WHY WILD FISH MATTER:

A BIOLOGIST'S VIEW

BY RAY J. WHITE

NATURE'S BUSINESS: LUSH, OLD GROWTH PACIFIC HABITAT IS HOME TO WILD, NATIVE COASTAL CUTTHROAT TROUT. ANCIENT FORESTS SUPPLY WATER AND FOOD, AND MODERATE STREAM TEMPERATURE. FALLEN TREES HOLD TOGETHER STREAMBEDS, TRAP SPAWNING GRAVEL, CREATE POOLS, AND FURNISH FISH WITH HIDING COVER. SUCH ORIGINAL ECOSYSTEMS ARE INCREASINGLY APPRECIATED AS GEMS TO BE PRESERVED.

Wild fish matter because they are superior performers in streams, lakes and seas. They have passed the tests of Nature. They are true members of their aquatic homes. They function better in the wild than do artificially produced versions.

Wild fish matter from standpoints of biology, sound fishery management, and economics. They matter beyond the value they hold for anglers by virtue of beauty or fighting stamina—or what fishing for them offers in relief from the human world.

Wild fish matter especially for resilience and stability of fish populations and species. Long-term survival and ongoing productivity are at stake. Wild fish matter for the wholeness of natural communities of fishes and other organisms. They are often essential to—and indicate—the health of streams and lakes as ecosystems, that is, as proper homes for many creatures. If protected, natural habitat and wild fish stocks maintain themselves. And where damaged by human activity, they can often restore themselves, when abuse is halted.

Seeing the full value of wild fish lies in the long-term view. The worth ofwild fish involves inconveniently long time spans, and the need to manage for wild fish tends not to be seen until crisis descends.

Wild fish crises are indeed upon us. The recent listings of threatened and endangered species are just some of the worst cases. We need not look far for other examples. The crises are not new but are seen more clearly than in the past. They result from lack of faith in what Nature can provide if allowed to do so—and from misplaced faith in artificial propagation of non-wild fish.

WHAT IS WILD?

"What is a 'wild trout,' anyway?" asked an angler at a recent forum on the hatchery-versus-wild problem. A short answer is "naturally reproduced," but that response may be easily misconstrued. The forum's panel of biologists came up with the best definition I've heard yet: A *wild* fish is a free-living fish, hatched and reared in a stream, lake or sea from an egg spawned and deposited there by its *mother.* This may apply to all kinds of fish except live-bearers.

Consider the converse: A wild fish is not created or grown with direct human help—not bred from parents selected by humans, and not spawned, incubated, hatched or raised in an artificial facility. Any group of fish raised with human help changes to get along better under the helped conditions and to that extent is domesticated.

Severe domestication usually results. Hatchery workers want docile fish; they are easier to handle and grow better. Yet even a little domestication can be harmful when the fish are released into harsh life outside the hatchery.

PERFECTLY POISED: WILD YELLOWSTONE CUTTHROAT HOLDING POSITIONS NEAR SURFACE OVER DEEP WATER TO FEED ON A HEAVY HATCH OF STONEFLIES. THE FISH ARE UNDOUBTEDLY ARRANGED BY SOCIAL RANK, WHICH DEPENDS ON SIZE, THE DOMINANT FISH IN THE BEST FEEDING POSITION. SUCH A FEEDING AGGREGATION OF 15-TO 18-INCH TROUT IS DENSE BY NATURAL STANDARDS, BUT COMPARED TO CONDITIONS IN HATCHERIES (FACING PAGE) ALLOWS EACH FISH A SUBSTANTIAL PERSONAL SPACE IN WHICH TO FEED WITHOUT MUCH STRUGGLE.

The term wild fish should not be confused with native fish. There can be "wild natives" and "wild non-natives." A native or indigenous species (or race) is one originating in and characterizing a given locality or region.

An exotic species is one from outside the specified area. Brown trout, for instance, brought from Europe, are exotic to America, and one stream's special genetic strain of brook trout, if reproductively isolated long enough, may be genetically exotic to nearby streams. From stocked exotics, wild non-native populations can develop and harm native fishes, as described later.

Natural and artificial are essential concepts. Instead of "wild fish," we should probably say "natural fish," but the former term has taken hold. Artificial means created, at least in part, by humans. Natural means, in this context, created without human help. (Other meanings exist, as in "the natural course of human events.") Natural versus artificial is seldom an either-or question. Little in the modern land- or waterscape remains unaffected by humans, but natural processes persist.

NATURAL WORKINGS

Why wild fish matter can be explained from two angles: how things work so well in Nature and how they so often fail to work when we tamper with them. The bright, positive angle is natural biology, especially the intertwined fields of genetics and ecology. Within these are the newer, less used subfields of population genetics and behavioral *ecology*.

Population genetics is the study of genetic variation within and among populations, and of the mechanisms regulating this. It deals with heritable messages that guide body function and behavior.

Behavioral ecology may be ecology at its most intimate—the study of overt (visible or otherwise detectable) actions of animals in responding to their natural environment, and ofwhat this means for survival. It involves letting animals tell us by their actions what they like and do not like about their surroundings and how they best operate there.

Studying how fish operate in streams, lakes and seas in relation to the features and processes of these water bodies involves examining interactions as individuals and social groups with other organisms there, importantly other fish. Included are interactions with fish of the same species, such as between trout of the same and different sizes in the same population—or between wild and stocked fish.

THE ADAPTIVE ADVANTAGE

Biological adaptation is a process of overriding importance. "Of all the things we need to know about biology," wrote cancer researcher Van R. Potter, "adaptation is the phenomenon that we can least afford to ignore. We ought to begin with adaptation and use it to bring into focus all the other facets of biological knowledge..."

Wild fish are adapted to survive and thrive in the natural world, especially native wild fish in the natural assemblage of fishes in a lake or stream. Such a community is well adapted to normal conditions, which include normal patterns of variation. It can be disrupted by non-native fish, for, once released into streams and lakes, they are literally out of place and constitute a non-normal condition.

Wild native fish are highly developed as individuals, as social groups, as populations, and as communities of species and races. Nature's crafting is unfathomably complex—so complex that human ingenuity could not possibly duplicate wild fish, much less design or produce fish better adapted to natural conditions than wild fish are. Moreover, the human effect is often to destroy natural complexity. Simplifying habitat and fish communities has harmed much of the life support system.

Through years of refinement, each genetic strain within each wild species has become attuned to flourish in good times and endure bad times. By good and bad times I refer to normal natural variation of local conditions, such as wetted space, water currents, temperature, food supply, hiding cover, and predatory pressures. The self-molding of a strain of fish to such conditions is a form of adaptation.

Potter recognized three interacting kinds of adaptation: evolutionary adaptation, which is change in inherited capacity to perform appropriately in the environment—a population process; physiological adaptation, which is change in the individual organism's body processes in response to changing environmental conditions; and cultural adaptation, which occurs in individuals and populations, "involves psychological and behavioral changes that are affected by the underlying physiological and cellular biology," and "seems to impinge on evolutionary adaptation and physiological adaptation in virtually every instance that can be imagined."

By cultural adaptation, Potter may have meant human cultural adaptation only. He was concerned whether our outlooks and arrangements could change fast enough to assure survival in the face of modern threats, such as nuclear disaster and drug addiction. Perhaps we could add human overpopulation and technology to them. The cultural adaptation of humans will strongly influence what becomes of many other species.

In fish, we might regard the forms of adaptation as *evolutionary*, physiological and *behavioral*. That fish undergo cultural adaptation is arguable, but I won't go into that here.

To Potter, survival of any species is its crucial task, the survival of life itself may be our crucial task, and each form of adaptation is essential to this end. I think each type of adaptation also helps explain why wild trout matter.

Evolutionary adaptation, as Potter described, "applies to populations and occurs by mutations (copy errors) in the genetic material. The change in hereditary material may be an improvement, a disadvantage or neutral, and neutral changes may persist until some future generation in which they are helpful or harmful." The hereditary makeup of the population "keeps changing from generation to generation, always being challenged in terms of reproduction and survival in the current environment." Population geneticists point to substantial variation of genetic traits within healthy populations and the importance of not altering it in non-natural ways, such as by selecting part of the variation and breeding more of it than would occur in the wild.

A FINE KETTLE OF FISH: EXTREME CROWDING IS ONE OF THE MOST UNNATURAL, HARMFUL-AND UNAVOIDABLE-INFLUENCES OF ARTIFICIAL REARING OF SALMONIDS. IN THE CONTINUAL STRUGGLE OF HATCHERY HYPERCONCENTRATION, THE FISH LEARN ABERRANT, OVERLY AGGRESSIVE BEHAVIOR. BECAUSE OF THIS, TECHNICAL HATCHERY "REFORM" EFFORTS PROBABLY WILL NEITHER MAKE STREAM STOCKING COST EFFECTIVE, NOR HALT THE DAMAGING EFFECTS OF HATCHERY FISH THRUST ON WILD POPULATIONS.

As evolutionary adaptation proceeds in a population of stream-dwelling fish, the fish become better suited to stream conditions. In contrast, adaptation in a hatchery—and it is always going on there—causes the fish to become better suited to hatchery life and lose traits needed in the wild.

Physiological adaptation has limits set by evolutionary adaptation but operates mainly on a scale of seconds to seasons. As water warms from morning to afternoon, the fish's body processes must change in response. Daily high or low temperatures gradually intensify as seasons progress, and the body acclimates to the new extremes and daily ranges, which would have killed it, had they happened too suddenly. (Occasional warm and cold snaps do kill fish, sometimes all of them in a water body, but usually just the ones least able to

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physiologically adapt, which connects back to evolutionary adaptation.)

As the fish's sensory system gets cues from seasonal patterns of rise or fall in temperature and in day length, the adult body readies itself for spawning—and perhaps for pre-spawning migration (a behavior often involving great change in environment)—or the fish will fail to reproduce.

Behavioral adaptation can be viewed as learning. When water warms, a trout may search out shade or cool springs. Even if the urge to find such features is innate—which I suspect is not completely so—the fish learns to seek more efficiently as it becomes more experienced.

In the stream, a trout learns that the most food drifts in threads of fast current, and that it is best watched for from nearby pockets of slow current—especially if in or near cover for hiding from predators. The behavior of competing for food by defending such profitable and safe sites against other fish is probably part innate and part learned. Undoubtedly learned is its sense that larger fish can outfight it, that it is futile (and wastes energy) to try to take over feeding sites they occupy, and that it is wise to quietly relinquish one's own sites to them.

Most wild fish are much better adapted physiologically and behaviorally—and are probably much better at such adaptation—than are most artificially raised fish.

As developed over thousands ofyears, the intricate, well adapted system of trout and salmon species and races spread divergingly over most of the northern hemisphere's coldwater range. It reached into remote stream branchlets, some of which later became isolated ponds and lakes. As glaciers advanced and retreated, some stocks had to move or perish. Later, reinvasions took place.

Geographic divergence meant genetic divergence by reduced gene flow or complete reproductive isolation. The community mix was enriched when the evolved kinds of trout and salmon found their ways back into remotely ancestral waters or otherwise overlapped distant relative species or races, with which they could no longer mate—and if the interlopers and established kinds adjusted to each other, which was probably far from easy in most cases.

Thus, in each accessible coldwater stream or lake, there developed a unique kind of trout or salmon or a whole suite of unique kinds. Lake Ohrid, Yugoslavia, has five races of a brown-trout-like species, each spawning at a different place or time within the lake. Together, the several or many kinds of fish in any water body form a community living in concert, in harmony but not without degrees of competitive or predatory tension and always with change. Such natural change is usually gradual, graceful, and adaptive.

A reach of small stream can harbor several kinds of fish. Seasonally, others can move in. And, even if the species are few, each size group of each species operates uniquely in some ways, thus functions as a different kind of fish.

Therefore, in terms of function, there tend to be many kinds of fish in the community. Most of them typically eat the same organisms as some other kinds of similar size, but each kind feeds from its own sort of place or time of day or night. As fishery ecologist Peter Larkin put it, "In general, fish are characterized by a place in which they feed rather than by a type of food."

Likewise, several species might use the same spawning habitat but at different seasons. Like clockwork, the kinds of fish in natural communities are adapted to each other genetically, physiologically and behaviorally.

What happens in this rather peaceable, well-tuned and smoothly functioning kingdom when we come along and put hatchery fish in it? Chaos, that's what. The old monkeywrench in the works.

funds are spent to fight disease. The Norwegian wild Atlantic salmon population is threatened by a parasite, which hatchery transfers from the Baltic region brought in. To combat diseases in 1990, Norwegian fish farmers used 37.4 tons of antibiotics, twice the previous year's amount. Another sickness is thought largely responsible for failure of Chinook salmon from some hatcheries intended to mitigate for the dams on the Snake-Columbia River system. And for three years, Alberta has had its trout hatchery system completely shut down due to disease.

• Water pollution from hatcheries: Hatcheries dump chemical pollutants, such as toxic disinfectants and wastes of the fish-feed-lot operation into streams and lakes. The fertilizing effect of the wastes can increase open-water fish production in downstream areas but can also upset aquatic communities by oxygen depletion and other effects.

• Nutrient depletion by anadromous run interception: Some hatcheries also cut off an important upward flow of nutrients to streams and lakes higher in the drainages. Many Pacific-drainage waters are deficient in dissolved minerals and grow few fish unless nutrients from the sea come upstream into them in the form of salmon spawners, which die, contributing decaying bodies as fertilizer to support the food needed for their young. When a downstream hatchery has its returning spawners home into the facility with little upstream straying, and when it also causes the stream's wild runs to decrease, it shortstops the upward flow of nutrients, further decreasing the capacity of upstream areas to produce wild fish. Therefore, as an alternative to present practice of burying the carcasses of spawned-out hatchery salmon or converting them to pet food, programs are under consideration to transport them to headwater streams as fertilizer—a substantial cost of fuel, equipment and labor that wild fish runs would make unnecessary, if restored.

• **Attraction** of predators: Stocking large concentrations of hatchery fish can attract concentrations of predatory animals, raising death rates of wild fish. For example, commercial "ocean-ranch" stocking of salmon in Oregon had this effect, and in British Columbia, releases of hatchery Chinook salmon attract abnormal numbers of dogfish sharks, putting them in position off river mouths to intercept with even more devastating effect the weaker runs of young wild salmon that follow.

• Harvest pump-priming: Like the attraction of wild predators, stocking hatchery fish tends to stimulate human fishing and increase the catch of wild fish. Technically, this is known as "weak-stock overharvest in mixed-stock fisheries." Raising fish abundance locally attracts mobile modern sport and commercial fishers, who quickly zero in with efficient gear on fishing hot spots. This is often abetted by eased fishing restrictions to allow increased harvest appropriate to the artificially boosted abundance. As a result, more wild fish in the mixed population are pumped out of the water than had there been no stocking. The scarcer the wild fish—hence the clear need for protection—the more detrimental the pump-priming effect of stocking hatchery fish becomes.

It is often claimed that adding hatchery fish into a wild population buffers wild fish against angling. This is true only if fishing pressure does not increase. Some people contend we can monitor fishing to see when the threshold between buffering and pump-priming is crossed, then adjust stocking and fishing pressure to safeguard wild populations. But sport fishery agencies can seldom afford the necessary monitoring, and fishing pressure is hard to regulate, especially in midseason. Turn on or off, yes, but not fine-tune downward.

"When hatcheries don't work, they're bad, and when they do work, they're bad," is a saying now echoed among fishery scientists. This is illustrated by the plight of the Strait of Georgia salmon fishery between Vancouver Island and the British Columbia mainland. The hatcheries producing young Chinook salmon there have resulted in disappointingly few harvestable adults of this largest, most-sought-after, king of the salmon. For unknown reasons, the fish haven't survived well enough at sea to make the Chinook hatcheries worthwhile. On the other hand, hatchery stocks of coho salmon became so abundant in the Strait that fishing pressure rose and severely reduced the wild coho population. Then, in 1991, the hatchery coho population moved out of the strait, leaving little salmon fishing and a collapsed tourist trade that summer.

• **False** sense of security: Building hatcheries and pouring fish into water makes people think everything is okay. This illusion helps "justify" continued abuse of habitat and overharvest of fish—and inadequate agency action to halt these things. The allure of hatcheries keeps us from biting politically hard bullets. Why clamp down on overfishing, stream channelization, damming, excessive irrigation, overgrazing, urban streamside "development," logging, mining, pollution, and highway encroachment? Heck, just let these things happen, then "mitigate" by building hatcheries. So, telling ourselves things must be better, we let habitat loss and overfishing continue, and things keep getting worse for wild fish. In the Pacific Northwest, in Colorado and some other places, fishery agencies seem to feel they have built a Maginot Line of concrete hatcheries against fish scarcity. It is proving to be a biological house of cards.

• Diversion of funds from better management: This is evident from agency budgets that devote more to building and operating hatcheries than to any other function. A sign at an Oregon Department of Fish and Wildlife hatchery says a third of the agency budget goes to fish hatcheries—a third of fish andwildlife funds. This probably means that over 50 percent of the fishery budget is for hatcheries. Oregon's main fishery resource is natural habitat and wild fish, and it has a wild fish policy, yet it sinks most of the fishery budget into artificial production. This must be true of many other states, too. James A. Lichatowich estimates that hatcheries typically consumed 50 to 80 percent of fishery budgets in the last 100 years. In contrast, Montana's hatchery program reportedly is now less than a third of its fishery budget—and some biologists feel that is still far too much.

Roderick Haig-Brown long ago summed it up: "Hatcheries are the easy way, the politically safe way. Dependence on hatcheries reduces the will to solve the real problems of natural production and absorbs far too much money that otherwise might be directed to these ends." ■

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And although stocking lakes usually yields much better results than in streams, we should be wary of displacing the native wild populations of lakes with fish that are genetically less suitable.

In artificially propagating sea-run salmonids, we cause trouble not only in streams, but also for the ocean phase. For stock after stock of hatchery salmon, survival and body growth rates have diminished as we plant increasing amounts. Is the ocean's capacity to feed hatchery salmon declining? Some suggest we are sending so many hatchery salmon into the Pacific as to overtax its food resources. Others say this is unlikely because the ocean's production of salmon food probably has not changed much in the last 100 years. Yet the sea yields us fewer salmon than before.

Geneticist Fred Utter suggests an explanation: Previously, many thousand streams each produced one or more species-stocks of salmon. Each was genetically programmed to a unique, successful ocean migration route, following the right currents to appear at the right places at the right times and temperatures to take advantage of local abundances of zooplankton, herring, or other prey. The myriad of stocks used the marine resources efficiently in *concert* and returned from the feast to natal rivers in abundance. Now we have destroyed or diminished many of those well-attuned stocks and from hatcheries send forth artificial salmon whose genetic program is mixed up. Their ocean wanderings may be haphazard and less efficient for feeding. Moreover, we inject too many salmon from the same hatchery that have the same genetic makeup. So too many follow the same route at the same time, overgrazing the food supply and growing poorly.

The last kind of genetic problem is that of preventing natural selection. Missing from the hatchery are such influences as predators, floods, droughts, starvation, and the courtship-and-mating ritual that cull poor performers from the wild. Missing also are the natural stream features that fish use in association with such factors. The natural selection that derived from the interplay of natural hazards and opportunities cannot be duplicated in hatcheries.

Population geneticists and behavioral ecologists point to functional evidence of genetic differences in social, migrational and habitat-selection behavior, as well as in such physiologic criteria as temperature adaptation and resistance to diseases. They point to the danger of reducing wild within-population genetic variation, the reserve capabilities for sustained production in the face of changing environmental conditions, such as global warming. Such scientists advocate reducing the risk of genetic damage by requiring fish culturists to present reasonable evidence of safety before stocking, rather than stocking until problems show up.

SOCIAL SKILLS

Outside the spawning season and times of dormancy, the social interactions of wild, stream-dwelling trout are characterized by subtle, graceful, low intensity struggle and signaling, punctuated with occasional intense fights. This suite of behaviors constitutes true competition; it is directed toward securing or defending resources, such as food or energetically profitable space. The behaviors establish a social hierarchy and conserve energy of the individual and social group. This we know mainly from the behavioral observations of Robert A. Bachman in a Pennsylvania stream, but also from such studies by Thomas M. Jenkins in California and by Charles E. Bassett and Kurt D. Fausch in Michigan.

In contrast, the hyperaggressiveness of hatchery fish is chaotic, apparently gets them too little of value, wastes energy, and ought not be called competition. Heightened aggressiveness in hatchery fish has been found for brook, brown and cutthroat trout, coho salmon, and possibly Atlantic salmon.

In the Bachman brown trout study, newly stocked hatchery fish not only attacked other fish more often than wild fish did, but wasted energy in excessive and aimless swimming about. They blundered into territories of wild trout, drawing them into energy-consuming defensive forays away from feeding stations. The hatchery fish also hovered foolishly in fast current, rather than resting in quiet pockets like wild trout.

THE SCIENTISTS SPEAK OUT

Professional pressure for more responsible fishery management has reached an uproar in the Pacific Northwest. Biologists are coming out of the woodwork en masse on the issue. Almost every major figure in stream fishery science has long had grave misgivings about fish stocking. Most held their tongues out of don't-rock-the-boat loyalty to institutions, deference to colleagues, or sheer timidity. But now things are different. The evidence has reached critical mass that the hatchery problem has gotten out of hand. Wild stocks are on the ropes (witness the many extinctions and endangerments), and hatcheries are cited as part of the problem.

Discussion proliferates. In 1991, a meeting or more a month took place on the wild-versus-hatchery issue in the Northwest alone—seminars, debates, symposia, public hearings and legislative panels. The subject was important in related meetings: interagency confabs, endangered species hearings, conservation strategy sessions and even a series of "salmon summits." The controversy boils in Colorado, too, where Trout Unlimited hosted a conference on it in November.

Highlighting the 1991 meetings were two international conclaves in June and July: one on interactions of wild and hatchery salmonids in Nanaimo, B.C., the other on genetic conservation of salmonids, held at the almost adjoining campuses of the University of Idaho and Washington State University. Researchers presented results; from the findings it was resoundingly clear that hatcheries and their fish have severe, inevitable flaws and cause major problems for wild trout and salmon.

Agency bias showed up in the Nanaimo conference title: "International Symposium on Biological Interaction of Enhanced and Wild Salmonids." "Enhanced" meant salmonids bred in hatcheries, but the evidence was that such fish generally fail after they are stocked, hence should be called degraded. After the symposium, a Canadian federal official said: "The symposium opened the eyes of a lot of us to the problems our hatchery fish are causing for wild stocks. We had always heard talk, but this time we saw the data that pin it down."