey.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: public opinion, drawdown, Lake Kissimmee

COPY OBTAINED: No

Cooke, G. D. 1980. Lake level drawdown as a macrophyte control technique. Water Resources Bulletin Vol. 16:317-322.

STUDY LOCATION: Murphy Flowage, Mondeaux Flowage, Wisconsin; and Louisiana Reservoirs (Anacoco, Bussey, and Lafourche)

DRAWDOWN TIMING/DURATION: Murphy Flowage, 5 month winter drawdown; Mondeaux Flowage, winter drawdowns

LAKE SIZE: 1,831 acres (Murphy Flowage), 410 acres (Mondeaux Flowage)

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Lake drawdown as a management or restoration technique for controlling macrophytes in eutrophic lakes is reviewed. Drawdown is effective, but is species specific, and some nuisance plants are revived or stimulated. Advantages of the technique include low cost, absence of toxic chemicals, enhancement of fisheries, and the opportunity to carry out other improvements. Drawbacks include nutrient release, algal blooms, dissolved oxygen, lake user dissatisfaction during the process, and need to refill. The technique is recommended for situations where susceptible species are the major nuisance and where prolonged (1-2 months) dewatering of sediments under rigorous conditions of heat or cold is possible.

In Murphy Flowage, winter drawdown resulted in control of 5 nuisance species. However, other (resistant) species began to spread after second year drawdown, and there was a heavy algal bloom in August in the year after drawdown. Recommendations are for a drawdown every 2-3 years so that resistant plants not become established as with annual drawdowns. In Louisiana, it was suggested that water level should be fluctuated each year for 2-3 years, and then 2 years of no fluctuation to give best macrophyte control and fish production in Louisiana reservoirs.

POSITIVE EFFECTS: Low cost, absence of toxic chemicals, enhancement of fisheries and the opportunity to carry out other improvements.

NEGATIVE EFFECTS: Nutrient release, algal blooms, dissolved oxygen, lake user dissatisfaction during the process and the problem of refilling.

KEYWORDS: Eutrophic, lake management, lake drawdown, macrophyte control, water quality

COPY OBTAINED: Yes

Cooke, G. D. 1981. In-lake control of nuisance vegetation: a review of eight procedures. Proceedings of a Round Table on Reclaiming and Managing Lakes in Illinois.

STUDY LOCATION: varies

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: macrophyte control

SUMMARY: Several techniques for restoring lakes are known, and each can provide long-term relief from symptoms, following diversion, if properly selected and applied. Eutrophication causes excessive biological production and decreased lake or reservoir volume. Improvement is possible if the sources of plant nutrients and silt are controlled. Following this, both rooted plants and nuisance algae may be limited by restricting light, preventing their growth by physical barriers or cutting, and controlling the recycling of nutrients from storage in lake sediments. Lake restoration cannot treat symptoms alone, but must include land management to control sources of the growth. In-lake restoration methods reviewed in this report are: sediment removal (dredging), aquatic plant harvesting, sediment covering to control nutrient release of rooted plant growth, lake level drawdown, aeration/circulation, dilution/flushing, phosphorus precipitation/inactivation, and biological controls. The report concludes that it is possible to prevent eutrophication of real lakes by planning the development before the lake is built, and that most lakes can be restored to a useful condition that reflects the desired activities of its users. An adequate lake management plan may require resources and time, but it will also give lasting control of eutrophication.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Review, in-lake restoration techniques

COPY OBTAINED: No

Cooke, G. D. 1983. Review of lake restoration techniques and an evaluation of harvesting and herbicides. Lake Restoration, Protection, and Management, pp. 257-266.

STUDY LOCATION: n/a

DRAWDOWN TIMING/DURATION: Variable

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a; review document

SUMMARY: Procedures with proven effectiveness in providing long-term, ecologically sound control of eutrophication symptoms include nutrient and silt diversion, dilution/flushing, phosphorus inactivation, sediment removal, lake level drawdown, and sediment covers. Procedures requiring further demonstration and/or scientific evaluation are hypolimnetic withdrawal, sediment oxidation, biological controls, artificial circulation, hypolimnetic aeration, harvesting, and herbicide-algicide applications. Harvesting may benefit lakes because biomass removal may interrupt nutrient release, tissue decay, and oxygen consumption, and prevent deposition leading to loss of lake volume. Costs are equal to or less than chemical treatments. Research is needed on cutting techniques. Data are presented to support the conclusions that herbicide-algicide treatments are only briefly effective, stimulate nutrient release, increase productivity, and promote oxygen depletion and invasion of resistant or opportunistic species. Further experiments are needed to evaluate questions about these chemicals, emphasizing studies of processes at the actual level of biological organization to which they are applied.

This review finds that lake level drawdown is used successfully to control the growth of certain macrophyte species, to consolidate flocculent lake sediments, to provide an opportunity to repair docks and dams, to remove sediment and for fish management.

POSITIVE EFFECTS: Macrophyte control of some species, sediment consolidation, lakeshore repair, sediment removal, fishery management

NEGATIVE EFFECTS:

KEYWORDS: Review document; harvesting; drawdown

COPY OBTAINED: Yes

Cooke, G.D., E.B. Welch, S.A Peterson, and P.R. Newroth. 1983. Water level drawdown. IN: Lake and Reservoir Restoration. Butterworths, ed., pages 253-274.

STUDY LOCATION: variable

DRAWDOWN TIMING/DURATION: variable

LAKE SIZE: variable

OBJECTIVES OF DRAWDOWN: macrophyte control

SUMMARY: Water level drawdown has been used successfully in many instances to produce at least short-term control of certain species of aquatic plants. This procedure is highly species specific, and some plants are unaffected or may even thrive in it, particularly if competitive plants are eliminated. At present, there is insufficient information to determine whether a summer or a winter drawdown is most effective in plant control. Long periods of drying and freezing are needed (3 weeks or more); therefore, this technique is probably inappropriate in moist, mild climates and in lakes where seepage in winter will keep the lake sediments moist. This procedure is unquestionably among the least expensive lake management techniques. Its use can also reduce the cost of other procedures such as sediment removal or application of sediment covers. A great deal of additional research is needed in the areas of species responses to drawdown, the release of nutrients from reflooded sediments, and the comparative merits of dry-hot versus dry-cold exposure. There is also contradictory evidence regarding the impact of this procedure on fish and other animal populations. Drawdown of enriched or shallow water impoundments will increase the risk of oxygen depletion.

POSITIVE EFFECTS: macrophyte control of some species, inexpensive, can reduce costs of other in-lake procedures

NEGATIVE EFFECTS: some macrophytes increase biomass, technique may be inappropriate in mild climates, other effects not completely understood, increased risk of oxygen depletion.

KEYWORDS: summary, macrophyte control

COPY OBTAINED: Yes

Courtemanch, D. 1986. The restoration of Sebasticook Lake; Final Report by the Maine Department of Environmental Protection. Maine Department of Environmental Protection.

STUDY LOCATION: Sebasticook Lake, Newport, Maine

DRAWDOWN TIMING/DURATION: Annual (since 1982-1985); September-December (4 months)

LAKE SIZE: 4,441 acres

OBJECTIVES OF DRAWDOWN: Water quality improvement

SUMMARY: The restoration plan for Sebasticook Lake included a 3-part program to control point sources from nearby towns, to reduce non-point sources by initiating agricultural BMP's, and to reduce internal sources of P in the lake. Control of the internal P load was initiated in 1982 using enhanced seasonal flushing. Beginning each year in September, the lake is lowered 3.2 meters (46% by volume). This technique has resulted in the elimination of about 18,200 kg of P over the three years this technique has been used (10,250 kg more than expected with no drawdown). Sediment core samples indicate that P in the near surface layers is reduced. Internal loading has shown a decline of 46-85% of pre-project estimates.

POSITIVE EFFECTS: Reduction of sediment P, reduction of water column P and in-lake P load; resulting in decreased incidence, duration, and intensity of algal blooms. Prey-fish populations more balanced. Drawdown as part of an integrated in-lake and watershed management plan appears to be successful for Sebasticook Lake.

NEGATIVE EFFECTS: Effects on predaceous gamefish were undetectable. Catastrophic loss of the mussel population following the first year of drawdown.

KEYWORDS: Maine, enhanced seasonal flushing

COPY OBTAINED: Yes

Crawford, B. 1957. Report on the second fall and winter drawdown on Nimrod Lake - 1956-1957. Arkansas Game and Fish Commission, 8 p.

STUDY LOCATION: Lake Nimrod, Yell and Peery Counties, Arkansas

DRAWDOWN TIMING/DURATION: Fall/winter for 2 years

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Fishery management, sediment consolidation

SUMMARY: Fall/winter drawdowns were implemented in 1955 and 1956. The lake was lowered 3.7 m (surface area reduced to 2.8 km^2) each year. Undesirable species were removed by netting during the drawdown period and rye grass was planted on the exposed sediments. About 93,000 kg of fish were removed during the 1955 drawdown (approx. 2270 kg of gamefish were also caught and released). After this drawdown, the water clarity increased from 10.2-30.5 cm to 91.5-122 cm; the sport fishery improved; and there was an increased survival and growth of the gamefish species. During the second drawdown, the weight of fish removed equalled only about one-third that taken during the first drawdown due to a reduced effort. These fish were in very good condition. The percentage of gamefish caught and released was 34% by number and 17% by weight.

POSITIVE EFFECTS: Improved water clarity; improved sport fishery; increased survival and growth of the gamefish species.

NEGATIVE EFFECTS:

KEYWORDS: Arkansas, fishery management, water clarity, sediment consolidation

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Culver, D. A., J. R. Triplett and G. B. Waterfield. 1980. The evaluation of reservoir water-level manipulation as a fisheries management tool in Ohio. Ohio Department of Natural Resources, Division of Wildlife, Federal Aid Project F-57-R. Study No. 8.

STUDY LOCATION: Ohio reservoirs

DRAWDOWN TIMING/DURATION:

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: Dual problems of high fishing pressure and declining fishing success associated with reservoir aging confront fishery managers in Ohio. Water-level fluctuation (drawdowns and reflooding) can do much to restore high productivity to fisheries of older lakes. In the application of this management technique an attempt is made to revert older lakes to an earlier stage of succession, when fish populations were expanding into new habitat. This study attempts to delineate potential applications of existing techniques of water-level management to enhance sport fisheries of Ohio impoundments. To identify existing techniques, the authors conducted an exhaustive literature survey and interviewed fishery administrators throughout the northeastern United States to ascertain current use of water-level manipulation in the region. Potential reservoir sites were selected for field studies. Available data on Ohio reservoirs were surveyed, and a list of studies that might be performed in Ohio to assess the utility of water-level manipulation was developed.

POSITIVE EFFECTS: "New lake" effects; improved fisheries

NEGATIVE EFFECTS:

KEYWORDS: Ohio reservoirs; new lake effect

COPY OBTAINED: Abstract in Ploskey (1982)

Davies, W. D. 1981. Effects of a fall drawdown on the benthic population of Lee County Public Fishing Lake. Investigations of Management Techniques for Public Fishing Waters. Project F-40.

STUDY LOCATION: Lee County Lake, Alabama

DRAWDOWN TIMING/DURATION: October, 1976 - March, 1977; 3 meters

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Algae control

SUMMARY: The water level of Lee County Public Fishing Lake was lowered 3 m from October, 1976 until March, 1977 in an effort to control filamentous algae. The effects of this drawdown upon the benthic population was determined by means of 1680 core samples taken at 0.61, 1.22, 1.83, 2.44, 3.05, 3.66, and 5.49 m before, during, and after the drawdown. Four dominant groups of organisms were found: ceratopogonids, chaoborids, chironomids, and oligochaetes. The total number of benthic organisms at all depths was either significantly increased (p .05) or at least, unchanged after the drawdown. Each of the four dominant groups also showed individual increases, even though the depth distribution of some groups was slightly altered.

POSITIVE EFFECTS: Increase in benthic organisms.

NEGATIVE EFFECTS:

KEYWORDS: Benthos, benthic invertebrates, drawdown, fall drawdown

COPY OBTAINED: Yes

Davis, J. T. and J. S. Hughes. 1970. Investigations of fish management practices in Bussy Lake. Louisiana Wildlife Fisheries Commission, Federal Aid Project F-7-R8.

STUDY LOCATION: Bussy Lake, Louisiana

DRAWDOWN TIMING/DURATION: Fall drawdown, 8 foot drawdown

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: An 8-foot drawdown was begun in October 1962 to control vegetation. Refilling of the lake started in 1963. The lake was drawn down again in late October of 1965 to manipulate the fish community. Water-level fluctuation effectively controlled aquatic vegetation and forage fishes. Densities of benthic invertebrates increased sharply during and immediately after drawdown, as did populations of game fish. Fishing pressure and harvest on the lake also increased after the drawdown, because fishing improved and interest in the lake project increased.

POSITIVE EFFECTS: Increase in densities of benthic invertebrates and fish and increased fishing harvest following drawdown. Aquatic macrophyte control.

NEGATIVE EFFECTS:

KEYWORDS: Louisiana reservoir, fall drawdown, fishery management

COPY OBTAINED: Abstract in Ploskey (1982)

Davis, J. T. and J. S. Hughes. 1964. The effect of summer drawdown on selected aquatic plants. Job Completion Report, Wildlife and Fisheries Commission, Baton Rouge, LA. 2p.

STUDY LOCATION: Bussey Lake near Bastrap, Louisiana

DRAWDOWN TIMING/DURATION: Winter, 5 months

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Drawdown occurred in 1962 and 1965. The water level was lowered about 2.5 m at a rate near 7.6 cm/day. Drawdown began in late October and refill, in March-February. After the first drawdown, the macrophytes were reduced by over 95%. The rate of fish catch continued to decrease but the weight harvested increased by over 100%. After the second drawdown there appeared to be an increase in the predatory gamefish population. Drawdown temporarily reduced the number of anglers but there was not a significant effect on the quality of the fishery.

POSITIVE EFFECTS: Macrophyte biomass reduction

NEGATIVE EFFECTS: No significant effect on the quality of the fishery resources.

KEYWORDS: Louisiana, winter drawdown, macrophyte control

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Dierberg, F.E., V.P. Williams, and W.H. Schneider. 1988. Water quality effects of lake enhancement techniques used in Florida. Final report submitted to the Water Resources Research Center and the Florida Department of Environmental Regulation.

STUDY LOCATION: Bear Lake, northwest FL

DRAWDOWN TIMING/DURATION: 1975; 1980

LAKE SIZE: 97.2 acres

OBJECTIVES OF DRAWDOWN: macrophyte control, panfish control

SUMMARY: Water level lowered 2.4 m by gravity in both years to control aquatic macrophytes and small panfish; 50% of the bottom exposed. Initial costs were $61.75/acre.

STUDY LOCATION: Lake Carlton, FL

DRAWDOWN TIMING/DURATION: 1977

LAKE SIZE: 392 acres

SUMMARY: Mechanical pumpdown lowered water level 4.0 m; 80% of the bottom was exposed. Infested with rooted aquatic macrophytes two years after refill. Initial costs were $5,177/acre.

STUDY LOCATION: Fox Lake, FL

DRAWDOWN TIMING/DURATION: 1979-1980; 13 weeks

LAKE SIZE: 99 acres

SUMMARY: Triplicate mechanical pumpdown to control Hydrilla. Excessive growth of cattail resulted. Initial costs were $2440/acre.

STUDY LOCATION: Lake Griffin, FL

DRAWDOWN TIMIMG/DURATION: 1984; 8 weeks

LAKE SIZE: 9097 acres

SUMMARY: Period of maximum drawdown (30% of the lake bottom exposed) was 53 days. Lake level lowered 1.8 m. Macrophytes established in exposed bottom for short time. Drying time of thick organic mud limited because of above normal rainfall. Initial costs were $383/acre. The 1984 drawdown did not improve water quality as measured by Trophic State Indices in Lake Griffin.

Dierberg et. al 1988, cont.

STUDY LOCATION: Lake Juniper, FL

DRAWDOWN TIMING/DURATION: 1984

LAKE SIZE: 669 acres

SUMMARY: Water level lowered 2.7 m by gravity, exposing 90% of the lake bottom. Purpose was to establish desirable fishery and aquatic plant community. Initial costs were $62/acre.

STUDY LOCATION: Lake Karick, FL

DRAWDOWN TIMING/DURATION: 1973, 1974, 1976, 1977

LAKE SIZE: 59 acres

SUMMARY: Water level lowered 4.3 m in 1973, exposing 90% of the lake bottom. The 1974, 1976, and 1977 lowerings were 2.3 m with 50% of the bottom exposed. All drawdowns were by gravity. Purpose was to control submerged bladderwort and establish sportsfishery. Success lasted 1 to 2 years. Initial costs were $62/acre for each year.

STUDY LOCATION: Lake Kissimmee, FL

DRAWDOWN TIMING/DURATION: 1977, 12 weeks

LAKE SIZE: 44000 acres

SUMMARY: Period of maximum drawdown was 60 days. Water level was lowered 2.6 m (45% exposure of bottom sediments). Initial costs were $119/acre. Trophic State Indices calculated before and after drawdown indicates that water quality did not improve, and may have worsened, after the drawdown. It appears that drawdowns (without dredging) as practiced in Florida do not lead to an improvement in water quality as measured by a trophic state index.

STUDY LOCATION: Lake Stone, FL

DRAWDOWN TIMING/DURATION: 1970, 1979

LAKE SIZE: 131 acres

SUMMARY: Water level lowered 3.4 m by gravity during both drawdowns for controlling submerged macrophytes (bladderwort and milfoil) and to stimulate a sportfishery. Success was apparent for both objectives. Initial costs were $62/acre.

Dierberg et al. 1988, cont.

STUDY LOCATION: Lake Tohopekaliga, FL

DRAWDOWN TIMING/DURATION: 1971, 1979, 1987; 26 weeks

LAKE SIZE: 20,106 acres

SUMMARY: Period of maximum drawdown during the first drawdown (1971) was 90 days in 1971 and 80 days in 1979. Initial costs were $69/acres, discounting research activities. Lake Toho was eutrophic before the first drawdown in 1971; however, in the first and second year after drawdown, trophic indices increased, indicating worsening water quality. This does not necessarily mean that the worsening water quality was a result of the drawdown; this was a period when sewage treatment plant discharges were increasing at a rapid rate.

STUDY LOCATION: Lake Eola, FL

DRAWDOWN TIMING/DURATION: 1972

LAKE SIZE: 27 acres

SUMMARY: Forty percent of bottom exposed after drawdown and sand added to bottom after dredging. Lake continued to degrade.

STUDY LOCATION: Lake Davis, Florida

DRAWDOWN TIMING/DURATION: 1978

LAKE SIZE: 17 acres

SUMMARY: Two-thirds of the bottom sediment removed (up to 4.1 m depth). Lake depth increased from a maximum of 0.45 m to an average of 1.8 m. Fish stocked. Seventeen stormwater outfalls left intact. Broken sewer main released raw sewage into lake after restoration was completed.

STUDY LOCATION: Lake Hunter, Florida

DRAWDOWN TIMING/DURATION: 1983

LAKE SIZE: 94 acres

SUMMARY: Drawdown by pumping (pumps were donated) completed in 31 days (95% of lake bottom exposed); duration of 4 months. Bottom sediment removed (10,000 cubic yards), deepening lake by 0.4 m. Shoreline contoured to increase littoral zone by 133,000 square feet. Chemical treatment during drawdown and mechanical harvesting (to control cattails; desirable aquatic

Dierberg et al. 1988, cont.

macrophytes planted in littoral zone; lake stocked with triploid grass carp and largemouth bass. No stormwater runoff improvement or diversion measures undertaken. Costs included $155,000 for dredging, resculptering, and revegetation; $40,000 for fish stocking and planning-designing-feasibility studies.

General notes: Nutrient diversion and stormwater treatment were the only two of the four enhancement techniques (nutrient diversity stormwater treatment, drawdown, and grass carp) which resulted in improved water quality. Lowering lake levels in Florida is primarily practiced by the Florida Game and Fresh Water Fish Commission for periodic aquatic habitat enhancement and sport fishery improvement. Lake drawdowns neither enhance water quality nor degrade it to a great extent as expressed by a trophic state index.

Dooris, P. M. and W. D. Courser. 1976. Determining stages and fluctuation schedules for regulated lakes in Central and South Florida. Florida Scientist, 39:14-18.

STUDY LOCATION: Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Approaches are discussed for integrating biological, hydrological, and cultural features of lakes in central and south Florida to determine operating stages and fluctuation schedules designed to approximate historical conditions.

Lack of water level fluctuation has been implicated as a major cause of accelerated accumulation of unconsolidated bottom sediments, decline in D. O., nutrient enrichment, vegetational changes, and reduction of fish and wildlife populations.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: Undesirable changes in lake and wetland biological communities from lack of water level fluctuation.

KEYWORDS: Florida, lake water level fluctuation

COPY OBTAINED: Yes

Dooris, T. C. and B. J. Copeland. 1962. Limnology of the Middle Mississippi River. III. Mayfly populations in relation to navigation water-level control. Limnology & Oceanography, 7:240-247.

STUDY LOCATION: Mississippi River Navigation Pool

DRAWDOWN TIMING/DURATION: 6 weeks, 4 foot reduction

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Navigational control

SUMMARY: Naiads of Hexagenia rigida in Navigation Pool 21 of the Mississippi River were most abundant at the upstream end of the channel during the summer. Densities of naiads were reduced at all stations, especially at near-shore sites, after a 6-week drawdown of about 4 feet.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Reduction in macroinvertebrate standing stock after drawdown

KEYWORDS: Navigation Pool, Mississippi; macroinvertebrate density

COPY OBTAINED: Abstract in Ploskey (1982)

Dooris, P.M., V. Ley and D.F. Martin. 1982. Laboratory experiments as an aid to lake restoration decisionmaking. Water Resources Bulletin, Vol. 18, No. 4, pp. 599-603.

STUDY LOCATION: Sawgrass Lake, St. Petersburg, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 24.9 acres

OBJECTIVES OF DRAWDOWN: Laboratory experiments

SUMMARY: Laboratory experiments are described which were used to evaluate the suitability of sediment from Sawgrass Lake for a drawdown/consolidation restoration procedure. The experiments as described could be applied to other lakes as an aid to decisionmaking in lake rehabilitation projects. Sawgrass Lake is located in Pinellas County on the outskirts of St. Petersburg, Florida. Laboratory experiments conducted included chemical analysis of sediment (water content, organic content, pesticides, nutrients), rate of sediment compaction studies and rehydration at ambient conditions, and the effect of treatment with alum and other chemicals. Several considerations indicated that drawdown was not a good choice for improving the condition of Sawgrass Lake. Chiefly these considerations centered on the composition of the peat or accumulated organic ooze overlying the hard bottom and the physical properties of the overlying organic material. Significant concentrations of chlordane and PCB were found in lake sediment with high concentrations of nitrogen, iron, zinc, and phosphorus. These data indicated the desirability of removing the sediments from the lake. Considering the problems of sediment composition and unfavorable properties, mechanical dredging of the lake was favored over drawdown for restoration. Storm water management problems also favored dredging. This study emphasizes the need for the feasibility evaluation of potential lake rehabilitation methods prior to their being incorporated into a restoration plan.

POSITIVE EFFECTS: No money or time wasted on drawdown that would not have been effective for this particular lake.

NEGATIVE EFFECTS: Lake sediment studies indicated that sediments would require an extremely long drying time, and the presence of toxic materials in sediments indicated that drawdown is not an effective restoration technique.

KEYWORDS: Lake restoration, sedimentation, dredging, Florida, drawdown, sediment control, decision making, management, rehabilitation, lakes, laboratory studies, Sawgrass Lake.

COPY OBTAINED: Yes

Driver, E. A. 1977. Chironomid communities in small prairie ponds: Some characteristics and controls. Freshwater Biology, 7:121-134.

STUDY LOCATION: Saskatchewan, Canada, small prairie ponds

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Natural drawdown

SUMMARY: In small prairie ponds in central Saskatchewan, chironomid diversity depends on the stage of development of the plant community within a moisture gradient. Rapid or complete water-level reduction in a pond maintains a very simple chironomid community of 3 to 10 species and a simple plant community of two to three species. Increased water levels eliminate emergent and submergent plants and associated chironomids.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Prairie ponds, Canada, macroinvertebrates, natural drawdown

COPY OBTAINED: Abstract in Ploskey (1982)

Dunst, R. C., S. M. Born, P. D. Uttormark, S. A. Smith, S. A. Nichols, J. O. Peterson, D. R. Knauer, S. L. Serns, D. R. Winter and T. L. Wirth. 1974. Survey of lake rehabilitation techniques and experiences. Wisconsin Department of Natural Resources, Technical Bulletin No. 75.

STUDY LOCATION: n/a

DRAWDOWN TIMING/DURATION: Varies according to each location.

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: A comprehensive survey of techniques for limiting fertility, controlling sedimentation, and managing eutrophication is presented. Results obtained in almost 600 accounts of management programs provide the basis for evaluating various techniques. Drawdown to consolidate sediments was successfully employed in a number of waters. In Beaver Lake, Wisconsin, for example, drawdown increased the lake depth by 11% after refilling and improved the fishery. Consolidation of flocculent sediments is largely irreversible and may increase nutrients in the lake when it is refilled. Many accounts of successfully control of macrophytes by drawdown are cited. Aquatic macrophytes are reduced primarily as a result of desiccation, freezing, mechanical removal, or soil compaction. Drawdown can be effective in controlling populations of fish by exposing eggs, by stranding small individuals, or by concentrating fish and thereby increasing harvest and predation. When drawdown is implemented in a non-spawning period, timing is less critical, perhaps because predation is the main factor affecting the fish community. Although drawdown can be successful, cause-effect relations are not always clear.

POSITIVE EFFECTS: Drawdown was utilized effectively to consolidate sediments, improve fisheries, and control aquatic macrophytes.

NEGATIVE EFFECTS: Possible increase in fish predation, increased nutrients in water columns

KEYWORDS: Survey; Review; lake management techniques

COPY OBTAINED: Yes

Duthie, H. C. 1968. Ecology of phytoplankton in Lake Belwood, a storage reservoir in Southern Ontario. Journal of Fisheries Research Board Canada 25:1229-1245.

STUDY LOCATION: Lake Belwood, Ontario; reservoir

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN:

SUMMARY: A 16-month investigation, conducted to determine what factors control the seasonal development of phytoplankton in an Ontario reservoir, revealed that populations of blue-green algae and flagellates were reduced in the upper end of the reservoir when water levels of the impoundment were lowered. Densities of phytoplankton below the dam increased at the same time.

POSITIVE EFFECTS: Reduced blue-green algae and flagellates during drawdown

NEGATIVE EFFECTS: Increased phytoplankton densities downstream

KEYWORDS: Ontario reservoir, phytoplankton densities

COPY OBTAINED: Abstract in Ploskey (1982)

Ellis, M. M. 1937. Some fishery problems in impounded waters. Transactions of the American Fisheries Society 66:63-71.

STUDY LOCATION: Variable

DRAWDOWN TIMING/DURATION: Variable

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN:

SUMMARY: Major fishery problems in reservoirs are associated with basin configuration (and the creation of large areas of slack water), reservoir age, water inflow, and water removal. One of the most difficult problems is the decline of fish production as reservoirs age and favorable biological conditions (produced by the solution of nutrients from organic debris and vegetation) are lost. The problem apparently is one of nutrient loss, and fish restocking programs are not entirely successful in restoring productivity. Some nutrients may be provided from plants that develop in areas dewatered during drawdowns, but effective operations for such drawdowns are difficult to schedule when other needs are considered first. Of all factors adversely affecting fisheries, drawdown is the easiest to recognize. Nesting areas are exposed in the spawning season, beds of submerged vegetation are left dry, and fish are often forced into waters that are unsuitable or lethal (anoxic). Some ways to ease the harmful effects of drawdown include the establishment of marginal pools with shallow stable water levels and the construction of floating nest areas that ride at anchor and maintain a constant spawning depth.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Loss of fisheries habitat; loss of nutrients

KEYWORDS: Old review paper, fisheries management, reservoirs

COPY OBTAINED: Abstract in Ploskey (1982)

Environmental Consulting & Technology, Inc. 1989. Bathymetric analysis of Lake Apopka. Project 10-150-01. Prepared for St. Johns River Water Management District.

STUDY LOCATION: Lake Apopka

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: A bathymetric survey of Lake Apopka was conducted using a 2200 foot sampling grid to define the water depth. Results indicate that the lake is generally flat and shallow with 79% of the lake falling between the 1.0 and 2.0 m contours. Results are quite similar with a bathymetric survey completed in 1968. Lake surface area at full stage (66 ft. above MSL) is 30,812 acres. Lowering the lake 2 feet would only reduce the surface area by about 4% due to a relatively steep shoreline drop-off zone. The greatest exposure of lake bottom would occur by lowering the lake to about 60 ft. MSL (down 6 feet from full bank), resulting in a total exposed area of about 85%. Average lake volume at 66 ft, MSL is 6.511 x 10^9 $ft.^3$. The estimate of lake volume at 60 ft. MSL is 0.322 x 10^9 $ft.^3$, indicating that 95.09% of the lake volume, or 6.23 x 10^9 $ft.^3$ of water would need to be drained to expose 85% of the sediment. Drawdown of up to 4 feet would result in very little sediment exposure (1.9% at 1 ft., 3.8% at 2 ft., 8.6% at 3 ft. and 22.7% at 4 ft.). To expose 50% of the lake bottom would require draining 87% of the lake.

POSITIVE EFFECTS: The determination of effective drawdown depths required for improvement.

NEGATIVE EFFECTS:

KEYWORDS: Lake Apopka, bathymetric survey

COPY OBTAINED: Yes

Eschmeyer, R. W. 1949. The fisheries picture - with special reference to TVA impoundments. Progressive Fish Culture 11:267-271.

STUDY LOCATION: TVA reservoirs

DRAWDOWN TIMING/DURATION: Winter drawdown

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Electric generation

SUMMARY: Three significant components of the picture of fish conservation are (1) the importance of fishing for relaxation in a stressful world, (2) the decline in satisfactory angling due to increased fishing pressure, and (3) the realization that more large impoundments will have to support increasing angling pressure. In addition to a discussion of the many different conditions that exist in mainstream and storage impoundments and of general trends in fishing on TVA reservoirs, topics related to water-level changes, such as spawning success, winter drawdown, food-chain interactions, and vegetation are discussed. Slowly declining waters apparently do not decrease spawning success, and under normal operations water levels usually are constant (mainstream reservoirs) or rising slowly (storage reservoirs) at spawning time. Winter drawdown does not seem to hinder the reproduction of game fishes, although rough fishes (bottom feeders such as common carp, buffalo, and adult shad) may be hindered by food shortages. Rough fishes are much more abundant in mainstream reservoirs. Although drawdown helps control rough fishes, it may interfere with boating and degrade aesthetic qualities of shorelines. Aquatic macrophytes seldom become established in storage reservoirs where drawdown is common, but they are present in mainstream impoundments where drawdown is limited to a few feet.

POSITIVE EFFECTS: Control of rough fish

NEGATIVE EFFECTS: Interfere with boating; degrade aesthetic quality of shoreline; negative effects on spawning if water level quickly withdrawn or returned

KEYWORDS: TVA reservoirs, fisheries management

COPY OBTAINED: Abstract in Ploskey (1982)

Fabre, A. 1988. Experimental studies on some factors influencing phosphorus solubilization in connection with the drawdown of a reservoir. Hydrobiologia, 159:153-158.

STUDY LOCATION: Puyvalador Reservoir, Pyrenees, France

DRAWDOWN TIMING/DURATION: Once per year; drained during winter, refill in May. 90% of the sediment is exposed 5-6 months.

LAKE SIZE: 252 acres

OBJECTIVES OF DRAWDOWN: Electric generation

SUMMARY: The periodical drawdown of reservoirs affects the phosphorus cycle. During the dry period the sediments are in immediate contact with the atmosphere, while part of them are resuspended when the water rises again. Experimental studies on the sediments of the Puyvalador reservoir (Pyrenees, France) which is subjected to a considerable drawdown every year, show that the quantity of phosphorus solubilized after resuspension of these sediments varies according to the speed with which the water rises, the preceding desiccation of the sediments and the origin of the water used in the experiments. The intensity with which the sediments are stirred depends on the refilling rate. The observed differences related to the origin of the water of the effluent streams are attributed to their initial ortho-phosphate content and their difference in pH. These variations related to drawdown make it necessary to take this important phenomenon into account when studying the solubilization of phosphorus in reservoirs.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Release of ortho-P when dried sediments are reinundated.

KEYWORDS: France, annual drawdown, phosphorus release

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1974. Oklawaha Basin Fisheries Investigations. Dingell-Johnson Project F-30-1.

STUDY LOCATION: Upper Oklawaha Basin; Lake Apopka, Lake Dora, Lake Griffin

DRAWDOWN TIMING/DURATION: July 1, 1973 - June 30,1974

LAKE SIZE: 31,000 acres, 4,475 acres and 9.378 acres, respectively

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: Sampling recovered 20 species of fish from Apopka (5 game), 22 species from Dora (6 game) and 28 species from Griffin (7 game). More pounds of fish, and more pounds of gamefish were recovered from vegetated (littoral) areas, compared to open water in all lakes for both sampling periods. The exotic cichlid Tilapia aurea was recovered for the first time ever in the Oklawaha chain from Crown Point, Lake Apopka, in the spring of 1974. The average number and weight of harvestable-sized gamefish available to fisherman is highest in Dora, and lowest in Apopka. The stabilization of lake stage and decline in rooted vegetation appear to be related to decline in the sportfisheries. Historic sampling data indicate a reduction in the number of fish species endemic to Lakes Apopka and Griffin. Competition for common food sources may explain the high standing crop of gizzard shad and large numbers of less than harvestable-sized panfish present in all lakes.

Recommendations for food habit studies of gizzard shad and development of a new approach to shad reduction are offered.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Lake Apopka, Lake Dora, Lake Griffin, fisheries management

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1974. Lake Management and Research. Lake Jackson Project F-12-15.

STUDY LOCATION: Lake Jackson, Florida

DRAWDOWN TIMING/DURATION: n/a; natural drawdown

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Lake Jackson has received national acclaim for its sport fishery, especially for trophy-sized largemouth bass, Micropterus salmoides. Although the factors responsible for this excellent fishery are not completely understood or documented, it is believed to be related to the natural drawdown of the lake in 1956. The lake has a history of fluctuating widely and has been dry or very low twice since 1900. Before the drawdown in 1956 the lake was known for large bluegill, Lepomis macrochirus, and shellcracker, Lepomis microlophus. Since 1965 it has been known as a trophy bass lake. Recent development within the basin threatens the ecosystem. A portion of the lake (Meginnis Arm) was damaged prior to the start of this study by siltation from runoff from areas of construction.

POSITIVE EFFECTS: Improved sportfishery

NEGATIVE EFFECTS:

KEYWORDS: Lake Jackson, natural drawdown, fisheries management

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1975. Oklawaha Basin Fisheries Investigations Project F-30-2.

STUDY LOCATION: Lake Apopka, Lake Dora, Lake Griffin

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 31,000 acres, 4,475 acres, 9,373 acres, respectively

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: Sampling recovered 24 species of fish from Apopka (5 game), 27 species from Dora (7 game) and 32 species from Griffin (9 game). More pounds of fish, and more pounds of gamefish were recovered from vegetated (littoral) areas, compared to open water in all lakes for both sampling periods. The average number and weight of harvestable-sized gamefish available to fisherman is highest in Griffin, and lowest in Apopka. The stabilization of lake stage and decline in rooted vegetation appear to be related to decline in the sportfisheries. The sportfish population of Lake Apopka is better than a year ago but still offers little to the fishing public due to the lack of suitable habitat. Lake Dora continues to support a fair fishery with black crappie as the strong species and adequate numbers of bass in the vegetation, but the fishery present is not being utilized. The sportfish population in Griffin has shown steady improvement based on sampling and creel returns.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Lake Apopka, Lake Griffin, Lake Dora, fisheries management

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1975. Water Level Manipulation Project F-29-4. Lake Tohopekaliga Creel Survey. Lower Kissimmee Basin Study.

STUDY LOCATION: Lake Tohopekaliga and Lower Kissimmee Basin, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 22,700 acres for Lake Toho

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: The Lake Tohopekaliga drawdown study was terminated in June 1974, however, the creel program was extended for two years to further monitor fishery responses. It is inevitable that the lakes sportfish populations, which increased dramatically following the drawdown, will eventually reach a peak and subsequently begin to decline. For management purposes, when this point is reached, it will be necessary to implement another drawdown in order to maintain the high quality fishery that was established following the 1971 dewatering. The major problems facing Lake Tohopekaliga are continued water level stabilization, excessive nutrient inflow, and rank, uncontrolled growth of water hyacinth. The first two factors mentioned are direct contributors to the rapid expansion of water hyacinth, which has increased from a narrow perimeter band around the lake during the 1971 drawdown, and now occupies or has affected an estimated 8,000 acres (70%) of the littoral zone. It has already caused extensive damage to this productive area of the lake by completely eliminating several thousand acres of native emergent vegetation. There is little doubt that uncontrolled growth of water hyacinth will necessitate future reestablishment and improvement of littoral communities by dewatering. The damages caused by this plant have considerably shortened the duration of the beneficial effects of the drawdown.

POSITIVE EFFECTS: Improved sportfishery

NEGATIVE EFFECTS: Rank, uncontrolled water hyacinth growth

KEYWORDS: Lake Tohopekaliga, Florida; fisheries management, water hyacinth control

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1976. Water Level Manipulation Project F-29-5. Lake Tohopekaliga Creel Survey.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: 15 months

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Total harvest and effort estimates for all fish creeled from Lake Tohopekaliga exhibit an increase following the 1971 drawdown. This peaked in the winter of 1975-75, and indications were that a decline may have been in progress through spring 1976. Corresponding total success estimates show a declining trend in 1975 and 1976. Largemouth bass harvest and effort increased significantly following the drawdown, and was nearly 4 times greater in 1975 than prior to the drawdown in 1970. Although angler effort remained high, harvest decreased significantly during the winter and spring of 1975-76. Success decreased to an all time low for largemouth bass in spring 1976. Maintenance of this high rate of effort is probably related to an increased catch of "trophy" bass.

POSITIVE EFFECTS: Temporary increased fishery for largemouth bass.

NEGATIVE EFFECTS:

KEYWORDS: Lake Tohopekaliga, Florida; drawdown; fisheries management

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1976. A fishery management plan for the Kissimmee Chain of Lakes with emphasis on a Lake Kissimmee drawdown. April, 1976.

STUDY LOCATION: Lake Kissimmee, Florida

DRAWDOWN TIMING/DURATION: n/a; preliminary study

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: Recreational sportfishing on the Kissimmee chain of lakes has increased phenomenally in the past few years, and indications are that this increase will be even more pronounced in the future. High quality aquatic habitat must be provided to insure adequate resources capable of meeting these future needs. The importance of maintaining desirable biological, physical and chemical conditions within individual lakes logically requires the development and implementation of a systematic basin-wide water management plan.

Drawdown on Lake Kissimmee should provide the following benefits:

1. Temporary control of water hyacinth and elimination of tussock problems
2. Improvement of bottom substrate
3. Increase in density and diversity of desirable vegetation
4. Increase in fish food organisms
5. Substantial increase in sportfish
6. Increased fisherman use
7. Economic

Disadvantages include: 1) initial expense of constructing bypass structure, 2) loss of revenue to local fish camp operators, 3) restricted access.

POSITIVE EFFECTS: n/a; preliminary study

NEGATIVE EFFECTS: n/a; preliminary study

KEYWORDS: Lake Kissimmee, drawdown, fishery management

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1977. Water Level Manipulation Project F-29-6. Lower Kissimmee Basin Study.

STUDY LOCATION: Lower Kissimmee Basin

DRAWDOWN TIMING/DURATION: December 1, 1976 to February 1977; 8 foot decrease

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: The SFWMD began the Lake Kissimmee drawdown on schedule, December 1, 1976, with the opening of the floodgates at control structure S-65 at the south end of the lake. Water levels on Lakes Cypress, Hatchineha, and Kissimmee were lowered to elevation 49.5 MSL by February 15, 1977. At this time an earthen plug was installed in C-37, the canal leading from Lake Hatchineha to Lake Kissimmee, by the SFWMD. During the dewatering period physical capabilities of the system were learned and the following observations made: drawdowns on Lake Kissimmee should be scheduled to take advantage of prevailing northerly winds during the months of January and February; maintenance dredging for navigation during a drawdown is less costly and minimizes environmental damage from siltation; and, repair of public boat ramps less costly during drawdown.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Lake Kissimmee, drawdown, water level manipulation

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1979. Lake Carlton rehabilitation evaluation; fish populations. Project F-30-6.

STUDY LOCATION: Lake Carlton, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Littoral blocknet samples average 690.2 lbs/acre, an increase of almost 100 lbs over those taken in 1975, before the drawdown. There were changes, however, in species composition, and greater numbers and weights were young-of-the-year fish. Total average pounds of fish collected from two limnetic samples dropped from 244.9 lbs/acre in 1975 to 177.0 lbs in 1978. This decrease was due to a loss of 157 lbs/acre of threadfin shad. Thus a net increase of 59.3 lbs/acre was found for game species. The decreasing trend in abundance of total fish taken by seine in Lake Carlton last year continued through August 1978.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Lake Carlton, fisheries management

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1979. Lake Carlton rehabilitation evaluation; benthic invertebrates. Project F-30-6.

STUDY LOCATION: Lake Carlton, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Habitat restoration; fisheries management

SUMMARY: The high diversity and number of invertebrates collected from the deeper contours in February 1978 were not present in the samples taken in August 1978. Higher numbers of organisms, similar to those collected in late summer before the drawdown, were however, found at higher elevations. The number of invertebrate taxons encountered in February 1979 were not as great as were found in years previous to the drawdown. The total transect average approximately equalled the pre-drawdown February 1977 average.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Decrease in benthic diversity and numbers

KEYWORDS: Lake Carlton, drawdown, benthic invertebrates

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1979. Lake Carlton rehabilitation evaluation. Project F-30-6. Reestablishment of rooted aquatic vegetation.

STUDY LOCATION: Lake Carlton, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE:

OBJECTIVES OF DRAWDOWN:

SUMMARY: Measurement of types and amounts of vegetation present following refill of Lake Carlton was made in September of 1978 for comparison with pre-drawdown data. Vegetation mapping following the refill of Lake Carlton indicated that the drawdown was not as successful from the standpoint of increasing aquatic vegetation as previously hoped. Although large numbers of Typha became established on the consolidated and unconsolidated muck areas of the lake bottom during the drawdown none survived refill of the lake. They either became uprooted in the case of those growing on the unconsolidated muds or were flooded over in the case of those growing on consolidated muds. Much of the exposed lake bottom at higher elevations (primarily sand) became covered with a variety of mainly terrestrial plants which germinated and grew profusely during the period in which the lake bottom was exposed, but were flooded out when the lake was refilled.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Drawdown did not increase aquatic vegetation as much as expected.

KEYWORDS: Lake Carlton, aquatic vegetation, drawdown

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1979. Oklawaha Basin Fisheries Investigations. Dingell-Johnson Project F-30-6. Lake Carlton Rehabilitation Study.

STUDY LOCATION: Lake Carlton, Florida

DRAWDOWN TIMING/DURATION: July 1, 1978 - June 30, 1979

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Sediment consolidation

SUMMARY: Studies conducted on established transects showed no detectable change in the distance from shore where the surface of the dried sediments could be felt with a pole, the firmness of this layer, or with the density of the dried mud clumps.

The sediments exposed during the drawdown were capped with a layer of dried mud 2-4 inches thick after a few weeks of exposure. Although the mud was broken up and somewhat mixed with softer sediments, the layer has persisted, following refill, over most of the 133.7 acres of drier sediments since the lake was refilled.

POSITIVE EFFECTS: Consolidation of sediments successful after one year.

NEGATIVE EFFECTS:

KEYWORDS: Lake Carlton, sediment consolidation, pumpdown

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1982. Water Level Manipulation Project F-29-12. Lake Kissimmee Monitoring.

STUDY LOCATION: Lake Kissimmee, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: The extreme drawdown of Lake Kissimmee was completed in October 1977. Restoring and maintaining quality aquatic habitat in Lake Kissimmee is the key to stimulating sportfish populations. All major sportfish species were positively impacted by the 1977 extreme drawdown. By fall 1981, the highest standing crop estimates for the period of record (beginning in 1974) were documented for largemouth bass and redear sunfish, both were present at 50 lbs/acre. In addition, peak biomass estimates were recorded in fall of 1982 for chain pickerel, black crappie and bluegill. Excellent numbers of harvestable largemouth bass, black crappie, redear sunfish and bluegill were collected in littoral blocknet samples at the termination of this study (1982).

Seven species of the families Poeciliidae (livebearers) and Cyprinodontidae (killifish) comprised 92% by number and 78% by weight of all fish present in shallow water areas less than 18" in depth. Numerical abundance and standing crops of these species declined sharply during 1981 when a prolonged drought essentially stabilized Lake Kissimmee. Reflooding of littoral habitat occurred in spring of 1982 and population parameters approximated estimates collected following the 1977 extreme drawdown of Lake Kissimmee. Also, numbers per acre of largemouth bass and bluegill peaked upon reflooding lake bottom marshes in 1982. Young of the year blue tilapia were first collected from Lake Kissimmee in spring 1982 shallow water samples.

POSITIVE EFFECTS: Increased sportfishery

NEGATIVE EFFECTS:

KEYWORDS: Lake Kissimmee, sportfishery, fisheries management, drawdown

COPY OBTAINED: Yes

Florida Game and Fish Commission. 1982. Lake Apopka Sport Fish Investigations Project F-30-9.

STUDY LOCATION: Lake Apopka, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: Background information

SUMMARY: Samples indicated that the largemouth bass population in Lake Apopka is functionally nonexistent, except for a very small area located around Gourd Neck Springs. Adult bass sampled in the freshwater spring area characteristically were large and have high condition factors (K_{SL} averaging 3.36). PSD ratios in Apopka are high (96% for all periods) indicating few largemouth bass between 20-30 cm (8-12 in). Sunshine bass stocked in 1981 showed little change in condition or apparent growth their first year from the first stocking of sunshine bass in Apopka in 1980. Young of the year sunshine bass were collected at a rate of 0.73/5 min of electrofishing in September to October 1981 samples and their collection sites were well dispersed throughout the lake. Approximately 493,820 largemouth bass averaging 35 mm TL were stocked in Lake Apopka in spring 1982.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Electrofishing, sportfishery, Lake Apopka

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1984. Lake Apopka Predator-Sport Fish Investigations. Project F-30.

STUDY LOCATION: Lake Apopka

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: Findings of this study have clearly demonstrated that the remnant population of largemouth bass in Lake Apopka (12,500 hectares) has not received significant recruitment for many years. Studies indicated that sufficient forage was present to warrant experimental stocking. Approximately 500,000 fingerling largemouth bass were stocked in the spring of 1982, thus bypassing reproductive problems caused by the degraded hypereutrophic condition of the lake. Although the largemouth bass population was augmented, the single stocking did not result in sufficient densities to produce a fishery. Growth and condition of the 1982 year class was good. In their second year of life the 1982 year class comprised 71 percent of the population and increased the population of bass $\geq$ Age 1 16 times. Survival of stocked fish at Age 2 was estimated at 5 percent (little mortality occurred in their second year of life). The 1981 and 1982 stockings of hybrid stripers produced a successful fishery which was limited to the area around Gourd Neck Springs for about 3 years. Limited creel data showed a success estimate of 0.41 hybrids per hour. By Age 2, size and condition of the hybrids was similar to other Florida lakes.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Initial stocking was not sufficient to increase bass population effectively.

KEYWORDS: Lake Apopka, sportfishery, fish stocking

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1985. Kissimmee Chain of Lakes Studies Completion Report for Fisheries Management Plan for the Alligator Lake Chain.

STUDY LOCATION: Alligator Lake Chain, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: Total of 27,000 acres for all 10 lakes

OBJECTIVES OF DRAWDOWN: Habitat management

SUMMARY: All 10 lakes included in the Alligator Lake Chain study have been negatively impacted by limited water level fluctuation. Recommendations to improve aquatic habitat and enhance sport fish populations include expanding currently restricted water level schedules to 4 foot ranges in fluctuation. These changes would provide for periodic higher maximum and lower minimum stages; the extremes should be achieved when natural rainfall patterns allow deviation from the relatively static annual fluctuation schedules which are presently employed. By periodically increasing the maximum stages of these lakes, further encroachment onto historic lake bottom would be stopped; this would eliminate future construction in flood prone areas as well as decrease the effects of non-point pollution sources upon these relatively clean systems.

Extreme drawdowns would be viable tools for restoring aquatic habitat in the 10 study lakes. This management program could reverse plant succession, improve bottom substrates and stimulate both forage base and sport fish populations. However to conduct such programs and expect positive benefits, lake front property owners must begin to protect aquatic resources. Presently, illegal and unpermitted vegetation removal, construction of seawalls and alterations of bottom substrate continue along the shorelines of all 10 lakes.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Alligator Lake Chain, water level fluctuation, lake management

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1986. Oklawaha Basin Fisheries Investigations. Project No. F-30-13.

STUDY LOCATION: Lake Griffin, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 9,100 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: A drawdown of Lake Griffin (9,100 acres) was conducted, beginning March 1, 1984, in an effort to consolidate organic sediments and promote the growth of aquatic vegetation, and thus improve the fishery. Although not all goals of the drawdown were achieved, the lake was lowered about 6 ft. for 53 days. Varying degrees of bottom exposure and consolidation were accomplished on 30% of the bottom; however, actual drying of thick organic sediments was limited. Refill to low pool was accomplished in September 1984.

An increased largemouth bass population was observed in the year following drawdown; however, spawning was limited during actual drawdown. During drawdown, germination produced 2,700 acres of aquatic and terrestrial vegetation on the exposed bottom; however, by December 1984, approximately 400 acres remained after refill. Hydrilla and naiad became established after drawdown. Total nitrogen and total phosphorus were significantly higher during drawdown, and did not show improved water quality after refill. During a period of about six weeks in spring 1986, Lake Griffin experienced increased visibility, during which expanding submerged vegetation occurred. Chlorophyll *a* concentrations did not respond to drawdown, but late fall peaks in chlorophyll *a* began earlier and lasted longer than previous fall peaks, possibly in response to increased total nitrogen.

POSITIVE EFFECTS: Improved sportfish spawning success, temporary increased visibility.

NEGATIVE EFFECTS: Establishment of hydrilla, nutrient levels high during drawdown, possible delayed response of chlorophyll *a* concentrations.

KEYWORDS: Lake Griffin, dewatering, fisheries management

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1987. Kissimmee Chain of Lakes Studies Completion Report for Lake Tohopekaliga Investigations.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: 15 months

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Fisheries management; macrophyte control

SUMMARY: Quarterly water samples were collected at 24 locations throughout the upper Kissimmee River Basin from 1979 until the present. Total nitrogen and total phosphorus concentrations at these sites has generally decreased since 1979 (extreme drawdown). Lake Tohopekaliga was once heavily polluted by the effluent of four municipal sewage treatment plants. Recent trends have indicated improved water quality. Further positive changes should be realized as two large STP's have diverted approximately 26 MGD of treated effluent for citrus irrigation and the remaining two STP's plan to implement evaporation pond facilities. Boggy Creek and East Lake Tohopekaliga have continued to exhibit the highest water quality in the system. Decreasing sports fish catches indicate that drawdown is needed every 6 years for rejuvenation of lake.

POSITIVE EFFECTS: Increased sportfishery for 5 years; improved water quality due to diversion of sewage

NEGATIVE EFFECTS:

KEYWORDS: Lake Tohopekaliga, water quality, fisheries management

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1989. East Lake Tohopekaliga 1990 extreme drawdown and muck removal project. An aquatic habitat and fishery management program.

STUDY LOCATION: East Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Habitat improvement

SUMMARY: Extreme drawdowns have been used to improve aquatic habitats in the Kissimmee Chain of Lakes since 1971. Basic results include consolidation of bottom sediments and expansion of rooted aquatic vegetation communities. Following reflooding, numbers of fish food organisms increase tremendously. Two years after the 1971 Lake Tohopekaliga extreme drawdown, fish populations in the lake's vegetated areas more than doubled when compared to pre-drawdown populations. Sport fish species such as largemouth bass, black crappie, bluegill and redear sunfish (shellcracker) all increased in abundance due to improvements in aquatic habitat and food supplies.

Restricted water level fluctuation has resulted in organic muck buildup, plant communities on the formed berms, and a deteriorating sportsfishery. FGFWFC will request that a drawdown and muck removal project be implemented. Major anticipated problems include temporary loss of navigational access.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: East Lake Tohopekaliga, Florida; extreme drawdown; fisheries management; habitat restoration; proposed drawdown

COPY OBTAINED: Yes

Florida Game and Fresh Water Fish Commission. 1989. Lake Hunter - an urban lake restoration project. Unpublished manuscript.

STUDY LOCATION: Lake Hunter, Lakeland, Florida

DRAWDOWN TIMING/DURATION: 5 months; 95% bottom exposure

LAKE SIZE: 101 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Lake Hunter is a 41 ha lake located within the city limits of Lakeland, Florida. A restoration project, begun in 1983 and completed in 1984, was designed to improve the degraded condition of this urban lake. Actual lake restoration was divided into three phases. Phase one dealt with de-watering and fish removal operations. Phase two was the mechanical removal of organic sediment deposits and lake bottom resculptering. Phase three included water control structure modification, development of a lake fluctuation schedule, re-establishment of vegetated littoral zones, fish restocking and control of undesirable vegetation. The Lake Hunter Restoration Project demonstrated the ability of state and local governments to cooperatively develop and implement an urban lake restoration program.

Dewatering by pumping began in December 1983, exposing 95% of the lake bottom for 5 months (December - May). Fish removal operations were undertaken during drawdown to prevent massive fish kills. After dewatering, mechanical removal of the organic sediments was initiated (limited by heavy equipment to approximately 50% of the exposed bottom). Based on a 125 day exposure period, organic mucks consolidated at a rate of 0.25 cm/day. Consolidation decreased the depth of organic sediments in Lake Hunter by 31.8 cm, forming a 15.2 cm thick crust over areas of deep much deposit. After muck removal and consolidation, a littoral shelf was resculptured and revegetated, and the lake allowed to refill. The water fluctuation regime was increased from 0.6 m to 1.0 m. Chemical control of cattail was necessary between May and October in areas not subjected to sediment removal. Refilling was completed in December 1984.

Total phosphorus was significantly higher in the year following drawdown than before, but total nitrogen was not found to have significantly changed. The TSI remained unchanged (75.9), indicating no improvement in Lake Hunter's trophic state. Sportfish stocks improved, and the revegetated littoral zone remained in 90% desirable species one year after drawdown. Total cost of the project was $196,000 ($4,780/ha) excluding pumps and associated equipment.

POSITIVE EFFECTS: Improved sport fishery, sediment consolidation, increased lake volume, increase in desirable vegetation.

NEGATIVE EFFECTS: Increased TP levels, no change in TN or TSI, lake remained highly eutrophic, cattail required chemical control.

KEYWORDS: Dewatering, Florida lakes, Lake Hunter

COPY OBTAINED: Yes

Florida State Board of Health. Bureau of Sanitary Engineering. 1965. Biological, physical, and chemical study of Lake Apopka 1962-1964. Prepared by the Florida State Board of Health, Bureau of Sanitary Engineering, Jacksonville, Florida.

STUDY LOCATION: Lake Apopka, FL

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a; characterization of Lake Apopka pollution sources

SUMMARY: As a result of two years of study (1962-1964), the Board of Health found that the citrus processors, citrus growers, truck farmers, and cities and communities surrounding the Lake, the water conservation activities, fish management activities, and the control of hyacinths have causes an undesirable condition to persist in the lake. Recommendations include: citrus processing industry treat wastes before dumping in lake, truck farms minimize backpumping into the lake, aerial spraying operations stop depositing insecticides (especially DDT) and fertilizers onto the lake surface, citrus fertilization be minimized, any masses of dead fish, especially when numbering in the thousands, be removed from the lake, and reduce the amount of hyacinths killed and left in the lake to decay.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Citrus, pollution, fertilizers, agricultural pollution

COPY OBTAINED: yes

Florida Technological University and Orange County Pollution Control Department. 1972. Lake Eola Restoration - Phase II. Presented to the Public Works Director, Orlando, Florida.

STUDY LOCATION: Lake Eola, Orange County, Florida

DRAWDOWN TIMING/DURATION: 4 months, summer; 50% bottom exposure

LAKE SIZE: 27 acres

OBJECTIVES OF DRAWDOWN: Lake restoration

SUMMARY: Lake drawdown (3.1 m) was achieved with the use of several 120 m deep drainage wells and pumps. Approximately one-half of the lake bottom was exposed for four months during the summer of 1972. During drawdown trashfish were removed from the lake and urban runoff was given primary treatment. Also, in the near shore areas about 38,000 m^3 of organic sediments were removed with conventional excavation equipment and 61,000 m^3 of sand were deposited. Storm sewer improvements, pumps, and water sampling programs cost about $11,000 USA, whereas the cost of the near shore alterations approximated $20,000-30,000. Future siltation will be reduced by a more extensive street cleaning program. Sand blanketing and sediment and trash removal greatly enhanced the aesthetic appeal. Drawdown also increased the stability of the remaining lake sediments. Information regarding the amount of sediment consolidation, the effect of drawdown and restoration measures on water quality, and changes in the fish population are not available at the present time.

POSITIVE EFFECTS: Increased stability of lake sediments; improved aesthetic appeal.

NEGATIVE EFFECTS:

KEYWORDS: Florida, sediment removal, restoration

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Fonyo, C. M. and W. G. Boggess. 1989. Coordination of public and private action: a case study of lake restoration. Water Resources Bulletin Vol. 25:309-317.

STUDY LOCATION: Lake Apopka, Florida

DRAWDOWN TIMING/DURATION: n/a; Lake Apopka background

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: The potential for joint public and private action for lake restoration is examined using Lake Apopka, Florida, as a case study. Initial calculations indicate that private incentives alone are inadequate to attract investment in a facility to grow and harvest water hyacinths for conversion to methane gas. However, the private externality of water quality improvement associated with harvesting water hyacinths provides a key linkage between the public's water quality objectives and the private gas producer's actions. In order to establish the potential basis for negotiation, the public's willingness to pay for environmental services associated with improved water quality is estimated and compared with the estimated subsidy required to induce private action. A conceptual framework is then presented for coordinating actions between private firms and public water management agencies in order to internalize the private externality of water quality improvement while simultaneously achieving the public and private objectives. Results indicate that the subsidization of water hyacinth production and harvesting compares favorably with alternative means of enhancing the water quality of Lake Apopka.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Apopka; cost feasibility of lake restoration

COPY OBTAINED: Yes

Fonyo, C. M., W. G. Boggess, C. F. Kiker, and J. W. Mishoe. 1989. Economic analysis of water hyacinth production and conversion to methane: the potential for lake restoration. Journal of Environmental Management, Vol. 28:337-348.

STUDY LOCATION: Lake Apopka, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a; Lake Apopka background

SUMMARY: Lake Apopka, a hyper-eutrophic lake in central Florida, has been the target of much study and political discourse over a 25-year period, but high costs have deterred restoration activities. This study investigates the potential of harvesting water hyacinths (Eichhornia crassipes) from Lake Apopka and converting harvested biomass to pipeline quality methane gas to defer some of the costs of lake restoration. The study is based on biological and technological studies undertaken by multidisciplinary teams working under a broad project coordinated by the Gas Research Institute and the University of Florida. Computer modeling of biomass production and conversion to methane (BIOMET) was used to investigate the operating strategies, management and financing of a facility on Lake Apopka. Results indicate substantial quantities of nutrients can be removed, and, over a period of approximately 15 years, water quality objectives can be met. When compared with current natural gas prices, it does not appear than methane gas can be produced competitively from water hyacinth biomass. If, however, public compensation for water quality improvement is provided, a water hyacinth production and gas conversion system has potential.

POSITIVE EFFECTS: Water quality could be improved from the removal of water hyacinths.

NEGATIVE EFFECTS: Methane gas production is not competitive with other gas production.

KEYWORDS: Eutrophication, lake restoration, biogas, economic analysis, biomass, water hyacinth, Lake Apopka

COPY OBTAINED: Yes

Fox, J. L., P. L. Brezonik, and M. A. Keirn. 1977. Lake drawdown as a method of improving water quality. Ecological Research Series.

STUDY LOCATION: Lake Apopka, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: Results of pilot scale investigations to determine if radical drawdown at Lake Apopka, Florida, would effectively restore the lake by reducing algal blooms and increasing the population of desirable macrophytes are described. Sediments were dredged from the lake bottom, placed in aquaria, columns, tanks, and pools, dewatered and dried over varying periods, and then refilled. Monitoring of a large number of physical, chemical, and biological parameters before, during and after sediment drying revealed that drawdown improved subsequent refill water quality. In the muck sediments at Lake Apopka, drying caused significant water loss and shrinkage with minimal loss of organic material. During and following refill, the sediment was colonized by two macrophytes, Typha and Chara. Only minor chemical changes occurred in the muck sediments. Refill water in the pool test simulations had the same or lower nutrient content, lower turbidity, higher dissolved oxygen, lower temperature, fewer algae, and a more diverse benthic invertebrate population. Based on these laboratory scale investigations, it was concluded that drawdown would be an effective restoration technique for Lake Apopka, but that drawdown was not a cure-all by itself and should be coupled with other measures such as the removal of dried muck from shore areas.

POSITIVE EFFECTS: Drying caused significant consolidation and little nutrient release

NEGATIVE EFFECTS:

KEYWORDS: Lake Apopka; laboratory sediment consolidation

COPY OBTAINED: Yes

Fraser, J. C. 1972. Water levels, fluctuation, and minimum pools in reservoirs for fish and other aquatic resources - an annotated bibliography. FAO Fisheries Technical Paper No. 113. 42pp.

STUDY LOCATION: Varies

DRAWDOWN TIMING/DURATION: Varies

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Literature bibliography

SUMMARY: A collection of references, abstracts, and notes is presented of much of the literature concerning the effects of water-level fluctuations and minimum pools on fish and other aquatic resources.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Literature review

COPY OBTAINED: Abstract in Ploskey (1982)

Frey, D. G. 1967. Reservoir research - objectives and practices with an example from the soviet union. Reservoir Fishery Resources Symposium, American Fisheries Society.

STUDY LOCATION: Varies

DRAWDOWN TIMING/DURATION: Variable

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Water supply demand; seasonal fluctuations

SUMMARY: Differences in approach and goals of reservoir research in the Soviet Union and United States are examined, and some limnological perspectives are presented on how reservoirs differ from natural lakes. A distinct difference between lakes and reservoirs is water-level fluctuation, a common phenomenon in many Soviet and U. S. impoundments. Some Soviet reservoirs are very large and shallow, consequently even a relatively small drop in water level exposes large areas of the bottom (as much as 75% in the Rybinsk Reservoir) and severely stresses benthos and fishes. As a result, Soviet biologists have extensively studied the drained zone of reservoirs. Invertebrates associated with gravel or well-drained soils are killed by drawdown, but many organisms on silt or clay soils often are able to burrow into the substrate and survive. In reservoirs where the drained substrate retains water and where bottom animals can burrow, productivity of the drained zone may not be appreciably less than that on continually flooded bottoms. In reservoirs where drawdown lasts long enough for dense growth of terrestrial vegetation to develop, reflooding usually increases production of algae and benthos.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Severe stress on benthos and fishes in large and shallow reservoirs due to drawdown, which exposes large areas of the bottom

KEYWORDS: Reservoir, Soviet Union, benthos

COPY OBTAINED: Yes

Galinato, M. I. and A. G. Van Der Valk. 1986. Seed germination traits of annuals and emergents recruited during drawdowns in the Delta Marsh, Manitoba, Canada. Aquatic Botany, 26:89-102.

STUDY LOCATION: Delta Marsh, Manitoba, Canada

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Naturally occurring periodic drawdowns

SUMMARY: Seed germination traits of the most abundant mudflat annuals and perennial emergents that become established during drawdowns (periods when all or part of a wetland is free of standing water) in the Delta Marsh, Manitoba, Canada, were examined. Seeds of both annuals and emergent perennials from this prairie, lacustrine marsh germinated best in the light. Stratification also improved the seed germination percentages of all species except for Scolochloa. Germination percentages were highest in alternating 15/25° C and 20/30° C temperature regimes and lowest in a 5/15° C regime. Seed germination percentages for all species were highest when the seeds were on the surface and declined sharply when seeds were covered by as little as 1 cm of sand. Seedlings of species with large seeds could reach the surface from soil depths of down to 5 cm whereas seedlings of the smallest seeded species could reach the surface from no more than 1 cm depth. Because the germination of seeds of each species is affected differently by temperature, salinity, light conditions and depth of burial, microenvironmental variations from site to site during a drawdown could result in different species becoming established as sites with identical seed banks.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Canada, marsh, seedbank

COPY OBTAINED: Yes

Gaudet, J. J. 1977. Natural drawdown on Lake Naivasha, Kenya, and the formation of papyrus swamps. Aquatic Botany, 3:1-47.

STUDY LOCATION: Lake Naivasha, Kenya

DRAWDOWN TIMING/DURATION: Annual seasonal drawdown

LAKE SIZE: 46 square miles

OBJECTIVES OF DRAWDOWN: The determination of general productivity as related to annual drawdown and reflooding.

SUMMARY: The flora of Lake Naivasha (108 species) is presented along with an account of primary succession on wet mud at the lake edge. During the course of succession three zones developed: Sphaeranthus Zone (closest to the lake water); Sedge Zone (dominated by Cyperus papyrus L., C. digitatus Roxb., and C. immensus C. B. Cl.); and a Composite Zone (dominated by Conyza spp., closest to dry land). This primary succession occurred during a recent drop in lake level (natural drawdown). Succession continued after reflooding and resulted in a papyrus fringe swamp, a most common sub-climax community along the edges of this lake. Analysis of lake-edge soils and germination and growth studies were carried out in order to determine some of the factors affecting lake-edge succession. It is concluded that of all species present, C. papyrus is the most adaptable, starting from seed on bare mud in competition with hygrophilous annuals and later growing up in water as a perennial emergent macrophyte. Annual drawdown and reflooding are discussed in relation to the general productivity of inshore regions of tropical water bodies. Primary succession of papyrus during a drawdown is recorded for the first time and the production of bands of papyrus swamp along the lake edge is shown to be correlated with the larger cycles of drying and flooding which occur on this lake.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Naivasha, Kenya; natural seasonal drawdown; macrophyte succession

COPY OBTAINED: Yes

Geagan, D. W. 1961. A report of a fish kill in Chicot Lake, Louisiana during a water level dawdown. Louisiana Academy of Science. 23:39-44.

STUDY LOCATION: Lake Chicot, Louisiana

DRAWDOWN TIMING/DURATION: Summer drawdown; annual

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: After water levels were reduced in Lake Chicot to control aquatic plants (especially Elodea, which covered 50% of the lake), large numbers of fish died due to near-anoxic conditions (oxygen concentrations were less than 0.1 mg/l^{-1} near the main boat landing). This kill reduced the fish standing crop from 146.2 to 19.1 pounds per acre. This kill might have been avoided if the lake had been drawn down annually to control plants (it was not drawn down in 1956-57; consequently plants became over-abundant).

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Fish kill occurred.

KEYWORDS: Louisiana lake

COPY OBTAINED: Abstract in Ploskey (1982)

Gluckman, D. 1977. The legal effects of lake drawdowns in Florida. Prepared for the Office of Water Resources Restoration and Preservation, Florida Department of Environmental Regulation.

STUDY LOCATION: n/a

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVE: n/a; background information

SUMMARY: Issues addressed include: legal definitions of public and private lakes, navigable waters, high water definitions, and riparian rights; who has legal authority to draw down lakes in Florida, landowner's permission for drawdown, existence of conditions requiring a drawdown, riparian rights compensations, who is responsible for damages resulting from a drawdown, and downstream owners rights.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Legal issues related to drawdown

COPY OBTAINED: Yes

Godshalk, G.L. and J.W. Barko. 1987. Effects of winter drawdown on submersed aquatic plants in Eau Galle Reservoir, Wisconsin. IN: Proceedings, 22nd Annual Meeting, Aquatic Plant Control Research Program, U.S. Army Corps of Engineers, Waterways Experiment Station. Miscellaneous Paper A-88-5.

STUDY LOCATION: Eau Galle Reservoir, Wisconsin

DRAWDOWN TIMING/DURATION: October-February 1985

LAKE SIZE: 150 acres

OBJECTIVES OF DRAWDOWN: maintenance of outfall structure

SUMMARY: Dramatic and desirable changes in the submersed plant populations were induced in spite of small changes in water level and brevity of exposure occurring during a brief lowering of water level for maintenance of the reservoir's outfall structure. The most significant consequences of drawdown on submerged macrophytes susceptible to frost and drying were expected only in a fairly shallow area in the littoral zone less than 1 m vertically below normal pool elevation. There was a distinct difference in susceptibility to desiccation and freezing among plant species. Some species increased in abundance, possibly due to release from competition with susceptible species. Differential rates of recovery from damage of the extreme conditions alter competitive advantages, allowing more species to survive, at least until strong dominance by a few species is reestablished. In the meantime, standing crop is reduced and both community and habitat diversity are increased. Thus, even brief, partial drawdowns of some reservoirs may provide many benefits for management without many of the disadvantages of more drastic manipulations of water levels.

POSITIVE EFFECTS: biomass reduction, habitat diversity increased

NEGATIVE EFFECTS: temporary effects

KEYWORDS: Wisconsin, macrophyte control

COPY OBTAINED: Yes

Goodrick, R. L. and J. F. Milleson. 1974. Studies of floodplain vegetation and water level fluctuation in the Kissimmee River Valley. Central and Southern Florida Flood Control District Technical Publication 74-2, 60 p.

STUDY LOCATION: Kissimmee River, Florida; Pool B

DRAWDOWN TIMING/DURATION: 60 days; March - May 1972; one foot drawdown

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Flood control

SUMMARY: The Central and Southern Florida Flood Control project in the Kissimmee River Basin consisted of enlarging existing canals connecting the upper chain of lakes, installing water control structures in several of these canals, and channelizing and providing control structures in the river proper (which extends from Lake Kissimmee to Lake Okeechobee). One major canal, designated C-38, was constructed within the Kissimmee River floodplain. Six regulatory structures were situated along the canal to control the drop in elevation. Stabilization of the water level in the impoundment area behind the regulatory structures since January 1969 has had a pronounced impact on the vegetational composition of the marshes. The lack of seasonal fluctuation has resulted in the dominance of terrestrial plants in the north end of the impoundment, the dominance of aquatic plants in the south end of the impoundment, and the inhibition of growth for most aquatic annuals.

Pool B, a section of the Kissimmee Canal, was experimentally exposed to a one-foot drawdown for 60 days in 1972 to examine the effects of a reestablishment of seasonal water-level fluctuations on vegetation. Emergent vegetation (especially wild millet) germinated in exposed sediment, and species diversity was higher than in marshlands where water levels have remained stabilized for a period of years. These authors state that a substantial body of information is being accumulated which indicates that the stabilization of water levels is detrimental to the ecology of freshwater marshes.

POSITIVE EFFECTS: Macrophyte species diversity increased following the drawdown.

NEGATIVE EFFECTS:

KEYWORDS: Kissimmee River, Florida; water level stabilization effects

COPY OBTAINED: Yes

Greening, H. S. and J. Gerritsen. 1987. Changes in macrophyte community structure following drought in the Okefenokee Swamp, Georgia, U.S.A. Aquatic Botany, 28 (1987) 113-128.

STUDY LOCATION: Okefenokee Swamp, Georgia

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Natural drawdown

SUMMARY: Following a severe drought, changes in macrophyte species composition and biomass dynamics were monitored in four marsh plant communities within the Okefenokee Swamp, located in southeastern Georgia and northeastern Florida, U.S.A. Marshes with three distinct patterns of water-level fluctuation were examined from April 1982 to January 1985. Two constantly inundated sites (water depth 34-113 cm) were dominated by a floating-leaved macrophyte, Nuphar luteum ssp. macrophyllum Michx., Cabomba pulcherrima (Harper) Fass. and filamentous algae). Live aboveground biomass values at these sites were lower than those at the two other sites, with mean values of 64 and 87 g dry weight (wt.) m^{-2}. The third site, which experienced frequent and predictable (seasonal) drawdown, was strongly dominated by the sedge Carex walteriana Bailey and a ground cover of Sphagnum. The data suggest that in these marshes, unpredictable and infrequent natural drawdowns may result in higher macrophyte diversity and greater variability in biomass dynamics than either frequent (annual) drawdown or continuous inundation.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Georgia marsh, natural drawdowns, plant succession

COPY OBTAINED: Yes

Griffin, T. T. and R. A. Ferrara. 1984. A multicomponent model of phosphorus dynamics in reservoirs. Water Resources Bulletin, 20:777-788.

STUDY LOCATION: Round Valley Reservoir, north central New Jersey

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Computer simulation study

SUMMARY: The models available for simulating phosphorus dynamics and trophic state in impoundments vary widely. The simpler empirically derived phosphorus models tend to be appropriate for long-term, steady or near steady state analyses. The more complex ecosystem models, because of computational expense and the importance of input parameter uncertainty, are impractical for very long-term simulation and most applicable for time-variable water quality simulations generally of short to intermediate time frames. An improved model for time variable, long-term simulation of trophic state in reservoirs with fluctuating inflow and outflow rates and volume is needed. Such a model is developed in this paper representing the phosphorus cycle in two-layer (i.e., epilimnion and hypolimnion) reservoirs. The model is designed to simulate seasonally varying reservoir water quality and eutrophication potential by using the phosphorus state variable as the water quality indicator. Long-term simulations with fluctuating volumes and variable influent and effluent flow rates are feasible and practical. The model utility is demonstrated through application to a pumped storage reservoir characteristic of these conditions.

Simulation results indicate that during the drawdown period, water quality remains relatively constant. During refill, however, water quality is degraded, primarily due to P loadings from input streams and, to a lesser degree, phosphorus release from dried sediments.

POSITIVE EFFECTS: During drawdown simulation indicates water quality is relatively constant

NEGATIVE EFFECTS: During refill, water quality is degraded

KEYWORDS: Phosphorus, eutrophication, reservoirs, impoundments, water quality modeling.

COPY OBTAINED: Yes

Grizzell, R. A., Jr. 1960. Fish and wildlife management of watershed projects. Transactions of the Twenty-fifth North American Wildlife Conference, 186-192.

STUDY LOCATION: Varies

DRAWDOWN TIMING/DURATION: Varies

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Habitat management

SUMMARY: Strategies are discussed for managing fish, waterfowl, and upland game resources on small watershed projects. A slot or gate release for flood-retarding structures increases flexibility in effecting drawdown on watershed impoundments of 4 to 100 acres in surface area. Advantages of such a release structure and drawdown include control of mosquitoes, manipulation of fish populations, and control of water supply to downstream areas.

POSITIVE EFFECTS: Flood-retarding structures allow for control of mosquitoes, manipulation of fish populations and control of water supply to downstream areas.

NEGATIVE EFFECTS:

KEYWORDS: Review; habitat management

COPY OBTAINED: Yes

Groen, C.L. and T.A. Schroeder. 1978. Effects of water level management on walleye and other coolwater fishes in Kansas Reservoirs. Am Fish. Soc. Spec. Publ. 11:278-283.

STUDY LOCATIONS: Kansas reservoirs

DRAWDOWN TIMING/DURATION: rising water levels in the spring, followed by a mid-summer drawdown. In an attempt to recreate "new reservoir" conditions, drawdown zones are generally 10 to 20% of the total reservoir surface.

LAKE SIZE: variable

OBJECTIVES OF DRAWDOWN: fisheries management

SUMMARY: The environmental and biological effects of water level management are monitored on several Kansas reservoirs. The basic water level management plan consists of a rising water level in the spring to improve fish spawning and nursery conditions, followed by a mid-summer drawdown for revegetation of the fluctuation zone and to increase forage availability for piscivorous fishes. An improved forage base, increased sportfish growth, production, and harvest, an improved fish population structure, and improved water clarity are attributed to water level management.

Water clarity has improved in years when vegetation in the drawdown zone was flooded. Rooted plants stabilize the shoreline and reduce turbidity from wave action. Improved water quality in Kansas reservoirs was achieved by yearly drawdowns that were small enough not to interfere with any intended purpose of the reservoirs. Greater water clarity improved sport fish spawning success, growth, and angler success, as well as being more attractive for all recreational users.

POSITIVE EFFECTS: improved fishery, water clarity, littoral zone vegetation

NEGATIVE EFFECTS: none noted

KEYWORDS: Kansas reservoirs, fishery management, water clarity

COPY OBTAINED: Yes

Hall, T. F., W. T. Penfound and A. D. Hess. 1946. Water level relationships of plants in the Tennessee Valley with particular reference to malaria control. Journal of Tennessee Academy of Science, 21:18-59.

STUDY LOCATION: Tennessee Valley Authority Reservoirs, Alabama, North Carolina and Tennessee

DRAWDOWN TIMING/DURATION:

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Mosquito control

SUMMARY: Three methods of control were used: 1) flooding, 2) overwinter drawdown, and 3) application of 2,4-D. Flooding was effective for some species but not for others. Overwinter drawdown, and application of 2,4-D in areas that were not exposed, resulted in some macrophyte-free regions for 4 years after treatment. Herbicide application was not detrimental to the benthos population except through elimination of the macrophytes. There was little uptake of 2,4-D by fish but some was taken up by mussels. Significant concentrations of 2,4-D occurred in the sediments for up to 10 months. No adverse effects were noted on the fauna or water quality.

POSITIVE EFFECTS: Macrophyte control achieved for 4 years after treatment; no adverse effects on water quality or fauna from herbicide.

NEGATIVE EFFECTS:

KEYWORDS: TVA, macrophyte control

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Haller, W. T., J. L. Miller and L. A. Garrard. 1976. Seasonal production and germination of hydrilla vegetative propagules. Journal of Aquatic Plant Management, Vol. 14:26-39.

STUDY LOCATION: Rodman Reservoir, Florida

DRAWDOWN TIMING/DURATION: Late winter; 2 months

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: The vegetative propagules (tubers and turions) of Hydrilla verticillata are the most important sources of regrowth. Data on growth characteristics of these propagules can be used effectively for hydrilla control. A one-year study at Rodman Reservoir in north-central Florida included a 0.91 m late winter drawdown which exposed the lake bottom. One sheet each of clear and black plastic was placed over sections of the hydrilla mat to study the effect of light and dark on tuber germination. The most important information collected was on seasonal formation of propagules and the stimulatory effect of the drawdown on tuber germination. A proposed drawdown schedule for hydrilla control is as follows: an optional winter drawdown (February to April) aerates the hydrosoil, kills existing hydrilla, and promotes extensive early summer tuber germination. A second drawdown in late summer (September to November) is essential, as it kills hydrilla regrowth from the germinated tubers, which prevents any new tuber formation. Tuber formation normally occurs from October to May. Since tubers only germinate once, and if the plant is destroyed after germination, the tuber cannot cause regrowth. Turions proved to be insignificant in causing regrowth. Optimum germination temperatures for tubers are 15-35 C, but carbon dioxide and oxygen levels in the hydrosoil are also important.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Aquatic weed control, reproduction, growth stages, drawdown, aquatic plants, plant growth, Florida, reservoirs, seasonal, water temperature

COPY OBTAINED: Yes

Heisey, P. G., D. Mathur, and N. C. Magnusson. 1980. Accelerated growth of smallmouth bass in a pumped storage system. Transactions of American Fisheries Society 109:371-377.

STUDY LOCATION: Muddy Run Reservoir, Pennsylvania

DRAWDOWN TIMING/DURATION: Variable

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Water storage

SUMMARY: In a 12-year study of smallmouth bass in Muddy Run Reservoir, a pumped storage impoundment in Pennsylvania, accelerated growth was related to the abundance of gizzard shad after their introduction in 1972. Drawdowns of 9m/day^{-1} or 15.6m/week^{-1} (volume reduced 45%) increased the vulnerability of shad by concentrating both shad and bass. In the lower reservoir (Conowingo Pond), where water levels fluctuated $\leq$ 1 m each day, growth of smallmouth bass was not greatly improved after shad were introduced. Water-level fluctuations inhibited successful spawning of most fishes in all years except 1967, when water levels were constant in spring and early summer. In 1967, large numbers of forage fish were produced.

POSITIVE EFFECTS: Increased predation on shad by smallmouth bass

NEGATIVE EFFECTS: Inhibition of spawning under highly variable drawdown regimes

KEYWORDS: Pennsylvania reservoirs; fishery spawning

COPY OBTAINED: Abstract in Ploskey (1982)

Heman, M. L., R. S. Campbell, and L. C. Redmond. 1969. Manipulations of fish populations through reservoir drawdown. Transactions of American Fisheries Society 98:293-304.

STUDY LOCATION: Little Dixie Lake, Missouri; reservoir

DRAWDOWN TIMING/DURATION: 10 days, July; surface area reduced by 42%

LAKE SIZE: 200 acres

OBJECTIVES OF DRAWDOWN: Fishery management

SUMMARY: Effects of a mid-summer drawdown (July 19-29) on growth of largemouth bass, total harvest, and the size composition of bluegills were examined in Little Dixie Lake, Missouri. In 10 days, water levels were lowered 2.4 m by releasing hypolimnial water. Surface area was reduced by 42%, volume by 58%, and the lake became isothermal at 30° C. The relative weight of food in stomachs of largemouth bass increased by a factor of 2.7, and the percent of empty stomachs decreased. Growth of largemouth bass, as indicated by scale reading, also increased after the drawdown. Harvest of bluegills increased immediately after drawdown and then decreased over the next 2 months. Harvest of largemouth bass was reduced in August but increased significantly in September and October. Drawdown presumably reduced the densities of fry and intermediate-sized bluegills by stranding them, increasing predation, and exposing nests.

POSITIVE EFFECTS: Increase in weight of food in largemouth bass stomachs, increase in growth of largemouth bass and increase in harvest of bluegills.

NEGATIVE EFFECTS: Reduced densities - fry and intermediate sized bluegills by stranding, increased predation, and exposing nests.

KEYWORDS: Missouri reservoir, 10 day summer drawdown, fisheries management

COPY OBTAINED: Abstract in Ploskey (1982)

Heman, M. L. 1965. Manipulation of fish populations through reservoir drawdown, with emphasis on Micropterus salmoides (Lacepeded). M. A. Thesis, University of Missouri, 65 p.

STUDY LOCATION: Little Dixie Lake, Callaway County, Missouri

DRAWDOWN TIMING/DURATION: 10 days

LAKE SIZE: 205 acres

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: The water level was lowered 2.4 m between 19-29 July, 1964. The impoundment was originally equipped with a drain pipe and gate valve. The surface area was reduced by 42% and the volume, by 58%. After drawdown there was an increase in largemouth bass food consumption and an increase in their growth rate. Bluegill harvest increased immediately after drawdown but later declined; the reverse was true for the largemouth bass. Forage-sized bluegills (fry and fish up to 10.2 cm in length) were greatly reduced in number as indicated by shoreline seining. The reduction in bluegill numbers was thought due to entrapment in the weed beds and shallow pools, exposure of nests, and largemouth bass predation.

POSITIVE EFFECTS: Increased growth rate of largemouth bass; increased bluegill harvest immediately after drawdown.

NEGATIVE EFFECTS: Reduced bluegill numbers.

KEYWORDS:

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Hestand, R. S. and C. C. Carter. 1974. The effects of a winter drawdown on aquatic vegetation in a shallow water reservoir. Hyacinth Control Journal, 12:9-12.

STUDY LOCATION: Lake Oklawaha, Florida

DRAWDOWN TIMING/DURATION: September-February; 1.5 m exposing 38% of sediment surface

LAKE SIZE: 6,500 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Lake Oklawaha has experienced aquatic weed problems since 1969, 1 year after it was formed. The lake surface elevation was lowered 5 ft. from September 1972 to February 1973. The May 1973 sampling indicated that the drawdown gave excellent control for coontail, hydrilla, naiad, and Brazilian elodea, but there was a substantial increase in water hyacinth, alligatorweed, smartweed, and waterpurslane.

POSITIVE EFFECTS: short-term control for coontail, hydrilla, naiad, and Brazilian elodea.

NEGATIVE EFFECTS: Increase in water hyacinth, alligatorweed, smartweed, and waterpurslane.

KEYWORDS: Lake Oklawaha, Florida; macrophyte control, winter drawdowns

COPY OBTAINED: Yes

Hestand, R. S. and C. C. Carter. 1975. Succession of aquatic vegetation in Lake Oklawaha two growing seasons following a winter drawdown. Hyacinth Control Journal, 13:43-47.

STUDY LOCATION: Lake Oklawaha, Florida

DRAWDOWN TIMING/DURATION: 5 months, September to February, lowered by 1.5 m to expose 38% of the sediment surface

LAKE SIZE: 6,500 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Lake Oklawaha has experienced aquatic weed problems since 1969, the year following impoundment. The lake surface elevation was lowered 1.5 m from September 1972 to February 1973. The May 1973 sampling indicated that the drawdown gave excellent control for coontail, hydrilla, southern naiad, and Brazilian elodea, but there was a substantial increased in water hyacinth, alligatorweed, smartweed, and waterpurslane. In the November 1973 sampling, hydrilla had increased tremendously in coverage as did pickerelweed, and water hyacinth; there was however continued control of coontail and Brazilian elodea.

POSITIVE EFFECTS: Short-term control of coontail, Brazilian elodea, hydrilla, and southern naiad.

NEGATIVE EFFECTS: Increase in water hyacinth, alligatorweed, smartweed, and waterpurslane growth. Within 6 months, hydrilla had increased tremendously and within one year, hydrilla and water hyacinth were the dominant plants, covering 50% of the lake surface.

KEYWORDS: Lake Oklawaha, Florida; winter drawdown; 5 months; macrophyte regrowth

COPY OBTAINED: Yes

Hestand, R.S., B.E. May, D.P. Schults, and C.R. Walker. 1973. Ecological implications of water levels on plant growth in a shallow water reservoir. Hyacinth Control Journal 11: 51-58.

STUDY LOCATION: Rodman Reservoir (Lake Oklawaha), FL

DRAWDOWN TIMING/DURATION: n/a; evaluation of proposed drawdown

LAKE SIZE: 11 mile drowned river reach

OBJECTIVES OF DRAWDOWN: Potential fishery management and macrophyte control

SUMMARY: Potential effects of a proposed 5' drawdown to the vegetational community include: 1) aquatic vegetation (coontail, hydrilla, naiad, and Brazilian elodea) will occupy entire water column remaining in lake. 2) Recommend a winter drawdown, with a refill in March for the sport fishery spawning and growing season. 3) Reflooding of terrestrial plants which have become established may result in high BOD from rotting vegetation. 4) May need chemical control of alligatorweed during drawdown because fleabeetle used to control alligatorweed require floating mats of vegetation which will not be available during drawdown.

These authors recommend that reflooding occur during late winter months when plant growth is least would result in maximum benefit to the fishery and for plant control.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Oklawaha, Florida, fishery management, macrophyte control, feasibility study.

COPY OBTAINED: Yes

Holcomb, D.E., W.L. Wegener, and V.P. WIlliams. 1975. Lake level fluctuation for habitat management: a case in point. IN: Brezonic, P.L. and J.L. Fox (ed). Water quality management through biological control. University of Florida, Gainesville.

STUDY LOCATION: Lake Tohopekaliga, FL

DRAWDOWN TIMING/DURATION: March 1970-August 1971 (15 months)

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Results observed after drawdown included: Sediments: A reduction in depth of organic sediments from 50 to 80 percent; flocculent sediments disappeared completely; deeper sediments took on the appearance of compacted peat. In all areas the substrate was firm and solid after drying, and rooted plants became abundant where they had previously been sparse or absent. Increased microbial activity in dried sediments. Aquatic macrophytes: Desirable aquatic and semi-aquatic species became established into new lakeward areas. Invertebrates: Average number of invertebrates living in open water habitats and in littoral areas increased phenomenally, contributing to an expanded fishery. Fish: improved stocks of sportfish, slight decrease in panfish for a short period, then increase. Economic benefits: the worth of the fishing resource increased $6,222,186 in 3 years as a result of the drawdown. Algae: the first major bloom documented in Lake Toho occurred just prior to the beginning of drawdown, and blooms occurred with greater frequency as the study progressed, up until late spring of 1974. Water chemistry. Most constituents measured, including nutrients, increased in concentration during drawdown, and remained higher than they had been prior to dewatering. However, during this period, the average daily inflow of sewage also increased.

POSITIVE EFFECTS: sediment consolidation, desirable macrophytes established, increased invertebrate production, expanded sport fishery, big economic benefit

NEGATIVE EFFECTS: persistent algal bloom, decreased water quality

KEYWORDS: Lake Tohopekaliga, fishery management, water quality

COPY OBTAINED: yes

Holcomb, D. E. and W. L. Wegener. 1971. Hydrophytic changes related to lake fluctuation as measured by point transects. Proceedings of 25th Annual Conference of Southeastern Association of Game Fish Commissions, pp. 570-583.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: One year; exposing 50% of the bottom

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Fishery management, habitat restoration

SUMMARY: After dewatering, littoral vegetation moved lakeward and expanded its coverage from 9,000 to 10,500 acres in Lake Tohopekaliga, Florida, an increase of 16% The distribution of vegetation was determined largely by the prevailing water levels within the basin, and the lakeward limit of perennial emergents was related to historically low water elevations. Many of the plants that increased after drawdown produced food for major sport fish and fish-food organisms, as indicated by the high standing crops of fish-food organisms present. Densities of water hyacinth (which was considered detrimental to the fishery) and other plants declined markedly after dewatering.

POSITIVE EFFECTS: Increase in lakeward extent of desirable aquatic plants for at least two years following drawdown; compaction of organic sediments ranged from 50 to 100%; decrease in water hyacinth density.

NEGATIVE EFFECTS: No reduction in algal biomass

KEYWORDS: Lake Tohopekaliga, Florida; one-year drawdown; vegetation reestablishment

COPY OBTAINED: Yes

Holcomb, D. E., W. L. Wegener, and V. P. Williams. Lake level fluctuation for habitat management: a case in point. Florida Game and Fresh Water Fish Commission.

STUDY LOCATION: Lake Tophopekaliga, Florida

DRAWDOWN TIMING/DURATION: 15 months; March 1970 to February 1971, then February 1971 to March 1972; exposing 50% of the bottom

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: A summary of some of the changes which occurred as a result of the drawdown: Lake sediments: desiccation caused a reduction in sediment depths of 50-80%. Flocculent sediments disappeared completely; apparently in part due to higher microbial activity within exposed sediments. Vascular hydrophytes: exposure triggered germination of many terrestrial and semi-aquatic plants, and eliminated vegetative portions of true aquatics. As reflooding occurred, terrestrials died out, and true aquatics increased. Invertebrates: average number of invertebrates increased greatly after reflooding, contributing to the expanded fishery. Fishes: significant improvement in fish population resulting in an increase in the worth of the fishing resource by more than 6 million dollars. Algae: blooms occurred with greater frequency as the study progressed, primarily blue-greens, for two years. Water chemistry: most constituents increased in concentration during drawdown. As reflooding occurred, concentrations declined but remained higher than they had prior to dewatering.

POSITIVE EFFECTS: Sediment consolidation, number of invertebrates increased, improved fishery; increase in desirable aquatic vegetation

NEGATIVE EFFECTS: Decreased water quality, increased occurrence of algae bloom

KEYWORDS: Lake Tohopekaliga, Florida, habitat restoration

COPY OBTAINED: Yes

Hughes, G. H. 1979. Analysis of water-level fluctuations of Lakes Winona and Winnemissett-two landlocked lakes in a karst terrain in Volusia County, Florida. U. S. Geological Survey Water Resources Investigation 79-55.

STUDY LOCATION: Lakes Winona and Winnemissett, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 156 and 169 acres, respectively

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: Lakes Winona and Winnemissett are landlocked lakes situated about 12 miles apart in a karst terrane near the city of DeLand in Volusia County, on the eastern coast of Florida. Given such conditions, a high degree of correlation could be expected between fluctuations of the levels of the two lakes. Analyses of the available lake-level data show that fluctuations of the two lake levels correlate reasonably well during dry spells, but only poorly during wet spells. Disparities between the fluctuations of the two lake levels develop mostly at times when the lake levels rise abruptly as a consequence of rainstorms passing over the lake basins. Differences between the rises of the two lake levels are attributed to the uneven distribution of the storm rainfall. The disparity between the fluctuations of the two lake levels stems mostly from differences in the quantities of rain that fall directly on the lakes. However, the uneven distribution of rainfall also causes disparate changes in the quantities of surface and ground water that enter the lakes, and also in the quantities of water that leak from the lakes.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Water level fluctuation, Florida lakes

COPY OBTAINED: Yes

Hughes, G. H. 1974. Water-level fluctuations of lakes in Florida. U. S. Geological Survey.

STUDY LOCATION: Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: Water-level fluctuations of some of the important lakes in Florida are shown on a map. As of 1972 lake-level records were being collected at 160 lakes. The range of fluctuation in level varies greatly among lakes: as small as 2 feet for some lakes, more than 30 feet for others. About 80 percent fluctuate 5 feet or more. Levels of lakes connected by a throughgoing stream tend to fluctuate together but the range of fluctuation may differ significantly. Levels of lakes in the same general area often fluctuate together, even though they are not connected by a throughgoing stream. One of the chief causes of differences in the magnitude of lake-level fluctuations is the variability in permeability of materials beneath the land surface. Other things being equal, a lake that receives water primarily from surface-water inflow will have a greater range of fluctuation than one that receives water primarily from groundwater inflow. Another factor that contributes greatly to differences int he magnitude of lake-level fluctuations is the relation between the lake level and the potentiometric surface of the confined aquifer. Lakes in recharge areas generally fluctuate more widely than do lakes in discharge areas. For any change in the hydrologic system of a lake, a reaction must take place somewhere in the system. Because of the relations and interrelations that exist between rainfall, runoff, lake levels, and groundwater levels, the hydrologic system of a lake must be adequately defined before effects of changes can be fully evaluated.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Florida lakes; water level fluctuation

COPY OBTAINED: Yes

Hulsey, A. H. 1956. Effects of a fall and winter drawdown on a flood control lake. Proceedings of Fifth Annual Conference of Southeastern Association of Game Fish Commissions.

STUDY LOCATION: Lake Nimrod, Arkansas

DRAWDOWN TIMING/DURATION: 1955-56; 1 year; 81% surface area exposed

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Fishery management

SUMMARY: Drawdown of Lake Nimrod, Arkansas, in 1955-56 reduced the surface area of about 81%. Over 200,000 pounds of rough fish (mostly smallmouth buffalo) were removed by commercial fisherman. A comparison of cove rotenone samples before and after drawdown showed increased abundance of young-of-year black and white basses after drawdown as well as a threefold increase in the standing crop of nonedible prey fishes (e.g., shads and minnows), and a 50% reduction in the biomass of edible forage species (buffalo and drum). The number of young catfish, common carp, and drum was reduced, but the abundance of young sunfishes and minnows increased. Sport fishing apparently improved after drawdown (especially for white crappie), as indicated by boat dock owners. Because the primary purpose of Lake Nimrod was flood control, lowering water levels did not hinder any other beneficial use of the reservoir, and drawdown enhanced the reservoir fishery by improving water clarity and sport-fish survival and harvest.

POSITIVE EFFECTS: Improved sport fishing and water clarity.

NEGATIVE EFFECTS:

KEYWORDS: Arkansas, fishery management, water clarity

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Hunt, P. C. and J. W. Jones. 1972. The effect of water level fluctuations on a littoral fauna. Journal of Fish Biology 4:385-394.

STUDY LOCATION: Llyn Celyn, North Wales

DRAWDOWN TIMING/DURATION: Variable

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Water supply and control

SUMMARY: This study compares the abundance and species composition of littoral benthos in 1968-69 with that recorded by other authors in 1951-52 and in 1957 and 1959. Water levels fluctuated 2 m before 1955, 4.3 m between 1955 and 1967, and about 2 m after 1967. In 1967-69, fluctuations were similar to those before 1955, except that lakes levels were 3 m lower. Nevertheless, all major groups of animals recorded before fluctuations increased in 1955 were found in 1968-69, when fluctuations were reduced, and most were fully reestablished. Long-term effects of regulation included an increase in the total number and a decrease in diversity of animals in the littoral zone. Numbers ranged from 1504 to 6488 organism m^{-2} in 1951-52 and from 2239 to 9224 organisms m^{-2} in 1968-69. The 42% increase in numbers was accounted for by chironimids and oligochaetes, exclusively. Gradual removal of silt by wave action and reestablishment of macrovegetation, after fluctuations in water level are reduced, should return the littoral zone to its original status, though it may take years. The reestablishment of Gammarus pulex and Asellus meridianus (perhaps the invertebrates most sensitive to water-level fluctuations) is indicative of decreased fluctuations in recent years. Comments on other major taxa are presented.

POSITIVE EFFECTS: Increase in littoral fauna numbers with water-level fluctuation regulation.

NEGATIVE EFFECTS: Decrease in diversity of littoral fauna with water-level fluctuation regulation.

KEYWORDS: North Wales

COPY OBTAINED: Abstract in Ploskey (1982)

Hynes, H. B. N. 1961. The effect of water-level fluctuations on littoral fauna. Verh. Internat. Verein. Limnol. 14:652-656.

STUDY LOCATION: Lake Bala, Great Britain

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: In 1955, a dam was installed in the outlet of Llyn Tegid (Lake Bala), Great Britain, and annual water-level fluctuations increased from about 2 m (before 1955) to about 5 m thereafter. Typical fluctuations involved a winter minimum and summer maximum. The first dewatering stranded and killed enormous numbers of animals, including small fish - as did subsequent fluctuations. Although water-level fluctuations greatly altered the species composition of the community and completely or almost completely eliminated sponges, flatworms, leeches, gastropods, amphipods, mites, stoneflies, mayflies, some bugs, and caddisflies, the density of bottom animals was not reduced but increased along shorelines with sparse cover because of a great abundance of oligochaetes. Two new species of worms appeared and became abundant. Low water levels altered the littoral substrate significantly. Lower portions of stony shores were more silty, and sheltered stone-covered shores gave way to gritty mud at about 1 m and to soft mud at greater depths.

POSITIVE EFFECTS: Increase in density of bottom animals; two new species of worms appeared and became abundant.

NEGATIVE EFFECTS: Alteration of species composition.

KEYWORDS: Enhanced fluctuation, annual, Great Britain

COPY OBTAINED: Yes

Jacoby, J. M., E. B. Welch, J. P. Michaud. 1983. Control of internal phosphorus loading in a shallow lake by drawdown and alum. Lake Restoration, Protection, and Management, Proceedings of the Second Annual Conference of the North American Lake Management Society, October, 1982, Vancouver, British Columbia.

STUDY LOCATION: Long Lake, Washington

DRAWDOWN TIMING/DURATION: June-October; 5 months; exposure of 30-40%

LAKE SIZE: 339 acres

OBJECTIVES OF DRAWDOWN: Water quality improvement, macrophyte control

SUMMARY: Internal loading of phosphorus in shallow Long Lake, Washington (Kitsap County) has been identified as a major factor causing eutrophy during summer. Chlorophyll a often exceeded 60 ugl^{-1} during three summers prior to restoration. Following lake drawdown (which exposed 30 to 40 percent of the area) sediment consolidation was minimal (0.1m); the macrophyte crop was reduced by 84 percent in 1980, and internal loading of phosphorus was curtailed resulting in a mean summer total phosphorus concentration of 36 ugl^{-1}. The rate of macrophyte recolonization during the post drawdown summer was rapid and biomass had nearly recovered to pre-drawdown levels the following summer (1981). Alum was applied during autumn of 1980 to inactivate midlake sediment. The treatment was successful in maintaining a curtailment of internal loading during 1981 and 1982. Mean summer total P decreased further to 29 ugl^{-1} both years and water transparency increased while the phytoplankton shifted away from blue-greens. The beneficial effect of alum has persisted for 2 years in spite of full macrophyte recovery and an assumed increased input of particulate P from senescent macrophytes to surficial sediments, which verifies sediment as the immediate source of P.

POSITIVE EFFECTS: Alum controlled internal loading of P; drawdown reduced the macrophyte crop, as well as, internal loading of P.

NEGATIVE EFFECTS: Sediment consolidation minimal; macrophyte control only 1 year

KEYWORDS: Washington, summer drawdown, water quality control, macrophyte control

COPY OBTAINED: Yes

Jacoby, J.M., D.D. Lynch, E.B. Welch, and M.A. Perkins. 1982. Internal phosphorus loading in a shallow eutrophic lake. Water Res. 16: 911-919.

STUDY LOCATION: Long Lake, Washington

DRAWDOWN TIMING/DURATION: summer, 4 months; 90% bottom exposure

LAKE SIZE: 339 acres

OBJECTIVES OF DRAWDOWN: sediment consolidation and macrophyte control

SUMMARY: Internal loading of phosphorus has been implicated as a major eutrophicating factor in Long Lake. As a result of such loading, summer total phosphorus concentrations approach or exceed 100 ug/l. Most of the summer loading of P is thought to have been released directly from the flocculent sediment as a result of high pH (up to 10) related to phytoplankton photosynthesis. The lake also supports a dense submerged macrophyte crop (Elodea), which may contribute as much as 25% to annual loading via decomposition.
As a component of the restoration program, the lake was drawn down nearly 2 m (90% bottom exposure) for 4 months during the summer of 1979. The drawdown resulted in an 84% reduction in macrophyte biomass in 1980 but minimal sediment consolidation (0.1m). During drawdown, TP content was high although blue-green algae blooms were relatively scarce. After drawdown, summer water column TP content was approximately 50% lower than during previous summers. Reduction in TP levels in 1980 (after drawdown) was largely due to the reduction in the macrophyte crop. However, since the rate of macrophyte recolonization was rapid, the beneficial effects of the drawdown are likely to be short term.

POSITIVE EFFECTS: aquatic macrophyte biomass reduction, TP reduction after reflooding

NEGATIVE EFFECTS: short term benefits; minimal sediment consolidation

KEYWORDS: Washington, summer drawdown, macrophyte control, phosphorus release

COPY OBTAINED: Yes

Jenkins, R. M. 1969. Large reservoirs - management possibilities. Proc. Midwest Assoc. Game Fish Comm. 36:82-89.

STUDY LOCATION: Various reservoirs

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Sediment consolidation, habitat enhancement, macrophyte control, fisheries management

SUMMARY: A number of fishery management practices for reservoirs are discussed, including fishing regulations, stocking, fertilization, optimum timber clearing, draining or population removal, aquatic weed control, brush shelters, artificial destratification, drawdown, and water-level manipulation. Drawdowns to aerate mud bottoms, to facilitate seeding of herbaceous vegetation and removal of rough fishes, and to concentrate forage should become increasingly useful to managers. Although uncontrolled water-level fluctuation may be harmful to sport fishes, soundly conceived and implemented schemes can be effective. Spring drawdowns are not compatible with spawning requirements of black basses and crappies and have not been consistently successful in controlling spawning of rough fishes. In suitable reservoirs, extreme drawdown followed by planting of herbaceous plants on exposed mud bottoms, refilling, and stocking of desired species is one of the important management tools available to fishery managers today.

POSITIVE EFFECTS: Aerate mud bottom, seeding of herbaceous vegetation, removal of rough fish, concentrate forage

NEGATIVE EFFECTS: Reduced spawning, if not done at right time of year

KEYWORDS: Reservoirs, review

COPY OBTAINED: Abstract in Ploskey (1982)

Jenkins, R. M. 1970. The influence of engineering design and operation and other environmental factors on reservoir fishery resources. Water Resources Bulletin 6:110-119.

STUDY LOCATION: Varies; 1,310 large reservoirs in the mid-South

DRAWDOWN TIMING/DURATION: Varies

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: The apparent effect of reservoir environmental variables (i.e., water-level fluctuation, mean depth, outlet depth, thermocline depth, surface area, storage ratio, shoreline development, total dissolved solids, growing season, and reservoir age) on the standing crop of fish in 140 large reservoirs was examined by partial correlation and multiple-regression analyses. Water-level fluctuation had a positive influence on the biomass of spotted gar, flathead catfish, black basses, and white crappies. It had a negative influence on the standing crops of gizzard shad, northern pike, pickerels, carpsuckers, and sunfishes. In reservoirs with a stable thermocline, fluctuation of water levels had a significant positive influence ($P < 0.05$) on the standing crops of largemouth bass and white crappies.

POSITIVE EFFECTS: Water-level fluctuations exerted a positive influence on standing crops of largemouth bass and white crappies in reservoirs with a stable thermocline.

NEGATIVE EFFECTS: Water-level fluctuations exerted a negative influence on standing crops of gizzard shad, northern pike, pickerels, carpsuckers, and sunfishes.

KEYWORDS: Reservoirs, fisheries management, statistical analysis

COPY OBTAINED: Yes

Jenkins, R. M. 1973. Reservoir management prognosis: migraines or miracles. Proceedings of Annual Conference of Southeastern Association of Game Fish Commissions 27:374-385.

STUDY LOCATION: Southern United States

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Variable

SUMMARY: Problems and progress in the management of fisheries in reservoirs of the southern United States are reviewed. Trends in data on the standing crop of fishes in 172 reservoirs are discussed with reference to potential production of sport fishes and to physicochemical variables. Certain management techniques that involve manipulation of controllable environmental factors deserve more emphasis. Deliberate, long-term management of the fluctuation zone of reservoirs is a critical need, and quantitative measurements of natural vegetation in this zone should be made to determine which species of plants provide optimum spawning habitat and cover for desirable sport fishes. Cultivation of seasonally exposed portions of reservoirs should enhance production of sport fish, other factors being equal. Fish attractors and standing timber have helped increase harvest but drawbacks exist (e.g., structures that have deteriorated due to exposure during drawdown must be refurbished).

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Reservoirs, review

COPY OBTAINED: Abstract in Ploskey (1982)

Johnson, F. A. and F. Montabano III. 1989. Southern reservoirs and lakes. IN: Habitat Management for Migrating and Wintering Waterfowl in North America. Edited by L. M. Smith, R. L. Pederson, and R. M. Kaminski, Texas Tech University Press.

STUDY LOCATION: Southeastern United States

DRAWDOWN TIMING/DURATION: Variable

LAKE SIZE: Variable

OBJECTIVES OF DRAWDOWN: Waterfowl management

SUMMARY: Reservoirs in the southern Atlantic Flyway generally provide poor habitat for wintering waterfowl, primarily due to inadequate food as a result of frequent water level fluctuations. Reservoirs are usually drawndown as a response to water supply demands, and many aquatic plants do not become reestablished after several annual drawdowns. In subbasins managed for waterfowl, early spring and summer drawdowns are recommended for good production of millets, panic grasses and smartweeds. Spring and summer drawdowns in Florida have rejuvenated substrates, stimulated production of waterfowl food plants, and increased the standing crop of macroinvertebrates. Winter drawdowns are not recommended where waterfowl depend heavily on submersed vegetation.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Waterfowl management, southern reservoirs, summary

COPY OBTAINED: Yes

Johnson, W. E., J. W. Benton, and D. R. Douglas. 1988. Lake drawdown as a strategy for restoring sportfish populations and aquatic vegetation in a hypereutrophic Central Florida lake. Manuscript for publication in "North American Journal of Fish Management."

STUDY LOCATION: Lake Griffin, Florida

DRAWDOWN TIMING/DURATION: Spring 1984; 53 days exposing 30% of the bottom

LAKE SIZE: 9,291 acres

OBJECTIVES OF DRAWDOWN: Fisheries management, habitat restoration

SUMMARY: An extreme drawdown was conducted in spring 1984 on Lake Griffin, a 3,760-hectare hypereutrophic lake in central Florida, to reestablish aquatic vegetation and improve sportfish populations. Although the dewatering goal of 2.1 m was not reached, the water level was lowered 1.8 m, exposing 30% of the lake bottom. As the lake refilled in late summer, bluegill and redear sunfish spawned prolifically; producing the highest number of young-of-the-year fish per hectare in fall 1984 blocknet samples of the five study years. In areas where submersed vegetation became established on the flocculent lake bottom, numbers of young-of-the-year largemouth bass were 30 times higher than similar areas having no vegetation. Angler success for bluegill and redear also reached record levels in 1987, while the black crappie fishery did not show benefits from the drawdown. Hydrilla and naiad were essentially eliminated from the lake by a fluridone treatment (Sonar trade name) in April 1987. Weak year classes of largemouth bass were produced in 1987 and 1988 following loss of hydrilla and other submerged vegetation. This loss of largemouth were produced in 1987 and 1988 following loss of hydrilla and other submerged vegetation. This loss of largemouth bass production documented the importance of submerged vegetation in a hypereutrophic central Florida lake.

POSITIVE EFFECTS: Increased sport fishery; increased aquatic vegetation established

NEGATIVE EFFECTS: Increased hydrilla infestation

KEYWORDS: Lake Griffin, spring drawdown, fishery management

COPY OBTAINED: Yes

Johnson, W. E., D. A. Dobbins and D. E. Holcomb. 1981. Drawdown response of a hypereutrophic Florida lake. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies.

STUDY LOCATION: Lake Carlton, Florida

DRAWDOWN TIMING/DURATION: March 1977-January 1978; 10 months; exposing 80.7% of the bottom

LAKE SIZE: 430 acres

OBJECTIVES OF DRAWDOWN: Habitat and fishery improvement

SUMMARY: A drawdown of Lake Carlton was conducted to evaluate complete dewatering as a method for rehabilitation of a severely eutrophic lake. The water level was lowered 4.1 m exposing 80.7% of the bottom (29.4% sand and 51.3% organic sediments). Following refill a layer of consolidated sediments persisted over most of the area where organic sediments had not been exposed. Most new vegetation was established at too great a water depth and died. A net gain in area covered by rooted aquatic vegetation persisted only 2 years after refill. No improvement in water quality was accomplished. Increased standing crops of benthic invertebrates were only detected the winter following refill in areas where consolidation of organic sediments and extensive Typha growth occurred. No substantial improvements were found for largemouth bass, bluegill, and redear sunfish populations.

About 27 acres of sediments exposed during drawdown were only moderately dried and supported vegetation (primarily cattails) which became uprooted during refill. Drawdown and subsequent refill of Lake Carlton did not result in any improvement of water quality, but actually resulted in short-term deterioration and eventual return to pre-drawdown eutrophication levels. In Florida, lakes with steep or no littoral zone and a deep average depth may not respond to this management technique.

POSITIVE EFFECTS: Small increase in standing crops of benthic invertebrates and black crappie population.

NEGATIVE EFFECTS: No improvement in new vegetation, water quality or sport fisheries. Extensive growth of Typha. Short-term benefits only.

KEYWORDS: Lake Carlton, Florida; Oklawaha River; dewatering; eutrophic lake

COPY OBTAINED: Yes

Jones, R. A. and G. F. Lee. 1980. An approach for the evaluation of Eefficacy of wetlands-based phosphorus control programs for eutrophication-related water quality improvement in downstream waterbodies. Water, Air, and Soil Pollution, Vol. 14:359-378.

STUDY LOCATION: Lake Okeechobee, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: A study of available information on eutrophication of Lake Okeechobee indicated that the proposed re-creation of marshes and wetlands may have little positive impact on the water quality of the lake. Present data on nutrients in the system show a confused picture, and further studies are needed on amounts and available forms of N and P during the summer growing season. The role of color as a factor in limiting algal growth should be determined. If it is significant, then control of phosphorus loading through wetlands restoration would have little effect on the lake's water quality. The long hydraulic residence time (1 year) permits nutrient released from the wetlands to accumulate in the lake, producing a net P balance unless aquatic plants are harvested. The Vollenweider Organization for Economic Cooperation and Development model appears to be useful for predicting the planktonic algal chlorophyll response to P loading in Lake Okeechobee. Based on limited data, a 50% total P load reduction to the lake would result in a decrease from 31 to 22 micrograms per liter of chlorophyll, a noticeable improvement in water quality; a 10% decrease, an undetectable change.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: The re-creation of marshes and wetlands may have little positive impact on the water quality.

KEYWORDS: Lake Okeechobee, marsh, phosphorus balance

COPY OBTAINED: Yes

Kadlec, J. A. 1960. The effect of a drawdown on the ecology of a waterfowl impoundment. Michigan Department of Conservation, Game Division Report No. 2276. 181 pp.

STUDY LOCATION: Backus Lake, Michigan

DRAWDOWN TIMING/DURATION: Summer drawdown; 4 feet

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Waterfowl management

SUMMARY: Ecological effects of drawdown on Backus Lake were studied in three phases - pre-drawdown in the summers of 1956 and 1957, drawdown (4 feet) during the summer of 1958, and post-drawdown in 1959. Effects of drawdown on soil, water, vegetation, invertebrates, and waterfowl were evaluated. Soil and water studies showed a definite increase in nutrient concentrations in the water during drawdown. Soil nitrates also increased during drawdown due to aerobic nitrification, and high concentrations persisted until the spring of the first year of reflooding. Although the response of other nutrients was less obvious, solubility and plant growth did increase. Most nutrient changes diminished after reflooding for 1 year. Invertebrate populations were considerably reduced by reflooding. Many submerged and floating-leaf plants were reduced in number during the first year of reflooding, except for waterlilies, smartweed, and bushy pondweed. Emergent vegetation spread and increased in abundance as a result of drawdown. Populations of breeding waterfowl did not change greatly during the study. Use of drawdown and its effectiveness as a management technique for marshes is discussed.

POSITIVE EFFECTS: The reduction of submerged and floating-leaf plants during the first year of reflooding, except for waterlilies, smartweed, and bushy pondweed.

NEGATIVE EFFECTS: The increase of emergent vegetation; increase in soil nitrates and the decrease of invertebrate populations. Nutrient content higher in water during drawdown. Waterfowl populations did not change.

KEYWORDS: Michigan waterfowl impoundment; summer drawdown

COPY OBTAINED: Abstract in Ploskey (1982)

Kalk, M., A. J. McLachlan, C. Howard-Williams. 1979. Lake Chilwa studies of change in a tropical ecosystem. Monographiae Biological, V. 35, pp. 107-122.

STUDY LOCATION: Lake Chilwa, Africa

DRAWDOWN TIMING/DURATION: Annual seasonal drawdown

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN:

SUMMARY: One of the most striking features of all temperate water bodies is the conspicuous zonation of vegetation, usually associated either directly or indirectly with changes in water depth. However, in Lake Chilwa, as in other tropical African lakes particularly the shallow ones, the relationship between zonation of vegetation and water depth is not as simple. This is due to the unusually large water level fluctuations relative to lake depth which occur here. Indeed, Beadle (1974) pointed out that the type of vegetation in tropical Africa seems to depend on water level fluctuations rather than merely a water depth gradient. In this chapter, the vegetation of Lake Chilwa is described in outline and the major environmental influences on the vegetation are discussed. Particular stress is laid on the fluctuations in water level and concentration of sodium chloride and bicarbonate, and the effects of these on the growth of various plant species. Of particular interest in the African context is the presence of Typha domingensis rather than Cyperus papyrus as the dominant swamp plant in Lake Chilwa. Species such as Salvinia hastata, present in other water bodies in the region, are conspicuous by their absence in Lake Chilwa.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Chilwa, Africa; natural seasonal drawdown

COPY OBTAINED: Yes

Kansas Water Office, State of Kansas. 1988-1989. Recommended lake level management plans, October 1988 to October 1989; Planned and actual lake elevations, October 1987 to October 1988; Reservoir water level management plans, October 1989- October 1990.

STUDY LOCATIONS: Kansas reservoirs

DRAWDOWN TIMING/DURATION: Generally drawdown in mid- to late-summer to allow vegetation of littoral zone, reflooding in fall for vegetation inundation and waterfowl habitat, drawdown in winter to protect structure from ice, and reflooding in spring to allow fish spawning in inundated areas.

LAKE SIZE: Variable

OBJECTIVE OF DRAWDOWN: fisheries management, waterfowl habitat and food supply

SUMMARY: Reservoir water level plans generally follow the basic plan: Maintain high water level to flood established vegetation for migratory waterfowl feeding enhancement during October-December. Drawdown in December-January to prevent ice damage and prepare for spring refill, maintain until March. Refill for fish spawning March-May. Drawdown for vegetation establishment in summer months. It is stressed that high release rates in the spring should be avoided due to the possibility of flushing fish larvae and fry from the lake.

In some reservoirs, mid-summer drawdowns, designed to enhance predation, created a recreational boating hazard and limited waterfowl hunting success. A fall water level increase produced good waterfowl habitat by flooding areas for feeding and resting.

POSITIVE EFFECTS: fishery management, waterfowl food enhancement, flood protection, ice damage protection

NEGATIVE EFFECTS: midsummer drawdowns create a boating hazard,lakes inaccessible.

KEYWORDS: Kansas reservoirs, fishery management, waterfowl enhancement

COPY OBTAINED: Yes

Keddy, P. A. and A. A. Reznicek. 1986. Great Lakes vegetation dynamics: the role of fluctuating water levels and buried seeds. Journal of Great Lakes Restoration 12(1):25-36.

STUDY LOCATION: Great Lakes, United States

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: The objective of this study was to review the relationship between fluctuating water levels and shoreline vegetation dynamics in the Great Lakes. Low water periods allow many plant species and vegetation types to regenerate from buried seeds. A review of published seed bank densities shows that some lakeshores have densities of buried seeds greater than 10^4 seeds m^{-2}, an order of magnitude greater than densities reported from prairie marshes. High water periods kill dominant species (e.g., Typha sp.), thereby creating gaps which other species can colonize during low water periods. High water also kills woody plants, thereby extending marshes landward. Fluctuating water levels therefore increase the area of shoreline vegetation, and the diversity of vegetation types and plant species. Any stabilization of water levels would likely reduce marsh area, vegetation diversity, and plant species diversity. Four basic shoreline vegetation types (forest and shrub thickets, wet meadow, marsh, and aquatic) can be recognized; both wet meadow and marsh largely result from fluctuating water levels.

POSITIVE EFFECTS: Fluctuating water levels increase the area of shoreline vegetation and the diversity of vegetation types and plant species.

NEGATIVE EFFECTS:

KEYWORDS: Seedbank study, Great Lakes

COPY OBTAINED: Yes

Keith, W. E. 1974. Management by water level manipulation. Arkansas Game and Fish Commission. 25 pp.

STUDY LOCATION: Variable; reservoirs

DRAWDOWN TIMING/DURATION: Variable

LAKE SIZE: Variable

OBJECTIVES OF DRAWDOWN:

SUMMARY: Fish populations respond to water-level changes in a predictable way, whether fluctuations are natural (due to variation in runoff) or artificial (created by dams, diversions, or some other structure). Effects are most pronounced in impounded waters or low-water streams where vast flat areas (flood plains) are inundated during high water. Simulating natural seasonal and annual cycles of increasing and decreasing water levels in an effective way to optimize black bass production and manage fisheries in general. Water-level controls are most feasible on impounded waters. In the southern United States, the largemouth bass is the principal bass affected by this technique. Increased water levels just before, during and for a short time after spawning increase the amount of desirable habitat for nearshore fishes and improve the productivity of impoundments. High water levels enhance spawning success, survival, growth, and recruitment. Controlled drawdowns can restrain the spread of nuisance aquatic vegetation, increase predator use of prey fishes, and accelerate nutrient recycling from bottom muds. Severe manipulation of water levels often conflicts with primary uses such as power generation or flood control. For many impoundments, the needs for different interests should be reevaluated periodically.

POSITIVE EFFECTS: Increased water levels near spawning time increase the amount of desirable habitat for nearshore fishes and improve the productivity of impoundments. Controlled drawdowns can restrain the spread of nuisance aquatic vegetation, increase predator use of prey fishes, and accelerate nutrient recycling from bottom muds.

NEGATIVE EFFECTS: May conflict with power generation or flood control

KEYWORDS: Reservoirs; review

COPY OBTAINED: Abstract in Ploskey (1982)

Kent State University Department of Biological Sciences. 1980. Water Resources Bulletin, v16, p317-322, Apr 80.

STUDY LOCATION: n/a

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: macrophyte control

SUMMARY: Lake drawdown as a management or restoration technique for controlling macrophytes in eutrophic lakes is reviewed for effectiveness, longevity, and positive and negative impacts. Drawdown can be effective but it is species specific, and some nuisance plants are resistant or stimulated. The responses of 63 nuisance plants are reviewed. Advantages of the technique include low cost, absence of toxic chemicals, enhancement of fisheries, and the opportunity to carry out other lake improvements. Drawbacks include nutrient release, algal blooms, low dissolved oxygen, lake user dissatisfaction during the process, and failure to refill.

POSITIVE EFFECTS: low cost, absence of toxic chemicals, fisheries enhancement, easy access to lake bottom during drawdown.

NEGATIVE EFFECTS: nutrient release from sediments, algal blooms, low dissolved oxygen, lake access impaired, failure to refill.

KEYWORDS:

COPY OBTAINED: Yes

Kurata, A. 1989. The effect of low water levels on the water quality of Lake Biwa. Hydrobiologia, 176/177:29-38.

STUDY LOCATION: Lake Biwa, Japan

DRAWDOWN TIMING/DURATION: 6 months, winter, lowering of 1 meter

LAKE SIZE: 909 square miles

OBJECTIVES OF DRAWDOWN: n/a; natural drawdown

SUMMARY: Because of a lack of precipitation, water levels in Lake Biwa, Japan, were extremely low between the beginning of September 1984 and the end of February 1985. Approximately 13 million people depend upon the lake as a source of drinking water and for industrial use, and the severe water shortage became a serious concern for downstream communities. Also, there was concern that deterioration of water quality caused by rotting macrophytes and the release of nutrients from vegetation and nearshore sediments might create additional problems. In this paper, the release of nutrients from vegetation and sediments is examined under conditions which simulate both calm and turbulent water motions in the nearshore, and the magnitude of nutrient loadings are estimated in relation to the specific effects of low lake level. Sample stations were established around the south shore of Lake Biwa. Sampling was undertaken at the time of low water and during the rising water levels. Sediment samples were particle sized into 7 groups (<2000um). Other measured values ranged as follows: BOD (0.5-1.3), COD (1.2-3.5), TP (0.019-0.037), SRP (0.013-0.030), SOP (0.005-0.007), TN (0.45-0.90), NO_2-N (0.004-0.007), NO_3-N (0.04-0.08), and NH_4N (0.026-0.053), all as mgL^{-1}. The sample data suggest that, overall, there was little impact on lake water quality as a result of low water levels. However, remedial actions may have had an important and beneficial impact on nearshore water quality in the southern basin of Lake Biwa.

POSITIVE EFFECTS: Low water levels did not appear to affect the water quality.

NEGATIVE EFFECTS:

KEYWORDS: Lake Biwa, Japan; natural drawdown; winter; water quality

COPY OBTAINED: Yes

Kushlan, J. A. 1976. Wading bird predation in a seasonally fluctuating pond. The Auk, 93:464-476.

STUDY LOCATION: Big Cypress Swamp, Florida

DRAWDOWN TIMING/DURATION: Annual spring drawdown

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: The vast wetlands of southern Florida are characterized by seasonal rainfall and extensive water level fluctuations, a pattern typical of many tropical ecosystems. When water levels fall in the dry season, aquatic organisms are concentrated within increasingly smaller areas of remaining water where they become readily utilizable patches of food for highly mobile predators, particularly wading birds of the order Ciconiiformes. Concentrations of herons, ibises, and storks feed on the aquatic animals concentrated in these dry season pools throughout the southern Florida wetlands, and because of their numbers and mobility, these birds play an important role in energy movement within the southern Florida ecosystem. However, little information exists on such wading bird feeding assemblages, called aggregations. Aggregations were apparently even greater in the past. A few comments in the literature suggest that they may be widespread in the tropics as well. This paper discusses aspects of the ecology of ciconiiform aggregations that utilized a small pond in the Big Cypress Swamp of southern Florida. Particular attention is given to how aggregations form, competitive relations among the predator species, and the impact of predation on prey populations in the pond. The study was conducted from 1969 through 1973. In 1969 observations were made on wading bird behavior and ecology. During 1970-73, data were gathered on changes in fish populations in relation to water level fluctuations. These data permit comment on the impact of wading bird predation because the study covered two comparable dry periods, one with (1973) and one without predation (1970).

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Florida swamps, wading bird feeding

COPY OBTAINED: Yes

Kushlan, J. A. 1976. Environmental stability and species diversity. Ecology, 57:821-825.

STUDY LOCATION: Everglades, Florida

DRAWDOWN TIMING/DURATION: January-May, annually

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Natural drawdown

SUMMARY: On marshes of the Everglades, drastic seasonal fluctuation of water level is the most important factor affecting fish. By May, water levels often recede to the extent that most surface water disappears and only localized pools remain. Although the density of fish decreased during 27 months of high stable water level, the biomass, average size, and diversity of fish increased. Populations of small omnivorous fishes were reduced, and populations of large piscivores (especially centrarchids) increased because of immigration of piscivores from other areas. Under stable water levels, predation assumes the major role in restructuring the fish community. Fish communities of Everglades' marshes are dominated by small omnivores during low water, when habitat is limiting, and by large predators during periods of high water.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Everglades marshes; natural fluctuation

COPY OBTAINED: Abstract in Ploskey (1982)

Kushlan, J. A., J. C. Ogden, and A. L. Higer. 1975. Relation to water level and fish availability to wood stork reproduction in the Southern Everglades, Florida. U. S. Geological Survey Open-File Report 75-434.

STUDY LOCATION: Shark River Slough, Everglades, Florida

DRAWDOWN TIMING/DURATION: Natural annual spring dry season

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a; natural drawdown

SUMMARY: The wood stork is a species of colonial wading bird in the Everglades that is most sensitive to changes in the availability of food. Previous studies have shown that the initiation and success of wood stork nesting depends on high densities of fish concentrated in ponds and other catchment basins during the dry season. The extreme dependence of the wood stork on the cyclic hydrologic regime of the southern Florida wetlands makes it an indicator of the wellbeing and ecological stability of the Everglades.

The wood stork has declined in numbers over the last 25 years. One reason for the decline in the wood stork population was the change in the hydrologic regimen of the Everglades which affected the feeding habitat and the food production. The fish on which the wood stork feeds increase in density during the dry season as water levels fall. In the Everglades marsh, densities were highest in front of the drying edge of surface water at a depth of about 0.3m. Dry-season densities were greatest when a drought occurred the previous year. Historically wood stork nesting success was associated with high summer water levels, high rates of surface-water discharge and high rates of drying.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Everglades, wood stork, Shark River Slough

COPY OBTAINED: Yes

Leslie, A. J., J. M. Van Dyke and L. E. Nall. 1982. Drawdown strategies for aquatic plant control in North Florida, 1. Brazilian elodea. Florida Department of Natural Resources Bureau of Aquatic Plant Research and Control.

STUDY LOCATION: Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: This proposed study on Brazilian elodea (Egeria densa) initiates a series of investigations to define specific water fluctuation strategies - including drawdowns - for control of specific aquatic plant problems. As a result of these investigations, we hope to be able to design a program whereby a problem plant association can be reduced through a series of consecutive drawdowns and then kept at a reduced level through initiations of a water fluctuation schedule that simulates the natural wet and dry cycles. When considering aquatic plant management programs, it is important to remember that aquatic plants are essential elements of aquatic systems: planktonic, epiphytic, and rooted aquatic plants are the primary energy source on which all other aquatic organisms depend. Moderate concentrations of rooted aquatic plants increase the stability of the ecosystem and are beneficial to fisheries and waterfowl. Aquatic plants can support large numbers of aquatic insects important in the diets of fishes; Holcomb and Wegener (1974) found a higher biomass of sports fishes in vegetated areas than in unvegetated areas of Lake Tohopekaliga.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Florida lakes; aquatic plant control strategies

COPY OBTAINED: Yes

Lantz, K. E. 1974. Natural and controlled water level fluctuation in a backwater lake and three Louisiana impoundments. Louisiana Wild Life and Fisheries Commission, Fisheries Bulletin Number 11.

STUDY LOCATION: Anacoco Lake, Bundicks Lake, Chicot Lake, Louisiana

DRAWDOWN TIMING/DURATION: Summer drawdown; summer drawdown; fall drawdown, respectively

LAKE SIZE: 2,600 acres; 1,750 acres; 1,625 acres, respectively

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Three shallow impoundments and a natural backwater lake were studied during several consecutive years of controlled and natural water level fluctuations. Two to three consecutive years of water fluctuation were usually required to obtain control of aquatic macrophyte growth and spread in the impoundments. Natural fluctuation in the backwater lake on an annual basis precluded establishment of troublesome amounts of submersed vegetation. Three significant fish population conditions were observed during five or more consecutive years of water fluctuation in the three impoundments: (1) a gradual increase in total standing crop values per acre occurred during the early years of fluctuation over values present during pre-fluctuation years (2) a rapid increase in available size game fish and game fish reproduction per acre occurred during the early years of fluctuation and (3) a leveling off of significant changes in standing crop values, available size game fish poundages and reproduction occurred after four to five consecutive years of fluctuation. No water chemistry or physical values toxic to aquatic life were recorded during the study period.

POSITIVE EFFECTS: Increased standing crop and increased available size of game fishes occurred in the early years of fluctuation; this change leveled off after several years. No water chemistry or physical values toxic to aquatic life were recorded.

NEGATIVE EFFECTS: Some macrophyte species' biomass increased

KEYWORDS: Louisiana reservoirs, macrophyte control, annual drawdown

COPY OBTAINED: Yes

Lantz, K. E., J. T. Davis, J. S. Hughes, and E. H. Schafer, Jr. 1964. Water level fluctuation - its effect on vegetation control and fish population management. Proceedings of Annual Conference of Southeastern Association of Game and Fish Commissions.

STUDY LOCATION: Lakes Anacoco, Bussey, and Lafourche, Louisiana

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 2,600 acres, 2,200 acres and 1,000 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Three Louisiana Lakes (Anacoco, Bussey, and Lafourche) are used as examples of water-level manipulation as a management practice. Drawdowns in all three lakes were extremely effective in controlling aquatic vegetation. For example, the drawdown of Lake Anacoco reduced the surface area covered by aquatic macrophytes from 40 to 5%; in Bussey Lake, the reduction was from 32.0 to 1.4% in 1 year. Drawdown increased the standing crop and numbers of fish of harvestable size, while reducing the biomass of intermediate sized fish (especially sunfishes) in Anacoco Lake. Similar results were observed in Bussey Lake, but the fish population changed somewhat (i.e., intermediate sized shad were severely reduced and in the following year were replaced by an enormous abundance of fingerlings). The slow refilling of Bussey Lake hindered the spawning of the black basses and crappies that year. In Lafourche Lake, drawdown rapidly increased the numbers of harvestable sized predatory and nonpredatory game fish and decreased the number of intermediate sized fish. However, because the water levels did not return to normal pool, spawning of predatory game fish failed for 2 consecutive years. The total harvest of fish from Bussey Lake increased in 1 year, though the catch in pounds per hour decreased. In Lafourche Lake, the harvest of fish decreased slightly after drawdown, perhaps due to the slow rate of refilling.

POSITIVE EFFECTS: Drawdowns were extremely effective in controlling aquatic vegetation. Drawdown increased the standing crop and numbers of fish of harvestable size.

NEGATIVE EFFECTS: Drawdown reduced the biomass of intermediate sized fish in Anacoco Lake. The slow refilling hindered the spawning of black bass and crappie.

KEYWORDS: Louisiana, fishery management, macrophyte control

COPY OBTAINED: Yes

Linde, A. F. 1969. Techniques for wetland management. Department of Natural Resources, Madison, Wisconsin.

STUDY LOCATION: Wisconsin impoundments, marshes

DRAWDOWN TIMING/DURATION: Summer drawdowns alternating with flooding

LAKE SIZE: n/a; marsh and wetland impoundments

OBJECTIVES OF DRAWDOWN: Waterfowl habitat enhancement, wildlife enhancement

SUMMARY: Purposes of drawdowns for wildlife habitat enhancement include 1) food patch establishment of planted grains and food species; 2) mud-flat food production, and 3) muskrat control, preventing animals from burrowing in wet mud. Summer drawdowns produce an extremely large amount of new vegetation; muskrat populations exploded; carp populations were reduced or eliminated if drawdown was complete.

Unless a marsh is in need of complete rejuvenation, a partial drawdown is probably preferable to a complete drawdown for the following reasons: 1) partial drawdown will maintain some water through the summer waterfowl brood period; 2) invertebrates (waterfowl food) are reduced to very low levels by a complete drawdown; and, 3) complete drawdowns practiced annually on a shallow marsh could result in the vegetative growth completely closing in all open-water areas in the impoundment.

POSITIVE EFFECTS: Increased desirable vegetation production, waterfowl and other wildlife enhancement

NEGATIVE EFFECTS: Some undesirable plants establish; muskrat populations may become too large

KEYWORDS: Wisconsin marsh impoundments, waterfowl habitat enhancement

COPY OBTAINED: Yes

Massarelli, R. J. 1984. Methods and techniques of multiple phase drawdown - Fox Lake, Brevard County, Florida. International Symposium on Lake and Reservoir Management, Third Annual Conference of the North American Lake Management Society, USEPA 440/5/84-001.

STUDY LOCATION: Fox Lake, Florida

DRAWDOWN TIMING/DURATION: 1 year

LAKE SIZE: 110 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Multiple phase drawdowns have been suggested as a possible restoration technique for controlling the aquatic weed hydrilla and for consolidating sediments. Brevard County, in cooperation with the Florida Game and Freshwater Fish Commission, implemented such a program in 1979-80. Fox Lake is a small 44.5 ha (110 acre) freshwater lake in Brevard County on Florida's east coast. This lake, the location of a major regional park, had become unusable to boaters and fishermen due to an excessive growth of hydrilla. In addition to the hydrilla, the lake had minimal fish and wildlife benefits due to a thick layer of unconsolidated muck. While the use of proper technique is important, the restoration of Fox Lake required methods which insure full community support, and the cooperation of other agencies and local elected officials' and public involvement are necessary. Techniques must be flexible enough to meet unforeseen or changing conditions. For example, during the Fox Lake drawdowns, lake conditions required innovations such as air boat pull plows and amphibious craft. The Fox Lake project demonstrated that lake restoration projects with maximum and innovative use of local resources can be completed with minimal impacts on local government budgets.

POSITIVE EFFECTS: Lake drawdowns can be accomplished with minimal impacts on local government budgets if cooperation of local resources is achieved.

NEGATIVE EFFECTS: Floating mats of emergent vegetation

KEYWORDS: Fox Lake, Florida; macrophyte control

COPY OBTAINED: Yes

Mathis, W. P. and A. Hulsey. 1959. Rough fish removal from Lake Catherine, Arkansas. Proceedings of Annual Conference of Southeastern Association of Game and Fish Commission. 13:197-203.

STUDY LOCATION: Lake Catherine near Hot Springs, Arkansas

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: Pro-Noxfish was applied in October, 1958 during a drawdown period. Pro-Noxfish is a 2.5% rotenone preparation. The cost of the chemical was $5000 USA. The lake was divided into seven areas. Pro-Noxfish was used to give concentrations of 0.15 to 0.30 mg/L. A small amount of derris powder (5.7% rotenone) was also used. Less than 1% of the kill consisted of gamefish. Subjective estimates placed the mortality (by weight) at 99% of the gizzard shad, 95% of the drum, and 5% of the gamefish populations. The lowered water level (1.2 m) realized a savings of $4400 USA in the chemical costs. Several gamefish species will be stocked before re-expansion of the trashfish population.

POSITIVE EFFECTS: Considerable savings when utilizing drawdown and chemical applications simultaneously.

NEGATIVE EFFECTS:

KEYWORDS: Arkansas, chemical fish management

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

McKee, K. L. and I. A. Mendelssohn. 1989. Response of a freshwater marsh plant community to increased water level. Aquatic Botany, 34:301-316.

STUDY LOCATION: Louisiana freshwater marshes

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Field and greenhouse experiments in which salinity and elevation were manipulated demonstrated that the response of freshwater marshes to saltwater intrusion may be variable and dependent upon a number of factors including: species composition; level, duration and abruptness of exposure to saline water; flooding depth; a source of propagules of more salt-tolerant species. In the field, saltwater intrusion was simulated by transplanting swards of a freshwater marsh to a higher salinity area. The three dominant species, Panicum hemitomon Schultes, Leersia oryzoides (L.) Swartz, and Sagittaria lancifolia L., succumbed to the sudden increase in salinity to 15%. However, the denuded plots were rapidly invaded by more salt-tolerant species that were present in the higher salinity marsh. Although growth was reduced, Panicum hemitomon and Leersia oryzoides were relatively tolerant of salinities up to 9.4% for at least one month in the greenhouse. Sagittaria lancifolia was less tolerant of salinity increases and showed symptoms of tissue damage at 4.8%. A decrease in elevation, which resulted in an increase in mean water level and a more reduced soil environment, caused a significant decrease in the live above-ground biomass and stem density in the experimental field plots.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: An increase in salinity decreased the plant biomass as did a decrease in elevation.

KEYWORDS: Louisiana freshwater marshes, inundation

COPY OBTAINED: Yes

McKinney, S. P, and W. S. Coleman. Hydrilla control and vegetation responses with multiple dewaterings. Florida Game and Fresh Water Fish Commission.

STUDY LOCATION: Fox Lake, Florida

DRAWDOWN TIMING/DURATION: Spring (11 weeks); fall-winter (4 months)

LAKE SIZE: 158 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: An experimental multiple dewatering plan designed to control Hydrilla verticillata Royle and improve sportfish habitat was implemented on Fox Lake in 1979 and 1980. Hydrilla above the hydrosoil and turions were eliminated while relative abundance of tubers decreased from 19.44 to 1.79 m^2 by termination of the project. The depth of organic sediments was reduced by 29%, 36% and 47% for the 30, 60 and 90 cm contour intervals respectively. Expansion of native vegetation was documented by a 40% increase in Vallisneria americana and basinwide germination of Typha latifolia. The proposed Fox Lake dewatering schedule consisted of three drawdowns: the spring (February-May) dewatering to maximize sediment consolidation, kill hydrilla plants, stimulate germination of hydrilla tubers and turions and encourage germination of native aquatic vegetation. Lake bottom was exposed within 11 days and lasted 11 weeks. Exposed hydrilla was desiccated within 2 weeks. Within 3 weeks of reflooding, cattail seedlings, hydrilla, watersprite, and eel grass were observed over most of the basin. The second dewatering occurred in October-March, after which cattail, nut grass, and millet covered at least 50% of the basin. Germination of hydrilla was confined to one moist area. The third dewatering occurred April-May, with drying at the top 5-10cm of organic sediment. However, moist muck remained below this crust, and dense stands of cattails and millet germinated. Hydrilla tubers and turions decreased by the end of the third dewatering; however, by the termination of the project, cattails occurred in dense stands over most of the basin.

POSITIVE EFFECTS: Decreased amounts of hydrilla and reduction in depth of organic sediments. Expansion of native vegetation.

NEGATIVE EFFECTS: Increased cattail occurrences

KEYWORDS: Fox Lake, Florida, macrophyte control, multiple drawdown

COPY OBTAINED: Yes

Meeks, R. L. 1969. The effect of drawdown date on wetland plant succession. Journal of Wildlife Management, 33:817-821.

STUDY LOCATION: Shallow marsh, Port Clinton, Ohio

DRAWDOWN TIMING/DURATION: 1 month, annually

LAKE SIZE: 80 acres

OBJECTIVES OF DRAWDOWN: Wildlife habitat enhancement

SUMMARY: A 7-year study was begun on the Winous Point Shooting Club in 1956 to determine the effect of drawdown date on plant succession. An 80-acre marsh was diked into four units, one of which was drained yearly in mid-March, one in mid-April, one in mid-May, and one in mid-June. All the units were reflooded during September. Plant succession followed the same general trend on all units, going from semi-aquatic species to predominantly annual weeds. Fewer years were required with early drawdowns for annual weeds to replace semi-aquatic species. The May drawdown unit had the best plant associations for wildlife after 7 seasons. Draining during mid-to-late May should allow muskrats (Ondatra zibethica) to raise two litters without interruption, and not interfere with duck nesting.

POSITIVE EFFECTS: Growth of wildlife forage plants in May unit

NEGATIVE EFFECTS: Annual-weed dominance in March and April units, rosemallow dominance in June unit

KEYWORDS: Marsh, Ohio, wildlife habitat

COPY OBTAINED: Yes

Miller, J. L., L. A. Garrard and W. T. Haller. 1976. Some characteristics of hydrilla tubers taken from Lake Oklawaha during drawdown. Journal of Aquatic Plant Management, Vol. 14:29-31.

STUDY LOCATION: Lake Oklawaha, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Tubers are considered the primary mode of hydrilla reinfestation. A study at Lake Oklawaha (Rodman Reservoir) in north central Florida in January 1975 during a drawdown attempted to define chemical and physical characteristics of tubers and to relate sprouting differences to depth. Light quality had no effect on sprouting, but light presence stimulated sprouting under both aerobic and anaerobic conditions, and appeared to have the most well-defined regulatory effect. The number and weight of tubers increased significantly with increases in depth, and tubers harvested between depths of 0.6 and 1.2 m sprouted more successfully in either light or darkness than those from 0.3 or 1.5 m depths. The presence of large numbers of mature nonsprouted tubers at great depths may be due to high concentrations of CO_2 in the tubers, water, and hydrosoil. Laboratory experiments confirmed that CO_2 was effective in inhibiting tuber sprouting. Starch was the main carbohydrate storage form, and Ca and K were the principal mineral components.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Reproduction, aquatic plants, growth stages, chemical analysis, reservoirs, plant growth, Florida, drawdown, depth.

COPY OBTAINED: Yes

Milleson, J.F. 1987. Vegetation changes in the Lake Okeechobee littoral zone 1972 to 1982. South Florida Water Management District, Technical Publication #87-3.

STUDY LOCATION: Lake Okeechobee, Florida

DRAWDOWN TIMIMG/DURATION: n/a

LAKE SIZE: 480,000 acres

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: The distribution of major plant communities within the Lake Okeechobee littoral zone, and its associated inundation characteristics, was first documented in 1972. The regulated water level in the Lake was increased by two feet in 1973. Substantial changes in the composition and distribution of plant communities were recorded, especially the elimination of spikerush community and the expansion of the cattail zone and domination of the mixed grass zone by torpedo grass. The higher stages of the Lake keep the marsh continuously inundated. Constant flooding selects for more water tolerant species over those requiring periodic drying. This could lead to a decline in the diversity of the littoral zone plant communities, not only affecting the marsh vegetation itself, by the waterfowl, wading birds, reptiles, fishes, and other species which depend on the variety of habitats provided by a complex marsh system.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Okeechobee, hydroperiod, vegetation

COPY OBTAINED: Yes

Mower, B. 1987. The Sabattus Pond Restoration Project. Maine Department of Environmental Protection.

STUDY LOCATION: Sabattus Pond, central Maine

DRAWDOWN TIMING/DURATION: August 15-30 for 6-8 weeks

LAKE SIZE: 1,785 acres

OBJECTIVES OF DRAWDOWN: Algae bloom control

SUMMARY: Sabattus Pond is a large eutrophic lake which has experienced annual algal blooms for decades (40 to 50 years). In 1979, a two phase restoration project was implemented. Phase I, enhanced seasonal flushing (ESF), involved drawdown of the lake at the height of the algal bloom to flush associated TP from the lake to reduce internal recycling. Phase II was the installation of BMP's on area farms. A 20% improvement in chlorophyll a, secchi disk, and TP levels was observed post-ESF compared to pre-ESF. ESF is drawdown of the lake as rapidly and to the greatest extent possible at the height of the algal bloom to maximize the export of phosphorus from the lake. New floodgates were required to accomplish fast flushing.

POSITIVE EFFECTS: Reduce chlorophyll a and TP levels. This experiment will continue until 1990, at which time more definitive results may be available.

NEGATIVE EFFECTS: No mention of downstream effects

KEYWORDS: Maine, enhanced seasonal flushing, algae bloom control

COPY OBTAINED: Yes

Nichols, S. A. 1975B. The impact of overwinter drawdown on the aquatic vegetation of Chippewa Flowage, Wisconsin. Transactions of Wisconsin Academy of Science.

STUDY LOCATION: Wisconsin

DRAWDOWN TIMING/DURATION:

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Potamogeton robbinsii was also the dominant higher aquatic plant in Mondeaux Flowage, which was drawn down during the winters of 1971-72 and 1972-73. Forty percent (66 ha) of the 166 ha was free of nuisance plant growth after one drawdown, compared to complete coverage before. The second drawdown gave little additional control except for a further reduction in the abundance of Nuphar variegatum. In 1974 the abundance of plants returned to predrawdown levels and Ceratophyllum demersum became the dominant. In this regard, the treatment was unsuccessful. Dissolved oxygen levels during water withdrawal became very low but there was no fish kill. Nichols suggest that a drawdown every 2-3 years would be more effective than an annual water withdrawal since resistant plants might not then become established.

POSITIVE EFFECTS: Substantial aquatic plant control after one drawdown; the second resulted in minimal control.

NEGATIVE EFFECTS: Low dissolved oxygen; short-term control of plants.

KEYWORDS: Wisconsin, macrophyte control

COPY OBTAINED: Yes

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STUDY LOCATION: Wisconsin

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NEGATIVE EFFECTS: Low dissolved oxygen; short-term control of plants.

KEYWORDS: Wisconsin, macrophyte control

COPY OBTAINED: No

Perez, A. I., W. C. Huber, J. P. Heaney, and E. E. Pyatt. 1972. A water quality model for a conjunctive surface-groundwater system: an overview. Water Resources Bulletin, 8:900-908.

STUDY LOCATION: Lake Apopka, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a; background information for Lake Apopka

SUMMARY: A mathematical model is designed to predict water quality in a surface-groundwater system. The goal is to obtain cause and effect relationships between pollutant sources and the ensuing concentrations at different locations in a basin. Several programs are used to model rainfall, runoff, flow in surface bodies of water, infiltration, and groundwater flow. At every time step in the simulation, the water quantity computations are performed first. Subsequently, the results of these computations, typically in the form of flow velocities, are used as input to the water quality calculations. The water quality routines involve the modeling of the associated physical, chemical, and biological processes. Emphasis is placed on pollution in agricultural areas. Accordingly the Lake Apopka Basin in Central Florida is being used as the application site.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Hydrology, water quality, pollution, conjunctive use, mathematical models, computers, simulations, agriculture

COPY OBTAINED: Yes

Pesnell, G.L. and R. T. Brown. 1977. The major plant communities of Lake Okeechobee, Florida, and their associated inundation characteristics as determined by gradient analysis. South Florida Water Management District, Technical Publication 77-1.

STUDY LOCATION: Lake Okeechobee, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 480,000 acres

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Frequency data collected from tow surveyed transect lines within the Lake Okeechobee littoral zone were used to determine the elevation ranges and preferred periods of inundation of six major plant communities. Species composition was documented within each community by use of species presence data. The study provides baseline data for assessing the impact that changes in hydroperiod, resulting from future water management techniques, may have upon littoral zone vegetation. Results included: 1. the littoral zone of the lake is a product of post-drainage lake stages; 2. the distribution of the indicator species of the 6 communities investigated is related primarily to land elevation, with soil type exerting an influence in some cases; 3. the hydroperiod under which each community has developed is characterized by the percent inundation of the upper and lower elevation limits of the community during March, April, May, and June for the 1951-1970 time period; 4. the identification of the hydroperiod under which the communities have developed has potential as a predictive tool in evaluating future water management decisions.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Okeechobee, vegetation, hydroperiod

COPY OBTAINED: Yes

Peterson, J. O., S. M. Born, and R. C. Dunst. 1974. Lake rehabilitation techniques and experiences. Water Resources Bulletin, Vol. 10:1228-1245.

STUDY LOCATION: Wisconsin lakes

DRAWDOWN TIMING/DURATION: Winter drawdown

LAKE SIZE: Variable

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: The degradation of many lakes is the result of aging processes which have been accelerated by the activities of man. Where it is too late to prevent sedimentation and eutrophication problems, lake rehabilitation and protection comprise a resource management option warranting serious consideration. A Wisconsin Lake Renewal Demonstration Project has been evaluating several rehabilitation schemes for the past five years. A selected summary of Project lake rehabilitation activities, including nutrient inactivation, dilution, aeration, and several types of aquatic plant management, suggests the present status of lake rehabilitation.

An innovative use of winter drawdown was used in Sweden to control macrophytes mechanically. The water was drawn down and the plants allowed to freeze in the ice. Water was then introduced under the ice, floating the ice mass and mechanically removing the plants. In Wisconsin, drawdown was used as a first step for sediment manipulation or removal by land-based mechanical means. Bottom coverings, stump removal, and dock repair was also accomplished during drawdown. Bottom covering was also accomplished by spreading plastic sheets on ice and then conducting an under-ice drawdown to move the sheets to the lake bottom.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS: Review; lake management techniques

COPY OBTAINED: Yes

Peterson, S.A. 1987. Lake restoration methods: some work, some don't. IN: Management of Bottom Sediments Containing Toxic Substances, Proceedings of the 11th U.S./Japan Experts Meeting, November 4-6, 1985, Seattle, WA., pp. 15-25.

STUDY LOCATION: n/a

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Review

SUMMARY: Lake restoration has grown out of pilot and full-scale lake manipulation studies of the late 1960s and early 1970s. Some procedures have proven to be successful, and some have failed. This paper broadly divides the techniques into those that have proven to be successful, those that require more research, and combinations of treatments that are desirable together and those that should be avoided together. The procedures are divided further into those that reduce nutrient concentrations, and those that control algal and macrophyte biomasses directly. At present, solutions seem to be based almost exclusively on the application of chemicals or the introduction of machinery. In many cases these approaches are effective, but they are also expensive. The developing interest in biological control may greatly add to the arsenal of effective and inexpensive techniques. This avenue may become extremely important in the near future as the demand for clean water increases. Nutrient diversion, dilution/flushing, sediment removal, drawdown, sediment covers, hypolimnetic withdrawal, and artificial circulation are just some of the techniques presented.

POSITIVE EFFECTS: Summary of successful and unsuccessful techniques, which could prevent wasted attempts at lake restoration.

NEGATIVE EFFECTS:

KEYWORDS: Review; lake management techniques

COPY OBTAINED: Yes

Peterson, S.A. 1987. Lake restoration methods: some work, some don't. IN: Management of Bottom Sediments Containing Toxic Substances, Proceedings of the 11th U.S./Japan Experts Meeting, November 4-6, 1985, Seattle, WA., pp. 15-25.

STUDY LOCATION: n/a

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Review

SUMMARY: Lake restoration has grown out of pilot and full-scale lake manipulation studies of the late 1960s and early 1970s. Some procedures have proven to be successful, and some have failed. This paper broadly divides the techniques into those that have proven to be successful, those that require more research, and combinations of treatments that are desirable together and those that should be avoided together. The procedures are divided further into those that reduce nutrient concentrations, and those that control algal and macrophyte biomasses directly. At present, solutions seem to be based almost exclusively on the application of chemicals or the introduction of machinery. In many cases these approaches are effective, but they are also expensive. The developing interest in biological control may greatly add to the arsenal of effective and inexpensive techniques. This avenue may become extremely important in the near future as the demand for clean water increases. Nutrient diversion, dilution/flushing, sediment removal, drawdown, sediment covers, hypolimnetic withdrawal, and artificial circulation are just some of the techniques presented.

POSITIVE EFFECTS: Summary of successful and unsuccessful techniques, which could prevent wasted attempts at lake restoration.

NEGATIVE EFFECTS:

KEYWORDS: Review; lake management techniques

COPY OBTAINED: No

Pierce, P. C., J. E. Frey and H. M. Yawn. 1963. An evaluation of fishery management techniques utilizing winter drawdowns. Presented at the Seventeenth Annual Conference Southeastern Association of Game and Fish Commissioners. 18:448-474.

STUDY LOCATION: Bear Camp Lake, Georgia

DRAWDOWN TIMING/DURATION: 4 months, winter; 50% bottom exposure

LAKE SIZE: 65 acres

OBJECTIVES OF DRAWDOWN: Fishery management

SUMMARY: During October-January, 1963 the pond was lowered about 50%. In 90 days 853.5 kg of golden shiners (Notomigonus crysoleucas) were removed by netting. There was an improvement in the condition of all gamefish species. The golden shiner population was reduced greatly during 1963; high reproduction was noted but these were apparently preyed upon heavily. The black crappie (Pomoxis nigromaculatus) population benefited the most from this management program, although the largemouth bass (Micropterus salmoides) and bluegill (Lepomis macrochirus) populations also responded favorably.

POSITIVE EFFECTS: Effective fish population control.

NEGATIVE EFFECTS:

KEYWORDS: Georgia, winter drawdown, fishery management

COPY OBTAINED: Abstract only from Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Preston, S. D. and P. L. Brezonik. 1985. Water quality in the Oklawaha Chain of Lakes: a case study on problems and limitations in compiling long-term data bases. Lake and Reservoir Management: Practical Applications, Proceedings of the Fourth Annual Conference and International Symposium of the North American Lake Management Society.

STUDY LOCATION: Oklahawa chain of lakes, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: n/a; background information

SUMMARY: The Oklawaha lake chain in central Florida has had poor water quality for several decades as a result of stress from sewage effluents and agricultural runoff. Large-scale efforts to improve water quality by reducing nutrient loadings were undertaken. Extensive monitoring to detect changes in water quality has yielded a large amount of data for assessing water quality trends over the past 2 decades. This paper examines the usefulness and shortcomings of this data base, including problems in collecting it.

POSITIVE EFFECTS:

NEGATIVE EFFECTS:

KEYWORDS:

COPY OBTAINED: Yes

Progressive Architects Engineers Planners. 1988. Wolverine Lake 1988 post-drawdown aquatic vegetation monitoring program final report. Prepared for the Village of Wolverine Lake and Land and Water Management Division, Michigan Department of Natural Resources.

STUDY LOCATION: Wolverine Lake, Michigan

DRAWDOWN TIMING/DURATION: winter 1987-88; 2.5 foot drawdown

LAKE SIZE: 241 acres

OBJECTIVES OF DRAWDOWN: macrophyte control

SUMMARY: The village of Wolverine Lake conducted a 2.5 foot drawdown of the lake during the 1987-1988 winter season. A primary objective of the drawdown was to mitigate aquatic plant growth in the littoral regions of the lake exposed during the period of drawdown. The primary plant of concern was milfoil. Macrophyte data collected in the year following drawdown indicated that more freeze tolerant species of macrophytes (Chara and Najas) became abundant in areas where milfoil had predominated. In general, these two species are not considered the nuisance that milfoil is, because they grow close to the bottom and thus do not normally interfere with open water navigation. Due to the fact that Wolverine Lake has a mean depth of 7.5 feet and a littoral zone which comprises 190 acres, much of the lake bottom can support macrophyte growth. Assuming sufficient dissolved oxygen levels can be maintained under ice cover during periods of drawdown and the lake can be refilled soon after ice-off, winter drawdown appears to provide a viable method to control targeted nuisance aquatic plant growth in Wolverine Lake.

POSITIVE EFFECTS: milfoil control

NEGATIVE EFFECTS: establishment of other macrophyte species, milfoil became established by the end of the growing season.

KEYWORDS: Michigan, winter drawdown, macrophyte control

COPY OBTAINED: Yes

Prophet, C. W. 1970. Limnological features of Lyon County Lake after drainage and reflooding. Southwestern Naturalist 14:317:325.

STUDY LOCATION: Lyon County Lake, Kansas

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Flood control

SUMMARY: Variations in physicochemical conditions, primary productivity, and the relative abundance and composition of zooplankton were studied from 1963 through 1967 to assess changes in these variables during and immediately after reflooding of Lyon County Lake, Kansas. No significant differences were found in dissolved oxygen or phosphate content in successive years, although mean oxygen concentrations were lower in the last year than in the first. Gross primary production recorded from April 1966 to April 1967 was lower than of the two previous years. Gross production (mg O_2 l^{-1} $hour^{-1}$) averaged 83 in the third year after refilling of the lake and 34 in the fourth year. Chlorophyll, organic seston, and phosphate also decreased during the fourth year. Cladocerans and copepods were nearly 10 times more abundant in the first two years following reflooding of the basin than they were in the last 2 years. In the four-year study, average annual zooplankton biomass was high in the first and second years after filling of the lake (13.01 g dry weight m^{-3} and 13.63 g m^{-3}) and significantly lower in the next 2 years (1.29 g m^{-3} in 1965-66 and 1.44 g m^{-3} in 1966-67).

POSITIVE EFFECTS: Zooplankton densities higher in the 2 years following reflooding

NEGATIVE EFFECTS: Effects appeared to last only 2 years

KEYWORDS: Kansas reservoir; zooplankton; production

COPY OBTAINED: Abstract in Ploskey (1982)

Prophet, C. W., N. Youngsteadt, and L. Schnittker. 1967. Limnology of Lyon County State Lake during reflooding, April 1964-March 1966. Transactions of Kansas Academy of Science, Vol. 69:214-225.

STUDY LOCATION: Lyon County State Lake, Lyon County, Kansas

DRAWDOWN TIMING/DURATION: 2 years

LAKE SIZE: 135 acres

OBJECTIVES OF DRAWDOWN: Fishery management

SUMMARY: In 1962 the lake was drained, leaving about 1 ha of surface. The fish population was removed by seining and poisoning; restocking occurred in 1963. The lake did not refill completely for nearly 32 months. Variations in physico-chemical conditions, primary productivity, and relative densities of Cladocera and Copepoda were recorded during the period the lake was refilling (1963-1967). Annual mean productivity, phosphate, specific conductance, and dissolved oxygen levels were significantly lower the final year of the study. In general, density and biomass of zooplankton decreased throughout the study.

POSITIVE EFFECTS: Significant lowering of annual mean productivity, phosphate, specific conductance. Zooplankton density and biomass decreased.

NEGATIVE EFFECTS: Lowered dissolved oxygen levels

KEYWORDS: Kansas, fishery management, water quality

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Prophet, C. W. 1965. Some limnological features of Lyon County State Lake during reflooding. Transactions of Kansas Academy of Science, Vol. 67:676-685.

STUDY LOCATION: Lyon County State Lake, Lyon County, Kansas

DRAWDOWN TIMING/DURATION: 2 years

LAKE SIZE: 135 acres

OBJECTIVES OF DRAWDOWN: Fishery management

SUMMARY: In 1962 the lake was drained, leaving about 1 ha of surface. The fish population was removed by seining and poisoning; restocking occurred in 1963. The lake did not refill completely for nearly 32 months. Variations in physico-chemical conditions, primary productivity, and relative densities of Cladocera and Copepoda were recorded during the period the lake was refilling (1963-1967). Annual mean productivity, phosphate, specific conductance, and dissolved oxygen levels were significantly lower the final year of the study. In general, density and biomass of zooplankton decreased throughout the study.

POSITIVE EFFECTS: Significant lowering of annual mean productivity, phosphate, specific conductance and dissolved oxygen levels. Zooplankton density and biomass decreased.

NEGATIVE EFFECTS:

KEYWORDS: Kansas, fishery management, zooplankton

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Reddy, K. R., R. E. Jessup and P. S. C. Rao. 1988. Nitrogen dynamics in a eutrophic lake sediment. Hydrobiologia, Vol. 159:177-188.

STUDY LOCATION: Lake Apopka, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Nitrogen flux from sediment of Lake Apopka, a shallow central Florida lake, and subsequent utilization by the water hyacinth (Eichhornia crassipes) were evaluated using an indoor-microcosm sediment/water column. Sediment N was enriched with N15 to quantitatively determine the movement of ammonium N from the sediment to the overlying water column. During the first 30 days, 48% of the total N uptake by water hyacinth was derived from sediment N15-labeled ammonium N. This had decreased to 14% after 183 days. Mass balance of N indicates that about 25% of sediment ammonium N was released into the overlying water, but only 17% was assimilated by water hyacinths. Ammonium-N levels in the water column were very low, with little or no concentration gradients. Ammonium-N levels in the interstitial water of the sediment were in the range of 30-35 mg/L for the lower depths (>35 cm), while in the surface 5 cm of depth ammonium-N levels decreased to 3.2 mg/L. Simulated results also showed similar trends for the interstitial ammonium-N flux from the sediment to the overlying water was 4.8 microg/square cm/day, and the soluble organic-N flux was 5.8 microg N/square cm/day. Total N flux was 10.6 microg N/square cm/day.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Apopka, water hyacinth, nitrogen flux, sediment release

COPY OBTAINED: Yes

Rorslett, B. 1984. Environmental factors and aquatic macrophyte response in regulated lakes - a statistical approach. Aquatic Botany, 19:199-220.

STUDY LOCATION: 9 lakes in Norway

DRAWDOWN TIMING/DURATION: Winter months, annual

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Hydroelectric power generation requirements

SUMMARY: In regulated lakes, it is necessary to distinguish between depth and relative elevation. Depth is the height of water overlaying the plants at any time, thus the instantaneous value may be nil. The optimal "depth" and elevation datum is shown to be the median water level. However, depth in its time-averaged sense is not equivalent to relative elevation when the water level fluctuates throughout time. The magnitude of the discrepancy is generally large in shallow waters. Environmental stress factors, e.g. ice-scour, influence aquatics over a much larger part of the "depth" gradient with a variable water level. Factors operating through threshold statistics, e.g. subsurface irradiance, are most adversely influenced by a time-varying water level. In general, regulation impact results in a compressed vertical niche. Simultaneously, the potential niche is shifted into deeper waters. Vegetation data from nine oligotrophic, regulated Norwegian lakes show significant correlation to the reduced vertical niche defined by ice-scour and threshold irradiance. Water-level schedules determine the actual vegetational response; thus the total probability distribution of water levels should replace the regulation height or mean annual range of water level variation in an analysis of response features.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Norway, hydroelectric power, macrophyte distribution

COPY OBTAINED: Yes

Sain, R. E., W. J. Fonferek, M. S. Simpson, and K. W. Whittinghall. 1984. First-year vegetation following exposure of the Edmondson Lake Bed, Washington County, Virginia. Castanea 49:158-166.

STUDY LOCATION: Edmondson Lake Bed, Virginia

DRAWDOWN TIMING/DURATION: Drainage of reservoir

LAKE SIZE: 84 acres

OBJECTIVES OF DRAWDOWN: accidental; dam destroyed

SUMMARY: The partial demolition of a dam in southwest Virginia resulted in the drainage of a 35-hectare reservoir. The first-year vegetation which colonized the lake bed included Polygonum lapathifolium, Bidens cernua, Juncus effusus, Leersia oryzoides, Panicum dichotomiflorum, and Muhlenbergia frondosa. The lake bed was colonized primarily by weedy annuals (including grasses) which apparently germinated from seeds buried in bottom sediments. Cover values were affected by slope but not by grazing. Similarities are noted between this vegetation and that of exposed mudflats in either marsh or riverine environments.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Virginia, reservoir drainage, seedbank germination

COPY OBTAINED: Yes

Schneider, R.F. and J.A. Little. 1969. Characterization of bottom sediments and selected nitrogen and phosphorus sources in Lake Apopka, FL. U.S. Department of the Interior, Federal Water Pollution Control Administration, Southeast Water Laboratory, Technical Programs, Athens, GA.

STUDY LOCATION: Lake Apopka, FL

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: In 1968, the FWPCA conducted studies to determine the extent and composition of Apopka sediments. Results included: Unconsolidated muck covers 90% of the lake bottom. In areas the deposit is 40 feet thick, but it averages 5 feet. Anaerobic conditions and flocculent consistency of the sediment make these areas unsuitable for fish-food organisms and game fish. Exposed deposits of sand, clay and shell provide the only biologically productive bottom area, and these deposits cover an area estimated to be less than 5% of the lake. Chemical analysis revealed that the top three feet of lake sediments contain approximately on half billion pounds total nitrogen and five to ten million pounds of total phosphorus. Individual values of total phosphorus varies between one and four percent (dry weight) in muck deposits, while total phosphorus varies between 0.02 and 0.21 percent. Any plan for restoration of Lake Apopka must include a program of reducing nutrient (principally nitrogen and phosphorus) input into the lake. Removal of nutrients already in the system must be considered as well. Point sources such as agricultural runoff and municipal and industrial waste appear to be the principal controllable nutrient inputs.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Apopka, sediment analysis

COPY OBTAINED: yes, summary only

Serruya, C. and U. Pollingher. 1977. Lowering of water level and algal biomass in Lake Kinneret. Hydrobiologia, 54:73-80.

STUDY LOCATION: Lake Kinneret, Israel

DRAWDOWN TIMING/DURATION: 3 years

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Natural drought

SUMMARY: Water levels of Lake Kinneret decreased rapidly from 1972 to 1975 as a result of drought. Lowering of the lake produced a number of events: (1) it reduced the volume to area ratio which in turn increased the input of mechanical energy (wind) per unit volume, which accelerated heat transfer by increasing the volume of water mixed; (2) it decreased the volume of the hypolimnion as thermocline depth increased; (3) it increased concentrations of nutrients due to decay of organics, improved solubility of salts such as calcium phosphate, and increased release of orthophosphate because of more effective oxidation of sediments at turnover; (4) it altered the species composition of algae (diatoms and green algae replaced Peridinium); and (5) it reduced algal biomass because of a lower biomass-to-phosphorus ratio and the fact that diatoms and green algae were grazed by zooplankton whereas Peridinium was not.

POSITIVE EFFECTS: Reduction of algal biomass due to drought conditions.

NEGATIVE EFFECTS: Increase in nutrient concentrations due to sediment oxidation.

KEYWORDS: Israel, drought, algae, phosphorus release

COPY OBTAINED: Yes

Sheffield, C. W. and W. H. Kuhrt. Lake Apopka - its decline and proposed restoration.

STUDY LOCATION: Lake Apopka, Florida

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: 31,000 acres

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: Lake Apopka was once known nationally as a very fine recreational lake, where record bass could be caught. It lies approximately fifteen miles west of Orlando. In recent years this lake has been one of the most studied in the State of Florida. A degrading history of the lake is very complex in nature, due to its tremendous size, 30,000 acres, and having an average depth of only six feet. The residents around the lake have indicated that there was good fishing and clear water up to 1940. Then, about this time, a tremendous growth of aquatic weeds appeared. The first algal bloom was observed in about 1947 after the aquatic rooted weeds were literally uprooted by a hurricane in the late forties. This lush aquatic weed growth disappeared completely sometime between 1948 and 1950 due mainly to shading effects of the algae not allowing these aquatics to grow. In general, bass and game fishing was still excellent up to 1955. To this point in time the lake was extremely beneficial due to its recreational aspects and was netting approximately 1.0 million dollars to the economy of Central Florida in 1950 compared to the 200,000 dollars in 1966.

A preliminary plan for restoring Lake Apopka should include: 1) treatment of nutrients entering lake; 2) control of other sources of nutrients entering lake; 3) drawdown of lake level to 58.0 ft. MSL to expose 25% of the shoreline; 4) dredge deep cuts across middle of lake so that loose unconsolidated material will settle into them; 5) construction of fish reefs and plantings; 6) remove rough fish and hyacinths; 7) development of recreational area around Gourd Neck Springs.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Lake Apopka background

COPY OBTAINED: Yes

Shields, J. T. 1957. Experimental control of carp reproduction through water drawdowns in Fort Randall Reservoir, South Dakota. Transactions of American Fisheries Society 87:23-33.

STUDY LOCATION: Fort Randall Reservoir, South Dakota

DRAWDOWN TIMING/DURATION: 5 days; 1.5 feet

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: Fishery management

SUMMARY: Major spawns of common carp were predicted by sampling, gonad inspection, and monitoring water temperatures to permit the use of rapid drawdown as a method of controlling the abundance of carp. Spawning was induced by rapidly rising water that inundated shallow vegetated areas, at the appropriate temperature. In 1955, levels were reduced 1.5 feet in 5 days. Freshly spawned eggs were located in areas less than 1 foot deep, and receding waters exposed and killed most of them. Because many carp spawned in the upstream end of the reservoir, where drawdown had less effect, significant numbers of young carp were caught later in the season. However, survival of young carp was poor because the drawdown apparently upset some biological condition (such as food availability) at a critical stage in the life of fry. The year classes of carp produced in the drawdown years of 1955, 1956, and 1957 were relatively weak, suggesting that planned drawdowns were primarily responsible for limited reproduction.

POSITIVE EFFECTS: The ability to control carp reproduction through water drawdowns during spawning season low survival rate of young carp due to supposed biological upset, such as food availability.

NEGATIVE EFFECTS:

KEYWORDS: South Dakota reservoir; fishery management

COPY OBTAINED: Abstract in Ploskey (1982)

Siver, P. A., A. M. Coleman, G. A. Benson and J. T. Simpson. 1986. The effects of winter drawdown on macrophytes in Candlewood Lake, Connecticut. Lake and Reservoir Management, Vol. II:69-73.

STUDY LOCATION: Candlewood Lake, Connecticut

DRAWDOWN TIMING/DURATION: Winter drawdown

LAKE SIZE: n/a; largest lake in Connecticut

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Between 1980 and 1983 dense beds of the macrophyte Myriophyllum spicatum L. became well established throughout Candlewood Lake, Conn., at the expense of a once diverse native flora. During 1983-84 and 1984-85 winter drawdowns of 2 and 2.7 m, respectively, were attempted to control the densities and further spread of the M. spicatum. After the initial drawdown, weed biomass was reduced by more than 90 percent in shallow sites; however, little change in densities occurred in deeper areas. The deeper drawdown resulted in a further reduction in M. spicatum densities, although it remained the dominant plant at depths greater than 2.5 m. Najas minor allioni became the dominant macrophyte in shallow areas, presumably developing from seeds.

The drawdowns appeared to have no adverse effects on the lake (phosphorus or chlorophyll concentrations, phytoplankton levels, or water clarity).

POSITIVE EFFECTS: Drawdown was effective for macrophyte control in shallow areas.

NEGATIVE EFFECTS: Drawdown was ineffective for macrophyte control in deeper areas.

KEYWORDS: Connecticut, macrophyte control, winter drawdown

COPY OBTAINED: Yes

Smith, G. E., T. F. Hall, and R. A. Stanley. 1967. Eurasian watermilfoil in the Tennessee Valley. Weeds 15:95-98.

STUDY LOCATION: Tennessee Valley Authority Reservoirs, Alabama, North Carolina and Tennessee

DRAWDOWN TIMING/DURATION: Overwinter drawdown

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Macrophyte control; mosquito control

SUMMARY: Three methods of control were used: 1) flooding, 2) overwinter drawdown, and 3) application of 2,4-D. Flooding was effective for some species but not for others. Overwinter drawdown, and application of 2,4-D in areas that were not exposed, resulted in some macrophyte-free regions for 4 years after treatment. Herbicide application was not detrimental to the benthos population except through elimination of the macrophytes. There was little uptake of 2,4-D by fish but some was taken up by mussels. Significant concentrations of 2,4-D occurred in the sediments for up to 10 months. No adverse effects were noted on the fauna or water quality.

POSITIVE EFFECTS: Macrophyte control achieved for 4 years after treatment; no adverse effects on water quality or fauna from herbicide.

NEGATIVE EFFECTS: 2,4-D in sediments for up to 10 months

KEYWORDS: TVA reservoirs, herbicide, overwinter drawdown

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Smith, L. M. and J. A. Kadlec. 1983. Seed banks and their role during drawdown of a North American marsh. Journal of Applied Ecology 20(2) 673-684.

STUDY LOCATION: Near Great Salt Lake, Utah

DRAWDOWN TIMING/DURATION: n/a

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: n/a

SUMMARY: The size and species composition of the seed banks were compared among six vegetation types (Typha spp., Scirpus acutus, S. maritimus, Distichlis spicata, Phragmites australis, and open water sites) in a North American marsh. Persistent seed banks were estimated from twenty five (20 x 20 x 4 cm depth) soil samples within each vegetation type. Samples were exposed to moist soil (no standing water) and submerged (4 cm depth) conditions in a greenhouse. More species germinated in the moist soil treatment (twenty-four) than in the submerged treatment (twelve). Typha spp. and Scirpus acutus had the greatest number of species germinate and S. acutus sites also had the highest seedling density. Open water sites had few species and low seedling densities. Scirpus spp. seedlings were found primarily in Scirpus spp. seed bank samples whereas Typha seedlings were found in high densities in all emergent vegetation types (Scirpus spp., Typha spp., and Phragmites australis). Mud-flat species (e.g., Chenopodium rubrum) were found at higher densities in Scirpus acutus sites. Frequency of marsh plant species shifted as the water table fell (drawdown) with emergent plant species decreasing and mud-flat species increasing. In the field, salinity increased and soil moisture decreased during drawdown. Watering of seed bank samples in the greenhouse maintained lower salinities and higher soil moisture than in vegetation types in the field. Rather than a complete drawdown for establishment of marsh plants in the area studied, maintenance of a few centimeters water depth will keep salinities low, allow germination of at least twelve species, and prevent establishment of Tamarix pentandra.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Seedbank study; Utah marsh; vegetation succession

COPY OBTAINED: Yes

Smith, S. A., J. O. Peterson, S. A. Nichols and S. M. Born. 1972. Lake deepening by sediment consolidation - Jyme Lake. Inland Lake Demonstrator Project Upper Great Lakes Regional Commission, Madison, Wisconsin. 36p.

STUDY LOCATION: Jyme Lake, Oneida County, Wisconsin

DRAWDOWN TIMING/DURATION:

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Sediment consolidation

SUMMARY: A high capacity irrigation pump was used to remove the lake water to a nearby marsh. The water level in the lake was lowered at about 15 cm/hr. The inflow of low density sediments from beneath a floating bog adjacent to the lake forced the termination of pumping prior to complete drawdown. Although laboratory testing indicated that the sediments were highly susceptible to consolidations, valid in-lake data were not obtained because of sediment flow and incomplete drawdown. The low strength characteristics of the upper layers of the sediments permitted movement as the lake level was lowered. Measurable consolidation did, however, occur in the stable portions of the adjacent bog at distances up to 30 m from the lake. Extensive slumping also occurred in the bog during lake drawdown, but most evidence of slumping disappeared as the lake refilled.

POSITIVE EFFECTS: Sediments susceptible to consolidations.

NEGATIVE EFFECTS: Adjacent marshlands subsidence

KEYWORDS: Wisconsin, marsh subsidence

COPY OBTAINED: Abstract only from the Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Snow, P. D. and F. W. Hardt. 1985. Computer modeling for inflow, drawdown, elevation, and detention time predictions in lakes and reservoirs. Lake and Reservoir Management: Practical Applications, Proceedings of the Fourth Annual Conference and International Symposium of the North American Lake Management Society.

STUDY LOCATION: Duck Pond and Iroquois Lake, Schenectady, New York

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 2 acres and 7 acres, respectively

OBJECTIVES OF DRAWDOWN: n/a; modeling study

SUMMARY: The paper presents the numerous limnological applications of the Soil Conservation Service TR-20 Computer Program for Project Formulation Hydrology. The model was used to simulate actual stream flows and volumes into lakes from rainfall data. Other applications for the model's output were in predicting the time of drawdown in the lake for low inflow and flood inflow periods, the design of a pre-lake-retention pond to remove sediment and nutrients, and the design of various outlet structures for predicted flood events. Further applications could be correlation of computer-generated rainfall/runoff relationships to predict sediment/nutrient loadings into a lake or reservoir, and simulation of historic flows.

POSITIVE EFFECTS: The ability to determine a yearly water budget for a lake; the prediction of sediment/nutrient loadings into a lake and the simulation of historic flows.

NEGATIVE EFFECTS:

KEYWORDS:

COPY OBTAINED: Yes

Steel, E. W. and B. B. Ewing. 1954. Controlling watermilfoil in a Texas reservoir. Public Works 85:89-90.

STUDY LOCATION: Lake Austin, Texas

DRAWDOWN TIMING/DURATION: Winter

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Three procedures were tested: 1) winter drawdown, 2) herbicides (2,4-D), and 3) winter drawdown with application of soil sterilants (2,4-D, borax, and CMU). Winter drawdown combined with the application of soil sterilants gave the best results. Macrophyte control was possible for a two-year period, minimum.

POSITIVE EFFECTS: Effective macrophyte control through combination of drawdown and soil sterilants.

NEGATIVE EFFECTS:

KEYWORDS: Texas, winter, macrophyte control

COPY OBTAINED: Abstract only from Wisconsin DNR Technical Bulletin #75, Survey of Lake Rehabilitation Techniques and Experiences (Dunst et al. 1974).

Tarver, D. P. 1980. Water fluctuation and the aquatic flora of Lake Miccosukee. Journal of Aquatic Plant Management, Vol. 18:19-23.

STUDY LOCATION: Lake Miccosukee, Florida

DRAWDOWN TIMING/DURATION: February to September 1977; 90% bottom exposure

LAKE SIZE: 7,299 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: In an attempt to control aquatic plant growth in Lake Miccosukee, Florida, a shallow lake, was drawn down 1.7 m, so that by September 1977 90% of the lake bottom was exposed to drying conditions. Water level returned to normal by April 1978. Total water surface macrophyte coverage in summer was 81% before drawdown (June 1976) and 75.6% after drawdown and refilling (June 1978); in winter 62% before drawdown (February 1977) and 26% after drawdown and refilling (February 1979). Some plant species were considerably reduced as a result of drawdown: water shield, cabomba, variable leaf milfoil, water willow and related plants, and bladderwort. Several other plant types increased in abundance or remained at constant levels: azolla, duckweed, bog mat, frog's bit, yellow cow lily, fragrant water lily, and terrestrial annuals. Drying and plant desiccation produced compaction and stabilization of sediments. The peat zone decreased 70% in depth (from 6-40 cm to 3-12 cm) and the muck zone, 17% (from 3-40 cm to 3-39 cm).

POSITIVE EFFECTS: Reduction of water shield, cabomba, variable leaf milfoil, water willow and related plants, and bladderwort. Sediments were compacted and stabilized; the peat zone decreased as did the muck zone.

NEGATIVE EFFECTS: Some plant types increased in abundance or remained at constant levels: azolla, duckweed, bog mat, frog's bit, yellow cow lily, fragrant water lily, and terrestrial annuals.

KEYWORDS: Water level fluctuations, aquatic plants, weed control, lakes, Lake Miccosukee, Florida, aquatic weeds, drawdown, vegetation, sediments, lake sediments, organic matter, plant populations, aquatic weed control.

COPY OBTAINED: Yes

Tazik, P. P., W. R. Kodrich and J. R. Moore. 1982. Effects of overwinter drawdown on bushy pondweed. Journal of Aquatic Plant Management, 20:19-21.

STUDY LOCATION: Kahle Lake, Pennsylvania

DRAWDOWN TIMING/DURATION: Overwinter; 2 meters

LAKE SIZE: 252 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: Kahle Lake, in Clarion and Venango Counties, Pennsylvania, was created in 1974 under the jurisdiction of the Pennsylvania Fish Commission by impounding Mill Creek. The lake has a surface area of 102 hectares with a normal depth of 12 meters at the dam and a relatively uniform bottom consisting mostly of clay with scattered stumps and boulders. Few aquatic vascular plants were present until early autumn, 1976, at which time they appeared in the shallow regions of the lake. Subsequently, the submergent vegetation has impeded fishing activities.

Drawdown proved to be ineffective in controlling the abundant growth of bushy pondweed in Kahle Lake. Pondweed reproduces primarily from seeds rather than rhizomes which may be one reason that reproduction is not hindered by drawdown.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Drawdown proved to be ineffective in controlling the growth of bushy pondweed and actually enhanced its growth.

KEYWORDS: Drawdown, Pennsylvania lakes, macrophyte control

COPY OBTAINED: Yes

Triplett, J.R., D. A. Culver and G. B. Waterfield. 1980. An annotated bibliography on the effects of water-level manipulation on lakes and reservoirs. Ohio Department of Natural Resources, Federal Aid Project F-57-R, Study No. 9.

STUDY LOCATION: Varies

DRAWDOWN TIMING/DURATION: Varies

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Varies

SUMMARY: This bibliography lists 348 annotated references dealing directly or indirectly with the effects of water-level fluctuations on the physical, chemical, and biological components of lakes and reservoirs. Emphasis is placed on references pertaining to fish management in reservoirs, but many related topics are included.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Water level manipulation; reservoirs; review

COPY OBTAINED: Abstract in Ploskey (1982)

University of Wisconsin and Wisconsin Department of Natural Resources. 1974. Inland Lake Demonstration Project. Upper Great Lakes Commission.

STUDY LOCATION: Upper Great Lakes

DRAWDOWN TIMING/DURATION: Overwinter

LAKE SIZE: Varies

OBJECTIVES OF DRAWDOWN: Macrophyte control

SUMMARY: In May, 1968, the Upper Great Lakes Regional Commission, an economic development agency created under the 1965 Public Works and Economic Development Act, funded the Inland Lake Renewal and Shoreland Management Demonstration Project. The project was a joint venture of the University of Wisconsin and the Wisconsin Department of Natural Resources. Project goals included the demonstration of techniques to restore, maintain, and protect a high-quality environment within and adjacent to lakes in the Upper Great Lakes Region. It aimed at relatively short-term demonstrations in problem-solving, such as "how to manage or rehabilitate a lake," and "how, when, where and whether to develop lake-oriented lands."

Drawdown, and especially water level fluctuation and manipulation, have been used in Wisconsin lakes for macrophyte control. Overwinter drawdown in cold climates exposes plants to destruction by freezing, frost heaving and desiccation. This technique was found to be a very effective and low-cost method for weed control

POSITIVE EFFECTS: Macrophyte control, cost-effective

NEGATIVE EFFECTS:

KEYWORDS: Wisconsin lakes, winter drawdown, macrophyte control

COPY OBTAINED: Yes

Van Der Valk, A. G. and C. B. Davis. 1980. The impact of a natural drawdown on the growth of four emergent species in a prairie gacial mrsh. Aquatic Botany, 9:301-322.

STUDY LOCATION: Prairie glacial marsh, Iowa

DRAWDOWN TIMING/DURATION: 1 year

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: Natural drawdown due to drought

SUMMARY: Changes in total, vegetative and flowering shoot densities, weights, heights and standing crops of four emergent species before, during, and after a drought indicate that the growth of three of these species (Typha glauca Godr., Scirpus fluviatilis (Torr.) Gray and Sparganium eurycarpum Engelm.) was adversely affected by the drought. The drought, however, temporarily reversed the decline in vigor, which had started before the drought, in the four species, Scirpus validus Vahl, and enabled this species to persist for two more years in the marsh. The data suggest that periodic drawdowns enable several emergent species to coexist in a community because of their diverse responses to disturbance.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Prairie glacial marsh, seedbank, drought, Iowa

COPY OBTAINED: Yes

Water and Air Resources, Inc. and Central Florida Regional Planning Council. 1980. Lake Howard Restoration Study.

STUDY LOCATION: Lake Howard, Winter Haven, Florida

DRAWDOWN TIMING/DURATION: Feasibility study

LAKE SIZE: 1184 acres

OBJECTIVES OF DRAWDOWN: Water quality improvement.

SUMMARY: Lake Howard exhibits eutrophic to hypereutrophic water quality characteristics. Internal recycling was regarded as a major contributor to nutrient levels in the lake. Drawdown was examined as a potential management technique. Drawdown and reinundation were experimentally simulated in the laboratory; results showed much higher nutrient concentrations in water over undried sediments than in water over dried sediments. Upon drying the sediment compacted into a solid mass which retained its cohesiveness upon reinundation. Dried sediment did not appear to resuspend as fully and lower amounts of nutrients were released. However, the location of the muck in the deepest portion of the lake (>12.5 feet) eliminated drawdown and compaction of the muck by drying in place as a feasible alternative for restoring Lake Howard.

POSITIVE EFFECTS: Drawdown compacted the sediment resulting in a lowering of nutrient release.

NEGATIVE EFFECTS: Drawdown was not feasible for the deeper portions of the lake.

KEYWORDS: Florida, Lake Howard, sediment consolidation, nutrient release

COPY OBTAINED: Yes

Wedepohl, R. E., A. T. Hanson and J. E. Szewczyk. 1983. Lake deepening using In situ techniques. Lake Restoration, Protection, and Management, pp. 41-45.

STUDY LOCATION: Jyme Lake, Wisconsin

DRAWDOWN TIMING/DURATION: 25 days with pumping.

LAKE SIZE: 1.5 acres

OBJECTIVES OF DRAWDOWN: Sediment consolidation, lake deepening

SUMMARY: Studies were conducted to evaluate alternatives to dredging, both for lake deepening and sediment treatment. Sediment consolidation by drawdown is the physical lake deepening technique that was studied. Although useful in many instances, it is often limited by physical problems associated with the dewatering, whether it be by surface pumping or by aquifer dewatering. Sediment digestion using aeration, nitrate, hydrogen peroxide, ozone, and proprietary microorganisms was evaluated in a laboratory scale study. Although hydrogen peroxide and ozone have the most dramatic effects on sediment volume reduction, degradation of the overlying water column may limit their usefulness. The lakes most susceptible to in situ treatments are those having highly organic sediments.

Field studies showed than an appreciable amount of consolidation occurred in the 10 acre bog area surrounding the lake after 25 days of pumping had lowered the lake level 2.5 meters. However, difficulties in pumping and sediment/bog migrations precluded a completed dewatering of the lake and only limited amounts of consolidation appeared to occur in the lake mud. Sediment consolidation by drawdown appears to have promise for whole-lake in-situ deepening; however, in many circumstances adverse side effects may prevent using this technique.

POSITIVE EFFECTS: Limited sediment consolidation

NEGATIVE EFFECTS: Physical problems associated with dewatering; limitation on effectiveness of sediment digestion through hydrogen peroxide or ozone by overlying water column.

KEYWORDS: Sediment consolidation, Wisconsin, lake-bog interaction

COPY OBTAINED: Yes

Wegener, W. and V. Williams. 1974. Fish population responses to improved lake habitat utilizing an extreme drawdown. Proceedings of the 28th Annual Conference of the Southeastern Association of Game and Fish Commission. 28:144-161.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: One year; 50% bottom exposure

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Fishery management

SUMMARY: An extreme drawdown conducted on Lake Tohopekaliga rejuvenated littoral substrate, stimulated development of desirable aquatic plants and increased macroinvertebrate production. As a result of these beneficial changes standing crops of fish in littoral areas increased from a high of 191 pounds per acre before the drawdown to 455 pounds per acre within two years after reflooding. Limnetic standing crops increased from 59 pounds per acre to 127 pounds per acre during the same period. Biomass of sportfish nearly doubled, although forage fish accounted for a higher percentage of the population following reflooding. Individual species response to the drawdown varied. Numbers of harvestable size sportfish increased following reflooding. The monetary value of the Lake Tohopekaliga fishery increased by 37 percent or $6,222,186.

POSITIVE EFFECTS: Increased fish stocks, desirable aquatic plants, macroinvertebrates.

NEGATIVE EFFECTS: Chain pickerel declined

KEYWORDS: Lake Tohopekaliga, Florida; fisheries management

COPY OBTAINED: Abstract in Ploskey (1982)

Wegener, W. and V. Williams. 1974. Organic deposition studies. Florida Game and Fresh Water Fish Commission, Federal Aid Project F-29. Job #4.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: One year; 50% bottom exposure

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Dewatering reduced the depth of organic sediments by 50 to 80% New organic materials deposited after reflooding consisted primarily of decomposing water hyacinth and algae. Observations on sediment decomposition indicated that improved condition of littoral sediments will last only a few years, and this fact shows the importance of frequent drawdowns in the future. Appreciable amounts of CO_2 were released from drying organic sediments.

POSITIVE EFFECTS: A reduction in the depth of organic sediments occurred following a drawdown.

NEGATIVE EFFECTS: The improved condition of organic sediments was short-lived, indicating that drawdowns need to be conducted frequently.

KEYWORDS: Lake Tohopekaliga, Florida; sediment consolidation

COPY OBTAINED: Abstract in Ploskey (1982)

Wegener, W. and V. Williams. 1974. Algae monitoring studies. Florida Game and Fresh Water Fish Commission, Federal Aid Project F-29. Job #5.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: One year; 50% bottom exposure

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Responses of algae populations to dewatering and reflooding of Lake Tohopekaliga were variable. Diversity of green and blue-green algae increased when littoral areas were initially flooded. Diversity of other major groups remained essentially the same. Bloom conditions became more frequent as the study progressed (especially for blue-green algae), as a result of increased nutrient concentrations that originated from sewage effluent.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Bloom conditions became more frequent as study progressed.

KEYWORDS: Lake Tohopekaliga, Florida; algae conditions; one-year drawdown

COPY OBTAINED: Abstract in Ploskey (1982)

Wegener, W. and V. Williams. 1974. Water chemistry studies. Florida Game and Fresh Water Fish Commission, Federal Aid Project F-29. Job #6.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: One year; 50% bottom exposure

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Concentrations of most chemical constituents increased during drawdown and decreased as Lake Tohopekaliga was refilled, though concentrations on refiling of the lake were higher than before drawdown. Although most physical and biological characteristics improved after drawdown, water quality deteriorated due to sewage-plant discharges into the lake.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Nutrients increased during drawdown. Water quality deterioration due to sewage-plant discharges into lake.

KEYWORDS: Lake Tohopekaliga, Florida; water quality

COPY OBTAINED: Abstract in Ploskey (1982)

Wegener, W. and V. Williams. 1974. Extreme drawdown, a working fish management tool. Florida Game and Fresh Water Fish Commission.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: One year; 50% bottom exposure

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Fishery data collected from Lake Tohopekaliga indicated that drawdown apparently funneled energy flow into the fishery, inasmuch as standing crops and yields of fish increased after drawdown. Some benefits derived from drawdown were short-lived, and therefore extreme drawdowns should be repeated about every 7 years.

POSITIVE EFFECTS: Increase in fish production due to drawdowns.

NEGATIVE EFFECTS: Some benefits were short-lived.

KEYWORDS: Lake Tohopekaliga, Florida; fishery management

COPY OBTAINED: Abstract in Ploskey (1982)

Wegener, W. and V. Williams. 1974. Fish population responses to improved lake habitat utilizing extreme drawdown. Proceedings of the 28th Annual Conference of Southeastern Association of Game and Fish Commissions. 28:144-161.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: One year, exposing 50% of bottom

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Fishery management, habitat improvement

SUMMARY: Water levels of Lake Tohopekaliga were limited to a 3-foot annual fluctuation by the Central and Southern Florida Flood Control District. In 1971, a drawdown that exposed 50% of the lake bottom was effected to improved the sport fishery and water quality of the 22,700-acre reservoir. The drawdown pool was maintained for 6 months, and refilling of the reservoir to normal pool required another 6 months. Water levels continued to rise above normal pool throughout the following year. Fish samples from coves (by application of rotenone within a blocked area) indicate that littoral standing crops increased from 191 to 455 pounds per acre within 2 years after the basin was reflooded. Biomass of sport-fish almost doubled, though forage fish accounted for a higher percentage of community biomass after reflooding of the impoundment. Numbers of harvestable-sized sport fish increased, as did the monetary value of the fishery (37%). Chain pickerel was the only sport fish that was adversely affected by dewatering. Bluegill populations declined during drawdown and early reflooding, but strong year classes were produced in the spring of the next two years (1972 and 1973). Redear sunfish seemed to benefit by dewatering and low water levels.

POSITIVE EFFECTS: Increase in sport-fish biomass, as well as monetary value of fishery, improved littoral substrate, increased density and diversity of desirable aquatic vegetation, stimulated production of fish food organisms.

NEGATIVE EFFECTS: Chain pickerel was adversely affected by dewatering.

KEYWORDS: Lake Tohopekaliga, Florida; one-year drawdown; revegetation; fishery improvement

COPY OBTAINED: Yes

Wegener, W. and V. Williams. 1977. The effect of extreme lake drawdown on largemouth bass populations. Florida Game and Fresh Water Fish Commission. 25pp.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: One year; 50% bottom exposure

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Habitat restoration

SUMMARY: Largemouth bass reproductive success, survival, and growth rates improved after a 7-foot drawdown of Lake Tohopekaliga, Florida. Flocculent organic sediments in exposed areas were reduced 50 to 80%. Desirable aquatic vegetation expanded and became more diverse. As a result, production of fish-food organisms was stimulated: within 1 year, numbers of amphipods per standard sample unit (5 net sweeps = ca. 1.38 m^{-3}) increased from 178 to 465; grass shrimp increased from 2.6 to 65.8, water boatmen from 0 to 61.1; and crayfish from 0 to 0.2. Standing crop of fishes increased 138% in 3 years, from 191 to 455 pounds per acre. Bass biomass increased from 35 to 60 pounds per acre in the first year after drawdown. Angler harvest of largemouth bass decreased slightly during the drawdown of 1971, but increased thereafter and peaked in 1975. The harvest was 4 times greater than in 1970. On this basis, extreme drawdown is recommended every sixth year. The number of bass caught during reflooding of Lake Kissimmee increased 18% over that before the drawdown.

POSITIVE EFFECTS: Increase in largemouth bass reproductive success, survival and growth rates following drawdown. Sediment consolidation by 50-80%. Revegetation by desirable species; increased macroinvertebrate densities.

NEGATIVE EFFECTS:

KEYWORDS: Lake Tohopekaliga, Florida; fishery management

COPY OBTAINED: Abstract in Ploskey (1982)

Wegener, W., V. Williams, and T. D. McCall. 1974. Aquatic macroinvertebrate responses to an extreme drawdown. Proceedings of the 28th Annual Conference of Southeastern Association of Game and Fish Commissions. pp. 126-144.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: One year, exposing 50% of the bottom for 6 months

LAKE SIZE: 22,700 acres

OBJECTIVES OF DRAWDOWN: Fishery management, habitat restoration

SUMMARY: Water levels of Lake Tohopekaliga were drawn down 7 feet from the maximum pool elevation in 1971, exposing 50% of the basin bottom for 6 months. Because of drought, the lake was not completely refilled for an entire year. Drawdown improved littoral substrate and increased the density and diversity of aquatic macrophytes and benthos. After reflooding of the basin, the density of benthic macroinvertebrates per square foot increased from 98 to 244 (limnetic), 154 to 250 (littoral), and from 304 to 1364 (on or associated with macrophytes). Densities returned to levels characteristic of the pre-treatment period within 2 years. The decline in numbers was associated with increases in the number of fish and invertebrate predators. Sport fishes that ate macroinvertebrates nearly doubled in weight, from 151 to 236 pounds per acre in the littoral zone and from 34 to 54 pounds per acre in the limnetic zone.

POSITIVE EFFECTS: Drawdown improved littoral substrate and increased the density and diversity of aquatic macrophytes and benthos. Increase in weight of sport fishes that preyed upon macroinvertebrates.

NEGATIVE EFFECTS:

KEYWORDS: Lake Tohopekaliga, Florida; one-year drawdown, macroinvertebrate increase, revegetation

COPY OBTAINED: Yes

Wegener, W. and V. Williams. 1974. Extreme lake drawdown: a working fish management technique. A contribution of Federal Aid D-J Project F-29-R. Florida Game and Fresh Water Fish Commission.

STUDY LOCATION: Lake Tohopekaliga, FL

DRAWDOWN TIMIMG/DURATION: March-September 1971; low pool in March 1972, and high pool in March 1973.

LAKE SIZE: 20,106 acres

OBJECTIVES OF DRAWDOWN: Reduce, moderate or reverse symptoms of habitat degradation.

SUMMARY: The 1971 Lake Toho drawdown consisted of a 7' vertical drop in water level for 6 months. Effects monitored included: 1) Sediments: depth of organic sediments decreased from 50-80%. Flocculent sediments disappeared completely, and deeper organic sediments were transformed into compacted, peatlike material. Substrate became firm after drying, and rooted plants became abundant. Organic substrate remained firm after reflooding. 2). Vegetation: Abundant growth of terrestrial and semi-aquatic plants which died out after reflooding. True aquatics increased after reflooding. Littoral vegetation advanced lakeward, expanding from 9000 to 10,500 acres (16%). Also increase in detrimental water hyacinth. 3) Invertebrates: Increase in the number of benthic invertebrates after reflooding due to increased density and diversity of aquatic vegetation in littoral zones. 4) Fish: Increase in the standing crops of forage fish and a near-doubling in sportfish populations. 5) Economic benefits: increase in value of fishery (more sportfish), and increase in recreational usage 6) Algae and water chemistry: no improvement in water quality and the incidence of algal blooms increased as the study progressed; however, this may be due in part to the discharge of sewage wastes to the lake. It is recommended that Lake Toho water levels be scheduled to fluctuate on a three year cycle (5' difference between highest and lowest water level), with an extreme drawdown scheduled every 7 years to mediate habitat degradation.

POSITIVE EFFECTS: Improvements in bottom sediment, littoral vegetation, invertebrate (fish forage) biomass, fish populations, and economic benefits.

NEGATIVE EFFECTS: No improvement in water quality, increase in algal blooms, formation of water hyacinth mats

KEYWORDS: Lake Toho, Florida, habitat improvement, fishery management, evaluation

COPY OBTAINED: Yes

Wegener, W. and D. Holcomb. 1972. Lake Tohopekaliga drawdown. 1971-1972 Annual Progress Report, Florida Game and Fresh Water Fish Commission, Water Level Manipulation Project F-29-1.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: 2 years

LAKE SIZE:

OBJECTIVES OF DRAWDOWN: To improve the conditions by consolidating and stabilizing the bottom sediments. To evaluate the effects of drawdown.

SUMMARY: After preliminary studies and local community acceptance, the lake was artificially lowered during 1970-72. Water levels were dropped 0.9 m between March and June, 1970; remained stable until February, 1971; reached the maximum drawdown by June, 1971; and raised to near normal between August, 1971 and March, 1972. Draining was done by gravity and costs were therefore nominal. Approximately $200,000 USA was spent over a period of four years for monitoring the effects of dewatering on physical, chemical, and biological parameters.

POSITIVE EFFECTS: Compaction or loss of organic sediments ranged from 55 to 100%.

NEGATIVE EFFECTS: No reduction in algal production although a greater species diversity was observed.

KEYWORDS: Florida, sediment consolidation, no water quality effects

COPY OBTAINED: Yes

Welch, E.B., C.L. DeGasperi, and D.E. Spyridakis. 1988. Sources for internal P loading in a shallow lake. Verh. Internat. Verein. Limnol. 23: 307-314.

STUDY LOCATION: Long Lake, Washington

DRAWDOWN TIMING/DURATION: summer, 4 months

LAKE SIZE: 339 acres

OBJECTIVES OF DRAWDOWN: macrophyte control, sediment consolidation

SUMMARY: Long Lake experiences a summer increase in TP, primarily from the release of P from decomposing macrophytes of the previous summer. There was some reduction in in-lake TP during the summer following drawdown, but a marked reduction and negative internal loading occurred following an alum treatment administered following the drawdown. Macrophyte decomposition has been implicated as a significant source of internal P loading through translocation from sediments and Elodea from Long Lake was shown to rely chiefly on sediments for their P supply.

POSITIVE EFFECTS: macrophyte biomass reduction, initial small TP reduction

NEGATIVE EFFECTS: short-term benefits

KEYWORDS: Washington, macrophyte control, TP release

Welch, E. B., J. P. Michaud, and M. A. Perkins. 1982. Alum control of internal phosphorus loading in a shallow lake. Water Resources Bulletin, 18:929-936.

STUDY LOCATION: Long Lake, Kitsap County, Washington

DRAWDOWN TIMING/DURATION: June - October; 5 months, oversummer

LAKE SIZE: 339 acres

OBJECTIVES OF DRAWDOWN: Sediment consolidation and macrophyte control

SUMMARY: Alum treatment of a shallow lake, with mean depth 2 m and area 137 ha, curtailed internal loading of P for at least one year. Mean summer total P and chl a decreased from 76 and 27 ug l^{-1}, respectively, in 1978 before treatment, to 29 and 14 ug l^{-1}, while mean summer Secchi transparency increased from 1.6 to 2.2 m and blue green algae were no longer dominant. Macrophyte biomass and distribution returned during the post-alum year, 1980-1981, to previous levels after a 1979 four-month lake level drawdown had reduced biomass by 84 percent. The improved transparency, resulting from the decrease in chl a following treatment, could encourage greater biomass of macrophytes in the deeper areas of the lake. Recovery of macrophyte biomass to predrawdown levels may restore internal loading of P through enrichment of deep water sediments during winter dieback and decomposition.

The lake level was drawn down 2 meters during June through October. Sediment consolidation was minimal, but macrophyte crop was reduced by 84 percent. Net internal P loading was curtailed in the following summer, indicating that P removed from the sediments by the macrophytes and redistributed to the deeper parts of the lake during winter breakdown of the crop was an important indirect source of internal loading.

POSITIVE EFFECTS: Decreased total P content; improved transparency and increased diversity in phytoplankton.

NEGATIVE EFFECTS: Long-term persistence of alum could result in increased macrophyte coverage, which could be a nuisance to recreational use of the lake.

KEYWORDS: Alum, phosphorus, internal loading, Washington, summer drawdown

COPY OBTAINED: Yes

Welling, C. H., R. L. Pederson and A. G. Van Der Valk. 1988. Recruitment from the seed bank and the development of zonation of emergent vegetation during a drawdown in a prairie wetland. Journal of Ecology, 76:483-496.

STUDY LOCATION: Delta Marsh, Lake Manitoba, Canada

DRAWDOWN TIMING/DURATION: 2 years and 1 year for separate areas

LAKE SIZE: 37,065 acres total, ten 12-15-acre parcels were utilized for study areas

OBJECTIVES OF DRAWDOWN: Experimental seedbank germination

SUMMARY: Patterns of recruitment of five emergent species from the seed-bank along a height gradient in an experimental wetland complex during a period with no standing water (drawdown), are described in relation to the development of zonation. The drawdown was preceded by two years in which water levels were maintained at 1 m higher than normal which destroyed most of the emergent vegetation. Zonation of established, adult emergents was shown by the separation of peak frequencies of different species along the height gradient and the occurrence of only one species in 64% of quadrats sampled.

POSITIVE EFFECTS: n/a

NEGATIVE EFFECTS: n/a

KEYWORDS: Prairie marsh, seedbank, Canada

COPY OBTAINED: Yes

White, D. S. and S. J. White. 1977. The effect of reservoir fluctuations on populations of Corbicula manilensis (Pelecypoda: Corbiculidae). Proceedings of the Oklahoma Academy of Sciences 57:106-109.

STUDY LOCATION: Lake Texoma, Oklahoma

DRAWDOWN TIMING/DURATION: August-February

LAKE SIZE: n/a

OBJECTIVES OF DRAWDOWN: water management

SUMMARY: Fluctuations in water level greatly reduced populations of the Asiatic clam in Lake Texoma, Oklahoma. Clams were most numerous near the shore in 2-30 cm of water. A drop in water level from August through February 1976 stranded so many clams that their shells formed wind rows along beaches. Laboratory experiments showed that clams exhibited 50% mortality after 4 days of desiccation, 75% after 6 days, and 90 to 98% after 10 days.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: Longer periods of desiccation increase mortality rates in clams.

KEYWORDS: Oklahoma reservoir; clam stranding

COPY OBTAINED: Abstract in Ploskey (1982)

Wilbur, R. L. 1974. Experimental dredging to convert lake bottom from abiotic muck to productive sand. Water Resources Bulletin. Vol. 10:372-383.

STUDY LOCATION: Trout Lake, and Carlton Lake, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 102 and 382 acres, respectively

OBJECTIVES OF DRAWDOWN: Benthic production

SUMMARY: Conversion of muck to sand bottom was tested to increase benthic production in two eutrophic Florida lakes, and preliminary results indicate that benthos will be increased in areas converted to sand. Muck removal with a specially designed dredge, or "Mudcat", was tested in Trout Lake. The Mudcat removed 41,650 cu. yds. of muck and exposed 17 acres of sand bottom, but 10 of those acres developed thin layers of muck, which proved too soft to be picked up by the Mudcat. Consequently, only 7 acres were satisfactorily converted. Bottom redistribution with a suction-type dredge was tested in Lake Carlton, and 14 acres were converted from muck to sand. Sand covered with muck was pumped from midlake areas to more peripheral areas of the lake where water depths were 11 to 13 feet and muck layer about 1.5 feet deep. The bottom was built up to an elevation above the previous muck elevation. Several methods for depositing the sand were tested. Level areas of sand fill developed accumulations of muck from fallout following dredging activities. Piles or dunes provided the best cost-return ratio. The bottom in filled areas changed very little during a 1 1/2 year period following filling.

POSITIVE EFFECTS: Increased benthic populations in areas that were successfully converted from muck to sand.

NEGATIVE EFFECTS: Surface flocculent muck caused problems with deeper muck removal.

KEYWORDS: Dredging, muck removal, bottom redistribution, habitat manipulation, benthos

COPY OBTAINED: Yes

Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Lake Talquin, Florida

DRAWDOWN TIMING/DURATION: 1983; 65% of bottom exposed

LAKE SIZE: 10,200 acres

OBJECTIVES OF DRAWDOWN: Dam repairs

SUMMARY: Lake Talquin, a man-made impoundment on the Ochlockonee River, was dewatered in 1983 to allow dam repairs mandated by the Army Corps of Engineers. Approximately 65% of the lake bottom was exposed, and the project was designed to accommodate a refilling schedule beneficial to aquatic plants and fisheries. Improvements in sportfish populations produced by the drawdown continued to manifest themselves in the reservoir through 1985. The 1984 year class of largemouth bass was estimated as being seven times larger than pre-drawdown year classes, and experienced good survival through the critical first year of life. Sampling in the fall of 1985 showed that these fish ranged in size from five to 17 inches. It is expected that substantial numbers of these fish will be caught in 1986; at the same time a protective 11 to 14 inch slot limit should greatly reduce the possibility of overharvest. Populations of bream species have so far demonstrated dramatic improvements from the standpoint of harvestable fish available to the angler. Cove rotenone samples taken in the fall of 1985 resulted in the recovery of an average 615 harvestable bream per acre; this is the largest population estimate ever for the lake.

POSITIVE EFFECTS: Short-term improvements in sportfish populations.

NEGATIVE EFFECTS: Much of the aquatic vegetation lost after stabilization of water levels.

KEYWORDS: Lake Talquin, Florida lakes, gravity drawdown, fisheries management

COPY OBTAINED: Abstract only

Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: 1971

LAKE SIZE: 23,000 acres

OBJECTIVES OF DRAWDOWN: Improve aquatic habitat and fisheries

SUMMARY: In 1971 Lake Tohopekaliga underwent the first experimental drawdown conducted in Florida which was designed specifically to improve aquatic habitat and fisheries. The program, which thoroughly researched the effects of drawdown, entailed lowering lake levels by 7 feet to expose half the lake bottom. Basic results included drying and consolidation of exposed bottom sediments and establishment of new vegetation communities. Following reflooding, numbers of fish food organisms increased five-fold. Within two years after the drawdown, fish populations in the lake's littoral zone (vegetated area) had more than doubled when compared to pre-drawdown populations; fish production peaked in 1973 with an estimated 455 pounds of fish per littoral acre. The total weight of fish in open water areas increased from 59 pounds to 127 pounds per acre during the same period. By the fall of 1972 there were 41 harvestable and 200 young of the year largemouth bass per littoral acre. This represented an increase of 130% in harvestable sized bass and 450% in young of the year. Overall fishing pressure on the lake increased from 229,000 hours/year in 1970 to 407,000 hours/year in 1975, an increase of 78% percent. For the same time period bass fishing increased from 46,000 hours/year to 220,000 hours/year, an increase of nearly 400% percent. The cost estimate was $375,000 or $16 per acre. This was spent in planning and extensive biological sampling conducted before and after the drawdown.

POSITIVE EFFECTS: Consolidation of bottom sediments, establishment of new vegetation communities and increased fish populations.

NEGATIVE EFFECTS:

KEYWORDS: Lake Tohopekaliga, drawdown, fisheries management

COPY OBTAINED: Abstract only

Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Karick Lake, Florida

DRAWDOWN TIMING/DURATION: Summer and winter of 4 separate years

LAKE SIZE: 58 acres

OBJECTIVES OF DRAWDOWN: Submerged plant control

SUMMARY: An extreme drawdown of 14 feet was conducted in mid-summer of 1973, exposing 90 percent of the lake bottom. During the winters of 1974, 1976, and early summer of 1977, Karick Lake underwent less extreme dewaterings of 7.5 feet, each of which exposed 50 percent of the lake bottom. These fluctuations were conducted in attempts to control excessive amounts of a submerged plant (Florida bladderwort) and stimulate the historically limited sportfishery in this clear water lake. The early summer dewatering was the most successful, resulting in a 2 1/2 year control of bladderwort. The winter drawdowns were typically effective in this regard for only one year. Each dewatering temporarily improved fishing success, and reproduction and recruitment of both largemouth bass and panfish. The cost estimate for each drawdown was $580, or $10 per acre.

POSITIVE EFFECTS: Short-term control of bladderwort, improved fisheries

NEGATIVE EFFECTS:

KEYWORDS: Macrophyte control, fisheries management

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Bear Lake, Florida

DRAWDOWN TIMING/DURATION: Winter and summer of two separate years

LAKE SIZE: 107 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control, fisheries management

SUMMARY: Water levels were lowered eight fee during the winter of 1975 and again during the summer of 1980 to control dense growths of a native submerged aquatic plant (milfoil), and to reduce excessive numbers of small panfish. Approximately 50 percent of the lake bottom was exposed. Significant reductions of milfoil occurred following the 1980 summer drawdown. In addition, within two years following dewatering the standing crop of fish expanded by 47%, from 116 pounds to 170 pounds per acre. Total weights of harvestable sportfish increased by 54%, from 52 pounds to 80 pounds per acre. The cost estimate for each dewatering was $1070, or $10 per acre.

POSITIVE EFFECTS: Reduction of milfoil, improved fisheries

NEGATIVE EFFECTS:

KEYWORDS: Dewatering, fisheries management

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Lake Kissimmee, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 44,000 acres

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: Water levels were lowered by 8.5 feet, exposing 45% of the lake bottom. Bottom sediments were consolidated and structure and coverage of vegetation communities were improved. Invertebrate and shallow water fish populations were still expanding a year later, at end of 1978. General trends in fish population sampling showed a positive response by all major sportfish species. The standing crop of sportfish in 1982 exceeded by 70% the highest estimate recorded prior to the 1977 drawdown. Numbers of young of the year and harvestable bass peaked in the fall of 1978 and fall 1981, respectively. Over 200 young of the year bass were documented in fall 1978 samples, an increase of 165% over pre-drawdown estimates. Harvestable bass increased by 130% when comparing pre-drawdown data to the 32 harvestable bass per acre collected in fall 1981. One year prior to the drawdown, bass fisherman harvested 21,443 bass during 78,082 hours of fishing pressure. By 1982, bass anglers harvested 70,228 bass in 171,809 man-hours of effort. This represented increases of 225% in bass harvest and 120% in angler effort compared to pre-drawdown data. The estimated cost was $850,000; $350,000 (GFC) Research, $500,000 (SFWMD) Construction ($19/acre).

POSITIVE EFFECTS: Improved fisheries

NEGATIVE EFFECTS:

KEYWORDS: Lake Kissimmee, drawdown, fisheries management

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Lake Carlton, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 393 acres

OBJECTIVES OF DRAWDOWN: Lake rehabilitation

SUMMARY: A pumpdown of Lake Carlton was conducted to evaluate complete dewatering as a method for rehabilitating a severely eutrophic lake. The water level was lowered over 13 feet, exposing 80% of the bottom. Substantial growth of terrestrial and aquatic vegetation occurred on the exposed bottom. Following refilling, a layer of compacted sediments persisted over most of the area where organic muds had been exposed. Most new vegetation was reflooded by deep water and died. A net gain in area covered by rooted aquatic vegetation persisted only 2 years after refill. No improvement in water quality was accomplished. Increased standing crops of invertebrates were detected only during the winter following refill in areas where consolidation of organic sediments and extensive cattail growth occurred. Black crappie populations increased following refilling, but no substantial improvements were found for largemouth bass, bluegill, and redear sunfish populations. Creel studies documented a high rate of fishing success for panfish (2.20 fish/hour) the second year following refilling, and above average success for largemouth bass (0.43 fish/hour) in the third year. Cost estimate: 1) Predrawdown studies (biological and hydrological) $60,336.00, 2) construction and engineering $131,672.00, and 3) postdrawdown studies $141,286.00 for a total of $333,294.00 or $848 per acre.

POSITIVE EFFECTS:

NEGATIVE EFFECTS: No improvement in water quality, layer of compact sediments persisted, growth of terrestrial and aquatic vegetation on bottom.

KEYWORDS: Eutrophic lake, pumpdown

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Lake Davis, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 18 acres

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: Pumps and a siphon hose were used to completely drain this small urban lake. Draglines and bulldozers moved muck deposits to shoreline areas where drying was allowed, and the dried material was then trucked away. Approximately 2/3 of the lake basin was cleaned to hard sand or clay bottom in this manner. The maximum water depth prior to the project was 1.5 feet; at project termination, water depth averaged 6 feet and reached maximum depths of 15 feet. Desirable fishery habitat was restored and a productive sportfishery was established. This project was a cooperative effort between the Game and Fish Commission and the City of Orlando. The cost estimate was $56,280 or $3,127/acre.

POSITIVE EFFECTS: Improved fisheries

NEGATIVE EFFECTS:

KEYWORDS: Mechanical drawdown, muck removal

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Lake Tohopekaliga, Florida

DRAWDOWN TIMING/DURATION: 1979

LAKE SIZE: 23,000 acres

OBJECTIVES OF DRAWDOWN: Improve aquatic habitat and fisheries management

SUMMARY: This second gravity drawdown of 23,000 acre Lake Tohopekaliga was necessitated by loss of aquatic habitat due to severe water pollution, and subsequent decline of sportfishery resources. Field observations indicated the drying period and consolidation of organic substrate may have been less than desired due to heavy rainfall which shortened the duration of the drawdown. There was adequate revegetation of littoral areas, which rejuvenated the food chain and increased production of sportfish. By fall 1983, the lake was supporting nearly 70 harvestable largemouth bass per acre of vegetated area; this was an increase of 400% compared to the 14 bass per acre present in 1978. Black crappie, another important sportfish, had excellent reproduction and survival of young in 1980 and 1981, and by fall 1983 produced 32 harvestable fish per littoral acre. Creel data collected in fall 1981 reflected the positive increase in sportfish populations. Largemouth bass and black crappie harvest estimates for this period were 30 to 35% greater than pre-drawdown estimates. Anglers expended over 40,900 hours of effort fishing for largemouth bass during this 3 month time frame. The cost estimate was $225,000 or $10/acre. The cost per acre compared to the 1971 drawdown was lower due to decreased research activity.

POSITIVE EFFECTS: Improved fisheries

NEGATIVE EFFECTS:

KEYWORDS: Lake Tohopekaliga, fisheries management

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Lake Stone, Florida

DRAWDOWN TIMING/DURATION: Winter and summer of two separate years

LAKE SIZE: 130 acres

OBJECTIVES OF DRAWDOWN: Macrophyte control, fisheries management

SUMMARY: The lake was lowered by 11 feet during the winter of 1970 and summer of 1979 to control two submerged aquatic plants (Florida bladderwort and native milfoil), and to stimulate a historically limited sportfishery. Approximately 70 percent lake bottom exposure was achieved. Significant reductions in submerged vegetation were documented. Two years after the 1979 drawdown total fish weight increased by 235% from 54 pounds to 181 pounds per acre. Total weight of largemouth bass more than doubled, from 11 pounds to 27 pounds per acre. Harvestable sportfish tripled, from 13 pounds to 39 pounds per acre. The cost estimate for each drawdown was $1,300 or $10 per acre.

POSITIVE EFFECTS: Macrophyte control, improved sportfishery

NEGATIVE EFFECTS:

KEYWORDS: Fisheries management, macrophyte control

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Fox Lake, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 100 acres

OBJECTIVES OF DRAWDOWN: Hydrilla control, consolidation of sediments

SUMMARY: This was an experimental triple dewatering program designed to control growth of hydrilla, (an exotic aquatic plant), stimulate growth of desirable native aquatic plants, and consolidate soft organic muds. The program accomplished near elimination of hydrilla, germination of desirable aquatic plants, and reduction and compaction of organic deposits. Some benefits of the program were negated due to excessive growth of cattails. This would not have occurred had the EPA not banned use of the only effective herbicide for cattail control midway through the project. The cost estimate was $40,000 or $400/acre, shared by Brevard County and the Game and Fish Commission.

POSITIVE EFFECTS: Near elimination of hydrilla, germination of desirable aquatic plants and compaction of sediments

NEGATIVE EFFECTS: Cattail growth

KEYWORDS: Hydrilla, sediment consolidation

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Lake Hunter, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 100 acres

OBJECTIVES OF DRAWDOWN: Fisheries management, recreational improvements

SUMMARY: This cooperative project between the Florida Game and Fresh Water Fish Commission and the City of Lakeland entailed a complete mechanical pumpdown of Lake Hunter. Organic muds were removed from 50% of the lake bottom, and 133,000 square feet of naturally vegetated shoreline areas were restored through shoreline resloping and re-establishment of native aquatic vegetation. Largemouth bass and other sportfish were stocked during refilling. Physical removal and natural drying of organic muds increased the lake depth by nearly 15 inches, allowing for an 11% improvement in water retention capacity. Shoreline resloping, native vegetation transplanting, and control of undesirable aquatic vegetation have also greatly improved the aesthetics of Lake Hunter. Fingerling largemouth bass stocked in mid-1984 responded well to the lakes improved condition, and had reached an average of 12 inches in length within six months. Cost estimates given by the Game and Fish Commission ($35,000) and the City of Lakeland ($127,000) totaled $162,000 or $1,620 per acre. Two portable electric pumps were provided free of charge by Grace Phosphate Mining Operations, and the necessary pipeline was donated by Agrico Phosphate.

POSITIVE EFFECTS: Improved native aquatic vegetation, improved fisheries

NEGATIVE EFFECTS:

KEYWORDS: Pumpdown, sediment consolidation, fisheries management

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Lake Griffin, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 9,100 acres

OBJECTIVES OF DRAWDOWN: Sediment consolidation, desirable aquatic vegetation growth, and fisheries management

SUMMARY: A drawdown of Lake Griffin was conducted in an effort to consolidate organic sediments, promote the growth of desirable aquatic vegetation, and improve the lakes fishery resource. Our goal was to lower the lake by 7 feet, expose 40% of the bottom for 90 days, and complete refill by November 1, 1984. Because of discharge restrictions and heavy rain the lake was lowered by 6 feet for only 53 days. Varying degrees of exposure and consolidation were accomplished on 30% of the bottom, however actual drying of thick organic muds was limited because of above normal rainfall. Vegetation produced on the exposed areas included spikerush, arrowhead, blueflag, pigweed, cattails, sedges, willow, and primrose willow. Although some uprooting of vegetation from unconsolidated mud bottom occurred upon reflooding, newly created vegetated habitat greatly exceeded the 75 acres of aquatic plants in Griffin prior to drawdown (Historically more than 4,500 acres were present). Survival of this new vegetation is being documented. Of particular value are new stands of aquatic grasses and water lilies. Experimental planting of pondweed and spatterdock lilies was conducted. Fishery and water quality responses to the drawdown will be monitored for the next several years. The estimated costs are $572,000 or $63 per acre. Of this $7,000 was spent by the SJRWMD for Hydrological Studies, the balance of $565,000 has been spent by the Game and Fish Commission on planning and biological monitoring, and includes estimated costs of continued studies through 1988.

POSITIVE EFFECTS: Aquatic vegetation increase

NEGATIVE EFFECTS:

KEYWORDS: Sediment consolidation, fisheries management, aquatic plants

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Williams, V. 1985. Florida Game and Fresh Water Fish Commission. Abstract only.

STUDY LOCATION: Juniper Lake, Florida

DRAWDOWN TIMING/DURATION:

LAKE SIZE: 670 acres

OBJECTIVES OF DRAWDOWN: Fisheries management

SUMMARY: Water levels were lowered by nine feet, exposing 85 percent of the lake bottom. The primary purpose of this project was to rejuvenate a badly deteriorated sportfishery. Additional important goals included County repair of severe dam erosion and control of excessive submerged aquatic vegetation. Our preliminary observations indicated that bass fed extensively upon crowded panfish during the drawdown. Successful consolidation of exposed lake bottom and drying of submerged plants was also noted. Desirable fishery and vegetation community benefits are anticipated following reflooding in 1985 and for several subsequent years. The cost estimate was $6,700 or $10 per acre. This includes the Florida Game and Fresh Water Fish Commission share only, and does not include dam repair costs. Cooperating public agencies in addition to Walton County include the NWFWMD, DNR and DER.

POSITIVE EFFECTS: Successful consolidation of exposed lake bottom, drying of submerged plants and improved fisheries

NEGATIVE EFFECTS:

KEYWORDS: Sediment consolidation, fisheries management

COPY OBTAINED: Abstract only