Satterfield, J. R. Jr., and S. A. Flickinger. 1996. Collection and care of broodfish. Pages 63–69 *in* R. C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Chapter 3

Collection and Care of Broodfish

James R. Satterfield, Jr.,[1] Colorado Division of Wildlife, 6060 Broadway, Denver, Colorado 80216 and Stephen A. Flickinger, Department of Fishery and Wildlife Biology, Colorado State University Fort Collins, Colorado 80523, USA

Introduction

Culture of walleye has traditionally involved collection of wild broodstock from public waters (Nickum 1978; Richard and Hynes 1986). This differs from production of many other important sport fish such as channel catfish and rainbow trout, where captive broodstock are normally used (Piper et al. 1982). Collection of wild broodstock can often be a limiting factor in an agency's ability to meet walleye production needs (Satterfield 1992). Fish farmers desiring to raise walleye may encounter complex legal restraints to procure fertilized eggs from wild fish. Thus, collection of sufficient wild broodstock is vital to overall success of many walleye management and culture programs throughout the **US.**

Besides collecting sufficient fish to meet production needs, other important objectives of broodfish collection include: maximizing operation efficiency in terms of cost and labor; maintaining a positive public image; minimizing impacts on walleye populations and nontarget fish species; and conducting operations which minimize hazards to personnel and the public. To fulfill these objectives, careful planning and attention to detail are required. Because no two spawning sites are identical, site-specific fish collection techniques are often needed.

The objectives of tlvs chapter are to provide biologists and culturists with a broad overview of broodstock collection and handling techniques. We hope information provided will be of particular use to state game and fish agencies and to fish farmers beginning new walleye culture programs. It is also hoped that well-established programs may find in this report methods and ideas that will improve their walleye production efforts.

Collection of wild broodstock

In the **U.S.,** most walleye broodstock are collected from public waters. Of the case studies in this chapter, only one state, Pennsylvania, reported conducting operations on a closed water (Harvey and Hood 1996). Certainly, it is advantageous to conduct operations on closed waters, thus alleviating concerns for fish theft, net and equipment vandalism, and user conflicts. However, walleye broodstock collection usually occurs in large lakes and reservoirs which contain adequate walleye populations to allow collection of large volumes of eggs and milt. Such waters are rarely privately owned and are usually open to the public.

Rules and regulations

Application of some simple regulations at spawning sites can greatly reduce potential conflicts between fisheries personnel and anglers, boaters, or other resource users. The most common problem at many spawning sites is interference in netting operations, both accidental and intentional. Fishing in the vicinity of nets by bank and boat anglers should be discouraged, if necessary, through regulations. Anglers often lose hooks and lures in nets, creating a dangerous situation for spawning personnel. This can be minimized, if necessary, by closing public access to specific shoreline areas that are heavily netted. Closures may be enforced for the duration of spawning operations or may be for specific daily hours, such as from late afternoon to early

---

[1] Present address: Montana Fish, Wildlife and Parks, 1420 East Sixth Avenue, Helena, Montana 59620-0701

morning, when nets are actually deployed. Temporary wakeless zones can also be established to avoid dangerous traffic around netting sites; these regulations will also reduce damage to nets by boaters.

Such regulations are most practical when netting sites are concentrated, as along dam rip-rapping, inlet areas, or windswept shoals. When collection efforts are too dispersed for closures, nets should be well marked with highly visible, fluorescent buoys, and signs should be placed on adjacent shoreline areas and at key access points such as boat ramps to notify and educate the public regarding spawning operations. Despite all of the above efforts, sometimes a night watchperson is necessary.

In addition to posting or closing netting sites, it is also necessary to provide personnel with facilities to spawn fish, dock boats, and store equipment which are closed to the public. Such sites should be secure, provide comfortable working conditions, and facilitate efficient operations. **A** review of case studies by Jorgensen (1996), Colesante (1996), and Harvey and Hood (1996) will reveal many useful innovations for selecting spawning sites.

Capture techniques

Most states rely primarily on trap-netting or gill-netting to collect walleye broodstock (Huet 1970; Krise and Meade 1986). Another gear that is often overlooked, but which can be effective for collecting walleye in certain situations, is boat-mounted electrofishing (Priegal 1970; Satterfield and Fliclunger 1995a). The effectiveness of different types of collection are site specific (Hayes 1983; Hubert 1983).

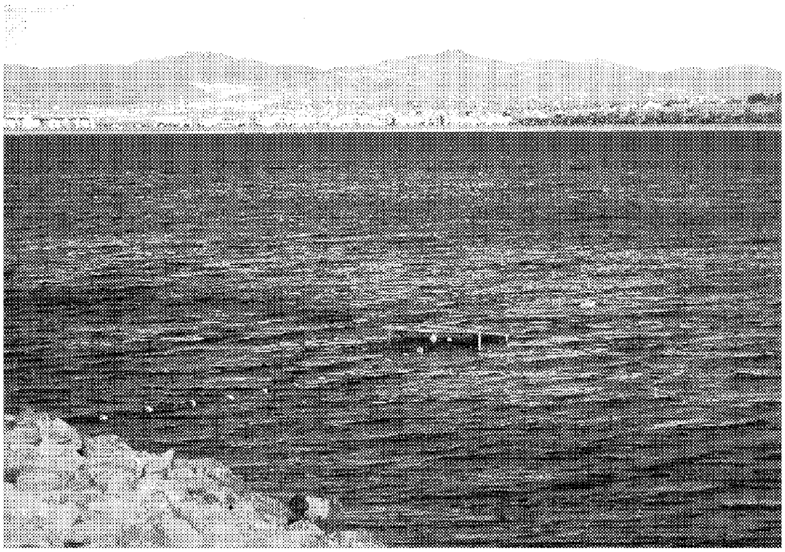


Figure 1. Trap-net deployed for collecting walleye broodstock.

Trap-netting, when practical, is probably the most desirable gear for collection of walleye broodstock. Deployment and fish retrieval is much less labor intensive than with gill nets, and mortality of collected fish is minimal (Dumont 1990; Langer 1994). Satterfield and Flickinger (1995a) also indicated that male walleye collected by trap-netting yield more semen per fish than when collected by gill-netting, presumably because of minimal handling of captured fish.

Size and construction of trap nets varies among states where this gear is commonly used, and it is influenced by number and size of fish typically caught, size of crew available to deploy and retrieve nets, and shoreline slope and configuration. Colesante (1996) reports the use of trap nets with 6.0 ft (1.83 m) square frames. Conversely, trap nets as small as 3.0 ft (0.93 m) have been effectively used in Colorado (Satterfield 1992). Obviously, larger trap nets require more labor and larger boats than smaller trap nets. Trap nets with bar mesh about 0.75–1.5 in. (1.9–3.8 cm) and center-mounted, single leads of **up** to 130 ft (40 m) are typically used.

Trap nets are often set perpendicular to shore on dam rip-rap, points, inlet areas, and other locations where spawning walleye concentrate. **As** a rule of thumb, trap nets are placed in deep enough water to barely cover the top of the front frame (Figure 1). Length of lead will vary, depending on depth of trap-net set and shoreline slope. Leads are attached to shore by use of natural structures such as logs or brush; fence posts temporarily placed on shore also make good attachment points.

The principle disadvantage of trap nets is that their use is confined to a relatively narrow range of depth and bottom slope configurations. Trap nets do not work well in water deeper than about 12 ft (3.7 m) because fish will usually swim over the lead and avoid capture. Trap nets also function poorly in locations with large broken rocks, because fish will swim under leads. Bottom configuration must be fairly flat or trap nets will have a tendency to twist, especially if strong crosswinds develop.

Trap-netting usually begins in March or April when surface temperature approaches 40°F (4.4°C). Because fish are rarely injured when captured in trap nets, it is not necessary to check them as often as gill nets which require daily removal of fish to minimize mortality to walleye and other fish. Use of gill nets requires more frequent inspection of nets than does trap nets, but gill nets are easier to move and are less expensive (Dumont 1990).

Gill-netting is a useful alternative for collecting walleye broodstock in waters where trap-netting is impractical. Gill-netting is particularly useful in lakes with steeply-sloped bottoms or extended reaches of rip-rap or rocky shoreline. When fish are dispersed or concentrations have not been identified, gill nets can sample a wider range of depths than trap nets or electrofishing.

As with trap nets, construction of gill nets is normally tailored to individual spawning sites. Factors influencing gill-net specifications include; average size of adult walleye present; depth and slope of netting sites; and nontarget fish species present. Gill nets are normally constructed of multifilament mesh to reduce injury to fish and are often dyed to reduce visibility and improve catch rate (Jester 1977). A common mesh size for gill nets is 2.0 in (5.1 cm) bar mesh, which is a useful size for collecting walleye 15 to 30 in (38.1 to 76.2 cm) total length. If larger males are in short supply, it may be necessary to use smaller mesh 1.5 in (3.8 cm) to capture first-time spawning walleye. A typical net depth for capturing broodsize walleye is 6.0 ft (1.83 m) and net lengths may range from about 150 to 300 ft (45.8 to 91.6 m).

For walleye broodstock collection, gill nets are often set parallel to dam rip-rap or other rocky, windswept shore areas in water about 6.0 ft (1.83 m) deep. Ideally, with the lead line resting on the bottom, the float-line of the gill net should just reach the surface (Figure 2). Gill nets set in this manner prevent fish from swimming over the top of the net or detecting the net before capture by encountering loosely bunched layers of net. When an extended reach of shoreline is to be netted, gaps between the ends of gill nets should be minimized to prevent fish from avoiding capture by swimming between nets (Figure 3).

Gill nets are usually set in the late afternoon and retrieved shortly after sunrise. To further reduce fish

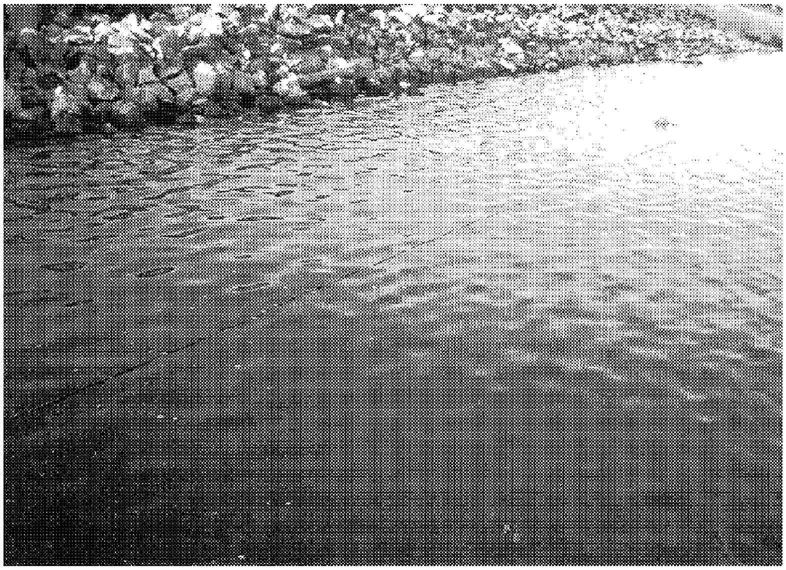


Figure 2. Gill-net set at proper depth to maximize capture of walleye broodstock. Note that float-line of gill-net just reaches the surface.

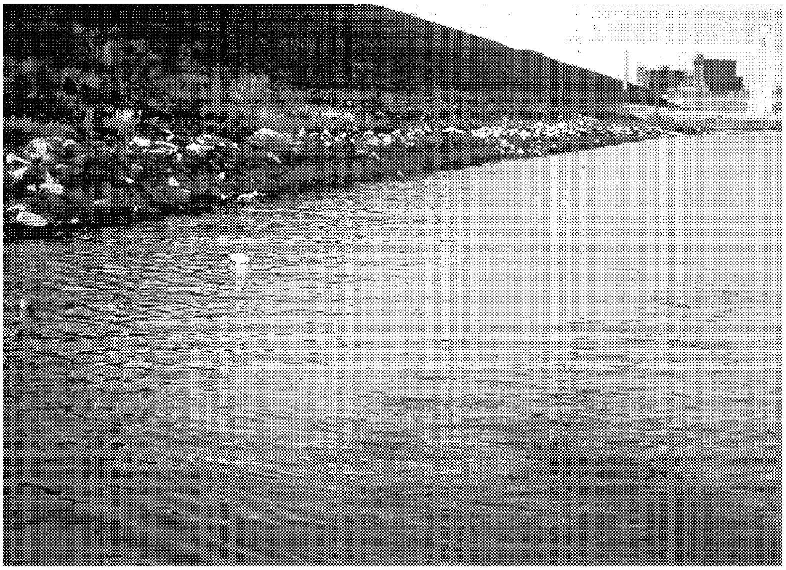


Figure 3. Series of gill nets set perpendicular to rip-rap on dam

mortality, some states (e.g., Iowa) check nets periodically throughout the evening to reduce the time captured fish are in the gill nets (Jorgenson 1996). However, it has been our experience that this is unnecessary as long as water temperature does not exceed 50°F (10°C). In many waters, gill net operations must be suspended after water temperature exceeds this point, not only to avoid high mortality rates, but also because capture of nontarget fish species may increase.

Gill-netting is labor-intensive. Nets must be checked daily to minimize fish mortality and must be removed from the water being netted, so that debris can be removed and the nets can be reset. Broodstock collections involving gill-netting require scheduling of a morning and an evening shift of personnel to deploy and retrieve nets, whereas trap-netting or electrofishing operations require only one shift.

Both gill-netting and trap-netting are passive sampling methods that rely on movement of fish to facilitate capture. Electrofishing, on the other hand, is an active gear which can be effective when fish are not moving (Satterfield 1992). Electrofishing is probably not suitable as a primary means of collecting broodstock, but it can be useful for augmenting trap nets or gill nets, and it is effective for collecting male walleye (Satterfield and Flickinger 1995a).

Night electrofishmg has been conducted for several years by the Colorado Division of Wildlife to collect walleye at the Marston Reservoir in Denver (Satterfield 1992). Electrofishing is performed with boat-mounted gear powered by a 5,000 watt generator through a variable voltage pulsator to deliver 200–300-v DC. It has been our experience at Marston Reservoir and other waters, that walleye are more vulnerable to electrofishing at night as they migrate into shallow water when light levels are reduced (Satterfield and Flickinger 1995a). Depending on water clarity, walleye may be collected in water up to 10 ft (3.0 m) with the use of extended dip-net handles. Walleye concentrated in inlet areas are particularly susceptible to electrofishng, and additional fish can also be collected by electrofishing parallel to shoreline at depths of 3.28–10 ft (1–3 m).

We are unaware of any evidence that electrofishmg damages eggs or milt of walleye or any other fish species (Maxfield et al. 1971; Walker et al. 1994). Personnel employed as netters on electrofishing boats rarely collect nontarget species (Langer 1994).

Care of broodstock

Proper care of broodstock is a vital element in successful spawning operations. Fish may be held for several days after capture, as when green females are held until maturation or when ripe males are reused for consecutive days. Improper care may lead to high mortality. Fish loss during spawning operations can impact walleye populations when a large number of adult fish are collected. High mortality of walleye can also lead to public relation problems.

Transportation of fish to spawning site

Proper care of broodstock begins when fish are removed from nets and transported to spawning sites. Tubs placed in boats or vehicles should be large enough to hold ample fresh water to avoid stress. The number or weight of walleye that can be safely transported from netting to spawning sites will depend on water temperature, travel time, and the overall condition of the fish (Stickney 1983). Water used for transporting fish should have 0.5% sodium chloride. During daylight operations, tanks should be covered because walleye are stressed from bright light.

Table 1. Summary of walleye milt production from multiple daily strippings at Marston Reservoir spawning operation, Denver, Colorado, 1991. Modified from Satterfield and Flickinger (1995a).

Stripping	Fish (N)	Fresh milt (mL)	Milt/fish (mL)
First	154	481	3.1
Second	154	201	1.3
Third	149	81	0.5

Tanks should be aerated, and pure oxygen can also be delivered via an airstone. If boat transportation time is lengthy, particularly with large loads of fish, it may be necessary to periodically exchange water in the holding tanks. Surface foam in hauling tanks is an indication of excessive mucous waste and a sign that life support systems for transported fish are compromised (Davis 1961).

Holding broodstock at spawning site

After fish are transported to the spawning site, they are usually segregated by sex, and females are sorted into: green and ripe groups. Females which are gravid but do not yield eggs with gentle abdominal pressure are defined as green, while ripe females are fish that can be easily stripped. At some sites, fish are held in cages which are secured in about 3.28 ft (1 m) of water so that cages are accessible to project personnel in chest-waders. If fish theft is a concern, cages may be locked and placed in deeper water, but a boat will be necessary to add and remove fish.

Several cages will be needed if males are to be reused and/or green females are held until maturation. Cages should be clearly labeled to ensure fish are placed in the proper cage. Cages should be covered to provide fish with shade and should be located so that adequate fresh water circulates through cages. Cages should be anchored sufficiently to withstand strong winds.

When spawning is to take place in the hatchery, removal and sorting of walleye is more automated and less labor-intensive. Obviously, this is preferred for operations which will be conducted in specific waters for many years. However, there may be a need to use more portable operations when evaluating new spawning sites or when traditional waters are not producing satisfactory results.

Spawning broodstock

Authors of the case studies for this chapter emphasized that ripe females should be spawned as soon after collection as possible to avoid egg loss. Green females may be held for up to about **3** d to allow for maturation, but females that do not ripen by this time are released. Maturation of green females may be accelerated under controlled conditions by holding them in slightly warmer water. Some research has also been conducted on the use of hormonal injections to ripen females, but this technique is still experimental (see Heidmger et al. case study Chapter 2).

Many culturists report that males come into sexual maturity prior to females and taper off while females are still ripe (Figure 4; Satterfield 1992). Males are also stripped as soon as possible to avoid loss of milt. Thus, male walleyes may be in short supply near the end of spawning operations. However, stripped males may be held and reused. When sufficient numbers of males are not available to meet spawning needs, males may be held for a second stripping, which provides about 40% as much semen as the first, without affecting quality of the semen (Table 1; Satterfield and Flickinger 1995a). However, holding fish for a third stripping is inefficient as the third stripping produces only about 16% as much milt as the first stripping. Use of extenders or cryopreservation of walleye semen should be considered when semen is in short supply (Moore 1995)

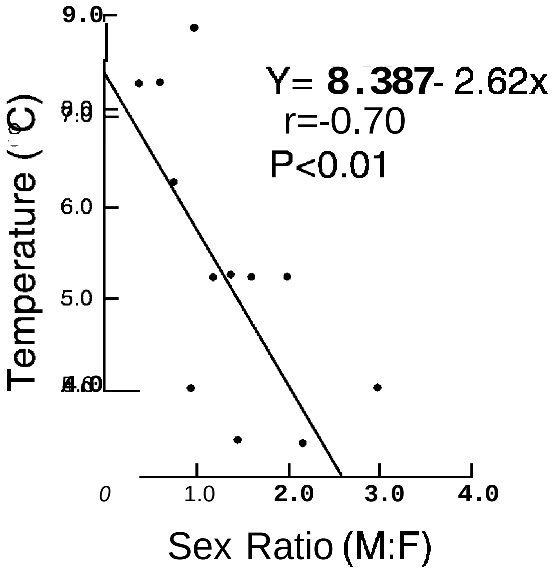


Figure 4. Relationship between walleye sex ratio (M:F) and temperature at Marston Reservoir. Denver, Colorado in 1991. Modified from Satterfield (1992).

Captive broodstocks

Use of captive walleye broodstocks will eventually become commonplace for private culturists. The ability to select for desirable genetic traits and to alter time of spawning will offset the negative aspects of space and maintenance costs. Domestication will be desirable for commercial production for out-of-season spawning. Guidelines for genetic selection are described in texts on fish genetics (Kapuscinslu and Jacobson 1987, Tave 1986).

It seems to be impractical to maintain a captive walleye broodstock using natural forage. Consequently, the chapters on feed-training and on raising fish to food size, as well as Nagle's case study **(1996)** on captive broodstocks, should be read. Typically, research on broodfish nutrition receives little attention, and therefore culturists should expect to encounter some nutritional problems (too much body fat is a common one) for many years.

Summary

Effective collection of wild broodstock is an essential part of a successful walleye spawning operation. Thorough planning is critical to ensure adequate equipment and labor are available. State game and fish agency personnel working on public waters should give attention to projecting a professional image and insuring safe conditions for both fishery workers and the public; implementation of temporary closures and other restrictions may be necessary to avoid user-conflicts and unsafe conditions.

A variety of gear is available for collection of broodstock. When starting new operations it may be necessary to evaluate several types of gear to determine which type is most suitable for a particular aquatic habitat. In some instances, a combination of gear such as gill nets and trap nets may be most useful. For established operations, some augmentation of existing collection techniques may further optimize operation efficiency.

Collected broodstock should be treated carefully to maximize spawn-taking potential and to avoid long-term damage to walleye populations. Fish should be removed as quickly as possible from collection gear, hauled at an appropriate density to a spawning site, and monitored throughout the entire spawning process to insure a high survival rate of fish after they are returned to the habitat where they were captured.

References

Colesante, R. T. 1996. Collection of walleye broodstock, egg take, incubation, and fry production at the Oneida Fish Cultural Station. Pages 71–74 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames, Iowa.

Davis, H.S. 1961. Culture and diseases of game fishes. University of California Press, Los Angeles.

Dumont, S.C. 1990. Evaluation of standardized fish sampling procedures in coldwater impoundments. Master's thesis, Colorado State University, Fort Collins.

Harvey, J. E., and S. E. Hood. 1996. Collection and spawning of walleye broodfish and incubation of fertilized eggs. Pages 25–28 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames, Iowa.

Hayes, M.L. 1983. Active fish capture techniques. Pages 123-146 *in* L.A. Nielsen and D.L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Heidinger R. C., B. L. Tetzlaff, and **R.** C. Brooks. 1996. Hormone induced spawning of walleye. Pages 59–62 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames, Iowa.

Hubert, W.A. 1983. Passive capture techniques. Pages 95-122 *in* L.A. Nielsen and D.L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Huet, M. 1970. Textbook of fish culture: breeding and cultivation of fish. Fishing News (Books) Ltd., Farnham, Surrey, England.

Jester, D. B. 1977. Effects of color, mesh size, fishing in seasonal concentrations, and baiting on catch rates of fishes in gill nets. Transactions of the American Fisheries Society 106: 43-56.

Jorgensen, W. 1996. Wild broodstock collection in Iowa. Page 77 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames, Iowa.

Kapuscinski, A.R., and L.D. Jacobson. 1987. Genetic guidelines for fisheries management. Minnesota Sea Grant Research Report No. 17, University of Minnesota, Duluth.

Krise, W.F., and J.W. Meade. 1986. Review of the intensive culture of walleye. Progressive Fish-Culturist 48:81-89.

Langer, G. J. 1994. Evaluation of the Colorado Division of Wildlife's warmwater fish sampling protocol. Master's thesis, Colorado State University, Fort Collins.

Maxfield, G.H., R.H. Lander, and K.L. Liscom. 1971. Survival, growth, and fecundity of hatchery-reared rainbow trout after exposure to pulsating direct current. Transactions of the American Fisheries Society 100:546-552.

Moore, A. 1996. Use of semen extenders for walleye. Pages 51–53 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames, Iowa.

Nagel, T. 1996. Development of a domestic walleye broodstock. Pages 75–76 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames, Iowa.

Nickum, J.G. 1978. Intensive culture of walleyes: the state of the art. American Fisheries Society Special Publication 11:187-194.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish hatchery management. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Priegal, G.R. 1970. Reproduction and early life history of the walleye in the Lake Winnebago Region. Technical Bulletin 45, Wisconsin Department of Natural Resources, Madison, Wisconsin.

Richard P.D., and J. Hynes. 1986. Walleye culture manual. Ontario Ministry of Natural Resources, Toronto.

Satterfield, J.R., Jr. 1992. Walleye semen collection, preservation, and storage. Doctoral dissertation, Colorado State University, Fort Collins.

Satterfield, J.R., Jr., and S.A. Flickinger. 1995a. Field collection and short-term storage of walleye semen. Progressive Fish-Culturist 57:182–187.

Satterfield, J.R., Jr., and S.A. Flickinger. 1995b. Factors influencing storage potential of preserved Walleye semen. Progresive Fish-Culturist 57:175–181

Stickney, R.R. 1983. Care and handling of live fish. Pages 85-94 *in* L.A. Nielsen and D.L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Tave, D. 1994. Genetics for fish hatchery managers, 2nd edition. AVI/Van Nostrand Reinhold, New York.

Walker, M.K., E.A. Yanke, and W.H. Gingerich. 1994. Use of electronarcosis to immobilize juvenile and adult northern pike. Progressive Fish-Culturist 56:237-243.

Colesante, R. T. 1996. Collection of walleye broodstock, egg take, incubation, and fry production at the Oneida Fish Cultural Station. Pages 71–74 *in* R. C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Collection of Walleye Broodstock, Egg Take, Incubation, and Fry Production at the Oneida Fish Cultural Station

Richard T. Colesante, New York State Department of Environmental Conservation, Oneida Fish Cultural Station, Constantia, New York 13044

Introduction

Since 1897, walleye have been collected by hatchery crews on Oneida Lake to obtain gametes for fry production to meet needs for fishery management in New York State. This case study describes techniques used to collect broodfish, obtain eggs and semen and produce fry at the New York State Department of Environmental Conservation Oneida Fish Cultural Station.

Oneida Lake is the largest inland lake within New York State. It is a shallow 50,000 acre (20,234 ha) lake with a mean depth of 22 ft (6.7 m). The lake is annually stocked with 102 million walleye fry (2,040 fry/acre, 5,040/ha) which contribute to the adult population that averages 10 fish/acre (25 fish/ha). Hatchery efforts at broodstock collection deal with this population.

The water supply for the Oneida Fish Culture Station comes from Scriba Creek, a major tributary to Oneida Lake. Generally, hatchery water is 2–8°F (1.1–4.4°C) warmer than lake water during the spawning period; this source of warmer water is very useful in handling “hard or green” female walleyes.

Spawning season

Oneida Lake is completely covered with ice from December-January through March-April. Ice normally leaves the lake during the first two weeks in April. As soon as ice is gone, trap nets are set. If ice leaves the lake in early-mid March, a test net is set. Spawning activity usually begins during the last week of March or early April when lake temperatures approach 40°F (4.4°C). Photoperiod appears very important in the timing of spawning; water temperature appears to be an immediate stimulus to initiate spawning activity only when “the time” is correct.

The length of the walleye spawning run in Oneida Lake is determined by many factors. A cold spring can extend the spawning period by a few days and the converse is also true. If the ice is gone by late March or early April, a 14 d spawning period is common; if ice out is later, spawning may last only 7–10 d. During the last 20 years, the annual walleye egg requirement for the hatchery has been about 320 million eggs. This target has been met every year except one. Typically, eggs must be collected for the entire spawning period.

Collection of broodstock

Oneida Lake trap nets, designed and built by hatchery staff, are used to collect adult fish. The nets are made with 0.75 in (1.9 cm) bar, 1.5 in (3.8 cm) stretch, nylon webbing placed on 4 ft (1.2 m) or 6-ft (1.8 m) frames (Figure 1). The net is equipped with wing (2), leader (1), and crib (1) anchors which stabilize the net even during periods of high wind and wave action. The nets are generally set at the mouth of Scriba Creek and selected locations withm 0.75 mi (1.2 km) in each direction of the mouth. Nets are set within 0.25 mi (0.4 km) of shore in water 6–8 feet (1.8–2.4 m) deep. The leader of the net, usually between 100–150 ft (30.5–45.7 m) long, generally extends toward, but does not reach, the shore. Netting sites have been standardized by hatchery crews over the years and are generally associated with rocky shoals or points along the lake. Fifteen to 24 nets are set each spring. Walleye in Oneida Lake spawn on shoals and in tributaries; netting operations collect fish from all locations. Normally, between 30,000–40,000 adult walleyes are netted and transported to the hatchery each year.

Trap nets are tended each day. Fish are removed from nets and transported by boat to the hatchery in live cars. Live cars are rectangular fiberglass tubs, 2.75 x 4.1 x

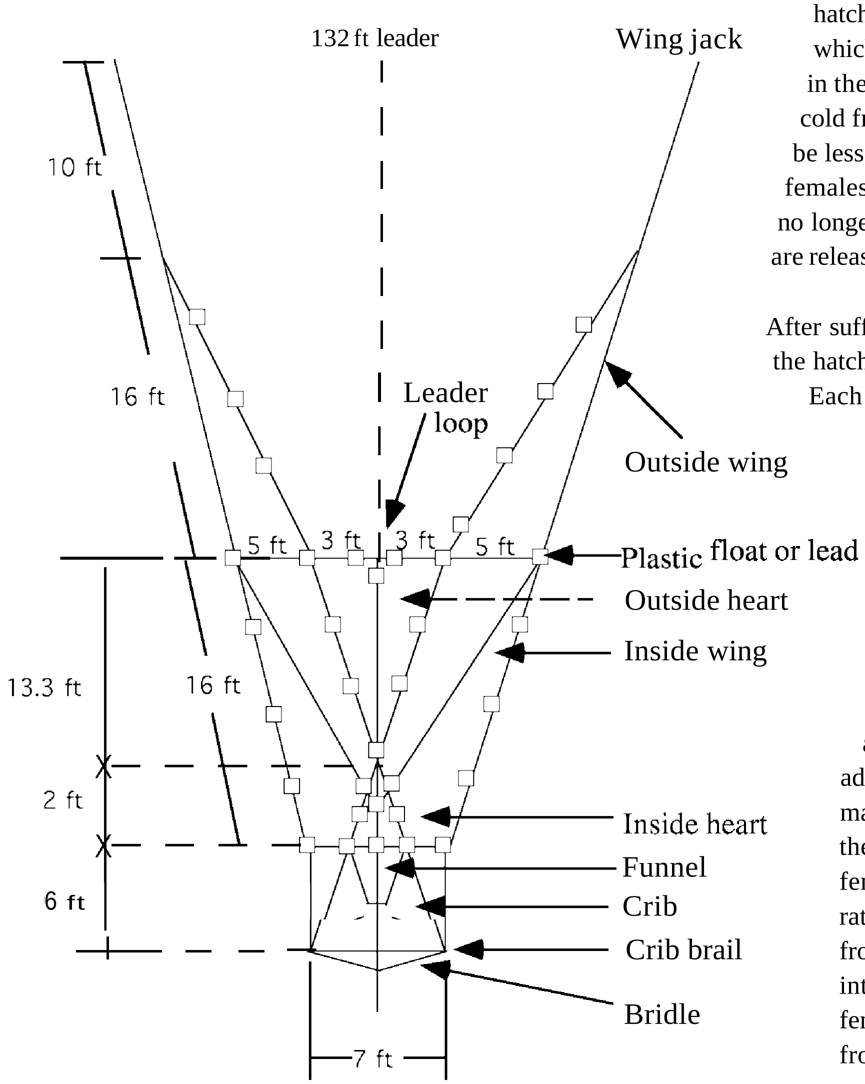
1.5 ft (0.8 x 1.2 x 0.5 m) (width x length x depth), containing approximately 30 gal (113.6 L) of water. There is no aeration or treatment of the water in the live cars. Early in the spawning run, over 90% of the fish in a net will be walleye; as the run progresses and water temperature increases, other species of fish become prevalent. At the hatchery, the live car is hoisted by a mechanical lift and moved along a rail to a sorting table. The live car is lowered onto the table and each walleye is sexed and spawning condition is determined; the live car commonly holds up to 200 adult walleye. Males, ripe females (ready to strip that day), and hard (green) females are placed in separate fiberglass holding tanks. The hatchery has 32 tanks, 25 x 4 x **2.3** ft (7.6 x 1.2 x 0.7 m), for use during this phase of the operation. Generally, up to 500 adults will be held in a tank, volume near 200 ft^3 (5.7 m^3), with a flow of approximately 80 gpm (5.0 L/sec). Tanks are not covered and fish are exposed to low light (≈140 lux) conditions while being held in the hatchery.

Spawning

Ripe females are stripped the day they are captured. Hard females netted on previous days are checked daily and, if they have become ripe, they are stripped. If the hatchery had to rely only on ripe fish captured from the lake, the production goal would never be met. It is the ripening of hard females that are collected from the lake that supplies more than 50% of our eggs. Hard females are held for up to 3 d; normally 60–80% of these fish become ripe. The typical temperature difference between the lake and the hatchery's water supply is 2–8°F (1.1–4.4°C), which probably stimulates these fish to ripen in the hatchery. Under unusual situations, a cold front can cause the stream temperature to be less than the lake; when this happens, few females ripen. Hard females are generally held no longer than 3 d. If they have not ripened, they are released.

After sufficient ripe walleyes are accumulated in the hatchery, stripping crews are established. Each crew consists of 3 people, one stripping females, another stripping males, and a third stirring eggs and adding water to the bowl containing eggs and sperm. Eggs and sperm are stripped into fiberglass bowls with a volume of 6.5 gallons (24.6 L); eggs are fertilized using the wet method. One pint (0.5 L) of water, is placed in the bowl; eggs and sperm are added simultaneously while additional water is added as needed to make a slurry of eggs, sperm and water. In the egg fertilization process, male and female fish are generally used in a 1:1 ratio. Early in the spawning run, gametes from 15 females and 15 males are stripped into a bowl; later in the run, when some females may be partially spent, gametes from 20 females and 20 males are used.

Figure 1. Frame diagram of Oneida Lake Trap net.



Typically, Oneida Lake walleye yield 40,000 to 50,000 eggs.

Bowls full of eggs are carried to the water hardening area where the eggs are stirred, using 3-in (7.6-cm) paint brushes. When four bowls are available, the fertilized eggs are poured into a 20 gal (75.7 L) tub containing 5 gal (18.9 L) of a 400 ppm tannic acid solution to remove the adhesiveness of the eggs. Eggs in the tannic acid solution are continuously stirred for 2.5 min. The eggs are decanted and the remaining egg slurry is stirred and egg clumps are broken up (as needed) by hand. Fresh water is added and decanted from the tub two more times, and eggs are stirred and clumps of eggs are broken up by hand each time. The tub is filled for a third time with fresh water, and the eggs are allowed to water harden for up to 1 h. About every 15 min during water hardening, eggs are stirred briefly by hand.

Incubation

Typically 320–350 million walleye eggs are collected annually. There are 13 jar batteries capable of holdmg 910 McDonald type incubation jars. After water hardening, the water in the tub is decanted and 3 qts (2.9 L) of eggs are placed in each jar. Water flow through the jar is about 1.5 gpm (5.7 Lpm) for the first 2–3 d, slowed to 1.0 gpm (3.8 Lpm) for the majority of the incubation period and increased to 1.5 gpm 5.7 Lpm) at hatching. During incubation, eggs are treated every other day with a 1:600 (1,667 ppm) formalin solution for **15** min to control fungus.

Periodically during incubation, dead eggs are siphoned from jars. Dead eggs accumulate at the top of each jar as incubation progresses. Siphoned eggs (which always include some live eggs) are placed in jars and allowed to roll and separate. When this “hospital” jar is siphoned, dead eggs are then discarded and live eggs are retained.

Eggs are incubated in creek water at ambient temperatures. The temperatures vary from 40–65°F (4.4–18.3°C) during the incubation period, but they may vary as much as 10°F (5.6°C) in a 24 h period. Typically incubation lasts about 21 d; however, in some years, incubation can take as few as 15 d or as many as 30 d. Generally, the longer the incubation period, the poorer the survival of eggs. Percent eye-up is determined by sampling 20% of the jars (randomly selected) on each battery, remeasuring the surviving eggs, and expanding this estimate for each battery and for all batteries. Normal yearly eye-up average is 80–86%; however, during periods of long incubation, eye-up may be as low as 70–75%.

Hatching can begin as early as 270°F (132.2°C) temperature units and usually peaks by 400°F (204.4°C) temperature units. Fry swim from jars, travel through an open drain system on the jar battery and drop into a holding tank. The holding tank is 25 x 4 x 2.3 ft (7.6 x 1.2 x 0.8 m), 210 ft^3 (5.9 m^3), with a single, 50-mesh, stainless steel, barrier screen. A “T” shaped bubbler, made of 0.5 in (1.3 cm) PVC, is placed near the bottom of the screen and along its length. Drilled ⅛ in (0.32 cm) holes release air towards the screen. Air is produced by two high-volume, low-pressure air pumps. The bubbler prevents egg shells and fry from accumulating on the screen which could limit the discharge of water. Water flow through individual batteries and holding tanks during hatching is between 70-100 gpm (18.5–26.4 Lpm).

As walleye fry accumulate in holding tanks, samples are taken to establish volumetric displacement values for inventory at stocking. Generally, between 200–230 newly hatched fry will displace 1 ml of water. Attempts are made to stock fry within hours of hatching, but many times this is not possible because of scheduling difficulties. All fry are stocked prior to the initiation of feeding (usually 3–5 d). If held beyond this time, cannibalism would occur in crowded holding tanks. Total fry production from the hatchery ranges between 150–200 million. About thirty bodies of water are stocked with the hatchery-spawned fry each spring.

Netting 30,000–40,000 adult walleye and collecting 320 million fertilized eggs in a 7–14 d period demands efficiency. The program at the Oneida Fish Cultural Station has evolved over 100 years. Improvements in egg handling techniques and modem fish moving equipment have reduced manpower requirements by one third. Table 1 summarizes broodstock collection, egg take, and fry production during the 1993 and 1994 production seasons. Each year of hatchery operation results in improvements in efficiency, which should continue over the ensuing production seasons.

Table 1. Broodstock collection, egg take, and fry production summary for 1993 and 1994 at the New York State Department of Environmental Conservation Oneida Fish Cultural Station.

	1993	1994
Date lake was first ice-free	4112	4/17
Date first net set	4112	4/17
Total nets set	20	20
First day tended	4113	4/18
Total net days	9	7
Last day tended	4/21	4/24
Hatchery temperature:		
Mean	48°F (8.9°C)	47°F (8.3°C)
Range	39–51"F (3.9–10.6°C)	42–52°F (5.6–11.1"C)
Lake temperature:		
Mean	41"F (5°C)	41"F (5°C)
Range	37–43°F (2.8–6.1"C)	38–43°F (3.3–6.1"C)
Total walleye collected	38,977	34,645
Males	26,337	22,925
Females (hard)	10,583	7,362
Females (ripe)	1,546	1,290
Females (spent)	1,511	3,086
Females stripped	7,421	7,920
Males stripped	7,421	8,451
Average eggs/female	50,209	42,420
Date first eggs taken	4/15	4/18
Date last eggs taken	4/21	4/25
Date of first hatching	5/3	4/30
Incubation days	20	15
Incubation temperature:		
Mean	55.7°F (13.2%)	53.6°F (12.0%)
Range	45–57°F (7.2–13.9°C)	46–64°F (7.8–17.8°C)
Total eggs taken	372,600,000	336,000,000
Estimated eye-up percentage	80.4%	88.5%
Total fry stocked	152,086,000	202,000,000

Nagel, T. 1996. Development of a domestic walleye broodstock. Pages 75–76 *in* R. C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Development of a Domestic Walleye Broodstock

*Tim Nagel, London Fish Hatchery, Ohio Department of Natural Resources, Division of Wildlife, London, Ohio **43140***

Introduction

This case study summarizes 20 years of breeding at the London Fish Hatchery, London, Ohio, to develop a line of domestic walleye broodstock. This project was initiated to develop a line of fish that were less excitable and that were more easily trained to accept pelleted feed. Some aspects of this program have been described (Nagel 1985,1991).

Acquisition of P, generation and production and culture of F, generation

Fertilized eggs were obtained from wild broodstock captured from the Pymatuning and Mosquito Reservoirs in northeast Ohio in the spring of 1975, 1976, and 1977 (Table 1). It is thought that the original source of walleye in these reservoirs was Lake Erie. Wild broodstock that were spawned were designated as the parental (P,) generation. There were three year classes (1975, 1976, and 1977) of P_1 broodstock.

The fertilized eggs were transported to the London Fish Hatchery where they became the F,-generation. This was the first generation of broodstock in the breeding program to be cultured at the London Hatchery. There were three F_1-generation year classes (1975, 1976, 1977). F_1-generation fish were raised in 0.1-acre (0.04 ha) earthen ponds until they were 1.4-1.5 in (31-38 mm), and were transferred to covered 50-ft^3 (1,421 L) troughs with internal lighting where they were trained to accept a formulated diet (W-16) using procedures developed at the London Hatchery from 1972-1975 (Nagel 1976). Solenoid-actuated feeders were used to dispense feed hourly from dawn to dusk. Hand feeding at dusk was also used, because it can reduce the acclimation period.

After 2 weeks, fingerlings were restocked in a 0.1-acre (0.04 ha) pond and were fed a floating trout chow. Each year class was stocked in a separate pond. A floating diet was used to observe feeding behavior and to prevent overfeeding, something which can occur when using a sinking pellet. Fish were fed just before sunrise and after sunset. Feeding was done daily, but only during crepuscular periods. Feed-trained fish were cultured in the ponds until they were 4 years old.

Males matured at 3 years, while females matured at 4-5 years. Brood fish averaged 3 lbs (1.36 kg). When water temperature reached 48°F (9°C), most males had **an** abundance of milt. However, most ceased semen production within 7-10 d. Four to 5-year-old females that were gravid ripened within 3-5 d. After harvest, fish were sexed, and males that were producing semen were placed in divided troughs up-water from gravid females. Fish were easily stripped 3-5 d after harvest, and hormonal injections were not needed.

Production of F, F, and F_4 generations

F_1-generation fish were spawned in 1979-1983 to produce five year classes of F_2-generation walleye (1979,1980,1981,1982, and 1983). The 1975 and 1976 F,-generation year classes were spawned in 1979 to produce the first (1979) year class F_2-generation fish. F_2-generation fish were cultured as described above. However, hatching success of the 1979 year class was poor.

This process was repeated to produce the F, and F_4 generations. F_2-generation fish were spawned in 1984 and 1986-1989 to produce five year classes of F_3-generation walleye (1984, 1986, 1987, 1988, and 1989). F_3-generation fish were spawned 1990-1994 to produce five year classes of F_4-generation fish (1990, 1991, 1992, 1993, and 1994) (Table 1). The year classes within each generation were not produced by the same parents or by the same parental generation year class.

During this breeding program, 13.2 million eggs were produced, more than 200,000 pond-raised fingerlings were trained to accept pelleted feed, and 4,000 feed-acclimated walleye were raised as broodstock. Percent hatch was 50-60%.

The breeding program has been terminated; as of fall, 1995, only 100 brooders were at the station. All other brood fish were stocked or used in experiments.

Benefits of domestication

To date, the only success with producing fry under intense culture conditions at the London Hatchery has been by using fry produced from London strain broodstock. In one year, 1.5 million eggs were produced from 4-year-old brood fish. Prior to 1980, maximum survival to 4.9 in (12.5 cm) was 40-50%. Survival of F_2-generation fish increased to 90%.

During the 20-year domestication process, changes in walleye behavior were observed. The fish became far less excitable during the course of the breeding project. During the dusk feeding, walleye swam towards me immediately upon my arrival at the ponds. Brood fish did not have to be induced to spawn, and even spawned in the ponds for several years.

References

Nagel, T. 1976. Intensive culture of fingerling walleyes on formulated feeds. Progressive Fish-Culturist 38:90-91.

Nagel, T. 1985. Development of a domestic walleye broodstock. Progressive Fish-Culturist 47:121-122.

Nagel, T. 1991. Artificial propagation of walleye. Pages 259-261 *in* NCRAC-91. Proceedings of North Central Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991. North Central Regional Aquaculture Center, Michigan State University, East Lansing.

Table 1. Breeding history of London strain walleye broodstock development program. Fish were developed from broodstock captured from Pymantuning and Mosquito Reservoirs, Ohio.

Year	Generation year class	Description of mating
1975	F_1 (1975)	P_1 generation was wild broodstock
1976	F_1 (1976)	P_1 generation was wild broodstock
1977	F_1 (1977)	P_1 generation was wild broodstock
1979	F_2 (1979)	1975, 1976 F_1 year classes spawned
1980	F_2 (1980)	1975, 1976, 1977 F_1 year classes spawned
1981	F_2 (1981)	1975, 1976, 1977 F_1 year classes spawned
1982	F_2 (1982)	975, 1976, 1977 F_1 year classes spawned
1983	F_2 (1983)	975, 1976, 1977 F, year classes spawned; F_1-generation fish removed
1984	F3 (1984)	979, 1980 F_2 year classes spawned
1986	F3 (1986)	980, 1981, 1982 F_2 year classes spawned
1987	F3 (1987)	980, 1981, 1982, 1983 F_2 year classes spawned
1988	F3 (1988)	981, 1982, 1983 F_2 year classes spawned
1989	F3 (1989)	981, 1982, 1983 F2 year classes spawned; F_2-generation fish removed
1990	F_4 (1990)	984,1986, 1987, 1988, 1989 F_3 year classes spawned
1991	F_4 (1991)	1984, 1987, 1988, 1989 F_3 year classes spawned
1992	F_4 (1992)	1988, 1989 F_3 year classes spawned
1993	F_4 (1993)	1988, 1989 F_3 year classes spawned
1994	F_4 (1994)	1988, 1989 F_3 year classes spawned

Jorgensen, W. D. 1996. Wild broodstock collection in Iowa. Page 77 *in* R. C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Wild Broodstock Collection in Iowa

Wallace D. Jorgensen, Spirit Lake Hatchery; 611 252nd Avenue, Spirit Lake, IA 51360

Introduction

This case study describes procedures used at the Spirit Lake Hatchery to collect walleye broodstock from natural lakes in northwest Iowa. The lakes range in size from 1,875 to 5,684 acres (759–2,300 ha). Because walleye in these lakes are not greatly attracted to flowing water at inlets or outlets, gill nets have been the most successful method for capture. After capture, fish are transported to the hatchery for stripping and fertilization.

Procedures

Ice cover leaves the lakes in northwest Iowa between late March and mid-April. However, the normal or average ice free condition of the lakes is April 8 to April 11. After ice out, water temperatures are monitored daily and when temperatures reach 44-46°F (6.6–7.7°C) gill netting operations begin.

Gill nets

The gill nets we use are a multi-filament nylon gill net which are dyed brown. The netting is a size 104 nylon twine with a 2.5 in (6.4 cm) bar measure opening. These nets are 21 meshes (8.7 ft, 2.7 m) deep by 360 ft (110 m) long. Nets are tied on float and lead lines, placing three, 5 in (13 cm) stretch meshes per 4.5 in (11.4 cm) ties. A 2.5 in (6.4 cm) bar measure will capture walleye 16–32 in (40–81 cm).

Ten, two-person crews set two nets each night at 7:00 p.m. Nets are lifted and fish removed at about 10:00 p.m., the nets are reset and lifted again at 1:00 a.m. The nets are removed after the 1:00 a.m. run.

Each crew uses a 14-ft (4.3 m) aluminum boat for net placement and fish removal. Illumination is provided by a gas lantern secured to the top of a 5 ft (1.5 m) steel rod and the bottom fastened to the side rail of the boat. All nets are set perpendicular to the shoreline and then extended from the shore into deeper water. Water depths will range from 8 to 20 ft (2.4–6.1 m) deep at the outer end of the net. Nets usually will be set out from sand beaches, rock/rubble shorelines and adjacent to rock points.

Handling and transporting broodstock

Fish are removed from the nets and placed in 20 gal (75.7 L) tubs of water located in the center of the boats. Crews change the water frequently, however, when large numbers of fish are captured, fish are placed in 4 **x** **6** ft (1.2 x 1.8 m) by 1 in (2.5 cm) bar measure purse type live bags until the trucks arrive.

Hatchery trucks transport fish from the lake sites to the hatchery (2–19 miles, 3.2–30.6 km). This is done after both the 10:00 p.m. and 1:00 a.m. fish collection times. The tanks have a capacity of 1,400 gal (5,300 L). The water is oxygenated using liquid oxygen supplied from dewars on the truck. Normally the trucks are transporting up to 0.5 lb fish per 1 gal (60 g/L) water. Lake, transport, and hatchery water temperatures range from 46 to 56°F (7.7–13.3°C) during broodfish collection.

A modified isotonic saline solution is added to the water of the hauling tank. The saline solution consists of 4.3 lb (1.9 kg) sodium chloride, 0.17 lb (77 g) potassium chloride, 0.11 lb (50 g) monopotassium phosphate, 0.09 lb (40.9 g) magnesium sulfate/100 gallons (378 L) of water.

Personnel at the hatchery sort and sex all fish and separate male, female, ripe female, and green female into individual tanks. Ripe females are defined as fish that will emit eggs from the ovaries with very slight pressure on the abdomen, and green females are fish that emit few or no eggs using the same technique. Green females are segregated by date of capture, and are checked every 24 hrs for ripeness. All stripped fish are transported back to the lakes in a saline solution. Dependmg on weather conditions, all broodstock are captured within a 7 to 14 d period. Average broodstock needs are approximately 2,000 to 2,500 fish annually. We have found that post-spawning mortality is less than 1%.