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by Vernon E Craig

A THESIS Submitted to tbe Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management at Montana State College
Montana State University

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I

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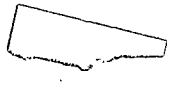

Head, Major Department

Chairman, Examining Committee

Dean, Graduate Division

Bozeman, Montana
June, 1952

Table of Contents

Abstract

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Introduction

Most of the literature dealing with fisheries management is so technical that it is little understood by anyone without extensive biological training. Non-technical literature dealing with fish management and productivity is found in conservation bulletins, sports magazines, and newspaper articles. Much of the information available, however, emphasizes recreational rather than management aspects of fish production. Publications that do deal with management usually apply to local problems and fail to present a complete picture of fish production. For example, an explanation of the fish planting needs in a state having high fishing pressure would not necessarily apply in states where there is little pressure.

Persons who are not familiar with the problems of fisheries management are less apt to support good management practices. Without public support a fisheries program has no chance of success.

An attempt is made in this paper to present the layman with a simple and easily understood discussion of the more important aspects of fish productivity as they apply to management in Montana. The material presented should be of value to such groups as sportsmen, 4-H clubs, schools, boy scouts, etc.

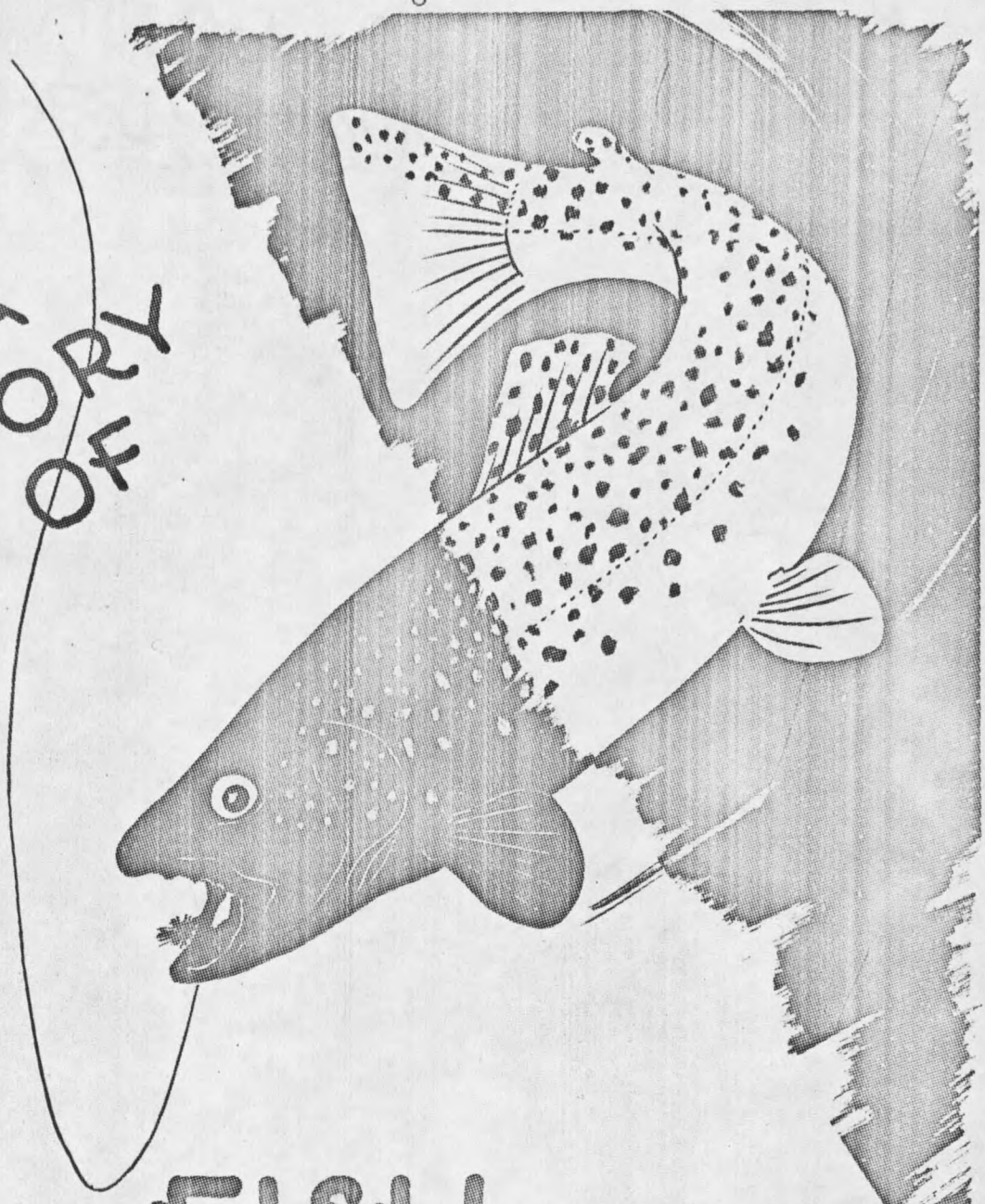
Important factors which affect the production of fish are discussed under individual headings. These are, however,

arranged in such a manner as to present the story of fish production and management.

Illustrations have been prepared which should not only make the text more readable, but drive home important points. These fall roughly into two categories: humorous, and depictive. The abundance of cartoons in our magazines, advertising, and movies bears witness to the popularity and value of humor in illustration. Cartoons stimulate the imagination of young and old alike, and often lead the reader through accompanying text. Those cartoons that tell stories within themselves are very effective in selling ideas. In this presentation, continuity between text and illustrations is maintained by placing the cartoons near the text which concerns them. Simplified but depictive drawings of the plants and animals involved in fisheries management supplement descriptive material to facilitate their identification.

Acknowledgements

The writer is indepted to Dr. C. J. D. Brown for counsel and assistance in the preparation of this paper.



A STORY OF

FISH PRODUCTION

PROBLEMS OF FISH PRODUCTION

SOIL CONSERVATION IS WATER CONSERVATION.

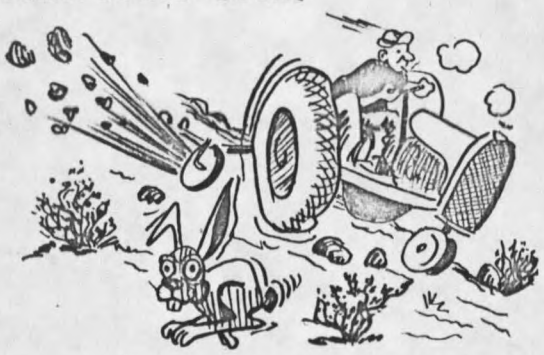
"Fertile," is a common word that generally brings to mind rich acres of grain, lush carpets of green pasture, and fields heavy with hay. In all ways, it declares bountiful production. On the other hand, we associate, "infertile," with bleak land, scanty vegetation, and starved crops. Water

1 ACRE OF WATER
= POUNDS OF FISH.

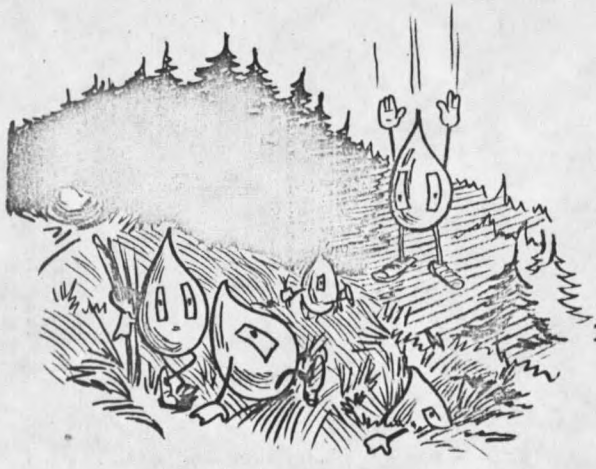
1 ACRE OF LAND
= POUNDS OF BEEF.

is exactly like land in this respect, yet how many people think of a stream or lake as being fertile or infertile? The same minerals and decayed plant and animal materials that make soil capable of producing good crops of hay and grain are the ones that make streams and lakes capable of producing good crops of fish. Water can be only as fertile as the land from which it drains. The crop of fish that can be raised,

then, depends upon the way we treat our land. Misuse of land means fewer fish.

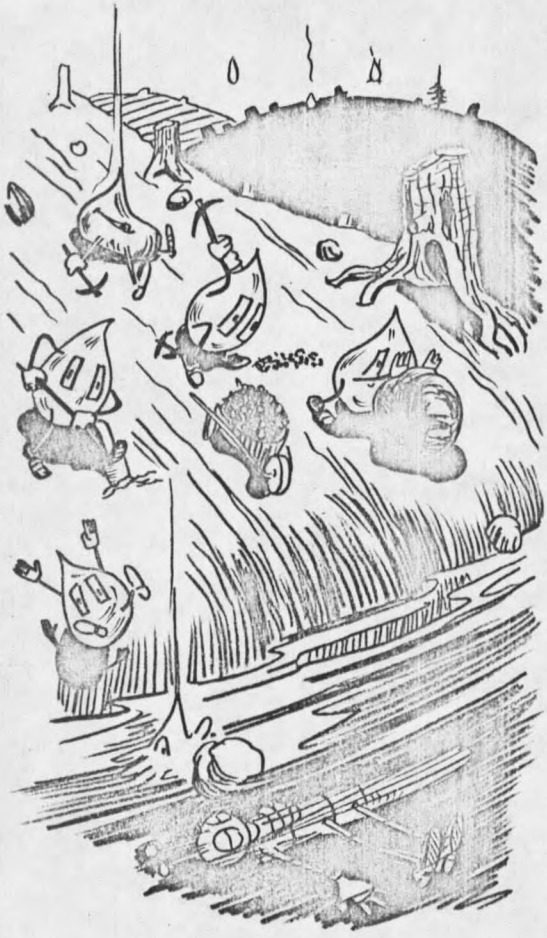


Three practices in Montana that have contributed most to the destruction of soil, and consequently streams, are excessive cutting of trees, overgrazing, and poor farming practices. Many forests that once existed have been completely destroyed, and others are still being unwisely cut. Stockmen in an effort to utilize every blade of grass have permitted serious overgrazing of ranges, and farmers tempted by the high prices of grain have broken many acres better suited for range land. In some parts of the state, big-game have done a lot of harm through overgrazing and overbrowsing.



Mountain snow under the shade of trees lingers for a long while after all evidence of winter has gone from open areas. A blanket of grass on range land and leaves in the forest sops up much of the snow water and prevents it from being evaporated rapidly. Water held in this manner is allowed to seep slowly into the soil instead of running off. Plant ma-

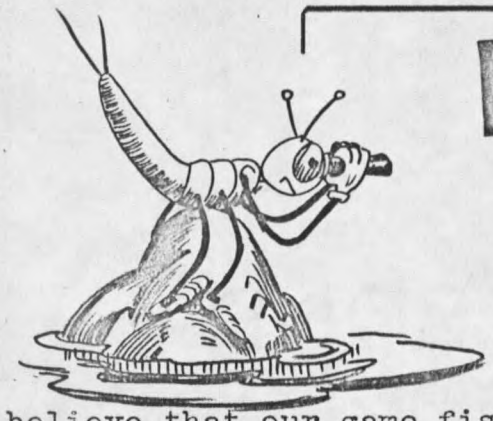
terial manteling the ground cushions the fall of rain and prevents the soil from being churned and carried away. The rain, like the snow water, is held back and permitted to sink into undisturbed soil. Water captured in this manner forms an underground reservoir which replenishes streams throughout the year.



When blocks of forest are cleared, and when grass has been burned or grazed from the range, the protective covering is gone. The sun can then beat down with full force and evaporate moisture from the earth. With no cushion to break its fall, rain can stir the soil and carry it away. Soil carried into streams is dropped in the quieter water, covering fish spawn and food-producing areas. Unable to get needed oxygen through the blanket of dirt, the spawn and food organisms are readily destroyed.

Man has learned, to some degree, the folly of tree destruction. Through cutting regulations, reforestation programs, and fire-fighting systems, progress has been made in forest conservation and consequently the protection of the

watershed. The damage caused by overgrazing is also recognized, but in many places little is being done to correct this practice.

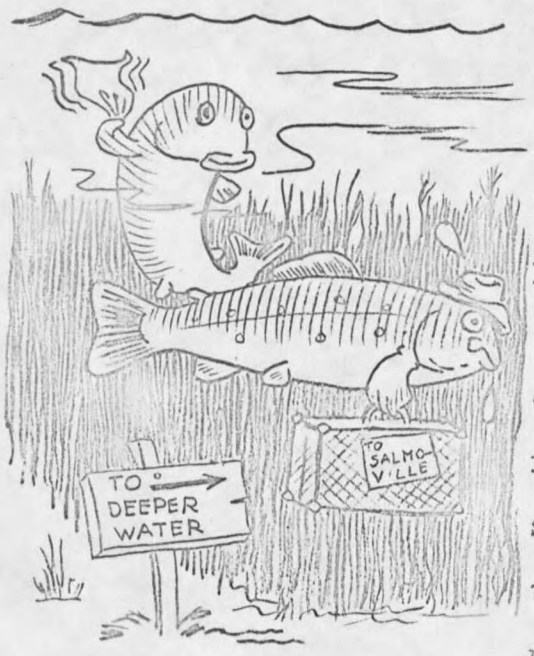


DAMS AND FISH

For some reason, many people believe that our game fish take long trips up and down streams in order to secure food and to spawn; consequently, we hear a lot about the damage done to fish by blocking streams with dams. Damage may be done when fish are cut off from spawning areas, but since most of our streams have abundant suitable spawning and feeding areas all along their courses, fish movement is very limited.

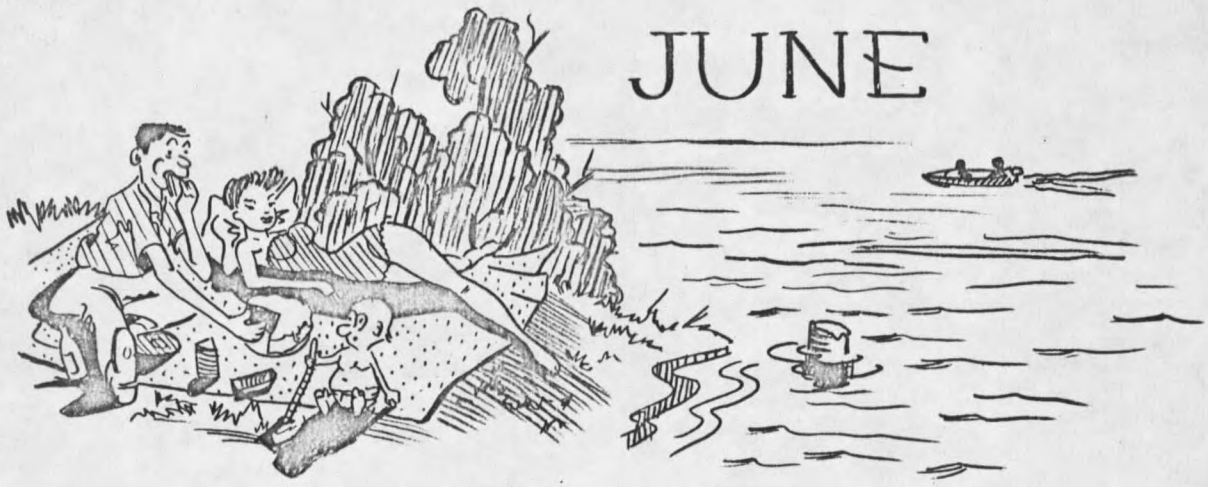
When a dam is built across a stream, the life caught in the impounded area, including fish, which requires flowing water suddenly finds its home unsuitable, and as the stream organisms die or move out, those suited to live in quiet water move in. As the reservoir rises and creeps over new areas, flooded vegetation and soil give up rich materials to the water. If the submerged soil is fertile and covered with vegetation, the reservoir becomes rich and the numbers of fish

will increase and grow rapidly in the new environment. However, the rich materials given off by the flooded land and vegetation are used up in a relatively short time, and a decline in fertility results. With a decline in fertility, there is also a decline in the number and pounds of fish.

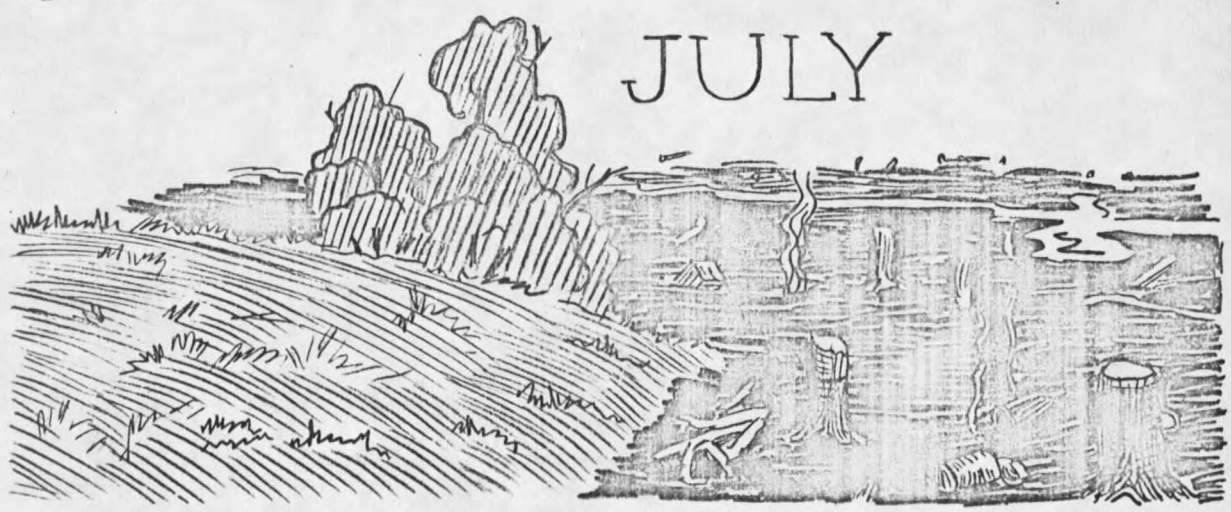


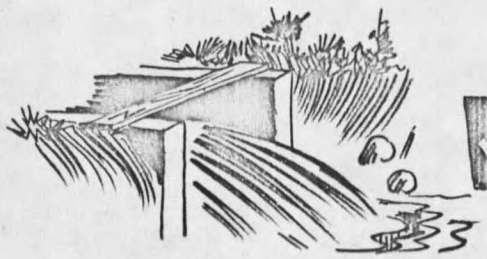
When trout streams are dammed, a large surface of water is exposed directly to the heating action of the sun. This water, especially in shallow areas, may become unfavorable for trout and other cold-water fish. Coarse fish, such as chubs, carp, and suckers, find the changed conditions very favorable and take the place of game fish.

We can not judge an artificial reservoir by the way it appears when filled with water, for the next time we see it there may be only a pool or trickle of water framed by soggy stumps and mud flats. Such is the case with most irrigation and flood control reservoirs and, to some extent, reservoirs designed for power. Most plants and fish foods become established in the shallow areas, and these are destroyed when left high and dry by a drop in the water level. Those that get a foothold when the water is low are destroyed when the lake is



again filled, for they can not live in deep water. Under conditions of constant water fluctuation, there can be little fish production. A lake that is dry for one week might as well be dry the entire year as far as fish are concerned. Streams below reservoirs may benefit if a steady flow of water is maintained during the entire year, but in many instances streams are dry during periods when the water is being impounded.



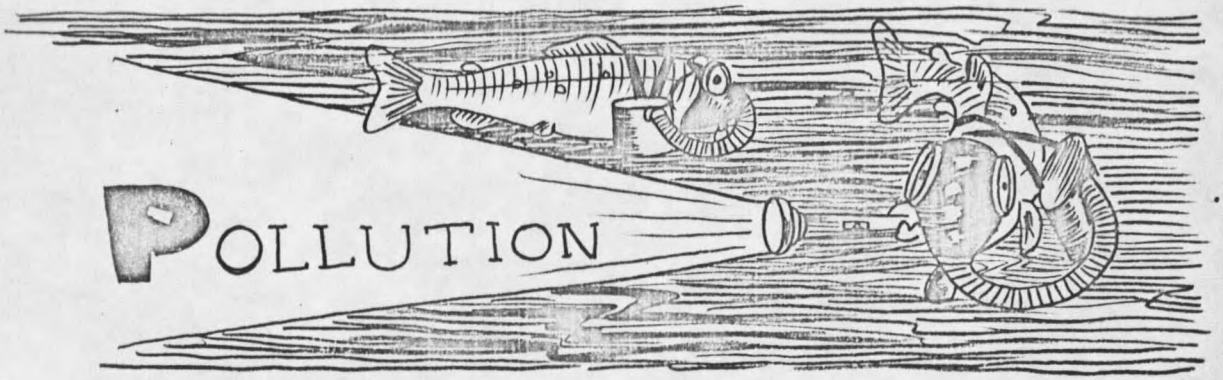


IRRIGATION

The full signifigance of fish loss in irrigation canals is not known. Those lost may represent a surplus over and above the population that can be carried by the streams they leave, and we have no assurance that fishing would be improved if game fish were kept from entering the canals. For reasons yet unknown, certain canals attract more fish than others. Studies are now being conducted that should provide the reasons why. Some of the fish which enter the ditches return to the streams when the water level drops. Because fish concentrate in pools when ditches are turned off, the loss may appear greater than it actually is. The loss of fish in West Gallatin River canals was estimated to be to be 2,835 legal size trout and whitefish (Clothier, 1952). The destruction of fish foods and spawning grounds in streams that have been lowered or dewatered through irrigation probably represents a far greater loss to fishing than the loss in ditches themselves.

A lot of work has been done in an attempt to devise methods to prevent fish from entering canals. So far nothing has proven wholly satisfactory. Electric screens have been tried without much success, and while mechanical screens will work

if properly installed and maintained, they are very expensive and require regular attention. Only when the fish loss is very great can they be justified.



There has always been a certain amount of natural pollution from such things as eroding soil, mineral deposits, and potash of forest fire areas, but the damage to fish from natural sources is not great when compared with that resulting from improper land use, pollution from industry, and from domestic sources. Some of the more important existing and potential sources of industrial pollution in Montana are metal refining plants, oil refineries, wood pulp mills, sugar beet factories, and meat packing houses. Domestic sewage is also a detriment to fishing in parts of this state.

Sediment from metal refining plants, fibrous material from pulp mill wastes, and sludge from sewage blanket stream and lake bottoms and smother fish food organisms, ruin the spawning beds, and even suffocate the fish by clogging their gills. Some sediments are carried many miles by streams and

may remain suspended in lakes for weeks or even months. These materials darken the water and prevent the normal growth of aquatic plants.

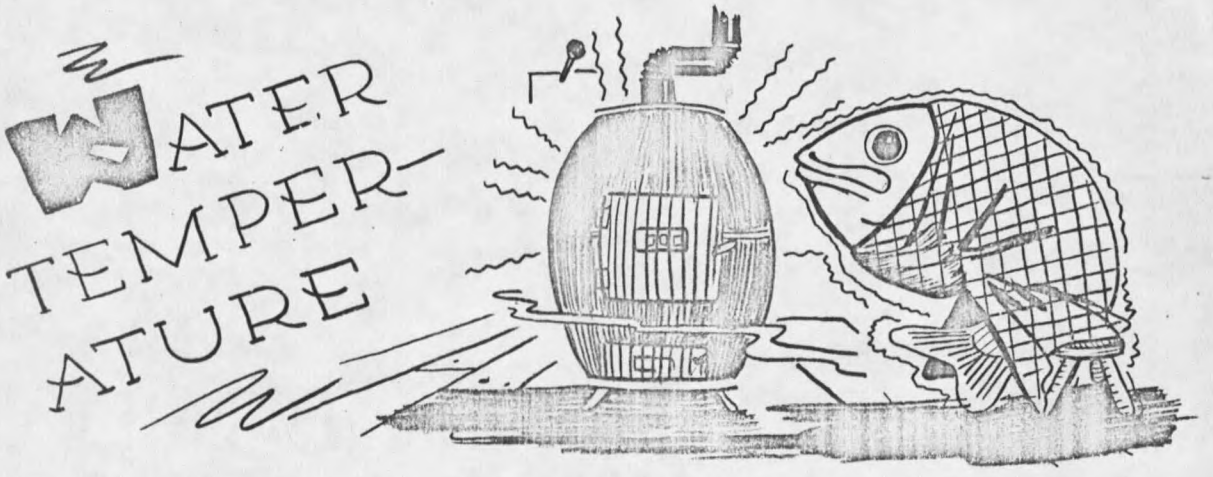
Wastes that result from metal refining plants, oil refineries, pulp mills, and other industries may irritate the delicate gill or other body tissues of fish. Others make streams and lakes unsuitable for proper growth and development of fish because they are disagreeable to their taste or smell.

While small amounts of organic material entering streams and lakes may act as a fertilizer and be beneficial, large quantities that may be dumped in by wood pulp mills, sugar beet factories, packing houses, and city sewers are very detrimental. Organic materials require much dissolved oxygen when they decay, and with dissolved oxygen reduced or completely removed, the fish and fish food organisms can not live. Certain waste organic chemicals actually poison fish.

Water that is heavily polluted becomes quite useless. It is unfit to drink and may be unfit for irrigation. Industry upstream may ruin the water for others located downstream. Domestic pollution even in moderate amounts may

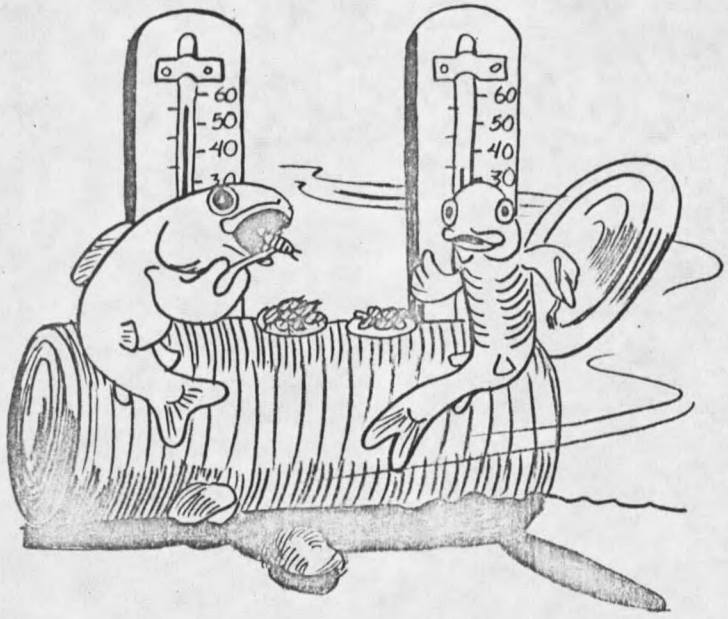
ruin areas for recreation. Who cares to spread a picnic lunch beside a stream that is foul with wastes, and what fisherman cares to wade or dip a fly in such water?

This does not mean that cities, industries, and good fishing can not exist together if proper treatment and disposal of wastes are practiced; however, experience has taught us that towns and industries fail to provide adequate treatment unless forced to. To protect water resources, and consequently their recreational values, it is necessary to have pollution laws. The laws should be fair but firm enough to insure the proper treatment and disposal of all wastes.



The body temperatures of fish and associated food organisms are not constant like those of warm-blooded animals such as man, birds, etc. Instead, their temperatures closely follow that of the water. In such animals, changes in water temperatures speed up or slow down body activities. Because of this, there is probably no other single environmental fac-

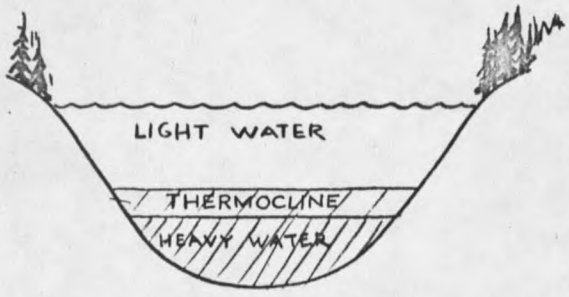
tor more important to fish than the temperatures in which they live.



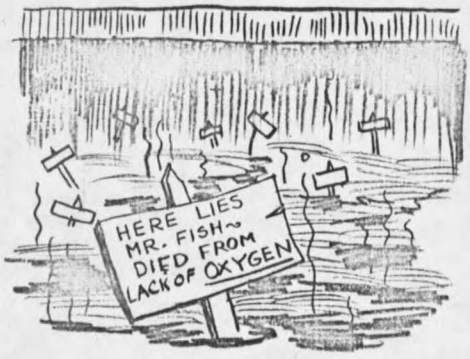
Trout are better suited to live in cold water than are bass, bluegills, crappie, etc., but contrary to popular belief, very cold water is not conducive to good growth and reproduction of trout. These fish do not eat as much, and the food they do consume is only partially digested when temperatures are too low. Under very cold temperatures, food organisms have been noted to pass completely through the digestive tracts of fishes without being killed. Trout living constantly in cold water become stunted, even through they appear to be healthy.

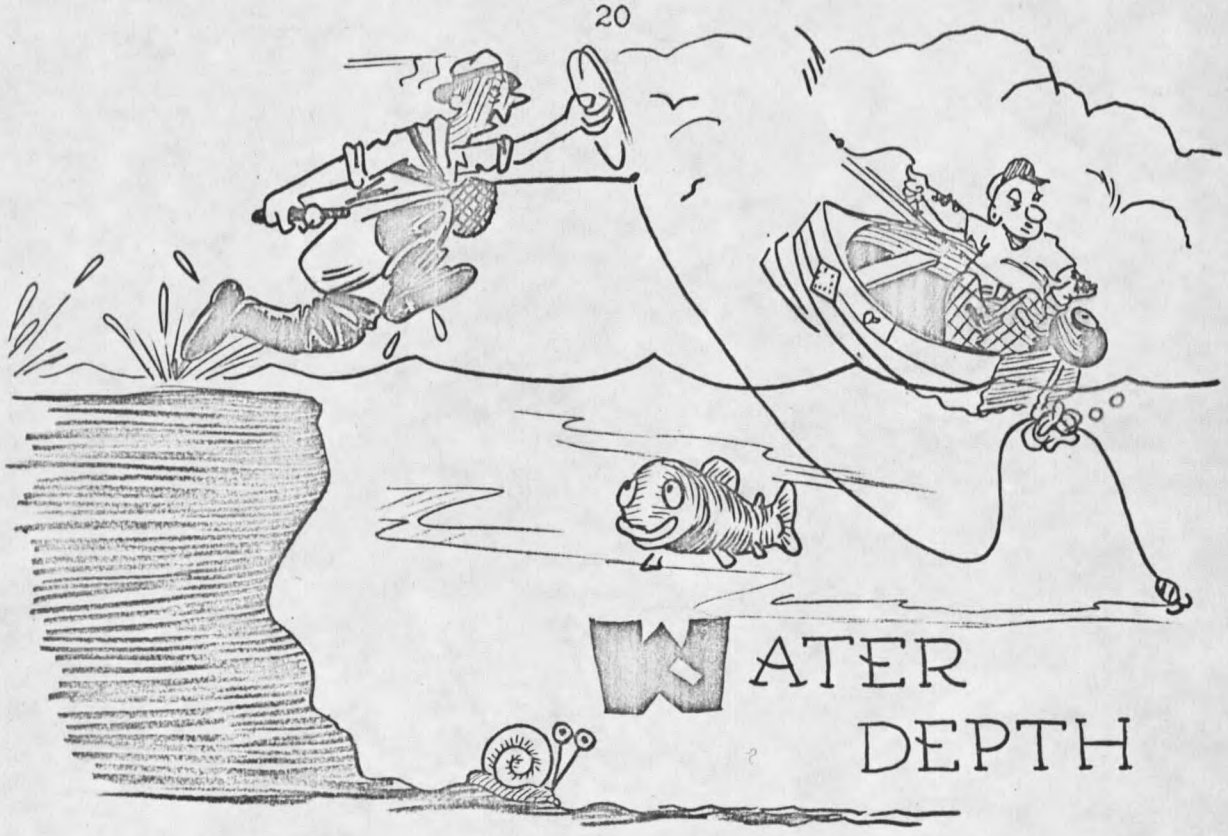
Water is heaviest at about thirty-nine degrees fahrenheit, and becomes lighter as the temperatures increase or decrease from this point. When the water of a lake cools down to this temperature in the fall of the year, it sinks to the bottom and causes complete mixing of all water in the lake. In the spring, there is also mixing when surface water warms up to thirty-nine degrees fahrenheit. The mixings are known

as spring and fall overturns. Between overturns, some lakes have layers of water with different temperatures. In Montana, conditions are such that layering of lakes is not as pronounced as in areas with hotter summers.



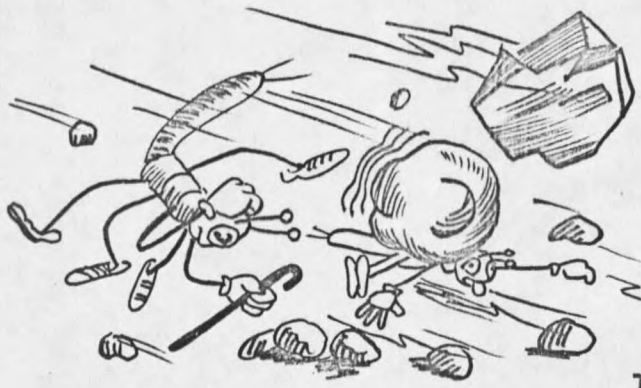
Lakes and ponds may also be layered chemically. Dead plant and animal materials use up dissolved oxygen in the process of decay, and may so deplete oxygen in the deeper waters that fish cannot live there. The upper layers are replenished with oxygen from the air, and during periods of sunlight plants add to this supply. When the water is covered with ice it is cut off from an oxygen supply, and ponds that contain large quantities of decaying plant material may lack sufficient oxygen to carry fish through long winters. This is one reason why many of our ranch ponds are unable to maintain fish. Warm water generally contains less dissolved oxygen than cold water, because it is unable to hold as much, and because higher temperatures stimulate decay of organic debris.





Shallow water will generally produce more fish food and, consequently, more fish than will deep water. One reason for this is that light usually penetrates only short distances into water, and light is necessary for plant life and growth. Shallow water is also a more favorable place because it becomes warmer, and aquatic animals grow more rapidly at the warm temperatures.

Although shallow water is most productive, deep areas are necessary in lakes and ponds that freeze over, for they provide space and oxygen during this critical period. Some fish, like the lake trout, will not thrive in shallow water.



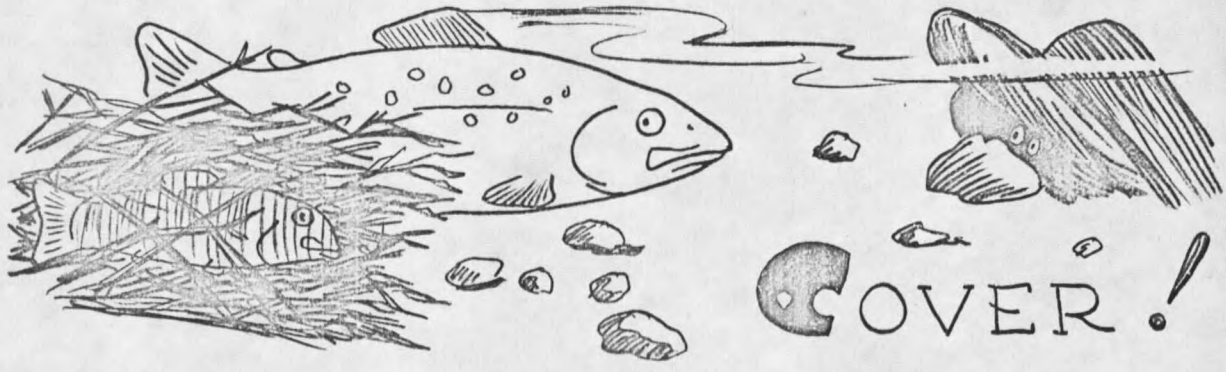
WATER MOVEMENT

When waves boom against lake shores, or flood waters scour the land, we become fully aware of the power in moving water. The results of movement under ordinary conditions are less spectacular, but its existence has a definite effect on fish production.

In lakes, water movement is generally confined to the upper few feet. Waves jostle the sand of shore and shoal areas so that plants are prevented from taking root, except in protected areas. Opposite sides of lakes and reservoirs may have entirely different appearances because one is exposed to wave action from prevailing winds while the other is protected.

During much of the year there is relatively little movement of stream bed materials, but the high water of spring runoffs and freshets may set even the larger boulders into motion. When the streams are high and swift, fish are unable to resist mid-stream currents for any length of time, and seek

shelter in the quiet water near the banks or in the eddies behind boulders and other objects. The small fish are especially in danger of being swept away. Sand, gravel, and boulders grind together, and as they move along the stream bed they tear loose and often destroy large numbers of fish food organisms. The scouring prevents plants from taking root in streams, and about the only place they can become established is in quiet inlets and backwaters.



Rocks, brush, weeds, and overhanging banks provide shelter where fish may rest and find protection. Such shelters are collectively called cover, and are an important part of the fish's environment. Young fish, especially, need hiding areas, for if there is no place for them to hide they soon fall prey to their larger, cannibalistic relatives.

While sufficient cover is present in many lakes and streams, there are instances where additional cover enables the water to produce more fish. This is particularly true

in trout streams. Warm-water fish produce so many young that they rarely need added protection. The ideal situation is to have only enough cover for protection of fish that can be adequately supported under existing conditions.

Without plants there would be no fish; indeed, there would be no life as we know it today, for plants alone are able to combine materials of air, water, and soil into matter that can be utilized by the animal body. Not only are they important as an ultimate food source for fish, but they also provide shelter. Plants are, then, a necessary part of a fish's environment, and their abundance or scarcity is a limiting factor in fish production.

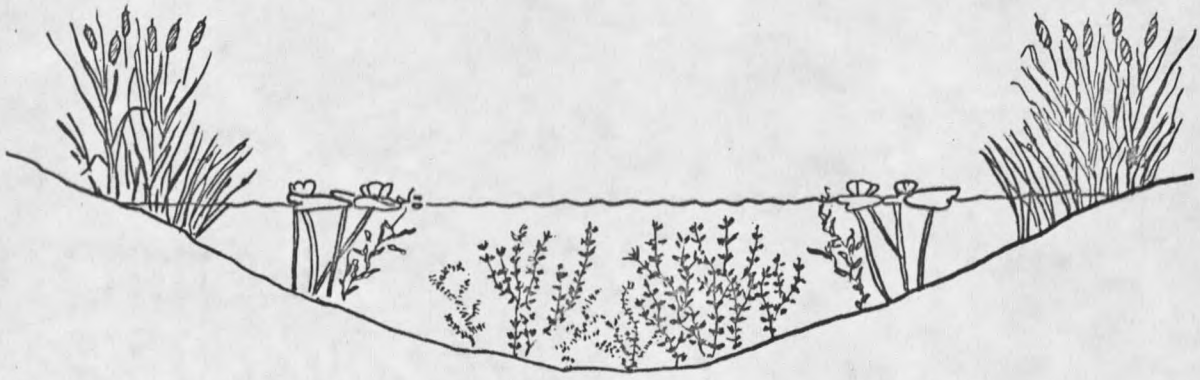
Millions of small plants (algae) are found in nearly all waters. These are the basic food supply for fish foods, and are even eaten directly by fish, especially the young fish. Algae are of many shapes, sizes, and colors. Some are one-celled and exist singly or in colonies. Most of the one-celled types are so tiny that they can not be seen without the

aid of a microscope, and many thousands may be contained in a spoonfull of water. Others are joined end to end like a string of weaners, long and hair-like, branched, etc., and are easily seen. Countless algae form the scum you see upon ponds, the water bloom in lakes, and the slippery coats upon submerged rocks that often make acrobats of wading fishermen.

Most algae in flowing water are attached to submerged objects so they will not be swept away. These attached plants and associated animal organisms are collectively called periphyton. Some of the same kinds found in streams are also found in lakes. Many float about freely in ponds and lakes. These free-floating kinds are called phytoplankton. If you look at these tiny plants under a microscope, you may see some of them move and suspect they are animals. Many one-celled plants and animals are very much alike, and even the experts can not agree on just how to tell them apart.

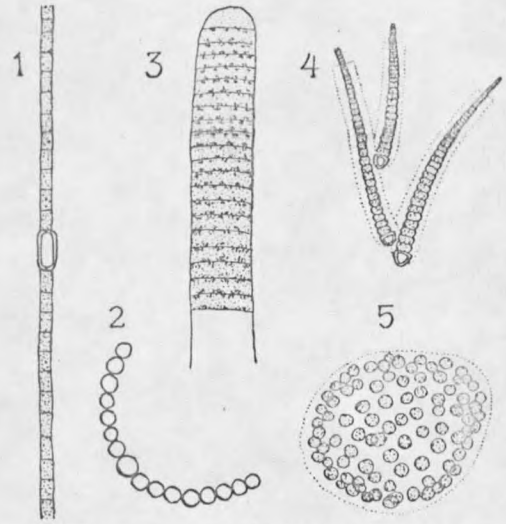
The higher water plants furnish cover for fish, and when they decay fertility is added to the water, making conditions better for further growth of all water organisms.

Each kind of rooted water plant will grow in water of only a certain depth. For instance, in shallow water one

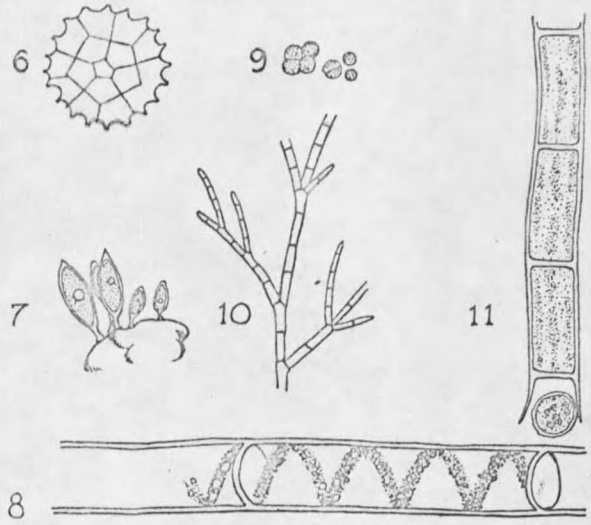


finds cattails, bulrush, etc. (emergent plants). As the water becomes progressively deeper, cattails give way to water-lilies, some pondweeds, etc. whose leaves float upon the water surface (floating plants). In still deeper water, milfoil, elodea, etc. grow entirely under the water surface (submerged plants). The distribution of plants according to water depth is known as zonation.

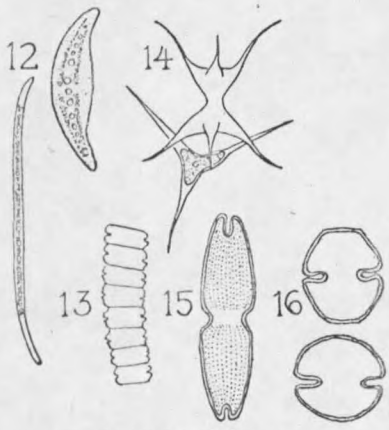
In order to grow, plants must have light, and so we find them only at depths where there is effective light. Suspended material cuts down light penetration so that plants are not found in very muddy or turbid water.



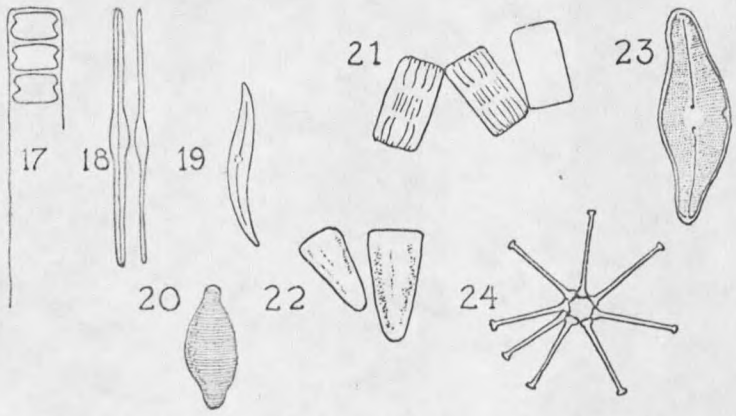
BLUE-GREEN ALGAE



GREEN ALGAE



DESMIDS



DIATOMS

1. APHANIZOMENON
2. ANABAENA
3. OSCILLATORIA
4. RIVULARIA
5. COELOSPHAERIUM
6. PEDIASTRUM
7. CHARACIUM
8. SPIROGYRA
9. PLEUROCOCCUS
10. CLADOPHORA
11. TIIBONEMA
12. CLOSTERIUM
13. DESMIDIUM
14. STAURASTRUM
15. TETMEMORUS
16. COSMARIUM
17. MELOSIRA
18. FRAGILARIA
19. GYROSIGMA
20. NAVICULA
21. TABELLARIA
22. GOMPHONEMA
23. CYMBELLA
24. ASTERIONELLA