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*Supplement No. 1 to the 29th Annual Report of the Department of
Marine and Fisheries, Fisheries Branch.*

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SPECIAL REPORTS

ON

- I.—Natural History of the Lobster, with special reference
to the Canadian Lobster Industry
- II.—A concise account of Fishes' Eggs
- III.—The place of Carp in Fish Culture

BY

PROF. EDWARD E. PRINCE,

COMMISSIONER OF FISHERIES FOR CANADA.

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I.

NOTES ON THE NATURAL HISTORY OF THE LOBSTER, WITH SPECIAL REFERENCE TO THE CANADIAN LOBSTER INDUSTRY.

BY PROFESSOR EDWARD E. PRINCE, COMMISSIONER AND GENERAL INSPECTOR OF
FISHERIES FOR CANADA.

Introductory.

Three years ago in my first report as Dominion Commissioner of Fisheries, which I submitted to the Minister of Marine and Fisheries, I ventured to say that "of all the valuable inhabitants of our inshore waters there is not one about which we have so little reliable information as the lobster. A thorough research upon its habits, propagation, life-history and migrations, would be of the utmost value, and would afford a basis for wise legislation."

Since then certain scientific investigators, notably Professor Herrick, of Adelbert College, U.S., have made advances in the direction indicated, but much remains to be done before it can be said that the natural history of the lobster has been satisfactorily outlined. Amongst fishermen, lobster packers and others interested in the lobster fisheries a desire has arisen for information about the habits and life-history of the lobster, and to supply this desire the following account, divested of scientific technicalities, has been prepared.

A large amount of the injury done in the past, and now being done by parties engaged in lobster fishing and packing is due to lack of knowledge. Many points yet remain to be ascertained regarding the lobster; but a summary of existing knowledge on the subject cannot fail to be of practical value.

Incredible abundance of lobsters formerly.

The Atlantic shores of Canada are perhaps the most remarkable lobster grounds in the world. Their extent and the abundant supplies of lobsters which, during the last twenty-five years they have produced, are not to be paralleled elsewhere. Not many years ago it was no uncommon spectacle to see, after a storm, miles of the shore strewn, between tide-marks with lobsters. In some localities in New Brunswick and Quebec lobsters in wind-rows four or five feet high were cast up by the waves and left stranded and dead along considerable lengths of the coast. As many as one thousand dead lobsters have been counted along two rods of shore and in some years, as in 1873, the destruction of lobsters in this way, especially along the Shippegan shore, Gloucester county, New Brunswick, was memorable.

Lobsters were so common that their value was not appreciated. Not only so, but extremely erroneous views prevailed as to the inexhaustibility of the Canadian lobster supply, and the peculiarities of the lobster's habits, migrations and distribution. It is only very recently that the possibility of the depletion of these crustaceans was realized by the fishing population and packers.

Diminishing supply in recent years.

An eminent United States authority in reference to the New England lobster industry remarks:—

"The statement that the lobster fishery once carried on extensively along the New England coast, has about become a thing of the past, and that the catch here is now scarcely sufficient to supply one-fifth of the demand of Boston alone for this crustacean, may well occasion dismay among the lovers of one of our most delicious and popular food specialties, as well as among those who formerly derived handsome returns from the pursuit of the lobster fishing industry on our coast. There seems to be no doubt that the exhaustion of the lobster supply is due to the greediness of the lobstermen who have levied excessive drafts on their resources without giving due heed to the work of replenishing them. This state of things demonstrates anew the importance of the protection of our fisheries by legal enactments and the rigid enforcement of such legislation."

The Department of Marine and Fisheries, realizing the great and increasing value of the lobster fisheries of Canada, attempted with more or less success to preserve them from injury and extinction. It may be that various circumstances have interfered with a strict and fair enforcement of the protective regulations framed; but it is generally admitted that our lobster fishery might have already succumbed, had no legal restriction existed.

Increased value of lobsters.

Sweden 200 years ago enacted laws to protect its lobster fisheries, the earliest lobster regulations being enacted in 1686, and the Scandinavian lobster supply has outlasted that of all other European countries. Many considerations might be adduced to show that, unless overfishing and illegal capture be prevented, the lobster must inevitably become extinct in Canada as it has become practically in many other countries. Lobsters are admittedly becoming more and more scarce, while the demand and the market price continue to increase. A live lobster of 11 inches in length which ten years ago could not be sold for more than 1 or 2 cents will bring to the fishermen, especially early in the year 10 to 20 cents. A case of canned lobsters which sold in 1887 for \$4 or \$5, can now readily be sold for \$8 or \$9.

Causes of depletion.

Among other reasons worthy of mention are its limited geographical range, its extremely local habits and migrations, its perils when shelling, the dangers that threaten the lobster's eggs, and the delicate character of the young fry for many months of their life. The enemies of the lobster are legion, and man adds infinitely to its dangers by spreading baited traps over the grounds which it haunts when it comes in from deeper water to hatch its young. The principal fishing season covers the very months when the parents are hatching out their broods of fry.

Geographical range of the lobster.

The lobster is an inshore creature and does not wander far out to sea. Its geographical range along the Atlantic shore is very limited, as no lobsters are found north of Chateau Bay in Labrador or south of Delaware Breakwater. A specimen is recorded as far south as Cape Hatteras, N.C., as taken by the United States Fish Commission Steamer "Albatross" in 1884, and this appears to be the most southerly record of its occurrence. The vast waters off Northern Labrador, Hudson's Bay and the Arctic circle appear to be destitute of this valuable crustacean, nor do the prolific shores of British Columbia yield any lobsters. Each particular bay or inshore area within the range above referred to may be said to have its own local supply of lobsters. Such localities, when once cleaned out, are not replenished in the way they would be, did schools of lobsters constantly move over extensive areas. Certain bays could be named which once abounded with lobsters, but reckless and illegal fishing cleaned them out and lobsters from the localities have not migrated in to take their vacant place.

Decrease in other countries.

In England, Scotland and Ireland as well as along the Atlantic coast of the United States grounds have been overfished, which were once prolific and valuable, and the lobster fisheries in those areas have practically ceased. The *New York Fishing Gazette*, February 26, 1897, significantly publishes the following intimation:—

"It is believed that there will be no lobsters packed on the coast of Maine during the coming season. The principal packing will be done in the British Provinces."

In the Dominion of Canada there remains the last great lobster fishery of the world, and it is not too much to say that this fishery has reached a critical stage.

Small size of lobsters in the markets.

The signs of exhaustion are unmistakable. Small immature lobsters, 5 to 8 or 9 inches long, which a few years ago were rejected with contempt are now eagerly taken, and form in some districts the staple article upon which the lobster canneries depend. Instead of two or three lobsters sufficing to fill a 1 lb. can, not less than five, six, seven or even ten lobsters are now required.

Ten years ago the average size of lobsters was of 10 inches (2 lbs. weight), while thirty years ago an old fisherman has testified that 13 inches (3½ lbs.) was the average.

Increased amount of lobster gear.

In order to keep up the catch each season the quantity of gear is being increased year by year all around the coast. Yet the average number of lobsters taken per trap has been steadily diminishing.

A prominent packer in Prince Edward Island publicly stated that in a certain cannery with which he was acquainted, the number of cans packed as compared with the number of traps fished from that factory showed this startling decrease:—during a period of six seasons at that factory the average number of 1 lb cans to each trap fished was in 1891, 24; in 1892 it was 16½; in 1893 it was 13½; in 1894 it was 12½; in 1895 it was 7½, and in 1896 it was 5½.

The capture and packing of lobsters inferior in size and quality cannot continue, and the taking of "berried" females and even soft shell lobsters indicates the desperate efforts now being made to keep up the aggregate pack. In prolific inshore waters such as those of Newfoundland these strenuous attempts are viewed with the gravest fears by those qualified, by knowledge and business experience to judge. The best authority on United States fishing matters made a few weeks ago this announcement:—

Newfoundland lobster-packers propose to enter into the packing of this fish more largely than ever the coming season, and many new men will operate small factories in various parts of the island. This, in view of the fact that the ground all about the island is being overfished, would indicate that unless some restrictions other than those now in force are placed upon the fishery, the lobster in Newfoundland will soon be extinct.

Local distribution of lobsters.

Fishermen have discovered that lobsters can be caught in deeper water than was formerly fished; but their occurrence in deeper water merely shows that the lobsters when they forsake the inshore shallow areas resort to these greater depths. Instead of moving, as many still think, over great portions of the coast, the lobsters, as the fact stated shows, migrate from deeper water into shallower and back again. No doubt the great schools pass the winter at depths of 40 or 50 fathoms; but during the warm summer months they move into shallow water, 2 to 10 fathoms, where the females ripen their eggs and hatch them out.

Habits of lobster.

When moving at leisure the lobster walks nimbly along on the tips of its toes holding its nipping claws slightly raised in front, waving its long feelers aloft, while the

short second pair is held straight to the front like rigid bayonets, and turning its protruding stalked eyes in every direction. The tail is held spread out behind so as not to touch the ground.

When alarmed or in danger instead of proceeding forward, it swims backward by the convulsive and powerful strokes of its tail. It shoots along at the rate of twenty-five or thirty feet per second; but rapid swimming is so exhausting to the lobster that it is physically unable to continue this violent method of progression very long. Moreover, when swimming the lobster cannot see where it is going; it only sees the danger from which it is fleeing; but observers have noted with astonishment how accurately it directs its course. A lobster, it is said, will at times bound tail foremost out of the narrow entrance of a lobster-trap in which it finds itself confined. The very young lobster uses its feathery feet for swimming, as will be described on a later page, and progresses rapidly head foremost quite in contrast to the habit of swimming backward in the adult.

The lobster is most active at night and shuns excess of light. It is impatient of heat or extreme cold, and under such conditions becomes sick and inactive; but in water of a temperature of 40° to 50° F. it is most vigorous and healthy. The heart and principal blood-vessels of the lobster as well as the main venous sinuses lie in the back of the creature, hence exposure to the hot rays of the sun is rapidly fatal. Lobsters confined in inshore ponds and in floating cays die in great numbers from heat and exposure for the physiological reason just stated.

Food and Growth.

Lobsters may be almost said to be omnivorous, they are certainly not particular in their diet and greedily devour fish alive, dead, or even putrid, seaweed, eelgrass (*Zostera*) shrimps, starfish, indeed anything in the shape of edible material. At times they turn cannibal and will devour each other, while they are fond of tearing off and eating the bunches of eggs attached to the female lobster in a "berried condition." Just as the owl or kingfisher rejects the bones and indigestible portions of fish or animals which they have eaten, so the lobster ejects from its mouth the hard parts of the creatures which it has devoured. Such pieces cannot pass down the intestine, which is a slender and delicate tube lying along the fleshy jointed tail of the lobster. The lobster has a keen sense of smell which is believed to be located on the under surface of the outer limb of each of the small pair of feelers (the antennule). No doubt it is mainly by the sense of smell that it is led into the baited cage or trap used in the lobster fishery. There is certainly no just reason for regarding putrid bait as more attractive than fresh bait. It is possible that semi-decayed fish may have a certain amount of luminosity or phosphorescence, which affects the lobster's sense of vision; but the Norwegians have for centuries proved by practice that pieces of fresh flounder placed as bait in their cane traps form the best possible bait.

Structure of the shell.

The dense armour of hard limy material which encases the lobster permits only of limited growth so that the shell must be cast off repeatedly, as the lobster increases in size, season after season. This growth is most rapid in the very young or infant stages, hence moulting is then most frequent, as will be shown on a later page in the account of the life of the larval lobster. A lobster cannot continue to wear the same shell any more than a growing youth could continue to wear a small boy's suit after he has become a man. The shell consists of four layers:—(1) An outside horny layer, which shows no definite structure. Professor Herrick calls it the enamel layer. (2) A thicker canalculated layer, crowded with lime salts, and coloured with pigment. Dr. Carpenter called it the "areolar" layer. (3) A very thick, non-coloured, laminated layer, recalling the structure of dentine in a tooth. It is Carpenter's "tubular" layer, and is the gleaming white part of the shell, which is so noticeable at the broken edge when a lobster shell is fractured. It is this layer which is absent in the case of *Phyllosoma*, and the glass crabs, *Portunus*, and others. (4) A very thin lamellar layer which is not calcified.

The inside lining is formed by a soft layer consisting of epithelial cells. These cells build up the shell, and become greatly enlarged and cylindrical, when actively secreting a new shell.

All four layers are pierced by delicate canals, viz. : the skin-gland ducts, the hair-pores, and the tegumental gland tubes. Inside the shell, of course, lie the great masses of white flesh or muscles ; but there is an intervening space between the shell and the muscles which is occupied by loose connective tissue, large blood-spaces, and the great glands, called by Professor Herriek "tegumental" glands.

Shelling or moulting.

The shell undergoes peculiar changes when the "shelling" period arrives. Some of the salts, which impart hardness to it, begin to disappear in such places as the middle of the great shield covering the head and thorax, and along each side of the snout and other parts. This change gives the elasticity required to allow of the shell being more easily thrown off. A thin skin forms underneath the shell, and the lobster then shows very evident signs of the painful process about to begin. A lobster about to moult loses its bright colour, acquires a loose lax appearance, and becomes very uneasy and shy. It seeks the shelter of rocky clefts, or if these be not at hand, immerses itself in a soft sandy bottom, lying sidewise. It bends upon itself so that the skin connecting the shield and the tail bursts. There are no violent convulsions such as some writers have described. The muscles of the limbs tug vigorously, and the great claws, soft and pliable as indian rubber, are withdrawn like the hand from a glove. The creature pushes itself through the gaping slit, the head being pushed out leaving the tail to be drawn out last of all. The newly shelled lobster has a limp and collapsed appearance, but its colours are extremely fresh and bright. Water is so rapidly absorbed through the soft new shell that the lobster enlarges and swells up with surprising rapidity. The empty cast-off shell resembles a dull dingy live lobster, as it is rarely split or broken although extremely brittle. At the end of a month the shell is not really hard ; but still has a pliable leathery character. Many observers have declared that within twenty-four hours, or at most within a week the shell is perfectly hard. This is not so. A lobster is really not completely hard for seven or eight weeks after moulting. The process of shelling takes place every year, especially during the summer months, for which two reasons can be adduced. The water is warmer then, and the soft and sensitive lobster at that time escapes the peril of extreme cold. A vast number of females hatch their young in the warmer months, and, after hatching, they invariably cast off the shell, partly no doubt to get rid of the clinging empty eggs, and their attachments, which become foul ; but chiefly, as already indicated, owing to the growth of the animal inside its covering whereby the old shell becomes too small for it. Actual observations on the shelling process are very meagre, indeed those of my friend the late George Brooke are almost the only continuous observations on record. His studies were carried on in Scotland for about sixteen months, viz., from July 1st, 1883, to November 19th, 1884, during which time he found that four moultings took place, the size at each moult being:— $6\frac{1}{16}$ inches, 8 inches, $8\frac{1}{16}$ inches and $9\frac{9}{16}$ inches, a total increase of $2\frac{7}{16}$ inches. The dates, when the shelling process was effected were, July 1st and December 25th, in the first year, and July 25th and November 19th, in the second year. Professor Herriek justifiably calculates that, under natural conditions, a 6 inch lobster would attain a length of 9 or 10 inches in two years and that a 10 inch lobster is probably four and a half or five years old. Of course during its more rapid growth in infancy, the shell is cast off much more frequently. During the first six or eight weeks after hatching the young lobster moults not less than five or six times.

Features of male and female lobster.

Before describing in detail the breeding habits, the production of eggs and hatching of the young, a few words may be here said regarding the external features of the male and female lobsters. A comparison of a large number of specimens has shown that the male is more slender than the female and he possesses larger and stronger claws. The

body of the female is not only broader, but the side plates or flaps at the margin of each tail ring are deepened in order to provide a larger space under the tail for the reception of the bunches of eggs. The first pair of legs in the lobster are the "nipping claws" or large forceps, and there are four pairs of true walking limbs. Behind the walking legs there are five pairs of smaller limbs called "swimmerets." In the male the first pair of swimmerets are transformed into stout rods each consisting of two joints, while at the inner edge of the basal joint of the fourth or last pair of walking legs a minute opening may be noted, on close examination, which is the aperture of the seminal duct. In the female, on the other hand, the first pair of swimmerets consists of a slender feathery rod, composed of one long joint and twelve or thirteen very small joints. The second pair of walking legs show a couple of small openings (oviducal apertures) at the base similar to those in the male; but in the interspace between the third pair of walking limbs is placed the V-shaped sperm pouch. It is a very sensitive organ studded with small sensory hairs, and in it the male deposits a thick gummy matter which acquires a somewhat solid character after a short time. A most reliable distinguishing external feature in the two sexes is the position of the small sex apertures. In the female they are at the base of the second pair of walking legs, and in the male at the base of the fourth, or last pair.

Spermaries of the Male.

It is necessary to describe the structure of the egg-forming and sperm-producing organs before the peculiar features seen in the breeding of lobsters can be understood. The latter organs or spermaries can be seen upon cutting open the back of a male lobster. A pair of slender much corrugated tubes appears passing down the back, and placed immediately above the massive green liver. They rudely resemble the letter H as the two tubes are connected by a slender bridge, immediately behind which connection there passes off on either side a duct. Each duct swells to form a sperm vesicle before terminating in the small external opening or sperm aperture, already described as occurring at the base of each of the last pair of walking legs.

Ovaries of Female.

In the female, the ovaries where the eggs are formed have all the character of a pair of tubes passing along the back behind the eyes and immediately under the shield or shell forming the forepart of the back of the lobster. When in a mature condition they extend along two-thirds of the length of the body from the fourth or fifth ring of the jointed tail almost to the eye-sockets. They exhibit much variation in colour as they approach the ripe stage, recalling the green, pink and yellow ovaries of certain fish such as *Cyclopterus*, for the ovaries of the female lobster may be either of a cream yellow, a pale flesh tint, or a light olive green colour. When the lobster is boiled, the eggs contained in the ovaries, if fairly ripe, turn to an intense red colour and are known as coral. In some great markets (as for instance London) lobsters containing coral are prized for culinary purposes especially for lobster sauces, etc., and this demand for ripe females has no doubt had much to do with the depletion of lobsters in Britain.

Deposition of eggs.

At the spawning time the eggs enlarge and become loose in the ovary. They then glide down the oviducal tubes, their passage being facilitated by a fluid, which is secreted at that time by the swollen cells lining the oviduct and they are rapidly ejected from the two orifices, already described as occurring at the bases of the second pair of walking legs. Each egg is globular or rather spheroidal, about $\frac{1}{16}$ inch in diameter. They are received in the space inclosed by the incurved tail of the lobster, and become glued to the five pairs of feathery swimmerets so that they hang like crowded bunches of grapes. The liquid glue is secreted by the glands in the skin or rather shell, in the tail region, and it hardens on exposure to water. The eggs are dark green, almost black; the colour being due to the yolk which is visible through the transparent shell

or chorion. Unless they are vivified the eggs come to nothing; but the further changes in the progress of the fertilized eggs will be briefly described below.

Pairing Process.

In order that the sperms emitted from these two small openings, in the male lobster, shall be transferred to the female, pairing must take place. No doubt the peculiar first pair of swimmerets are utilised in pairing; but full and accurate observations regarding the pairing of lobsters remain yet to be made. Sufficient information is afforded by the structure of the organs described in the foregoing account, and by what is known in many other creatures of the same subkingdom (*Arthropoda*) to establish the fact. That pairing takes place admits of no doubt. It must, in many respects, resemble the pairing of spiders, in which creatures, we know that the male takes a quantity of sperms from underside of its body, and by means of its pointed second pair of limbs (the pedipalps) transfers these sperms to the special receptacle of its mate. The sperms of the lobster differ from those of most animals, because they are apparently motionless and are able to retain their vitality for a long period of time. In most animals the sperms exhibit wonderful activity for a very short time when they lose their activity and vitality. The lobster's sperms may be described as star-like in form and massed together in a gelatinous capsule (distinguished as a spermatophor). Probably the first pair of swimmerets, which in the male are of very peculiar shape, convey the spermatophors to the female. They are received, no doubt, when lying in a reverse position, and the female stores them in the triangular sperm-receptacle. In the animal kingdom, as a rule, pairing takes place just before or coincidently with the spawning time, and the eggs are at once and directly vivified or fertilized. But in the lobster the conditions are peculiar and wholly different. The male does not directly fertilize the eggs; but the motionless sperms, transferred to the female at the pairing time, are stored up by the female until required. If pairing occurs in the fall when lobsters are found to migrate inshore in great numbers (say in October or November and several months after the hatching period is over), the sperms emitted by the male at that time must be carried by the female for from six to nine months when the female deposits her eggs in spring or summer, April to July seems to be the main time on our shores, then extruded eggs come into contact with the stored up sperms which are now poured out. By the contact of the eggs and the sperms the eggs are at once vivified.

Cleavage of the egg.

Changes immediately commence within each egg. The dark coloured yolk divides up into segments during the first two or three days. This is what is called the cleavage of the egg, and at its conclusion it has the appearance of a thimble-berry or bramble-berry. A thin skin forms inside the egg-shell, and both unite to form a double capsule. It has been frequently noticed that when a young embryo lobster is artificially removed from the shell, the antennæ or horns are found attached to this inner layer of the capsule and are often torn off with the shell.

The embryo within the egg.

During the first ten to fifteen days, while one side of the yolk remains dark, the other side becomes clear and shows a little creature like a spider lying on its back inside the egg. This is the embryo lobster.

The formation of this embryo, embracing the process of cleavage just described, may be rapid, under a high temperature, or very slow if the temperature of the surrounding water be very low.

Hatching period.

There can be no doubt that lobsters, which extrude their eggs in April, May and June, accomplish the hatching of their fry in a few weeks, whereas late spawners, during

the months of September, October and November, probably do not hatch their young for six or eight months. This accounts for the fact noticed by Dr. Fullerton; that a female lobster in the middle of November was found carrying eggs which were in the stage, that in the case of other female lobsters was not reached until about the middle of May. Prof. Herrick, it is true, quotes a case of the hatching out of eggs in the latter part of January under a temperature of 36° F., which had been removed from a female at Christmas. Such facts support the assertion that lobsters may hatch during every month in the year. "I am satisfied," said an experienced fisherman in Prince Edward Island, "that lobsters spawn all the year around." Yet certain months, June, July and August embrace the principal part of the year during which most female lobsters are in Canada found carrying berries. The Department of Marine and Fisheries has been able to confirm this after conducting artificial lobster hatching at Pictou, N. S., for the last five years, the supplies of eggs being mainly obtained from May 15th to early in July or late in June, and the fry as a rule hatching out in from seven to fourteen or twenty-one days. Some very mature eggs hatch within twenty-four hours after being received at the hatchery.

The course followed in artificial hatching in the department's establishment is briefly described below.

Method of artificial hatching in Canada.

After the eggs are received from the lobster canneries usually at the rate of 1½ millions per day, they are placed in glass hatching jars through which pure sea-water constantly passes, and this circulation keeps them in motion. The hatching jars are upright cylindrical vases, with a central glass tube supplying water which passes up through the jar and escapes by a conical tip at the top of the jar.

About the middle of June the earliest lobster fry hatch out, and are carried by the circulating stream into a capacious reception trough, which receives the waste water.

When the hatching-out begins the assistants are kept busy night and day attending to the eggs and fry to see that they do not collect and clog together, as they soon die under such circumstances.

When the time for distribution comes the fry are placed in barrels of sea-water open at the top, and conveyed out to sea on a small steam tug.

They are not simply thrown overboard; but from a low steamer are scattered by means of small tin dippers, or passed through a hose, one inch in diameter and about 8 feet long, provided with a funnel shaped box at the top; they are scattered about one million to the mile over a distance of 60 miles. The bottom is rock and kelp, and the fry are distributed not less than 3 miles from shore.

The number of eggs placed in the hatching jars is about 65 millions each season and the eggs are so healthy that at no time have more than a hundred dead eggs been found in all the jars.

Female lobsters are found from 6 inches to 8 inches in length bearing eggs, but the larger lobsters carry proportionately far more eggs.

Since the Bay View hatchery, Pictou, N.S., was opened, over 500,000,000 of fry have been hatched, the numbers being as below for the following years, viz:—

1891.....	7,000,000
1892.....	63,500,000
1893.....	153,600,000
1894.....	160,000,000
1895....	100,000,000

Before emerging from the egg, the advanced embryo lobster is shielded very effectively from harm. Thus there are (1) the shell of the lobster, (2) a temporary larval skin, which fits around the shell like a glove, (3) the egg-shell or primary chorion: (4)

the secondary egg-membrane which is outside. The chorion is formed in the oviduct and is attached only at the stalk to the secondary, outside shell, the latter is thick and translucent and secreted by the cement glands. Both shells split, like a bean, into two halves at the time of hatching and out comes the larva tail foremost. It is very unlike the lobster in form and habits. It rises to the surface of the sea and appears to frequent the upper waters for over two months, as Professor G. O. Sars, the famous Norse naturalist long ago conjectured, during which time it undergoes a series of changes described as follows in which seven stages may be distinguished.

Larval life—Seven stages.

The newly hatched larva exhibits a short shrimplike body and ringed tail stretched out almost horizontally. It is of glassy transparency, with gleaming emerald eyes, and possesses a huge pointed snout or rostrum, consisting of a central blade and a lateral spike on each side. Two pairs of very short horns protrude in front (antennae and antennule) the second pair being forked or split into two. Four of the six tail-joints bear spines, two on each side, and one in the middle standing erect. Most young marine larvae, having the pelagic habits of the lobster, carry for some days a small bag of yolk; but all trace of the green yolk has disappeared by the time the young lobster hatches out. The yellow liver is plainly visible through the translucent shell. There are no swimmerets along the under surface of the tail; but minute buds indicate their future position. The jointed foot jaws and the five pairs of legs are paddle-like, and the creature shoots forward through the water with great rapidity. The triangular tail is provided with spines and is fringed with hairs. In length the larva is over $\frac{1}{2}$ of an inch (7.50 to 8.50 mm. long.) from the tip of the snout to the end of the tail.

(2.) During the second week after hatching five changes may be noted: (a) the snout becomes toothed and is less blade-like in character; (b) paired swimmerets grow out along the under side of the tail: the second to the fifth tail rings; (c) green colour appears along the back region. The length increases by nearly one-twelfth of an inch, and the larva is now about half an inch long (9.50 to 11 mm.)

(3.) During the third week the principal change is the development of the nipping-claws or chelae. All the feet hitherto were adapted for swimming and the first pair (or nippers) differed little from the rest; but at this stage they become proportionately much larger and their inner margins exhibit serrations or tooth-like projections. The eye still shows a bright metallic lustre, and green spots distinctly appear in the thin shell mingled with a brown coloration. This stage appears to rarely last more than a week.

(4.) The fourth or fifth week witnesses further changes. In outline the small lobster shows a resemblance to the adult lobster greater than it has hitherto exhibited. It has, after moulting, increased in length, and measures more than half an inch (13 to 15 mm.) The erect spines down the back have gone, while a deeper colour, brown or green, extends over the shell, and the nipping claws are of a warm brown or reddish colour.

(5.) The young lobster, six weeks to two months old, still swims about actively near the surface. Though its prevailing reddish brown tint renders it less inconspicuous than in its younger stages when its glassy translucency is more marked, yet it is really a small insignificant object $\frac{3}{4}$ inch to $\frac{2}{3}$ inch long, and not readily distinguished from the small fishes, young cod, gurnard, sculpins, &c., which abound in the same surface waters. A young lobster at this stage is often mistaken for a larval gurnard (*Prionotus*) as both swim rapidly forward in a similar way, and the moving reddish claws of the lobster bear no little resemblance to the orange tinted pectoral wings, or fins, of the minute gurnard. The snout is narrower and therefore appears more prominent and pointed, while the feathery outer joint or exopodite of the swimming feet becomes much diminished. This last feature, with the loss of the glassy translucency, characteristic of previous stages, indicates that the young lobster is about to take to the bottom.

Swimming larva descends to the bottom of the sea.

(6.) One or two weeks later when the lobster moults a fraction more in length (15 to 17 mm.) it changes its swimming pelagic habit and comes inshore. Its colour is darker than hitherto, though there is great variation in this respect. Dark green, pale bluish or greenish brown are most frequent. As Professor Herrick points out there appear at this time on the head shield two white spots, really points of internal attachment for tendons, very apparent a little behind the eyes. The projecting edge (pleuron) on each side of the first tail ring is also white. The snout or rostrum measures about one-quarter of the length of the head shield (or cephalothorax).

(7.) During the third month of larval life which Herrick divides into two stages, the changes are mainly internal and only the trained specialist is able to notice the slight external modifications which take place. The most important point is the assumption of the external characters of sex. The males and females, in early larval stages, cannot be distinguished. Up to the sixth or eighth week the first pair of swimmerets beneath the tail are mere rounded tubercles, and up to the stage now described the oviducal openings on the second pair of walking limbs are not apparent in the female. They now appear distinctly, and from this stage onwards the changes which take place are mainly connected with growth and increase in size. The young lobster thus passes through changes in its early life of a very striking character. In outline it changes less no doubt than the shore crab, but in habits, mode of progression, food, &c., the changes are momentous. From a transparent free swimming, almost transparent, mite in the open sea, it becomes transformed into a heavy opaque bottom-living scavenger. As the length of $\frac{1}{4}$ of an inch is approached (19.5 or 20 mm.) the eyes begin to grow more rapidly and during the stages immediately subsequent are unduly prominent. This in fact is true of young marine larvæ generally. Of course young lobsters, like other developing aquatic organisms vary in rate of growth and features of colour, &c., but the foregoing brief sketch may be said to represent the average larval life of the lobster. As in its mature adult stages so in its early days its food is varied. Minute marine plants, algae, diatoms, as well as minute crustaceans, copepods or water fleas, &c., chiefly constitute its food. Cannibalism is frequent, and the method adopted of attacking each other is very striking as the young lobster barely a few weeks old invariably selects the most vulnerable point, viz.: the opening behind the head-shield. The stronger larva springs upon the back of the weaker and savagely bites him at the point named. Larval lobsters feed chiefly at night, hence their illimitable myriads are not readily noted by fishermen or sailors; but on bright sunny days they rise to the surface of the sea. Light has a fascination which is common to many creatures in the water.

Rare captures of larval lobsters in the sea.

Considering the countless millions scattered every season through the sea, near the lobster breeding grounds, it is astonishing that so few have been seen or captured. I have myself received specimens of some of the stages described on three occasions only.* They were captured in the Straits of Northumberland, where, during the latter portion of the summer, certain areas must be crowded with various stages. Prior to the capture of my specimens the only actual record in Canadian waters which I can find is that of Mr. J. F. Whiteaves, of the Geological Survey, who eighteen years ago, captured specimens half an inch long in the months of July and August off Pictou Island, N.S. The fact is that the free-swimming lobster larvæ, like other young pelagic creatures, range within one or two fathoms of the surface of the sea, not quite at the surface where the concussion of the waves would be hurtful. The late Dr. Honeyman (of Halifax, N.S.) is recorded to have computed the following table of growth:—

Young reddish transparent lobster . . .	6 weeks old is $\frac{1}{2}$ inch in length.
Small, but perfect lobster	16 do is 1 inch to $1\frac{1}{2}$ inch.
Larger hard shelled lobster	1 year old is 4 inch to $4\frac{1}{2}$ inch.

* I owe some very fine specimens of stage 5 to Commander Spain, R.N., Head of the Fisheries Protection Service. They were obtained by Capt. Knowlton, D.G.S., "Kingfisher." Mr. C.A. Stayner of Halifax, also kindly gave me specimens of a still younger stage (say stage 3).

I have not been able to ascertain on what grounds this computation was made, though some of the details given are very remarkable and of extreme interest, dating back as they do ten or fifteen years. The post-larval growth of the lobster it must be confessed is even now largely a matter of conjecture; but some data exist. Professor Herriek succeeded in keeping one specimen alive, which hatched out on May 27th and lived until September 11th, a period of 107 days, in which period it increased about three times its original size.

Growth and Maturity.

We have seen that the adult lobster has been proved by actual observations to grow about $2\frac{1}{2}$ inches in sixteen and a half months, and the larval lobster has been demonstrated to grow in three and a half months no less than half an inch and these facts go to show that in four or five years it is quite possible for the mature size to be reached and at that age no doubt many females carry spawn.

They continue to grow for a period of many years as is proved by the capture occasionally of gigantic specimens. These are more rare than formerly, but this season (1897) a fine specimen was taken off the Jersey coast, which measured three and one-half feet in length, two feet round the body, feelers one and one-half feet long, small legs one foot long, felt claw two feet long and ten inches wide, tail fourteen inches from end of tail to body.

Size of spawners and number of eggs.

Professor Herriek arrived at the conclusion that very few spawn before reaching a length of 9 inches; but so many "berried" specimens $7\frac{1}{4}$ to 8 inches in length have reached me from various parts of the Canadian coast that a considerable proportion of females would appear to carry spawn at 8 inches and under. The ratio of reproductiveness, is however, so low in these small female lobsters that the abundance of lobsters in any locality must depend upon the larger females. A 7 inch lobster will produce 5,000 eggs, whereas when one inch larger the number of eggs carried is just about double that quantity. A 10 inch lobster carries as a rule 18,000 or 20,000 eggs; but when 14 inches long the number of eggs is 40,000, and at 16 inches the number is estimated at no less than 80,000 eggs. Variations are not infrequent and a 10 inch lobster may produce only 12,000 or 14,000 eggs; but on other hand one specimen of this size is recorded which carried 21,000 eggs.

Lobster's fertility compared with oysters, fishes, etc.

These figures might appear large did we not know, by comparison with other marine creatures of economic importance, that the lobster is perhaps the least productive numerically of all. A herring deposits double the number of eggs produced on an average by the lobster; a mackerel four times as many, a cod four hundred times and a Canadian oyster four thousand times as many. No wonder that no lobster fishery in any country has been able for many years to withstand the tremendous annual drain implied by a large market. The lobster fishery of Canada it is estimated annually destroys between sixty and one hundred millions of lobsters, a considerable proportion of these being females about to spawn, or recently spawned. It is indeed astonishing that our lobster grounds have been able to hold out so long with this gigantic destruction going on year after year.

Waste of eggs during fishing season.

The destruction does not end merely with the annual loss of many millions of parent lobsters, for the loss of the spawn about to be laid, or already deposited and scraped from the lobsters before being landed cannot be ignored. In the department's report for 1890, the late Lieut. Gordon laid stress, and rightly so, on this waste of eggs, which is so readily overlooked, and he referred to certain means which might effect (to quote from his report p. 18) "the saving of the ova, the destruction of which now, perhaps,

more than anything else, militates against the speedy restoration of the fishery. To show that this is no idle statement the case of a cannery putting up 2,000 cases, or 96,000 lbs., may be taken; these require say half a million lobsters to put up, and my inquiries show that probably 1 in 5 are "berried" lobsters—say 100,000. Now, take even one-half of this, and say that 50,000 "berried" lobsters, each carrying about 20,000 exuded ova, were destroyed in putting up the 2,000 cases, we have no less than 1,000,000,000 ova destroyed; and if this rule be applied to the 220,000 cases which constituted the product of the fishery for the year 1889, we have a number of 110,000,000,000 as the wanton destruction of ova which it is possible to save—at any rate, in some small measure; for even a saving of 1 per cent of such a total represents a number the magnitude of which figures fail to bring home to the mind."

Theory of Biennial Spawning.

Closely connected with the interesting questions respecting the reproductive capacity of the lobster, and the probable interval elapsing before it reaches maturity and reproduces, is the further question as to the frequency of spawning.

A very erroneous opinion was in circulation some years ago that the female lobster spawns once in two years. Curiously enough this notion first put forward by parties wholly untrained and unqualified to frame a reliable judgment has received countenance recently from men of scientific standing. Professor Garman, and more recently Professor Herrick, have favoured the idea, and Dr. Fullerton has also adopted it in his recent Scottish paper on Lobster Development, though the evidence when analysed instead of establishing biennial spawning all points the other way. Herrick indeed himself found in "paper shell" lobsters in July that just after the brood had hatched and the moulting was over the eggs in the ovaries were no less than half the size of mature ova. Ehrenbaum inferred that the female lobster spawns every fourth year, and the evidence on which this new view is based would just as conclusively prove that the lobster spawns quadrennially. My own embryological studies upon a variety of marine fishes and other creatures have established beyond question in my mind that the growth of the ovarian ovum may be astonishingly hastened after the dispersion superficially of the nucleoli over the surface of the nucleus or germinal vesicle.

In the female *Gastrosteus*, ova developed and ripened in the months of July, August and September, when the conditions were most favourable, in periods of from 60 to 80 days, and passed through stages which later in the year occupied no less than 220 to 240 days. Yet Prof. Herrick does not hesitate to affirm concerning this supposed biennial spawning that to prove it requires only the dissection of a female with eggs ready to hatch in June, July or August, and it will be found that "the ovarian eggs have had, in all these cases, from ten months to a year's growth"—the very point in fact being assumed which requires proof. Further on in his excellent memoir he adds: "That the spawning periods are thus two years apart is a valid inference drawn from the study of the anatomy of these organs."

We have, indeed, available the fullest scientific proof that a Decapod, closely allied to the lobster, spawns not once in two years, but twice in one year, thus the shrimp, *Crangon vulgaris* spawns in April and May as well as in early November. A valid inference would be that the lobster spawns not less frequently than once a year. Dr. Fullerton in adopting Herrick's view says: "From an examination of the ovaries of lobsters which had shortly before hatched a brood, and others periodically between that time and the following January, it is certain that lobsters do not breed annually." As I have shown a mere anatomical examination of the ovaries is insufficient to establish any such conclusion, and an embryologist familiar with the various stages of egg-maturation, in different animal types, is bound to pronounce any such inference as unwarranted collateral evidence is all unfavourable to the theory of biennial spawning.

Annual spawning of lobsters.

When Professor Herrick again affirms in these words: "When the external eggs are ready to hatch the ovarian ova have had nearly a year's growth," an experienced

embryologist could accept this opinion with difficulty. My own observations for which Canada offers opportunities incomparably greater than those of any other country, lead me to the view that lobsters as a rule spawn annually, and that a female lobster which has hatched her brood early in the season does in many cases produce a second crop of eggs late in the fall which are carried all winter. The details of my examination of a large number of specimens supporting this view cannot be given here; but will be published in due course elsewhere.

There is certainly little justification physiological or anatomical for holding with Fullarton that in no case "lobsters that had just hatched a brood, had eggs in the ovary which could become fully ripe under a good many months." The oftquoted case of the lobster in Rothesay Aquarium, Scotland, which was carrying ova when placed in the tanks in August, 1886, and did not complete the hatching of the same until August, 1887, though larvæ hatched out as early as April, 1887, proves only that the conditions were abnormal and unfavourable. The fact that the brood were hatching for a period of five months, April to August, from eggs which were extruded the summer before fully demonstrates the abnormality of this special case. The fact that the lobster spawns annually is evidenced by (1.) The fairly uniform proportion of "berried" females taken season after season.

(2.) The occurrence of the berried conditions in all sizes of females from 7 inches to 18 inches. It might be expected that females of certain specified sizes would never or rarely be found with eggs were biennial spawning a fact.

(3.) Exact researches upon allied decapod crustaceans prove the greater frequency of spawning.

(4.) The rapid growth of ovarian eggs so familiar to embryologists is unfavourable to the biennial theory.

Enemies and diseases of the lobsters.

As with other valuable inhabitants of the sea the lobster's enemies are legion. In its earliest days the young swimming larvæ are sadly decimated during the first eight or ten weeks of their life, when as we have seen they range from $\frac{1}{8}$ inch to $\frac{3}{8}$ inch in length. Physical and chemical impurities also kill them. Later they are more hardy; but intense cold and excessive heat are equally fatal. Adult lobsters confined in floating cars are found to die in great numbers when the sun's rays are powerful. I have examined such cars and found a large proportion in a sick and dying condition.

Almost every predaceous fish in the sea devours the lobster. The mackerel feeds largely on the larval lobster, while the cod, haddock, pollack, sea bass, skate, etc., eat it when it attains a larger size; but to add to its dangers and enemies I have found in Nova Scotia that crows are most destructive, for when the tide goes down these birds destroy the lobsters left amongst rocks and sea-weed. They pierce the shield of the lobster where the heart and main blood vessels are situated and the crustacean is at once rendered helpless and is devoured by its assailant. The flocks of crows busy amongst the rocks inshore must destroy large quantities of this valuable crustacean. Boeckh has described a curious habit in the Scandinavian crows. They seize the lobster and fly up into the air with it and let it fall, breaking its hard shell into fragments and exposing the delicate masses of flesh in the claws and tail.

The lobster suffers from few diseases or parasitic affections. A large Gregarine (*G. giganteum*) abounds in the intestine as Van Beneden found, and a peculiar Trematode worm occurs in the liver. Prof. Herrick remarks that no specific disease characterizes this crustacean, though Mr. Rathbun has described a tumoid protuberance on the outside of the carapace which was attributed to a wound. As a matter of fact an internal disease does, in rare instances, affect the lobster, and Professor McIntosh, many years ago, described a tumour which originated in the wall of the grinding stomach and pushed its way through the carapace behind the eyes. The tumour enlarged and finally resulted in the death of the lobster, which was a very large and old specimen.

The lobster has more than the usual quota of perils to face, and man's systematic destruction has not merely added to them, but overbalanced them all. It is probably

in early larval life that the decimation of the lobster chiefly takes place, for there are few fishes in the sea that will not eagerly devour the young as they float in cloudy masses through the water.

The influences fatal, or at least hurtful, to the lobster in mature life have been already pointed out; but there is one to be added, viz., fresh water. Lobsters avoid localities where fresh water streams run in unmingled with salt water. In shipping live lobsters packed in ice, the fresh water trickling down from the melting ice is most harmful and ultimately fatal.

Shipping of live lobsters.

With proper precautions, however, lobsters may be carried alive and healthy over great distances. Early this century some loyal Nova Scotians shipped in a sailing vessel several barrels of lobsters to King George III. They reached London safely and alive. In 1862, some tubs of sea-water containing live lobsters were sent from Maine, U.S., via Halifax, to the Emperor Napoleon III., and a few years ago the Otago Acclimatisation Society, Dunedin, New Zealand, succeeded in carrying live lobsters from England. In the first attempt only twelve were sent; three died during the first week though the rest survived, fed well during the voyage, and at the end of the 54 days' sail were planted in a healthy condition at the Antipodes. The Society was encouraged by this success to arrange for a second shipment; but all died on account of the detention of the ship for a month by a broken shaft at sea. The extensive exportation of live lobsters is in Canada a comparatively new thing, and is growing rapidly. What its effect upon the lobster supply will be, remains to be seen.

For many years very large exportations of live lobsters have been made from Norway averaging in value \$150,000 per annum, the number actually taken in the fishery ranging from 800,000 to 1,000,000 lobsters, and most of them destined for the English market.

The method of packing and shipping them may be described as follows:—The boxes generally used have the following outside dimensions: Length, 39 inches; breadth, 19 inches; and height, 15 inches. If ice is used they are made 4 inches lower. Each box contains from 100 to 120 lobsters. Sometimes smaller boxes are used, with the following dimensions: Length, 24 inches; breadth, 19; height, 13. Between the boards there are suitable openings to admit fresh air.

In summer there is placed at the bottom of the box a layer of ice two or three inches thick, and on this a frame, so that the lobsters are not disturbed in their position even if the ice melts. On this frame there is first spread a thin layer of fresh heather (long, thin grass) or straw, on which the lobsters are laid carefully, back downward, the tail being bent forward and across the box, with the claws turned inside towards the centre. When the box is full some heather or straw is spread over the lobsters and the box is closed. Heather is preferable to straw, as the latter spoils on account of the moisture caused by the ice, and the lobsters cannot well endure any bad odour. For this reason it is not advisable to use dry sea-weeds, which formerly were often employed. Old sail-cloth dipped in sea-water forms an excellent cover, as it keeps moist and cool for a long time. If ice cannot be had, heather soaked in sea-water may be used, dry fresh straw, or sail-cloth. During the cooler season only heather or straw should be placed at the top and bottom of the box.

In winter the sides of the box may be lined on the inside with paper, so as to protect the lobsters against the cold, but there should not be any paper either at the top or bottom, as the lobsters would be stifled, owing to the lack of air. When the lobsters have not been kept prisoners for more than eight days, they will, when packed in boxes in the manner described above, keep for four days. The fresher the lobsters the better they are able to stand the fatigue of the voyage.

The boxes are placed on the deck in such a position that the water from the melting ice does not reach the lobsters, which cannot well endure fresh water, and so that the lobsters are protected against rain, as rain-water is very apt to injure them. Lobsters which during transportation have been exposed to the rain, when placed in tanks generally lose their claws. The persons who ship lobsters usually see to it that

the boxes are placed in proper position on board the steamer. It always appears best to place the boxes containing lobsters on the forepart of the steamer, so that the lobsters may get the benefit of the spray from the waves.

Necessity of judicious protection.

Whether the canning of lobsters in the Dominion or their shipment alive to the great markets will have supremacy in the future it is impossible to say. Excessive and unrestricted fishing carried on for either industry, or both, must have the same result viz. : sure and certain extermination.

This calamity has already happened in the United States. As has recently been stated in a leading United States fishery journal :—"Canadian fishermen are awakening to the possibility of a famine in lobsters, and the Fisheries Department is calling meetings, at which Professor Prince will confer with the fishermen and representative men in the industry, who will present their views on close seasons and other regulations affecting the lobster industry. It is a very serious question, and should be given attention at once. The United States Fish Commission should co-operate with the Canadian, as our lobsters are growing more scarce yearly. This industry was very profitable along the Maine and Massachusetts coasts in former years, but now is anything but remunerative."

That Canadian fishermen and canners realize the grave possibility has been shown by the recent conferences held in the Maritime Provinces, the first of the series being attended by the Hon. the Minister of Marine and Fisheries. In accordance with the wishes of the Hon. L. H. Davies, the further meetings held were attended by the Commissioner of Fisheries. A Nova Scotia journal (the *Pictou Advocate*) briefly summarized the situation in these words :—

"The attendance at and interest manifested in the meetings held throughout the province lately by Prof. Prince show that our people recognize the great importance of the lobster industry. To preserve it on a permanent basis is a matter of the greatest possible importance. "You can not have your cake and eat it" is true in regard to this question. As other countries have lost the wealth which follows successful fishing, so also will these Maritime Provinces if those most interested in its permanency, the fishermen, along the coasts are not impressed with the importance of fostering it in every way. The idea of Hon. Mr. Davies of local discussions and expressions of opinion from those interested is a splendid one, and we trust will lead to the framing of a good law which will benefit and protect the industry."

Canada has an object lesson before her in the depleted United States lobster fisheries in reference to which Dr. Lavoie, Fishery Officer for the Gulf of St. Lawrence division, wrote in 1876 :—

"*The ruin of the lobster fishery on the shores of the United States ought to warn and at the same time teach us a lesson which we should take advantage of: that is to regulate with as little delay as possible, the mode of carrying on this fishery, if we would not suffer the same results.*"

The New York *Fishing Gazette* recently gave expression to similar sagacious warnings, and a quotation from that acknowledged authority may fitly conclude these notes. The quotation is extracted from an article referring to the growing scarcity of the lobster in Canadian waters. "In these waters, it may be said, are the remains of the only remaining lobster fishery of the world. That this is so is not due to the exercise of greater care in its preservation than was bestowed upon those other lobster fisheries that are now unprofitable; but rather to the fact that it has existed as a fishery of importance only a few years, or since the packing of lobsters ceased on the coast of Maine. Practically the same methods have been pursued. The packing interests have been in the hands, in a manner, of those who controlled the industry when it flourished in New England. The manner of prosecuting the fishery has been similar to that in vogue here, and its operation is being followed by results almost identical. The difference between the Maine fishery that was, and the Canadian fishery that is, lies in the fact that in the case of the former the gravity of the situation escaped the attention of the authorities until it was too late to apply the needed remedies. In the latter case, investigations—some-

what tardily begun—are being pushed with vigour while there is yet life left in the industry. It remains to be seen whether those in charge of these investigations and the correctives that will have to be applied will profit by the mistakes that were made here."

The further observations of the same journal in regard to the market for 1896 and 1897 are of the gravest import: "It is nearly certain," says this authority, "that the markets here will be dependent wholly upon the output of the Canadian packers. The high prices that ruled during the last season curtailed the consumption both here and abroad, and yet in spite of this the demand was sufficient to absorb everything in first hands long before the close of the packing season, and for several months the market has been virtually bare, the small stock remaining being held firmly by jobbers.

As this is practically the situation at present, those engaging in the packing industry may be reasonably certain of finding a ready market with prices well in the lead of those prevailing at last year's opening. Some of the larger packers of lobsters, indeed, have made prices on the 1897 pack which range from 35 to 37½ cents above the opening figures of last year. Notwithstanding these prices, which are the highest that have been quoted for many years, it is reported that the bulk of the contemplated pack of the brands so far offered has been placed. It is not expected that the output of any of these brands will be larger than was the case in 1896; indeed, there are reasons for believing that the number of cases packed during the coming season will be the smallest in the history of the business."

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II.

A CONCISE ACCOUNT OF FISHES' EGGS.

By PROFESSOR E. E. PRINCE, DOMINION COMMISSIONER OF FISHERIES FOR CANADA.

It has long been apparent to fishery authorities everywhere, that the preservation of existing fisheries by appropriate regulations is an impossible task, and the restoration of depleted or destroyed fisheries by protective measures, is hopeless, unless based upon accurate knowledge of fish life. Many fishery laws would never have been framed, and numberless suggestions would never have been made, had any real knowledge whatever existed in regard to the eggs and habits of fishes, the periods of spawning, and the sites selected for the breeding grounds.

Proposals are continually made for the establishment of government hatcheries for the culture of fishes the nature of whose eggs and fry render futile any attempts at artificial propagation. But so long as dense ignorance prevailed respecting the character of fishes' eggs, the times of spawning, and the locations chosen by the parent fish, and the time occupied in developing the young fry, the enactment of close seasons, and other legal restrictions, was as likely to be wrong and mischievous, as right and salutary. Even to those versed in the knowledge of fishes in our seas and inland waters, and familiar with their habits, the actual facts in regard to the spawning periods, and the nature of the ova, were for the most part unknown. The attempt to hatch and rear species which had decreased in numbers was practically impossible if the eggs and natural spawning habits of such fish were not known. That the causes of the depletion of certain fisheries and the disappearance of valuable kinds of fish are in many cases due to peculiarities in the eggs or spawning habits, or the nature of the young fry, admits of no doubt and were the facts scientifically ascertained such injurious causes might be removed. Prior to 1862, a law for the protection of spawning herring was enforced in certain areas in Scotland. All the fishermen interested were most anxious for its enforcement but as Lord Playfair has frequently pointed out the Royal Commission on herring fisheries, which first sat in 1862, established one or two facts of the greatest importance to great fisheries, for instance, that restrictive laws framed by man in ignorance of the laws of nature, were excessively destructive to the interests of fishermen instead of being favourable to them. When the commission first began to examine this subject, they found different laws prevailing on the east coast of Scotland to those which prevailed on the west. On the east coast there were no restrictive laws, and fishermen were encouraged to catch fish, even full fish containing ova, for curing purposes. Each of these fish had on an average 50,000 eggs, and the enormous number that were taken in this state would seem to indicate a process of extermination; but the fisheries of the east coast, without restrictive laws, increased, and did not diminish. On proceeding to the west coast of Scotland, however, in the inner waters of the Firth of Clyde, they found restrictive laws prevailing. For several months no herrings were allowed to be taken, there being a close time for herrings for the purpose of protecting them. As they went further into the open waters out of the Firth of Clyde along the islands up to near the Highlands, those restrictive laws still prevailed; but there was a relaxation as to the period when the close time ended. A very curious result was made apparent, and a most unexpected one. At the periods of close time, the herrings came to the banks to spawn, and were followed by their natural enemies in great number, among which might be named the cod and the ling, which consumed them in great numbers. There were innumerable fish which lived upon the young fry and the full-grown herring; the cod, ling, dog-fish and conger, fed on the full-grown herring; while the flat-fish and crabs eat the spawn, and there were innumerable other fish which eat herring-fry. At the time when they found them on their spawning banks, these fish had an appetite for nothing else but herring, and this

result followed, that the fishermen of cod and ling could catch nothing, because they would only take herring bait at the time, and the close time prevented the fishermen getting any herring-bait for catching these fish. The consequence was, that the laws invented for the protection of the herring became laws for their destruction, because their natural enemies, which could not be caught because of the want of bait, multiplied exceedingly, and devoured the very herrings which the laws intended to protect. That was the result of interfering with the laws of nature by an indiscreet law passed by Parliament. The lesson which might be drawn, was that though Parliament might make laws for keeping order and safety amongst fishermen; that the balance of nature in the sea should not be unduly interfered with, where the balance of animal life depends upon unknown factors. Of these unknown factors none were more vital than the nature of the spawn and the character of the early life-history of fishes. Since Dr. Lord Playfair's declaration just referred to science has largely removed our ignorance.

Again, for many years prior to 1884, Scottish fishermen urged that the use of steam trawls, a kind of large beam dredge, should be prohibited by law, for the reason that it was supposed to destroy immense quantities of spawn on the floor of the sea, and was thus regarded as seriously endangering the supplies of most valuable fish. We now know that no such extensive destruction of spawn could possibly take place, as the fish chiefly taken on the Scottish coast do not deposit their eggs at the bottom of the sea. The herring, it is true, does so; but it was not claimed that the herring were showing signs of diminution. The complaint had reference mainly to the cod, haddock, turbot and flat-fishes. A still more glaring example of the folly of fisheries legislation based upon ignorance is that of a certain bay in Kerry on the west coast of Ireland, where trawling was at one time forbidden by law because of the alleged abundance there of turbot spawn. This spawn, it was stated, lay in extensive soft patches all over the bottom of the bay. After the prohibition had been strictly carried out, some of the alleged turbot spawn was submitted to a scientific authority, who, at once, discovered that it was not spawn at all; but a worthless kind of sponge, which was positively injurious to fish spawn and young fry on account of its poisonous exhalations. Under this law a source of danger and injury to the fisheries had been ignorantly protected and encouraged. A well-known fishery expert at the Plymouth Laboratory, England, in reference to these erroneous views held by men usually regarded as practical men, has pointed out that "other things are frequently mistaken by fishermen for floating spawn. For instance, in early summer off the coast of Cornwall, there are frequently seen great quantities of a pinkish scum, which is found to consist of small round globules. This stuff has been brought in as mackerel spawn. It is not the spawn of fish at all, the little globules being . . . a lowly organised member of the animal kingdom, which never develops into anything different. It is called Noctiluca."

Such great advances have been made in our knowledge of the eggs of fishes, especially those of economic value in our seas and inland waters, that the continued prevalence of erroneous opinions, even among fishermen and persons connected with fishing industries, is a matter of surprise. It is, moreover, no uncommon thing for intelligent persons to apply to the Department of Marine and Fisheries for spawn, or for the young fry of fishes, the eggs and young of which have never yet been seen by any one, and it is still more common for similar applications to be made for fry which, on account of peculiar features in the nature of the spawn, it is impossible, or very unprofitable, to deal with in fish culture-establishments. It is well known that in zoological gardens and menageries it is perfectly easy to breed and rear lions, while no case is on record of elephants under domestication producing young. The peculiar features characteristic of any species, be it animal, bird or fish, must be taken into account before the artificial culture of such species can be taken in hand.

Adhesive eggs, such as those of the black bass, maskinonge, sturgeon, &c., are most unsatisfactory for treatment by methods of artificial culture. With extra precautions and care a small percentage of their eggs can be hatched; but to obtain the best results the separate, non-adhesive kind of eggs only, should be hatched artificially. As the late Professor J. A. Ryder said (Bulletin U. S. Fish Comm., 1888) "our experience with adhesive eggs of all kinds has always shown that it is difficult to prevent the

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lodgement and rapidly fatal germination of the spores of *Saprolegnia* or *Achyla*, i.e., aquatic fungi or moulds, found in all fresh waters upon dead as well as living eggs. So rapidly do these fungi grow that in a very short time their ravages will extend over an entire tray of adhesive eggs. The eggs are destroyed by the fungus sending filaments into their substance, while the mesh or the mycelium also affords lodgement for dirt, so that the two together effectually shut off the possibility of oxygenating the ova, so that they are smothered."

The eggs of the numerous order of bony fishes (Teleostei) which, it may be said, includes almost every kind of fish of market value, such as the cod, herring, salmon, lake white fish, halibut, &c., may be readily arranged in a limited number of groups, each group distinguished by marked peculiarities. There are two very distinct types of eggs under which these groups fall: (1) buoyant or pelagic eggs, which possess the power of floating in water; and (2), demersal or non-pelagic eggs, which sink to the bottom when deposited. It is not too much to say that most fishes in the sea, so far as our present knowledge shows, produce floating ova, which are borne about in the surface waters of the sea in clouds as multitudinous as snow flakes in the winter air, until the young fish develops and bursts from each egg at the time of hatching.

Though our seas have for ages formed a vast nursery for the floating ova and young fry, the amazing fact was unknown and unsuspected, and fishermen, in common with the public generally imagined, that fishes spawned on the bottom of the sea, or selected special banks, or scattered rocky shores on which to place their eggs. Thomas Pennant, one of the most diligent and painstaking of the older British naturalists says, for instance, of the cod (British Zoology, 1769, Vol. III, page 141.) "In our seas they begin to spawn in January, and deposit their eggs on rough ground, among rocks. Some continue in roe until the beginning of April."

Dr. Eugène Cuvier aptly says, in his recent memoir entitled, "Ponte, Oeufs, et Larves des Poissons Osseux, Utiles et Comestibles." (Ann. Stat. Agric. Boulogne-sur-Mer, 1893):—"Contrairement aux croyances répandues dans le monde des pêcheries, la plupart des poissons osseux comestibles donnent des œufs flottants, dispersés à la surface de la mer à quelque distance des côtes et que certaines espèces produisent seules ce qui était attribué à la généralité, à savoir, des œufs tombant au fond de l'eau en raison de leur poids ou fixés aux corps submergés (hareng, éperlan, etc.)."

The pelagic or the demersal character of the egg in any particular species of fish is altogether independent of its zoological affinities. The most surprising diversity obtains in this respect, and we cannot forget the nature of the eggs of any kind of fish from the general character of the ova known to be produced by the group to which it zoologically belongs. The general laws which hold true in the case of the eggs and young of birds, or of insects, do not hold true of fishes. The herring and many of the herring tribe (Clupeidae), for example, produce small adhesive eggs which cling to rocks, &c., at the bottom of the sea, yet the sprat (*Clupea sprattus*) and the pilchard (*Clupea pilchardus*) produce the most delicate and buoyant of all floating eggs. The skulpins (*Cottus*), as a rule, deposit spongy masses of non-floating eggs, yet Alex. Agassiz describes the egg of one species of *Cottus* as floating. So widespread again, is the pelagic character of the eggs of flat fishes, such as the halibut, turbot, sole, &c., that it was a surprise to naturalists to find that the winter flounder (*Pseudopleuronectes americanus*) has adhesive eggs, which sink to the bottom of the water, and cling in adherent masses.

The nearest relative of the winter flounder, viz., the common flounder (*Paralichthys dentatus*) of our Atlantic shores, produces floating eggs. The Cunner (*Ctenolabrus adspersus*) has a very transparent pelagic ovum about $\frac{1}{7}$ of an inch in diameter, whereas the allied species, *Labrus maculatus*, the Bullen Wrasse, deposits dense, heavy eggs in a nest in rock pools. The discovery that the eggs of such fishes as the cod and mackerel were possessed of such buoyancy as to compel them to swim near the sea's surface is due to Professor G. O. Sars, the eminent Norwegian zoologist, and what Sars, early in the sixties (1864) proved of the cod, mackerel and gurnard, was established later by Professor McIntosh, of St. Andrews, Scotland, in the case of the sole and flat fishes, as well as of the ling, whiting and other important species used for food.

Of the two types of fishes' eggs, the demersal and the pelagic or floating type, there are many varieties; but it is possible to group them under a number of heads, and thus concisely enumerate, in brief compass, most of them.

A vast number of fishes' eggs are spherical like peas, or small shot, consisting essentially of a ball of soft yolk, capped by a more or less transparent sheet of germinal matter, the whole being inclosed in a translucent capsule or shell. The shell is often very tough, but usually sufficiently thin to permit a careful observer, with the aid of a lens or a microscope, to make out the main features of the early germ, and, later, the larval fish inside the egg. Those who practise fish culture are able, on account of this feature in the egg capsule, to see the progress of the developing fish. It is usual, indeed, to speak of a certain stage as the "eyed egg," because the black eyes of the larva are so readily visible through the shell. The shell in the cod, haddock and mackerel is exceptionally thin, no more, in fact, than $\frac{1}{3000}$ of an inch thick (.0078 or .0084 mm.), whereas in the shad it is about twice as thick, and in the trout and salmon at least five or six times thicker. Many eggs exhibit remarkable shining and coloured oil-globules. In the salmon they give the warm orange tint to the egg; but in the whitefish the oil globules are pale and nearly colourless, hence the eggs exhibit no tint. The eggs of the sticklebacks are golden yellow, and those of the lump-fish (*Cyclopterus*) vary very much, and may be either yellow, greenish, or even light pink in colour, these colours being due apparently to tinted matter scattered in the yolk. The eggs of the sturgeon are either of a dull green or of light or very dark brown colour, due to the grains of colouring matter which are crowded all over the surface of the yolk, and are especially numerous and dense in the germinal area. The olive-green colour of the eggs of certain Siluroids or cat-fishes is due to the colour of the yolk substance, as is probably also the case with the pale green egg of the striped bass (*Roccus lineatus*) and the rich yellow eggs of the pipe-fish (*Siphostoma*).

The nature of the yolk varies greatly and may be of the consistency of syrup, clear and translucent, or coarsely granular as in the carp tribe, or broken up into segments or lumps, like the separate grains in a pomegranate, a condition well marked in the shad, pilchard and sea herring. In the eggs of the sole, anchovy, blue fish (*Temnodon*) and others, there is a partial segmentation of the yolk, which is confined to the surface of the yolk. Other interesting features might be referred to, but they are, to the ordinary observer, of minor importance, and are of less practical moment in connection with the fisheries.

Turning then to the various types referred to, it may be premised that the following grouping of fish under their several distinctive heads, must be regarded merely as a provisional and convenient classification which may require modification or extension with the advancement of our knowledge regarding the ova and early life history of fishes. The sharks, rays, lampreys and other fishes, not of prime importance from an economic point of view, are excluded; but the eggs of those Teleostean or Bony fishes which are of principal value in the markets, and of moment, therefore, in connection with the fishes are all embraced in the seventeen separate divisions enumerated below. Of these seventeen groups or types of eggs, no less than seven are pelagic and characterized by the special features which belong to floating or buoyant kinds. So many fishes produce eggs of this character deposited in the open sea within a fathom or two of the surface that, in the brief summary here given, they may be placed first in order.

Pelagic or Floating Fish-Eggs.

(1.) Eggs, such as those deposited in the sea by cod, haddock, halibut, plaice and sprat, and other valuable commercial fishes, are spherical in form, with an extremely thin shell or capsule, clear translucent ball of yolk, and no large oil globules. They float separate from each other in the surface waters of the sea, and from their delicate structure, buoyancy and colourless transparency, they may not inaptly be compared to minute soap-bubbles wafted hither and thither by every current or movement in the surrounding water. They are always of minute size and so difficult to see in the water, that they are practically invisible. A practised eye can discover them if the water be very smooth, but they are most readily obtained for examination

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in a floating tow-net or bag of fine mosquito netting. They vary greatly in size from the minute egg of the Dragonet (*Callionymus*) about $\frac{1}{50}$ of an inch in diameter (0.56 to 0.60 mm.) to that of the halibut, which possesses the largest floating fish egg up to the present time discovered, and measuring in diameter no less than $\frac{1}{4}$ or $\frac{1}{2}$ of an inch (3.07 to 3.8 mm.) The cod's egg is about $\frac{1}{17}$ inch (1.4 or 1.5 mm.), the sand dab's egg (*Pleuronectes maculatus*) measures $\frac{1}{24}$ inch while the cunner's egg (*Ctenolabrus adspersus*) is about $\frac{1}{30}$ inch in diameter.

(2.) Eggs, similar to those embraced in the last group in all particulars, except in the possession of a large oil globule, rarely with one or two smaller globules adjacent. This so-called oil globule is so striking a feature that many eggs of this type can be readily discerned with the naked eye. Otherwise they are colourless, delicate and transparent and would be practically invisible when floating in sea-water. The most important of these eggs is that of the mackerel which measures a fraction over $\frac{1}{16}$ of an inch in diameter (1.23 mm.) while the oil globule is very large, viz., about one quarter of the diameter of the egg. The Silver Hake (*Merluccius*) produces eggs $\frac{1}{25}$ inch in diameter (the oil globule about $\frac{1}{100}$ of an inch across), while the sea cusk or torsk (*Brosniius brosne*) the turbot (*Rhombus maximus*) the Gurnard (*Trigla*), the Spanish Mackerel (*Scomberomorus*) and the File fish (*Elacate*) may be instanced as species whose eggs contain a single bright globule of oily matter. The globule may in some cases be tinted viz., a reddish brown in the torsk and a dull pink in the gurnard's egg.

(3.) Eggs in which the characteristic feature is the presence of small oil globules distributed all over the surface of the yolk ball, or collected in scattered groups. In other respects, by their smooth transparent shell, clear yolk, and extreme lightness or buoyancy, this type of ovum is not distinguishable from the two preceding groups. The appearance presented by the so-called oil globules is very distinctive.

The most important commercial species of fish that may be instanced is the English sole (*Solea vulgaris*), the globules in which are extremely small, silvery, and collected together in separate groups upon the surface of the yolk. The egg of the Weever-fish (*Trachinus vipera*) is also studded with small glistening globules scattered over the yolk, while Alexander Agassiz long ago described a floating egg which he regarded as produced by an American species of Skulpin (*Cottus*), exhibiting similar globules of a greenish tint. Other species of Skulpin (*Cottus*), it may be mentioned, are known to have wholly different eggs, destitute of the power of floating, possessed of tough and thick capsules or shells, and strongly adhesive to each other.

(4.) Floating eggs without oil globules, which present on the outside of the shell projecting hairs, knobs or other external structures. Comparatively few fishes produce eggs of this character, but they are sufficiently noteworthy to entitle them to be regarded as a very marked distinctive type. The Silver Gar (*Belone*), as Haeckel long ago discovered, produces eggs about $\frac{1}{8}$ inch in diameter, which are covered with long hairs or filaments, many of them half an inch in length. The eggs of the flying fish (*E. vocatus*) and of the Saury pike (*Scomber-saur*) exhibit the same striking peculiarity. The late Professor Ryder held the view that by these hairs the eggs were able to cling to floating objects in the sea, and be thus transported through the water and incubation favoured. They also become attached to each other and collect in entangled groups, instead of floating isolated far apart. The theory that these filamentous tendrils have for their object the attachment of the eggs to foreign objects is open to question. At times they no doubt accidentally come into contact with stake nets and other fixed objects inshore—the floating egg-ribbons of the Angler Fish frequently do that, but the presence of similar fine filaments projecting from the shell of certain rooted eggs in tidal pools indicates rather a protective function. The ova of the Dragonet (*Callionymus*) present externally an erect honey-comb structure, produced by delicate intersecting projections of the shell extending over the whole surface of the egg, and resulting in a hexagonal pattern. Like the coat of soft mucus which envelops many eggs, these hairs and projections on the outside of the shell may deter certain natural enemies from eating them.

(5.) To this division belong pelagic eggs provided with external projections, but unlike those already mentioned, exhibit one or more oil globules. Raffaele has described an egg showing these features measuring about $\frac{1}{16}$ inch in diameter and having conical pro-

jections studding the whole of the egg capsule. The oil globule is rather more than $\frac{1}{100}$ inch across, and the structure of the ovum is exceedingly delicate and striking. The discoverer regards it as the egg of *Macrurus*, belonging to a family of fishes closely allied to the cod (the Gadidae).

(6.) Floating eggs imbedded in gelatinous ribbons or strings, such as are produced by the angler (*Lophius*). E. van Beneden, many years ago, obtained floating eggs which resembled in all essential features the eggs grouped under division 2, being spherical in form, extremely delicate in structure, and possessing a large oil globule, but characterized by this striking additional feature, that the eggs were imbedded in a floating mass of clear jelly. Van Beneden's eggs were attributed to some species of the family Gadidae; but the most familiar, and in many respects the most remarkable example of this group, is that of the egg-bands of the Angler or Goosefish already alluded to. Each egg, individually, is a small sphere ($\frac{1}{16}$ inch in diameter) and provided with a shining oil globule of a pinkish-brown colour, and $\frac{1}{30}$ inch in diameter. Many thousands of them are produced by the female *Lophius*, agglutinated together in a mucous band, thirty or forty feet long in some cases, and 6 to 10 inches wide. One ribbon of eggs is recorded over 90 feet in length. This ponderous ribbon, a soft slippery mass, floats in the open sea secure from every predacious foe. Observers have described it as recalling a band of pale purplish crape; but the specimens, obtained when entangled in inshore fish pounds, which I have had the opportunity of studying, appeared like flat bands of colourless glistening jelly, with a delicate hexagonal pattern internally, due to the gelatinous capsules of adjacent eggs pressing upon each other. No animal known to the naturalist could readily swallow this formidable slippery mass, and the envelope of the egg-ribbon is so tough and tenacious that, as Dr. T. H. Bean reported when he secured a mass of these eggs in 1887 "we were obliged to cut it with a knife. The eggs," he added, "are in honey-comb-like cells," a condition really due to the mutual pressure of adjacent eggs all provided with a thick mucous envelope. Eggs of this type are most effectually protected, and the young fry, on hatching out, are well provided for coping with the perils which beset newly liberated larval fishes, as I described in the Ninth Annual Report of the Scottish Fishery Board, 1891. In consequence *Lophius* is an abundant and widely distributed species.

(7.) Eggs of an elongated or oval shape form a somewhat restricted and uncommon type of floating ova. Many of the spherical fish-eggs embraced under the foregoing divisions at times are ellipsoidal; but the normal form is a more or less perfect sphere. The anchovy (*Engraulis*) produces eggs of a marked elongated oval form, which has been characterized as sausage-shaped. Each egg is about $\frac{1}{16}$ inch from end to end, and about $\frac{1}{30}$ inch transverse diameter. In structure it is extremely delicate and transparent, destitute of oil globules with faint lines of yolk segmentation, in the early living stages. The young fish on bursting from the egg is extremely elongated, and shows the characteristic features of the clupeoid or herring form being destitute of colouring matter.

Demersal or Non-floating Eggs.

Passing from pelagic or floating eggs to demersal or non-buoyant eggs we find that there may be distinguished no less than nine groups.

(8.) The first group consists of eggs which are free, non-adhesive or very slightly so, spherical and usually of considerable size. They lack the extreme translucency and delicacy of the floating eggs described above. Indeed compared with the almost invisible and insignificant pelagic ova, the eggs of salmon, or smelt, lumpfish or herring are coarse and heavy and can be readily handled if due care be exercised. Floating eggs can in most cases not be touched or lifted out of the water without injury and usually death. The eggs of the salmon (about $\frac{1}{4}$ inch in diameter) are typical, and an abundance of reddish oil globules in the yolk imparts to them their characteristic colour. The eggs of the brook trout ($\frac{1}{16}$ inch in diameter) are very similar and those of the great lake trout about $\frac{1}{3}$ of an inch in diameter are much paler. The eggs of the whitefish exhibit no tint at all. On account of their wholly non-adhesive character they are hidden by the parent fish in crevices in honey-comb rock, in gravel, coarse sand and the

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like. When newly deposited they are smooth and slippery to the touch, and are lightly carried by the water into crevices at the bottom, and thus secure safe protection though many fall a prey to enemies, which pelagic eggs entirely escape. On several occasions I have tried to secure newly deposited eggs, say of British Columbia salmon, immediately after the female had laid them. I found it almost impossible to seize any with forceps or the hand as the slippery eggs eluded the grasp, and in the swift current they flew from one crevice to another as though endowed with life. So far as known few fishes in the sea produce eggs of this type. The larger and lesser Sandeel or Sand Lance (*Ammodytes*) do so, though the eggs for a time are slightly adhesive, and are hidden in loose sand or gravel between tide marks. The eggs of the shad are deposited in shallow water some distance up rivers where the water is fresh. They are of comparatively large size for a clupeoid, viz. : $\frac{1}{4}$ or $\frac{1}{2}$ inch in diameter, fairly translucent, and with a very small yolk-ball which occupies only a part of the spacious chamber inside the egg-capsule. When newly deposited shad eggs often cling together, by reason of a slight adhesiveness, in layers one egg deep. The striped bass *Morone saxatilis*, one of the most valuable of food fishes, enters estuaries in spring and deposits its eggs toward the head of tide on a sandy or gravelly bottom. They are $\frac{1}{4}$ of an inch in diameter and of a pale green tint when first laid. The first record regarding the eggs of this species appears to be that of Mr. Marcettus, who in the report of the Maryland Fish Commission, United States, 1880, states that Mr. Hamlin, on May 6th, 1879, obtained them and noticed that they were larger than herring's eggs and increased in size after fertilization, losing their green colour and opacity and assuming a transparency which rendered them almost invisible, only the oil globule arresting attention by its glistening appearance. They are deposited by the parent fish apparently in fresh-water above the limits of the inflowing tidal sea water, in some important Canadian rivers. Prof. J. A. Ryder, surmised that they also may be deposited in salt water in some localities, and in the Miramichi River, New Brunswick, it is claimed that the main spawning grounds coincide with or are lower down than the principal winter haunts of the fish, and in that case the eggs are placed in brackish water. That the eggs of any species of fish can thus be deposited indifferently in fresh and in brackish water is contrary to exact observations on the physical effect of such diverse conditions upon ova, and further investigations are needed regarding the actual spawning habits of the striped bass. A considerable quantity of eggs (not less than two or three millions) is produced by a single spawner.

(9.) Separate, non-adhesive eggs provided with numerous long filaments like the ova of the sand smelt or Atherine (*Atherina hepsetus*, L.) which are very large, not less than $\frac{1}{10}$ in diameter, although the full grown fish is only five or six inches in length. Upon one side of the yolk ball there is a wreath of small oil globules; but the most distinguishing feature is the tangled mass of wavy filaments projecting from the external surface of the egg capsule. The egg is attached to sea weeds, corallines, and even to star fishes and sea-urchins, by means of these filaments.

(10.) Globular eggs sufficiently adhesive, when deposited, to cling to the bottom, or to adjacent objects under water, but never adhering together in large spongy masses. The Capelin deposits free adhesive eggs of this character. The eggs of the Gaspereau or alewife, a clupeoid which ascends rivers in May for spawning, deposits clear, glassy eggs, smaller than those of the shad and destitute of oil globules. Dr. J. B. Gilpin recorded the opinion that the spawning beds might be in lakes of some depth. "Although the salmon and trout are often seen spawning, I never met any one," he says, "who has seen the Gaspereaux in the act. So I suppose he spawns in deep water as we know he loves the deep lakes with clear sandy margins." Fields over-flooded in the spring are, however, often chosen, and as the eggs hatch in three or four days, the schools of fry usually reach the river channel before the floods subside. The female fish produces 60,000 to 100,000 eggs.

A similar egg is produced by the pike-perch (pickereel or doré), which readily adheres to adjacent objects when newly deposited. Each egg measures $\frac{1}{10}$ inch in diameter, and a yellow or reddish globule of oil is seated in the yolk. The eggs of the sturgeon, about $\frac{1}{10}$ inch in diameter, are enveloped in a tenacious gummy substance,

and no doubt, when deposited naturally they encrust the interstices of rocky ledges, gravel, stones, &c. Including their coat of mucus they measure over $\frac{1}{4}$ inch (3 mm.) in diameter. No observer appears to have discovered them on the spawning grounds, and lumps of sturgeon spawn are not known; but when artificially manipulated they readily form huge irregular masses and long ropes of an extremely adherent nature. Fishermen or others would certainly obtain such masses of sturgeon spawn did they occur in our lakes and rivers, but the eggs appear to be not found naturally adhering to each other. The tenacious matter hardens in about thirty minutes, and Prof. Ryder has recorded, "after that has occurred it is scarcely possible to detach them without injury to their delicate thin envelopes and their soft viscid contents. The sticky coating of the eggs finally remains as a grayish white, tough, slightly elastic covering enveloping the egg-membrane proper, and varies in thickness at different points on the surface of the ova."

If allowed to harden in round or irregular masses the inner eggs die rapidly from suffocation, and in our lakes and rivers the sturgeons' ova are probably deposited in thin layers. Indeed, it is found in handling freshly laid sturgeon ova that if a basin or tray be inclined only for a moment the eggs flow to that side and a coating of a single layer is formed upon the surface to which they have been so briefly exposed. They hatch in four or five days, but it is probable that a very large percentage perish annually on the spawning grounds.

(11.) This division includes eggs, which closely resemble in their tenacious character and general features, the last described yet a distinguishing point about them is the fact that they form clumps or irregular groups, rather than layers. The eggs are so attached to each other and to stones, weeds, shells and other debris, that they form a loose spongy mass, through which water freely percolates. Demersal eggs thus irregularly cemented together, exhibit the utmost variety of form, colour and distribution. They may be pale and translucent like the herrings eggs about the size of No. 7 shot or more dense and as large as peas (slightly less than a quarter of an inch in diameter, viz., 6 mm.), like those of the wolf-fish (*Anarrhichas*). The lump fish *Cyclopterus*, whose eggs are $\frac{1}{10}$ inch in diameter, and those of the trout or tom-cod (*Gadus tomcod* Walb), measuring rather less than $\frac{1}{30}$ inch in diameter, belong to this group. The eggs of the tom-cod have a conspicuous oil globule, and the thick adhesive shell is coated with an mucous cement enabling them to cling to sea-weeds, and stones inshore and below low-water mark.

(12.) Eggs of spherical shape and clothed in a distinct layer of soft mucous matter, which causes them to adhere to plants and foreign objects. Most of them contain numerous oil globules, and they are the type of ovum produced by some of our most familiar freshwater fishes such as the pike, maskinonge, white perch (*Roccus americanus*), the suckers (*Catostomidae*) and many allied Cyprinidae. The tenacity of the mucous coat is such that as one observer has said of the small adhesive ova of the white perch, they "may be hatched on threads which have been drawn through the freshly extended spawn, the threads being suspended in a hatching jar, through which water is kept flowing." The eggs in this group are frequently found to be deposited singly upon plants, submerged roots of trees, branches &c., and the adhesive coat instead of hardening under the action of water remains as a soft protective coat, which prevents many predacious animals from eating them.

One of the carp family viz., *Rhodeus amarus*, Bloch, by means of a long ovipositor, like a protrusible tube, places its eggs inside the open shell of pond-mussels. The familiar gold-fish deposits its eggs ($\frac{1}{10}$ inch in diameter) on weeds.

(13.) Eggs similar to the last are produced by the black bass of our lakes and rivers and the allied river sun-fishes (*Centrarchidae*), the bearded catfishes and other common fresh-water species. The eggs with their soft mucous coat cling together in masses and are generally placed in a nest of more or less perfect construction. They become attached by this viscid envelope of jelly to pebbles, twigs and weeds of which a kind of nest is usually constructed by the parent fish.

Mr. C. F. Holt, who described this nest in the case of the black bass (*Micropterus*), says:—

The places selected are in nearly still water, near the shore, and in water from one to two feet in depth.

The beds are circular in form, from eighteen inches to three feet in diameter, and are formed by cleaning from the bottom all sediment, sand, &c., leaving a bed of clean pebbles. This is the joint work of both male and female fish. The bed having been prepared, the female then moves slowly over it, depositing her ova, and the male impregnates them as fast as laid. The eggs, which are very small, are glued fast to the pebbles. The impregnation is almost absolutely perfect. In the past three years I have examined a large number of beds, by carefully removing one or more of the pebbles covered with eggs, and examining them with a microscope, and have never yet found more than one per cent of unimpregnated eggs.

After the eggs are impregnated the male leaves to the female the whole care of the eggs and the young brood. She now passes constantly backwards and forwards over the bed, the motion of her fin and tail keeping the eggs clean, which the fact of their being glued fast permits her to do without washing them away.

The catfishes (*Ameiurus* and others) construct a similar nest, over which the parent fish keep guard. The eggs, $\frac{1}{8}$ to $\frac{1}{2}$ -inch in diameter, and of a dull whitish, sometimes greenish colour are aerated by the male during the six or eight days occupied in incubation. The male hovers around the viscid mass agitating the water constantly with the pectoral, ventral and anal fins. The female fish remains near but takes no part in the work of protection. A recent writer in the "American Angler" refers to the nest in these terms:—

In laying their eggs, the parent catfishes select a spot where the water is quiet, if possible, protected by aquatic plants, and there they make a nest, perhaps eight inches by six, including the spawn.

The nest has a soft outer envelope, and over it the male hovers, forcing fresh water through the mass by rapid vibrations of his fins, until after about a week they are hatched.

The late Professor Ryder estimated in a nest of the kind just described that there were probably 2,000 ova covering a space eight inches by four inches. In each egg it has been found that the outside viscid layer is separated from an inner and extremely thin shell or capsule by a considerable space across which strands of elastic substance extend. This remarkable separation of the shell adds to the hardy nature of the egg by providing a cushion for resisting violence or injury. In the sea catfish (*Euriichthys*) the capsule is simple and unlike that just described.

(14.) A further and most interesting type of adhesive egg is that exemplified by the yellow perch (*Perca flavescens*). Each egg is globular and possesses a triple egg-shell, viz., a thin, delicate, innermost membrane, surrounded by a very thick, soft layer, stretched radially in a most remarkable way, and inclosed externally by a thin viscid layer. The eggs adhere together in the form of a band, like the egg-ribbon of the Angler (*Lophius*), except that instead of being flattened it has a bellows or folded angular arrangement, up the middle of which there passes a space allowing of aeration. These jelly-like bands, in which the eggs are massed like the cells in a honey comb, are heavy and often lie in the bottom of still water like a long hollow frill in a circular or semicircular form. They are 2 or 3 inches across and 12 to 30 inches long. Each egg exhibits a large oil globule, and when free from its jelly ribbon measures about $\frac{1}{4}$ of an inch in diameter.

Mr. G. P. Dunbar described the eggs of the Bill fish (*Lepidosteus*) as suspended in long ropes of thick jelly several inches in diameter and hung to old snags, roots of trees, &c.

(15.) Stalked or rooted eggs form a distinct group, and while all exhibit the common feature of a fibrous plate or facet of attachment, they vary in shape and structural details in the utmost degree. Thus the egg of the smelt (*Osmerus eperlanus*) is globular, but exhibits upon one side a coneshaped attachment or root, really formed by the splitting and inversion of the external adhesive membrane. J. T. Cunningham carefully studied the features of this peculiar conical attachment in a series of eggs, and his observations may be here quoted —

"They all possessed a kind of membranous appendage, and there were two or three which were suspended from the surface of the stones by means of this membrane, the

distal end of which had become attached at the moment of extrusion. In the free eggs no power of adhesion any longer existed. It was obvious enough that the membranous appendage is the so-called suspensory filament mentioned in the existing literature. But the word filament is a very inappropriate term. The membrane is flexible, and in the form of a hollow truncated cone, the sides of which are thrown into irregular folds; the narrow end of the cone is continuous with the envelope of the egg; the attachment between the enveloping and the suspensory membrane thus forms a ring on the surface of the former. Examination of the eggs in this condition does not afford evidence of the origin of the suspensory membrane. All that could be seen was that the suspensory membrane was dotted all over with pores of considerable size, and that the enveloping membrane was perforated everywhere by finer pores more closely crowded. The enveloping membrane is thus a zona radiata.

Examination of the eggs freshly pressed from the female gave the complete explanation of all the facts. These eggs were nearly, and some of them quite, mature. They are inclosed in a thick zona radiata, which is differentiated into two layers, the outer of which is somewhat thinner than the internal. In the zona radiata externa the pores are larger and farther apart than in the interna. The external zona separates very readily from the internal, and, rupturing at one portion of the ovum, peels off, becoming turned inside out in the process, and, remaining attached over a small circular area, forms the suspensory membrane. Slight pressure and rolling of the eggs by means of a cover-glass is sufficient to cause the rupture of the external zona, and the two membranes can be examined in all stages of separation.

If it be true that the ova of *Osmerus eperlanus* are during development, fixed to solid objects, it is in the highest degree improbable that the ova of *Osmerus mordax* are pelagic; but the adhesive nature of the eggs of the British smelt is beyond all question."

The speckled goby (*Gobius minutus*) has a pear-shaped egg, the black goby (*Gobius niger*) has an almond-shaped egg like a very minute oat-grain with a narrow stalk or root, while the general surface of the moderately thin egg shell is beset by wavy filaments of extreme fineness and on that account difficult to distinguish, even under magnifying lens. The pretty *Gobius ruthensparri* produces a small pear-shaped egg, not larger than the head of a pin, with the free end of the egg pointed and not blunt as is the egg of *Gobius minutus*. A curious egg is that of the small double spotted sucking fish (*Lepadogaster bimaculatus*) which is oval or egg-shaped but much flattened upon one side. On the flattened side a fringe of long hairs occurs, the purpose of which is to attach the egg to foreign objects, such as the inside of empty sea-shells. A single large colourless globule occurs in the fine y granular yolk. In 1885 an egg of this character was described by Professor Ryder. Its length was $\frac{1}{16}$ inch, about the same as that of *Lepadogaster*, which is a species occurring in tidal rock-pools, but Ryder speaks of his specimens as eggs of a fresh-water fish, probably a river sunfish or a cyprinoid, and they were procured attached to a piece of leather at Havre de Grace, Maryland, early in the month of May.

(16.) A group of demersal eggs, sufficiently well-marked, is formed of comparatively large demersal ova adhering in small irregular lumps, in the midst of which considerable interspaces and chambers occur. In their loose spongy character these masses differ from the more compact layers, and lumps deposited by fish like the herring. The most important feature in these eggs is the fact that they are laid in nests. These nests may be neatly built rounded masses of weeds bound together by tenacious threads produced by the male fish, or may be merely loose mounds of gravel and pebbles. The sea blenny (*Gastosteus spinachia* L.) builds a nest of seaweeds two to eight inches in diameter, and places in pocket-like cavities, these bunches of eggs, each egg about $\frac{1}{12}$ inch in diameter, and of a bright amber tint. The fresh water species (*G. aculeatus*) forms a similar like nest about half the size of a small lemon, composed of weeds and small stones bound together by strong threads of animal matter. The eggs are rather smaller than those of the marine species, and the separate lumps contain fifteen to twenty eggs and probably a total of two or three hundred eggs in each nest, agglutinated together as firmly as the ova of the herring. The ballan wrasse and other species are also credited with the construction of a nest; and these fishes usually are very solicitous

of the welfare of the fry when they emerge from the egg. Few fishes, however, exhibit much solicitude for their young, the eggs and fry being generally left to the tender mercies of their common mother, the sea.

The Chinese Gourami (*Ospromemus*), which has long been artificially bred and cultivated in Asiatic waters, and is stated to have excellent culinary qualities, builds a similar nest. An observer has described in detail the building of this structure and the following particulars may be here given:—

"In one of the corners of the pond, among the plants which grow there, the gouramis attach their nest, which is of a nearly spherical form, and composed of plants and mud, and considerably resembles in form those of some birds.

The nests, of course, vary in size in proportion to the fishes, but the usual size is somewhat less than a man's hand in length (about 5 or six inches). The fishes are employed some five or six days or a week in building, and their task is rendered easier, when the pairing-season has arrived, by placing in the water, almost at the surface, branches of bamboo (*Bambusa arundinacea*), to which are attached bundles of fine dog's-tooth grass. The gouramis take this grass, and with it form their nests in the branches of submerged bamboo, in a manner analogous to that with which the common silk-worm avails itself of the branch which is presented for it to make its nest on. When the nest is completed, the female deposits her eggs, which in a moderate-sized individual amount to about 800 to 1,000. After the eggs have been deposited and fecundated, and while they are hatching, the parents remain near, jealously guarding them, and rushing with vehement fury at any ordinary intruder near their domains, and thus they continue to guard the young for a time after they are hatched."

Of the nests composed of stones and pebbles, the nest of the Black-nosed Dace (*Rhinichthys atronatus*) may be selected as an example. It is recorded that the male and female fishes combine their efforts and after selecting a shallow depression one and a half or two feet across, they carry small stones and drop them upon the chosen site until a layer is formed. The female then deposits a layer of eggs upon the pebbles, and in this way a layer of eggs and a layer of pebbles are alternately formed until the depression is filled up, and a dome-shaped pile or nest results.

Chaetobranchius, a species allied to the Wrasses, builds a nest in which the eggs are protected, and the Gunnel (*Centronotus*) or Shore Butter-fish is said to deposit a small mass of eggs, not larger than a walnut in bulk, and the parent fish curls around the mass which is partly inclosed in a hole or depression, and thus keeps watch until the young hatch out.

(17.) A very remarkable group of fishes' eggs consists of those which are carried about by one of the parents until the young fry hatch out. The marine pipe-fishes afford interesting examples. The small sea-horse (*Hippocampus*) carries the eggs in a ventral pouch, the ova being arranged in regular rows down the front of the body, however, in *Xerophis* and *Syngnathus*, and covered by a somewhat transparent growth of the skin. The Indian *Solenostoma* shelters the ova between the ventral fins, an extension of the integument adding to the completeness of the egg-pouch for the reception and incubation of the eggs, which duty is performed by the female whereas in the three preceding species it is the male that does so. In the female *Aspreno* of Guiana, a fish allied to the North American catfishes, the eggs are found attached to the under surface of the female fish, extending from the chin to the tail. Even the fins have been found sprinkled with eggs, which are $\frac{1}{5}$ to $\frac{1}{12}$ inch in diameter, and protected by a cup of skin which becomes spongy and forms stalked capsules. Related species in Indian waters, *Arius*, for example, carry their eggs in the mouth and gills. The male performs the duty, and as the eggs are large, $\frac{1}{5}$ to $\frac{1}{4}$ inch in diameter, the breathing and feeding operations are seriously incommoded, though the palatine denticles aid in surmounting the difficulty. Some South American species, according to Steindachner, have a similar habit. The common marine pipefish (*Siphostoma*) develops a pocket in the skin behind the rudimentary anal fin, and a thick viscid mucus is formed, in which the lemon yellow eggs, $\frac{1}{3}$ inch in diameter, are imbedded.

The foregoing sketch, while it does not profess to be completely exhaustive, comprehends most of the types of eggs which have been described by scientific observers in

recent years. There remain excluded, however, certain fishes which never deposit eggs. One of these, the viviparous blenny (*Zoarces*), is not at all uncommon on our coasts, and has gained its name from its remarkable habit of producing living young. The eggs of this species—which, by-the-by, is in some parts wrongly called the eel pout—are retained within the body of the female, and there the young develop and reach a length of about two inches before they issue from the parent. Another form is the Norway haddock (*Sebastes*), but its young on extrusion are small. Some of the shark tribe are also viviparous; but the peculiarity is one very uncommon amongst bony fishes.

Certain small marine fishes, the Embiotocidae, the shore sun fishes which occur in marine rock pools, and some of the Scorpaenidae produce, like *Sebastes norvegicus* above mentioned, three to twenty young about five months after the act of fertilization. The cave fishes (*Amblyopsidae*) are also viviparous; but this feature is a far from common one.

Continued researches by diligent scientific workers will add to our knowledge of fishes' eggs, and much remains to be done in this field of study. But the above seventeen groups comprise all the essential types which experts have distinguished.

III.

THE PLACE OF CARP IN FISH-CULTURE.

BY PROFESSOR EDWARD E. PRINCE, COMMISSIONER OF FISHERIES FOR CANADA.

Fishery authorities are very far from being agreed concerning the merits of the German carp. The mediæval monks of England esteemed it highly, and after its introduction into English waters from the continent of Europe, in 1514 by Leonard Marchal, a carp pond was considered a necessary adjunct to every monastic establishment. German carp appear to have been brought across the Atlantic in 1870, and were first planted by Mr. Poffe, a Californian pisciculturist in his ponds in Sonoma. Six years later the United States Fish Commission followed this step up, but without success as the fish died in transit; but in 1877, a successful shipment was made, and since that time carp propagation has been very extensively carried out. There has, however, been no unanimity in regard to the claims of carp to attention, and the wisdom of their introduction into the waters of this continent has been seriously questioned. These waters were already peopled by the closely allied family of suckers and carp-mullets, the various species of which, though not highly esteemed as food, are superior in edible qualities to the foreign carp.

In the report of the Department of Marine and Fisheries for 1895, I briefly indicated my views upon this matter in the following words:—

“One word of warning is necessary in view of a common opinion that German carp and other coarse fish merit the attention of fish culturists. In pure and prolific waters, such as those of Canada, abounding in trout, salmon, and all the highest grades of fish, it is claimed these lower inferior kinds are a positive curse and injury if introduced. They increase fast and survive under the most unfavourable conditions; but their propagation in Canadian waters is little short of a crime, and entails the destruction of food upon which the finer indigenous kinds live, and the crowding out of the splendid fish native to our rivers and lakes.

“Even of the higher kinds, the Salmonidae, there are species and varieties which should be regarded with disfavour, especially those from the continent of Europe. German and Austrian trout, full of the germs of disease, should not be hastily introduced.”

I see no reason for modifying this unfavourable view, and after fully considering all its bearings, as an expert, it appears to me to be injudicious and erroneous to adopt the policy of peopling our waters with fish having the qualities and habits of German carp. Inquiries respecting carp-culture and applications for the eggs and fry of carp constantly reach the department, and a concise statement of the points, favourable and unfavourable, which have been raised by fishery authorities, and a brief reference to the claims of German carp to the attention of Canadian fish-culturists, appear to be very opportune.

Unlike the principal fish native to the waters of the Dominion, German carp are not essentially sweet and wholesome, but require, as all carp culturists are aware, to be transferred after capture to clear running water to rid them of their characteristic muddy flavour. Carp require to be seasoned and stuffed and subjected to more or less elaborate cooking methods before being served up at the table. The salmon, trout, whitefish, bass and other finny inhabitants of our lakes and rivers require no such elaborate treatment—an undeniable proof of their superiority. The wandering habits of the carp also detract from its desirability. It is impossible to retain them within reasonable limitations, if by any means they obtain freedom for migration. Our native fish, such as the salmon, the lake trout, whitefish, pickerel, etc., have definite courses. Year after year they follow practically the same line of migration, though winds and

storms may cause them to deviate to some extent; yet they unflinchingly make for their accustomed spawning grounds and resort, season after season, to their recognized feeding localities. Fishermen are so well aware of this that it is possible to set nets (gillnets, pound nets, traps, etc.), directly in the track which they are accustomed to follow. Certain points are known to be better than others for intercepting the fish, and some net-locations are, therefore, far more valuable than others. It is not so with the carp, which wander from one side of a lake or river to the other in the most erratic, uncertain way, and wander into every sheltered creek or muddy inlet. Localities in which they have never been planted may thus become crowded with these wandering intruders. On Lake Erie and in the St. Clair waters, Canadian fishermen complain of the abundance of these inferior fish, which were planted in localities distant from these areas, but have so widely spread that in some seasons the nets set for better kinds make large captures of these less valuable fish. They spawn everywhere, and it is probable that they spawn more than once each season. They increase with remarkable rapidity and crowd out the native species. "It is my experience," wrote Roger North, one of the earliest of British pisciculturists, "that most waters, the first year after having lain dry a summer, do breed, and that numerously, especially carps, which I have known increase to such an incredible fry, that I have been troubled how to dispose of them."

Of their rapid growth, a recent United States writer has said:—

"The growth of this fish is even more remarkable than was at first supposed. Recently, in letting the water off of a pond constructed by the late Dr. Geo. R. Dennis, in which, just a year ago, he placed some carp about an inch long, it was found that six carp taken out weighed and averaged a little over three pounds each. About a month ago a carp was caught, which escaped from the pond of Dr. I. L. Adkins, and which had been placed there two years ago not more than an inch long. When weighed it carried the scales down at six pounds. And so numberless examples might be given of cases where the growth is shown to have been from twelve to fifteen inches in one year, and the weight to have been from comparatively nothing to two and even three pounds in the same length of time."

Notwithstanding the serious objections to the planting of carp, either indicated above or more fully stated on a subsequent page, it must be admitted respecting the carp:—

- (1.) That it has a certain market value in the United States markets, and is regarded by some persons as a fish possessed of edible qualities.
- (2.) That there are inferior waters well adapted for carp-culture.
- (3.) That the fish are hatched and reared with comparatively little difficulty.
- (4.) That they are very prolific and grow rapidly on very coarse food.
- (5.) That some anglers have found carp-fishing to be an enjoyable pastime.

It cannot be questioned that carp-culture may be commendable in some countries and in the sluggish waters of Central Europe, of Germany, Austria and other lands, carp are cultivated with as much care and industry as fowls or ducks, but while there are enthusiasts like the late Professor Spencer Baird, who held that in the future the carp would come to be regarded as of high importance as a commercial fish, yet the general trend of public opinion has not been strongly in its favour. Professor Baird, it is true, mentioned especially the waters of the Southern States, and in these remarks it is, of course, to be borne in mind that the waters of Canada are alone kept in view, and the criticisms here set forth apply, therefore, to proposals only for extensive planting of of German carp in the Dominion.

In England the carp has never been highly esteemed for its food qualities, and in Scotland and Ireland it is practically unknown. In the United States on account no doubt of the large German population in some of the great manufacturing centres, the demand for German carp has in some seasons been quite considerable and examples like the following may be quoted in proof of its economic value though not in full accordance with other views published upon this point:—

"Many carp have been caught near Easton and eaten by the citizens of that community, and in every instance they have been pronounced a fine food fish. Your commissioners are particularly gratified to note an increase of interest on the part of the

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people in this fish. They have been advised that the citizens of Queen Anne county have, in many instances, purchased a supply for their ponds from Richard Hollyday, of that county, who was one of the first citizens in the state to build ponds and embark into carp-culture. Another year or two will prove that this venture will be as profitable to him as his wheat, corn or peach crop, in proportion to the labour, time and money spent upon it (Maryland Fish Commissioner's Report., 1883).

There is no doubt, however, that the culinary merits of German carp have been exaggerated, and that the authorities who heralded its introduction, with high hopes, have slowly realized that these hopes were not entirely fulfilled.

As to their qualities as table fish, there are contrary opinions. Some hold that they are a superior table fish, and others count them poor and insipid. Probably their quality largely depends upon the care that has been expended in rearing them. A chicken brought upon short commons is poor meat indeed. The same animal, properly fed and nourished, is a luxury that all delight in. Doubtless a poor, half-fed, half-grown, neglected and bony carp will not make an attractive dish; but if raised according to the manner of his native country, he may be fat, flaky, and possibly delicious. It is certain that in Germany they are rated a standard fish, and are in more general use than any other. A gentleman who has seen much of them in that country has recorded the fact that hotel keepers like them because they are cheap and their customers eat so little.

Some states after spending considerable sums of public money on carp-culture have resolved to discontinue it, and in certain cases have decided to devote such money in the future to the work of extirpating and destroying these fish. The *Canadian Fishing Gazette* (Selkirk Record), in December, 1895, published the following comments on the matter:—

"A few years ago many people in the United States and Canada went crazy over the introduction of carp. Hatcheries all over the Union raised and distributed them, and the Canadian hatcheries were blamed for not giving the fry to the public. The Fish Commission's report of the state of New Jersey will show what carp are. It is a blessing they were kept from Canadian waters, and there ought to be a heavy fine for any one planting them in Canada. A dispensation has been granted to fishermen to take carp out of the streams by net under the watchful eye of the wardens, who have seen that no food fish were appropriated out of season. The carp is regarded as an enemy of food fish and a general piscatorial nuisance. The commissioners officially say that the introduction of carp has been attended by nothing but evil results, and that of the most aggravating kind, as this fish destroys the clearness of the water and eats the spawn of valuable fish. The law against the liberating of carp has not been enacted too soon, and the wardens are watching that none are being put into the streams. Other states are seeking, but New Jersey has experimented and decided against the foreigner, who seems to thrive in Jersey waters."

The state of Ohio, like that of New Jersey, has concluded to deal with the carp question vigorously, but not without protests from journals such as the *New York Fishing Gazette*, which, towards the close of last year, remarked:—"The Fish and Game Commission of Ohio propose among other things to wage unceasing war against the carp, in spite of the fact that this species of fish has become recognized as one of the most valuable food fishes taken in fresh water. The reason given for this move against the fish is that it preys upon the young fry of other species of fresh water fishes. Just as if those same other fishes do not devour the smaller fry of their own species. It is not known how the fishermen who have in times past made their living in the carp fishery regard the proposed move of the commission. It is to be hoped, however, that they will not allow the destruction to proceed without first making a vigorous protest against such action. There is one thing in their favour, too, and that is that the carp will need a lot of destroying before it becomes extinct."

While it cannot be denied that carp have a certain value in those markets where inferior kinds of fish are in demand, the fact nevertheless remains that Canadian waters are perfectly adapted for all the higher grades of fish. These superior kinds not only have a claim to preference on economic grounds as articles of food, but also in most cases on grounds of sport. Fish, like salmon trout, black bass and others which add to

their excellent table qualities, the finest characteristics of game fish are entitled to principal consideration and the culture of carp, if in any inimical to these sporting, fish should be discountenanced. The famous angling authority, Mr. W. C. Harris, editor of the *American Angler*, N.Y., U.S.A., refers in the following trenchant manner to the question of the introduction of German carp :—

"Under no circumstances place carp in your waters. They are worthless both as edible and rod fishes. They are also destructive of the spawn of other fishes, and if your streams or ponds are frequented by wild fowl the carp will soon drive them away by eating the sprouts of all vegetable growth upon which wild fowl feed. If you have the carp already with you, seine, catch, kill and poison them out. The United States Government has spent thousands upon thousands of dollars to introduce them, and the sportsmen of the country would be willing to be taxed an equal amount that the carp might be exterminated."

Perhaps it is a fortunate circumstance that in Canada many of our waters are not the most suitable for this fish. It may be said as Superintendent Nevins, of Madison, Wisconsin, U.S., wrote of the Wisconsin waters :—

"Our streams are either too rapid or too cold for them to permit a speedy growth, even though other conditions were favourable. It is useless to undertake to grow carp where there are other fish. The carp must be cultivated in ponds expressly built for them, and those of different ages must be kept by themselves."

The water that is preferred by them is such as is preferred by frogs. In water that is stagnant and has plenty of vegetation they will thrive and do well, or they can be fed the same as hogs with cabbage, potato peelings or boiled corn.

The California Fish Commission (1894) while admitting that carp had proved disappointing as an addition to western food resources, yet adduced an ingenious plea that they would prove good food for better kinds of fish :—

"The development of the carp, which, like the catfish, do not take, with our people, the rank accorded them in the eastern markets, has been large. Of these fish 66,100 pounds were marketed in 1892, having a value of \$2,204. They probably never will figure largely in the value of our fish products, but they have proved of the greatest value as a food to striped bass."

The hardy nature of German carp has been urged in its favour, although some competent authorities have declared it to be easily and detrimentally affected by extremes of temperature. Experiments have proved that few kinds of fishes are so tenacious of life, and that changes which would prove fatal to better species have in their case proved harmless. They have been frozen rigid and thawed out again, they have been subjected to temperature almost as high as boiling point, and in every case they survived. In the tepid waters of Hawaii the foreign carp have flourished, and in the absence of better fish, have become of market value. When taken out of the water they will live for long periods if wrapped in damp cloths or cool moss. In Germany and Holland it has long been the practice to fatten carp upon bread and milk, the fish being suspended in nets in cool cellars and kept damp. In form they are coarse and far from graceful, yet on account of their lack of timidity and their hardy character they are very suitable for exhibition purposes in ponds or aquaria. They live and grow rapidly under cramped and unfavourable conditions. A United States authority, connected with one of the State Fish Commissions, reported that : "for several years they had bred quite a number in the fountain, which served the purpose of affording pleasure and amusement to visitors, as well as increasing the supply. Sometime in July the park policeman, who fed them daily, meeting the writer in the street, said : 'There is quite a number of young fish in the basin. I wish you would come over and see them ; I believe they are young carp.' I replied that that was impossible, as there was but one large fish there, and that a male, but would go over and see them. Judge of my surprise when I found thousands of young carp there from one and a half to two inches in length, the product of carp then only one year old. The young will now aggregate many times more in weight than the original fish, and of extraordinary size for their age, five to six inches in length. The carp were taken out and loaned to the Interstate Industrial Exposition at Chicago, where they now are. Since the above mentioned

experience we have not been so ready to doubt the statements of quite a number who have repeatedly written us that their carp had spawned at the age of one year."

In spite of their hardy character, their tenacity of life, facility in feeding and rearing, and, at times, their ready sale amongst certain classes of the community who are not fastidious in their tastes, it is doubtful if there is justification for introducing these fish into Canadian waters not at present inhabited by them. The following considerations are certainly of weight and should be given attention by all who are interested in fish-culture.

(1.) The waters of Canada being as a rule pure, cold and in every way adapted for our native fish, and the superior edible species such as the introduced English brook-trout, the Loch Leven trout, &c., it is the less necessary or desirable to cultivate inferior kinds especially as the so called coarse fish native to our waters (suckers, pike &c.) are admittedly superior in quality to German carp.

(2.) German carp are nomadic in their habits, and wander apparently aimlessly into all accessible waters, hence if introduced into any streams or ponds adjacent to and connected with others, these fish will rapidly spread over the whole system. Salmon, trout, whitefish, pickerel or doré, indeed all our native fish are more local in their wanderings and as a rule have definite courses of migration, and confine themselves within recognized limits. The German carp has no such defined movements or habitat, thus Lake Erie, the St. Clair waters of Western Ontario, Lake Huron and other Canadian areas are being overrun by these fish, which have wandered from the more or less remote localities in United States territory where they were originally planted. Like undesirable weeds they spread everywhere and it is practically impossible to limit their progress or to effect their extirpation. Dr. Eugene Smith referring to this difficulty in rooting out these fish says: "The carp family have a pronounced tendency to burrow in the mud at the bottom of streams, and can live there for some time, so that it is hard to eradicate the carp from any particular body of water without thoroughly draining it off."

(3.) They are voracious and omnivorous. Their voracity may be judged by the great size they rapidly reach. They have been known to grow a foot in length in nine or ten months, and it is authentically recorded that a German carp in the state of New Jersey grew in three years to a weight of thirty pounds. The carp may be compared to the hog amongst quadrupeds, both in respect to its fattening capabilities and its coarse and repulsive tastes. This opinion, indeed, I find to be expressed in terms almost identical with the foregoing, by the New York Fish Commissioners, in their report, in 1881. In this report they say: "The carp tribe stand in the fish family much as the hog does among quadrupeds. Confine the latter in a pen and steadily respond to his cravings of appetite and he will increase in flesh and multiply in fat to an extent which will reward the care of his owner. Similar treatment applied to the carp, changed only to suit the different element in which he lives, will make him a productive and profitable fish."

Their natural food appears to be insects, frogs, the spawn of other fishes; but they devour offal, or, indeed, anything edible, either animal or vegetable. A vegetable diet is as acceptable as any other, and wild rice, water plants and the like are voraciously eaten by German carp. "The destructive nature of the carp to the spawn of nobler fishes," says a distinguished authority, "and to the vegetation upon which wild fowl feed should act as a caution signal in the introduction of foreign species of fish in American waters." In connection with this charge, a western, U. S., paper tells of a rancher's visit to Portland, Oreg., to sue for damages he had sustained from the introduction of carp, he wished to find out whether he had recourse against the United States fish commission for the introduction of carp into the rivers of this section. He says these fish are destroying his meadows by eating his grass and grubbing up the roots. As the water overflows his meadow the carp follow it up in thousands, the small ones weighing about three pounds pushing their way up where the water is only three inches or so in depth and clearing off all vegetation, so that when the water recedes he will have mud flats in the place of meadows.

Buckland in view of this herbivorous habit recommended that at times the water should be run off carp ponds and grass seed sown on the mud and the edges, "then let the water cover the grass," he said, "and it will afford excellent pasture for the carp."

(4.) Their market value can never be great in Canada. For many seasons our Lake Erie fishermen have been taking large quantities of German carp, which have wandered across from their haunts on the United States shores. Thus off the south Essex shore, (Ont.), individual pound nets occasionally take two or three tons of carp at a single catch. In many cases personal questioning has elicited the information that the fish were found to be so worthless and such a drag in the market, that they had to be buried on shore in order to get rid of them. Certain public bodies in order to shield themselves from severe criticism have exaggerated the value of these fish, and the demand and sale for them. No doubt the markets of Chicago or New York, which are not regarded as the best or most remunerative by fish buyers, shipments of carp find sale amongst Russians, Jews, and other foreigners to whom trout and the best kinds of fish are practically unknown. The demand for carp must, however, be limited, while the demand for salmon, whitefish, trout, &c., is in reality unlimited. The economic value of carp as a permanent element in the fish markets of this continent is problematical. They no doubt have met a demand in markets, which the great fish buyers have termed the "dumping ground" for the fisheries; but in the best markets of Canada and the United States, German carp will never be esteemed or demanded. A division of opinion amongst fishery authorities on this side of the Atlantic, has existed every since German carp have been imported. The late Professor Spencer Baird was somewhat hopeful and enthusiastic, but the plants of carp fry allocated under his personal supervision were not always received with confidence. Everywhere can be found views like those expressed by the fish commissioners of the state of Nevada (1887):—

Professor Baird also very kindly presented me with 295 young carp from the United States fish ear, all of which have been distributed to the best advantage possible. While fully appreciating the generous courtesy which prompted the gift, and gladly acknowledging our obligation to the donor, I feel it my duty to say that my observations have not impressed me favourably with the qualities of these fish. They multiply rapidly and attain a considerably size, but in my judgment they are not what can be fairly called a good table fish. I regard the Lake Michigan whitefish as being in every way superior.

5. They live upon the food of better fish, and propagate so fast that they prove injurious and even destructive to the higher kinds. It can be proven that whitefish and the yellow pickerel have been starved out and crowded out by hordes of hungry carp. Not only so, but it has been shown that other kinds forsake their usual haunts, and are in fact driven out by these foreign intruders. Recently the carp has been planted in Lake Michigan near Chicago, and competent authorities, including practical fishermen, hold that other fish will be driven out of these waters.

6. They ruin the waters which they frequent by destroying vegetation, rooting up the marginal banks and by disturbing the bottom. Ponds and waters which were clear and exhibited a hard bottom have become discoloured and "roily," and the bottom soft and tenacious by the grubbing actions of the carp. Such ponds have been changed into disgusting mud puddles. A Kansas authority who carries on private fish-culture operations recently wrote of the carp:—"The carp is a fussy fellow, and when not trying to pick a fight with some of the other denizens of the pond, is ploughing up the mud along the bottom of the waters and constantly keeps the pond in a roily and unpleasant state." The ill effects of carp upon other especially high grades of fish cannot be exaggerated.

7. They are destructive spawn eaters like all the tribe of sucking fishes. No spawning ground is safe from their attacks. There are predacious fish like the pickerel or doré, the pike, the salmon trout, &c., but these fish have their special haunts and the spawning grounds of whitefish and other kinds do not usually suffer seriously from their depredations. Not so with the carp. It has no favourite or special haunts, and every spot where fish eggs or other edibles are to be found will hardly fail of a visit from these marauding poachers. "I am quite certain," said the late Mr. Buckland, "that carp will eat their own eggs and very probably their young." No doubt this charge may

be made against many fishes, but the peculiar roving tendencies of the carp make it especially injurious, as few deposits of spawn can escape its inquisitive search.

(8.) German carp are especially subject to parasites and contagious diseases. From their omnivorous and lethargic habits no fish are so readily attacked by diseases and parasites as carp. The "fish leprosy," described by Blake as a fungoid growth which spreads over the whole skin, turning the fish white and rendering it most unhealthy and a source of disease to all other fish, is essentially a disease of the German carp. Frank Buckland studied some of the diseases of these fish, and amongst others enumerated one malady which he called small-pox in the carp.

Tapeworms and other disgusting endo-parasites occur most plentifully in carp. One described by Harrington Keene taken from a carp of 16 pounds weight measured no less than 45 feet in length. Of all fresh water fishes the German carp are the most subject to external and internal diseases. This is, in fact, unavoidable in a family like the carps, with sluggish habits, a fondness for coarse and loathsome food, and a preference for muddy and almost tepid waters.

Whatever may be urged in favour of the carp, and, as already indicated, some considerations of weight have been put forward by various authorities, it cannot be questioned that the points unfavourable to carp-culture, so far as Canadian waters are concerned, deserve serious attention. Certainly no fish culturist should determine to introduce these fish or set about artificially rearing them without fully considering the grave possibilities associated with the raising of German carp.