BRITISH SALT WATER FISH

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BRITISH SALT-WATER FISHES

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BY

F. G. AFLALO

AUTHOR OF "SEA FISH"

WITH A CHAPTER ON THE ARTIFICIAL CULTURE OF SEA FISH BY

R. B. MARSTON

EDITOR OF "THE FISHING GAZETTE"

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It is not every one who has the taste, capacity, or leisure for the scientific study of Natural History. But there are few persons who do not feel that some knowledge of the processes and products of Nature increases the enjoyment of country life. To supply this knowledge in a form at once easily assimilated and scientifically accurate is the object of the Woburn Series of Natural History.

Each subject will be treated by a writer who has made it his special study. In this volume, therefore, as in all the succeeding volumes, the writer speaks for himself, and the Editor has not attempted to impose his own opinions on those who have been asked to contribute to the series.

Bedford

PREFACE

The study of life in the seas has a practical bearing on British industrial supremacy that cannot perhaps be claimed for any other branch of zoology, for the arts of the stock-breeder and poultry-farmer have long since passed out of the domain of the laboratory into that of technical education. In our sea-fisheries, however, we have a great industry, already marvellously developed during the past fifty years, and capable, with proper care, of yet further growth and improvement in the near future. More and more is the administration of this industry dependent on the researches of the marine laboratory. The causes which lead to fluctuations in the supply by prompting irregular and hitherto immeasurable migrations of important fishes from one coast to another; the meaning of "over-fishing" and the nature of the measures necessary for its control; the difficulty in obtaining bait,—these and other problems it is the business of the marine biologist to solve. This, the fifth volume of the "Woburn Library," makes no pretence to throw any new light on these matters. All that has been attempted is to summarise the habits and appearance, the distribution and the migrations of every fish yet described as "British." Even before it is in the hands of the public there may be new species in the British list, for only while the last sheets were passing through the press our gobies were enriched by the discovery in Cornwall of a species larger than any hitherto admitted as belonging to this country. Too late for insertion in the text comes information (in the *Journal of the Marine Biological Association*, December, 1903) of the discovery of a new British rockling (*Motella fusca*). Messrs. Garstang and Balfour Brown omit to say on what part of the coast it was taken, but it is mentioned as having been found on the shore under a stone. That makes the second new fish added to the British list during 1903. Another recent addition to our knowledge of sea-fish is in respect of the grey mullets. Mr. Boulenger now recognises three British species, *Mugil chelo*, *M. auratus*, *M. capito*. It is, however, probable that, so far as the economic food-fishes are concerned, the list will for many years at any rate remain as it is, although, as the more esteemed kinds, like the sole, are gradually exhausted by the trawl, it is possible that, until at any rate artificial re-stocking has been raised from the domain of speculation to that of practical economics, other kinds of fish will be pressed into the service of man. It is, in fact, well known in the fish trade that many kinds formerly thrown overboard as offal now find their way to the tables of the polite, and this alone shows the need of knowing something about the smaller and less familiar denizens of our seas.

On the question of our fisheries the author has dealt in another work, and it has here been thought proper to devote only a single chapter to the methods by which sea fish are caught for the market. That done, they are no longer the concern of the biologist, for the problems of their transport inland then occupy the legislator on other grounds.

It is in the nature of an island kingdom like ours to have more than its proportionate share of seaboard, but, even making due allowance for this advantage of geographical position, it will be found that British seas harbour a marvellous abundance of fishes. How little is known of these by the ordinary citizen may be gathered from the probability that ninety-nine out of every hundred doubt that real sharks of great size occur within a mile or two of our bathing-stations, and any one stating as much would be abused as an alarmist. With not far short of two hundred species to notice, it has obviously been necessary to adopt some plan of treatment differing in degree of detail from that projected in those earlier volumes of the library, which dealt with the smaller groups of our mammals and fresh-water fishes. Even apart from the necessity for such compression, it must frankly be admitted that neither the limited extent of our present acquaintance with many of the fishes found in our seas nor the slighter personal interest which they have for sportsmen or amateur naturalists would have warranted any longer account of their life-histories. The more important, such as the mackerel, cod, and herring, have, as will be seen, been dealt with in some detail, though even in their case it is impossible to write with the same facility as, for instance, Sir Harry Johnston might employ when writing of the red deer, or as Sir Herbert Maxwell would command in treating of the salmon. When the Marine Laboratories at Plymouth and elsewhere have left another ten years of useful research behind them, those who make it their business to transcribe their erudite memoirs in commonplace language for the information of the public may have a different story to tell, but at present the biographer of our sea fish finds himself continually thwarted by missing clues and unsolved mysteries.

The author has to tender his best thanks to Dr. E. J. Allen, Mr. G. A. Boulenger, Professor Herdman, and many others for considerable assistance, while he cannot speak too highly of the patient labour which Miss F. Seth has devoted to the illustrations.

F. G. A.

CONTENTS

CHAPTER I

PAGE

GENERAL FACTS ABOUT SEA FISH 1

CHAPTER II

OUR FISHERIES: THEIR PRACTICE AND THEIR CONTROL 53

CHAPTER III

THE SHARKS AND RAYS 84

CHAPTER IV

THE BASS, BREAMS, AND RED MULLET 114

CHAPTER V

THE MACKERELS, HORSE-MACKERELS, AND ALLIED FORMS . . . 129

CHAPTER VI

THE GURNARDS, BULLHEADS, AND WEEVERS 144

CHAPTER VII

THE GOBIES, SUCKERS, AND BLENNIES 154

CHAPTER VIII

THE CONGER EEL 176

CHAPTER IX

PAGE

THE GREY MULLETS AND ATHERINES 184

CHAPTER X

THE WRASSES 190

CHAPTER XI

THE HERRING FAMILY 198

CHAPTER XII

THE FLAT-FISHES 211

CHAPTER XIII

THE COD FAMILY AND THE SAND-EELS 242

CHAPTER XIV

SOME RARE OR UNCOMMON FISHES 270

CHAPTER XV

THE CULTIVATION OF SEA FISH 299

INDEX 310

LIST OF ILLUSTRATIONS

		PAGE
BLUE SHARK	*Facing*	94
THORNBACK	,,	106
BASS	,,	114
RED MULLET	,,	114
MACKEREL	,,	114
JOHN DORY	,,	138
RED GURNARD	,,	148
LUMPSUCKER	,,	164
GREY MULLET	,,	184
STRIPED WRASSE	,,	184
PLAICE	,,	218
TURBOT	,,	230
COMMON SOLE	,,	238
COD	,,	244
WHITING	,,	244
THREE-BEARDED ROCKLING	,,	264
ROWHOUND	,,	264

SALT-WATER FISHES

CHAPTER I

GENERAL FACTS ABOUT SEA FISH

FISHES may, for present purposes, be described as cold-blooded, backboned animals that live in water, breathing by gills which are retained through life and attached to arches of bone or cartilage. The limbs are known as fins. The outer covering of the body consists, in the majority of cases, of scales, but these may be absent, or replaced by bony plates or rough tubercles.

Such is a very brief definition of the members of the class. It must, even to the most superficial observer, be obvious that the fishes of our seas, rather less than two hundred in number, have some characters in common. They all have a backbone, or skeleton, of either bone or gristle. In this they resemble ourselves. They differ from us, however, in that they reside in water, have cold blood, and oxygenate that blood by bringing it in contact at the gills with continual currents of sea-water holding atmospheric air in suspension. Frogs come in this respect between us and the fishes, for they breathe with gills when young and with lungs when full grown. Scales are a distinctive character of the majority of fishes, but reptiles also have scales, of somewhat different formation. Some fishes, on the other hand, have no scales, while in others they are minute and all but buried in the skin. Nor can fishes be defined as a class on the basis of their manner of reproducing their kind. The majority of our fishes, it is true, accomplish this, like frogs, by depositing spawn ; on the other hand, several of them, belonging to at least three widely separated groups, bring forth the young alive. Even the residence in salt water and the manner of breathing with the aid of gills are not sufficient, either separately or in conjunction, to distinguish the fishes from other classes of animals. The whale, the porpoise, and the seal live in the sea, but they are warm-blooded mammals, and they breath the air direct with lungs. The lobster and shrimp, which are crustaceans, and the oyster and the squid, which are molluscs, live in the sea and breathe with gills, but they have no backbone. Neither have the anemones and medusæ, and not even the vernacular use of the word " fish " in such compounds as star-fish, jelly-fish, or shell-fish, deceives many people in these days of universal knowledge. The last so-called " fish " to retain their hold as such on the popular belief were the lamprey and hag-fish, and indeed it is with some hesitation that the writer has excluded them from this volume. At the same time, it was felt that they were fish-like rather than true fishes, and that including them would have involved a detailed explanation of anatomical divergence unsuited to the scope of these pages.

If we desire to select some character that shall be constant in all fishes, from no matter what portion of the globe, from fresh waters or salt, we are restricted—so far, at any rate, as external features go—to the organs of locomotion known as fins, otherwise the limbs of the fish.

The ceratodus of Australia, with allies in South America and Central Africa, has a development of the air-bladder which is virtually a lung for use at those dry periods of the tropical year when water fails and the gill-breathing apparatus would be ineffectual. The common conger-eel has no scales. India and other countries contribute to our museums fishes that were during life capable of living for considerable periods out of water. It may be questioned, however, whether any true fish ever brought to life will be found to lack true fins. They may be small, or even atrophied; but in some form or other, allowing for all possible variation in size and number, they will be found to persist.

The fishes of the world are divided into a number of sub-classes, the arrangement differing slightly according to various authorities. One of these contains the aforementioned lung-fishes, and to another is relegated a curious form, the "bichir" of the Nile. These, being without representatives in our seas, need not further occupy our attention. If from the rest we eliminate the Arctic chimæra and sturgeon, both of which forms are briefly described in Chapter XIV., we have to concern ourselves in these pages with only two great groups—the comparatively useless cartilaginous fishes (*Selachii*), which include the sharks and rays, and the variously valuable bony fishes (*Teleostomi*), which include, with the exception of a few rays, all the fishes which commonly find their way to our tables. Before proceeding further to examine briefly some of the leading characters and habits of our sea fish generally, it may be as well to distinguish unmistakably between these two great groups. For this purpose, let us distinguish between a typical representative of either, the bass (*Labrax*) standing for the bony fishes, the tope (*Galeus*) for the sharks.

The bass has a bony frame, and its body is covered with silvery scales that are easily detached from the tough skin. The tope has a skeleton of gristle, or cartilage, and its skin has no silvery scales, but is granulated, like sand-paper, with a tooth-like covering. The gills of the bass, four in number on either side, open into one cavity protected by bony gill-covers. Those of the tope, which number five on either side, and are supplemented by holes called "spiracles," open separately on the side, showing five distinct gill-slits unprotected by any covers. The tope is able to close its eyes by drawing up the lower lid, rather like the shutter of some cameras, but the bass has no such power. The tope has curious arm-like organs, known as "claspers" and associated with reproduction, and it brings forth its young alive. The bass has no such "claspers," and it deposits floating eggs, which are fertilised in the water and which hatch out in the course of a few days. Other examples might perhaps have been selected from the sharks, even of our seas, which would at first sight have presented a series of contrasts less striking. Thus, had we chosen the rowhound (*Scyllium*), we should have found that it so far resembled the bass in depositing eggs and in being unable to close the eye. Had the blue shark been selected as the type of cartilaginous fishes, we should have found no distinguishing spiracles on the head to assist the breathing of the gills. In the main, however, the two fish above named serve the purpose of contrasting the two groups, the bony and the gristly. The former, as already mentioned, include practically all our table-fish—the cod, salmon, sole, whiting, mackerel, herring, eel; the latter comprise among eatable fishes only a few rays and, in addition, all the largest rays and fiercest sharks. These scavengers of the ocean scour every depth in search of dead or living prey, the sharks for the most part near the surface, the rays at the bottom. To this rule there are, however, well-marked exceptions, for many of the largest sharks prowl at the bottom, while some of the giant rays feed close to the top of the water.

It is not intended that the systematic classification of fishes shall occupy many lines of the present chapter. Not too much importance need be attached to even the latest recognised arrangement, that of Mr. Boulenger in the *Cambridge Natural History*, though perhaps more excellent than any of its predecessors. The fact is that the systematic grouping of fishes, like that of birds, is subject to somewhat frequent modification. Nature knows no such abruptly demarcated sub-orders and families and genera, which are, with their scientific names, a matter rather of convenience for the collaboration of ichthyologists of all nations. Were it not for some such understanding, it is dreadful to think of the loss of time and labour that would necessarily be involved in such an undertaking as the forthcoming international investigation of the North Sea.

Those who have made it their business to arrange and rearrange the fishes in families, genera, and species have relied upon more or less well-marked characters, such as the presence or absence of sharp spines in the fins. This system has its advantages, but the differences of opinion among those qualified to pronounce on such matters have been somewhat disconcerting to the student. Even in naming the fins, Mr. Cunningham and a few other modern workers deliberately depart, as will presently be shown, from the older nomenclature ; and such a course, whatever evidence it may afford of originality, is most distressing when it becomes necessary to compare the statements of different authorities. As to arrangement of the families in order of precedence, writers on fishes show as much diversity of opinion as ornithologists. Just as some of the latter give precedence to the birds of prey, while others prefer to open their treatise with the crows and thrushes, so does Couch commence with the sharks, while Day gives first place to the perches ; and the authors of the sumptuous volumes on the *Scandinavian Fishes*, so frequently alluded to in the following pages, open their account with the wrasses. In following Couch and taking the sharks and rays first, the writer has not desired to indicate any anatomical priority, but rather to preface the life-stories of the smaller and more familiar fishes with some account of the largest and most striking. If other reason were necessary, it might not perhaps be difficult to justify this preference for the sharks, on the ground of their undoubted antiquity. Almost all modern writers are agreed that the sharks and rays have come down to us as survivals of very ancient and important fish-families, possibly even indicating the structure of the parent stock of all fishes, if not indeed of all vertebrates.

While these pages are to concern themselves with the habits and life-history of our sea fish rather than with any detailed examination of their anatomical structure and affinities, it is obviously desirable, if the reader is to follow the accounts here given without inconvenience, to set down quite briefly in this first chapter some outline of the appearance and physical peculiarities of these fishes, of their food, their migrations, and their manner of reproducing their kind. The Latin, or rather scientific, name is given in brackets, even at the risk of apparently superfluous repetition, when any fish is cited in illustration of a principle, as confusion is otherwise likely to ensue. Any English reader, for instance, consulting Dr. Bashford Dean's fascinating volume on *Fishes, Living and Fossil*, might easily be misled on reading of the sea-bream (p. 225), were it not plainly indicated that *Ctenolabrus*, a wrasse, is intended.

Form, Colour, and Size.

A glance at the illustrations in the present volume, at the specimens in the Natural History Museum, or at the fishmonger's slab, should suffice to indicate the great variety of shape in our fishes. The extremes of size, it is true, can be seen only at the Museum, since the largest and smallest forms are alike unsuited to the requirements of commerce, and it is impossible even approximately to indicate these in a book. The two great divisions, so far as shape goes, are the round and the flat, the mackerel (*Scomber*) being the type of the former, and the plaice (*Pleuronectes*) standing for the second. A little more familiarity with the characters of these two groups will show us that there is no such combination as a silvery flat-fish. The dory (*Zeus*) is, in a sense, flat, and it is also in a measure silvery; but the flatness of the dory is not that of the plaice, and it swims on its belly, like other round fishes, whereas the plaice swims on its left side. Most of the fishes which lie at the bottom, such as the rays (*Raia*) and weevers (*Trachinus*), are dull of colour, while those which swim near the surface, like the herring (*Clupea*), exhibit silvery and other bright tints. There are exceptions to this rule, as to most, for the dragonet (*Callionymus*) and red gurnard (*Trigla*) are familiar examples of gaudily coloured ground-dwellers.

Anyone wishing to form some idea of the wonderful variety of shape in our sea fish should visit the Natural History Museum and compare, say, twelve such types as the thresher-shark (*Alopias*), skate (*Raia*), hammerhead (*Zygæna*), sturgeon (*Acipenser*), chimæra (*Chimæra*), sword-fish (*Xiphias*), plaice (*Pleuronectes*), conger-eel (*Conger*), angler-fish (*Lophius*), lumpsucker (*Cyclopterus*), sun-fish (*Orthagoriscus*), and sea-horse (*Hippocampus*) ; and let him further bear in mind the fact that not one of these can be said to conform to the conditions of some such typical fish as the bass (*Labrax*). It would be no very difficult matter to name a second dozen of our sea fish almost as remarkable in shape as those given above, but the examples chosen sufficiently illustrate the almost inexhaustible resources of Nature's workshop.

Nor do the colours of our fishes display less variety than their shape. Of all British forms the opah (*Lampris*) and one or two wrasses (*Labrus*) display the most brilliant and fanciful colouring, and after these come the gurnards. The fishmonger's shop, and to some extent also the best efforts of the taxidermist, must necessarily be an unsatisfactory guide in the matter of colour. Thus, the cod and its relatives, though comparatively bright-hued in life, soon fade to one-toned dulness after death ; and, on the other hand, the red mullet looks even brighter in the fish-market than when removed from the meshes of the trammel, owing to the trick by which the fishermen scrape off the large outer scales, in order to intensify the colour of the fish. In one or two groups of fishes the male and female differ appreciably in their colouring ; in other words, colour constitutes an important "secondary sexual character." The gemmeous dragonet, for instance, and dusky skulpin, now well known to be simply the male and female respectively of one and the same species (*Callionymus*), were long described as totally different fish. This sexual colour difference is associated by the majority of writers with the principle of natural selection, the brightest-coloured males being for generations more attractive to the females than those of less gay appearance. Mr. Holt has, however, made another suggestion by way of explaining the phenomenon, having found by experiment in the aquarium that the yellow pigment in the female dragonet is distasteful to pollack, gobies, and other kinds likely to prowl on the breeding-grounds.* He therefore regards the yellow female as particularly safe while engaged in the important work of reproducing the species, though, as the male is frequently found in quantities in the stomach of cod-fish and other larger forms, and as there are said to be three times as many females as males, it is not easy to understand in what way the particular protection of one sex only can secure the continuance of the species. At the same time, as will presently be shown, the milt of a single male is capable of fertilising the eggs deposited by several females, so that, individually, the male is perhaps somewhat less precious.

Spots, while characteristic of the salmon, trout, plaice, and two of our dog-fishes, are not a very common character in adult forms, but frequently occur in the young,† particularly during the very early larval and post-larval stages. In some species, even where absent in the mature, or full-grown, fish, the spots persist to a later stage, as in codlings (*Gadus*). Bars, on the other hand, which are retained throughout life by the

* See *Proc. Zool. Soc.*, 1898, p. 307.

† Curiously enough, spots are also characteristic of many young mammals. Some young lion cubs at the Zoo recently exhibited a uniform scheme of spots on the body and limbs.

pout (*Gadus*), mackerel (*Scomber*), and pilot-fish (*Naucrates*), are found in the young stages only of the salmon (*Salmo*), scad (*Caranx*), and gar-fish (*Belone*). Some fishes are, like the chameleon, able to change colour to suit their environment; and the dory (*Zeus*) has been observed to behave in this manner when about to seize its prey, at which moment the brown blotches on its sides take a distinctly darker hue. The late Matthias Dunn, whose name will frequently recur in these pages as that of certainly one of the most remarkable observers of fish life whom this country can claim, once showed the writer some little turbot (*Rhombus*) that had been taken half an hour before from the milky clay water off Pentewan, near Mevagissey. The fish were absolutely white and opaque. Transferred to a metal bucket, however, they soon took a dark shade and a semi-transparency. The wrasses (*Labrus*) are also known to adapt their colour to the background, taking hues suitable to the red or green weed, as the case may be, and they still further accommodate their appearance to the sides of their tank.* This phase of colour-protection is peculiarly associated with flat-fishes lying on the ground for long periods, either resting or waiting for their food, and this aspect of their life is well illustrated by an admirable coloured plate in Cunningham's treatise on the common sole.

Opinions sometimes differ on the question of what exactly constitutes colour-protection. For instance, in describing an abnormally coloured thornback skate (*Raïa*), which he regarded as a case of partial albinism, Professor Traquair † suggested that the colouring of the specimen in question could not, in his opinion, protect the skate when lying on any known kind of sea-bed. That specimen was trawled off the Isle of May, with the nature of which ground the writer can claim no acquaintance, but he knows several patches of

* An interesting account of this behaviour in *Labrus maculatus* may be read in the *Journ. Mar. Biolog. Assoc.*, 1898, p. 193.

† See *Annals of Scottish Natural History*, January, 1893.

shingly ground in the neighbourhood of Selsea Bill, on which the thornback, if accurately figured in the plate that accompanied Dr. Traquair's description, might easily have rested unseen.

It is generally assumed that the hottest seas, lying under constant sunshine and cloudless skies, produce the most gaily coloured fishes, and this is in the main a sound theory. Although some of our wrasses (*Labrus*) and gurnards (*Trigla*) are almost unsurpassed, while, at their best, the opah (*Lampris*) and dragonet (*Callionymus*) are quite without rivals, it must be granted that Australian seas, for example, give the angler an extraordinary proportion of bright red and golden fishes. The writer, who went to Australian sea-fishing fresh from seasons spent in Cornwall, in the Baltic, and in the Mediterranean, well remembers the interest of his first few outings on the coast of New South Wales, where one brilliant fish was swiftly followed by another, the schnapper eclipsed by the nannygai, and both rivalled by the sergeant-baker. What a contrast from the pollack and whiting of Plymouth Sound!

It must have occurred to most people who ever gave the matter a thought that the majority of fishes are much darker in colour along the back and sides than underneath. The cod (*Gadus*) and conger (*Conger*) illustrate this among round fishes, while in the skates (*Raia*) and flat-fish (*Heterosomata*) there is, as is well known, a still more striking concentration of dark pigment on the upper surface. The object of this is clearly protection, for in the remora (*Echeneis*), a little fish which clings to sharks and whales with the aid of a sucking-disc on the back of the head, and consequently passes much of its life upside-down, so to speak, it is the back which is white, while the belly is of dark colour. The cause of this restriction of colour to the upper surface is less apparent than its purpose, but it has not unreasonably been attributed to the action of light. In support of this view, indeed, we have important evidence in Mr. Cunningham's interesting experiments in the artificial colouring of the flounder (*Pleuronectes*), in which light was thrown up from a mirror arranged beneath the tank. Reference will, however, be made to this investigation on a later page, as also to the somewhat frequent occurrence of abnormally coloured flat-fish, such as albino brill (*Rhombus lævis*) and "double" turbot (*R. maximus*), the latter similarly coloured and, in some cases, studded with tubercles on both sides.

The size of fishes offers, at any rate, as great a contrast as the range in any other vertebrate class. Between the basking shark (*Selache*) of our seas, which may attain to a length of 40 feet, and the tiny "sinarapan" of Lake Buhi, in the Philippines, which never, when full-grown, exceeds ½ inch, there is a wide margin, and, without drawing on the fauna of so distant an archipelago, some of the smaller suckers (*Liparis*) of our own coast, with a maximum length of 2 or 3 inches sufficiently illustrate the contrast. As regards the bony fishes, at any rate, the females are usually the larger, as well as the more numerous. This subject will, however, be dealt with further on a later page, and the exceptions, which are numerous, will, where necessary, be noted. The size of a given species varies considerably according to locality; and it must not be forgotten that abundance or scarcity of food probably plays a more important part in this than in the case of any other vertebrates. Thus, the herring (*Clupea*) of the Baltic and the mackerel (*Scomber*) of the Mediterranean are both smaller than their kinsmen of the same age (as far as can be determined) on our coasts, while the former sea also has a race of dwarfed plaice (*Pleuronectes*), which sometimes, at certain seasons, find their way to the Grimsby market.

Abnormally shaped fishes are not uncommon, and many of these monstrosities were described by unsophisticated writers of a bygone generation as distinct species. In this connection reference should be made to an interesting explanation, quoted on a later page, which the late Matthias Dunn gave in respect of the malformed sea-breams so commonly caught in the Plymouth district.

The Fins.

It has already been pointed out that the specially modified limbs of fishes, which we call "fins," are their most permanent and enduring character. There is a persistence about these organs of balancing and movement that is not found in the limbs of higher vertebrates, and it has been shown by somewhat cruel experiment * that if a fish be deprived of its fins, it develops new ones in their place in an incredibly short time. As Bashford Dean points out,† those fins which look so important in profile dwindle to mere lines when the fish is viewed end on, and this difference shows how admirably these animals are suited to rapid and unhindered progress through so dense a medium as water. The fins of fishes are situated on the back, belly, and sides, and they are either vertical and unpaired, or horizontal (*i.e.* lateral) and paired. It seems probable that the latter are chiefly useful in balancing the fish, aided no doubt by the air-bladder, in a way that will be referred to later. The vertical fins enable the fish to steer its course, the tail-fin being most important in propelling the body forwards or backwards. Different authors have preferred different names for these fins. They agree in calling the fins on the back the first and second "dorsal" respectively, and also in naming the tail-fin the "caudal," and those immediately behind the head "pectorals." It is in respect of the "anal" fin (near the tail and below the fish) and "ventral" (the fin before the anal) that some authors, Mr. Cunningham among them, have elected to depart from the older nomenclature so far as to reverse these names, or to name that which was known as ventral "pelvic." What purpose can be served by such confusing alterations it is difficult to conceive, and in the present volume the older names of the fins have been retained.

* See Regnard, *La Vie dans les Eaux*, p. 446.

† *Fishes, Living and Fossil*, p. 3.

A fish like the bass (*Labrax*) presents what may be regarded as the normal condition of fins in the "spiny-finned" group, and the haddock (*Gadus*) might be taken as the type of the "soft-finned" fishes, the fins being merely rays inclosed in a loose fold of the skin, in which they can lie flat or stand erect. There are many departures from this normal form, as is particularly illustrated in the tail-fin. Normally, the tail-fin consists of two equal lobes, either joined by skin, and thus suggesting a fan, or else separate, and suggesting rather a prong or fork. Yet the widest differences may be seen on comparing the tail-fin of the thresher-shark (*Alopias*), which has an immensely long upper lobe, with that of the angler-fish (*Lophius*), the tunny (*Orcynus*), the deal-fish (*Trachypterus*), the sun-fish (*Orthagoriscus*), and the pipe-fish (*Sygnathus*). The other fin which shows the most marked departure from the normal rayed condition is the second dorsal, which, in the salmon family, is without rays and fatty, being known in that case as an "adipose" fin. The presence of a second *rayed* dorsal distinguishes, as will be illustrated later, the sand-smelt, or atherine, from the true (salmonoid) smelt. The ventral fins—that is to say, those on the lower edge of the body and almost beneath the head—are absent in the pipe-fishes (*Sygnathus*) and in some other groups. Another peculiarity about the dorsal fins of some fishes is their connection with the sex in the breeding season. The dragonet (*Callionymus*), already mentioned in connection with another secondary sexual character, develops long filaments on the dorsal fin of the mature male; and in other forms, such as the sword-fish (*Xiphias*), the young fish has proportionately longer fins than the adult.

The Scales.

Scales may, on the whole, be regarded as a characteristic covering of the class of fishes, but it must not be forgotten that not only are they also associated with the totally distinct class known as reptiles, but also that in some fishes, even on our own coasts, they are altogether absent, as in the conger (*Conger*), or else replaced by rough tubercles, as in the turbot (*Rhombus*). Scales are so familiar to all who have handled fish that they need little description and appear to us, when viewed casually, as horny, semi-transparent growths, generally covered with slime while the fish is alive, and overlapping each other like the feathers on the back of water-fowl. These scales exhibit in point of size a range almost as great as the fishes themselves, and between the scale of a tarpon and that of a fresh-water eel there is perhaps an even greater difference in measurement than between their owners.

When scales are viewed under a low-power microscope, they exhibit certain structural differences. Those which have the hinder free edge serrated are called "ctenoid" (*i.e.* comb-like), while those with the hinder edge smooth are known as "cycloid." It would also seem as if there is a regular formation of annual rings in the scales of bony fishes, or at any rate in those of the related cod and flat-fish families, which may, when further studied, give a rough clue to the age of the fish, just as the bark-rings give the age of a tree, and they may be further compared on the ground of the similar influence of abundant warmth and nourishment, their growth being accelerated in the summer and retarded in the winter months.*

The plates, or bucklers, which cover the body of the sturgeon are distinct from ordinary scales, and are partly composed of bone; and the same may be said of the rough tubercles on the turbot. Normally, these occur on the coloured, or upper, surface only; but numerous turbot reach our markets from the coast of Norway in which tubercles are frequently found on the uncoloured side as well, and this apparently without reference to abnormal colouring. In sharks the so-called scales are quite distinct from those of bony fishes, and it is questionable whether they should be described as scales

* See J. Stuart Thomson on "The Periodic Growth of Scales . . . as an Index of Age" (*Jour. Mar. Biol. Assoc.*, January, 1902).

at all. They contain much lime, and may more aptly be compared with teeth. In fact, in the embryo of some sharks, before the development of the lip, these granulations of the skin are actually continued into the mouth and there form the beginnings of teeth.

The Lateral Line.

The lateral line may be regarded as a system of modified scales, perforate and communicating with cells of a gelatinous substance so, in all probability, as to constitute a most complex and important sense-organ with functions that have not yet been more than vaguely determined. Formerly the duty of the lateral line was thought to begin and end with the lubrication of the body with mucous, but this very simple view of its purpose has long been superseded. Day and, later, Cunningham and others agree that the lateral line is usually wanting in fishes of the herring family; but the late Matthias Dunn, two years before his death, drew the writer's attention to its unquestionable presence in the pilchard. While on this subject, it would be unreasonable to overlook a most interesting article contributed by that remarkable observer to the *Contemporary Review* (August, 1899), entitled "The Seven Senses of Fishes." It may be that, in his zeal to advocate his two extra senses in fishes, Dunn went somewhat boldly, even a little wantonly, out of the well-trodden rut of modern research. It may even be that later investigations may not tend to confirm his theories. Yet even such a result would take nothing from the interest of his watchfulness and reasoning powers. The sixth and seventh senses which he claimed for fishes were termed respectively the electric and magnetic "dermal" sense, and he describes the first as one of weather forecast, and a second as a kind of bump of locality under water, the sense being in both cases resident in the lateral line. He regarded the brain of a fish, in fact, as a counterpart of Lord Kelvin's compass-magnet floating in a liquid, and he thought it might be sensibly affected by the long-recognised magnetic properties of the grim Cornish headlands, which have so often caused fatal deflections of ships' compasses.

To the sternly academic mind the inferences in the article under notice may seem a trifle far-fetched; but it was quite impossible for a man of Dunn's restless intelligence to contemplate the regular wanderings of the pilchard shoals for fifty years without making some attempt at finding a solution of the mystery of their return, year after year, along exactly the same course. It was equally impossible that he would be deterred from such attempt by any self-consciousness or by fear of ridicule.

The lateral line is more or less conspicuous, as a rule, through a great portion of its length, being, even in closely related fishes, either black (as in the haddock) or white (as in the cod), while in the scad it is flanked by rows of very rough scales. It does not end at the point where the eye sees it no longer, just behind the neck; but, disappearing below the surface of the skin, it branches over the head, and probably conveys to the brain the sensations communicated along its pores. Much, however, of what is written in connection with this characteristic organ of fishes is in the nature of pure speculation, and a full and exhaustive study of its properties has yet to be made. When made, it will be interesting in the extreme.

We must now briefly examine a number of external characters of fishes in the region of the head—the eyes, nostrils, ears, mouth and teeth, gills and gill-covers.

The Head, Teeth, Gills, etc.

As seen in the bass (*Labrax*) or cod (*Gadus*), the typical head of a fish is, roughly speaking, in the form of a wedge, with the line between the gill-covers for base and the lips for apex. The departures, however, from this simple form are so many and varied that considerations of space must restrict the list of exceptions to such few as the conical head of the skates (*Raia*), the beaked head of the garfish (*Belone*), the twisted head of the plaice (*Pleuronectes*), the mailed head of the gurnard (*Trigla*), the flattened head of the angler-fish (*Lophius*), the attenuated head of the stickleback (*Gasterosteus*) and pipe-fish (*Sygnathus*), and the truncated head of the wolf-fish (*Anarrhicas*). The conspicuous protrusion of either jaw imparts a characteristic and distinctive profile to the head of a fish. The greater length of the lower jaw (as in the pollack and hake) is usually associated with predatory habits ; the protrusion of the upper (as in the cod and haddock) indicates that the fish feeds near the ground. As these cases show, cases of either jaw protruding occur in the same family. As a matter of embryological knowledge, the lower jaw usually projects in the larval form of bony fishes, but that would not, of course, indicate that we should read these larval characters as a clue to ancestral peculiarities since dropped and regard all bony fishes as originally predatory.

Another feature that may conspicuously modify the outline of the head is the presence of barbels, or beards, usually (as in cod and red mullet) on the lower jaw, but sometimes (as in the rocklings) on the upper as well, and in various number. The finger-like front rays of the ventral fins in the gurnard bear at first sight a close resemblance to these barbels, and no doubt they perform much the same work when the fish is routing in the shingle for its minute food ; but the two structures are quite distinct and should not be confused. That the barbels of fishes are highly sensitive nerve-centres can hardly be doubted, but whether they are to be regarded as associated with the sense of touch, or rather with that of taste, we do not yet know. Dr. Bashford Dean inclines to the former view.*

The Eye.

The eye of fishes, into the anatomy of which it is not the purpose of the present volume to enter in detail, is subject to considerable structural modification, and we find by experiment that the sense of sight predominates in some groups, while in others it is of secondary importance only, the fishes relying in this case chiefly on their scent. It

* *Fishes, Living and Fossil*, p. 48.

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is, as a matter of fact, somewhat difficult to determine the exact relative importance of these two senses in any fish. It might, for instance, by means of one of those inferences which, while commonly practised by many, are usually dangerous in the study of natural history, be concluded that the sense of smell would be very slight in fishes gifted with large eyes, and correspondingly acute in fishes with only small eyes. The law of compensation would suggest some such balance of faculties. As a matter of fact, the exact converse is found to be the case in some well-known fishes. Thus, some of the flat-fish (*Heterosomata*) have both small eyes and feeble powers of smell, while the better-equipped conger (*Conger*) has not only very large eyes, but also a very strong scent. Attempts have also been made by ingenious writers to associate large eyes in fishes with a habit of seeking food in the darkness, the argument being that the larger eye would be able to utilise the failing light. The argument is not, however, sound. In the first place, it is not by any means satisfactorily established that the mere size of the eye would increase the power of sight; and, secondly, even granting that such were the case, the sole, a fish of undoubtedly nocturnal habits, has a smaller eye, in proportion to its size, than perhaps any other fish in our seas. Reference is made, when treating in a later chapter of that sub-order, to a special visual organ in flat-fish, as well as to the curious passage of one eye either over the ridge of the head or through its tissue. The existence of the pineal, or median, eye of fishes, which is doubted by Bashford Dean, is a question involving anatomical considerations that hardly fall within the scope of the present volume.

The muscular power that enables fishes to use the eyes independently, like chameleons, must be of great use to creatures that have often to keep one eye on their meal and the other on their enemies.

The eyes of sharks differ in many respects from those of bony fishes, and in some groups are provided with a "nictitating membrane," which, as mentioned in the foregoing brief contrast of the bass and tope, enables these sharks to close the eye, when the light is too strong, by drawing up the lower lid.* Rondelet appears to have been the first (in 1554) to call attention to the fact of some sharks being able in this fashion to shut their eyes, while others lack the power. The organ known as "nictitating membrane" is most highly developed in the genus *Carcharias* (*e.g.* the blue shark), and least, where present at all, in *Mustelus* (*e.g.* the smooth hound). In *Galeus* (*e.g.* the tope) the organ is moderately well developed, but in *Scyllium* (*e.g.* the rowhound) it is no more than a rudimentary fold of skin. Yet it acts even so, for a smaller spotted dog-fish (*Scyllium*) in the Brighton Aquarium was seen to shut its eye completely when on one occasion a crab walked over its head. This nictitating membrane is absent in the monk-fish (*Rhina*), spur-dog (*Acanthias*), and rays (*Raia*).

A curious bulging condition of the eyes of pout (*Gadus*) brought up rapidly from deep water will be referred to in the chapter on the cod family.

Sometimes really deep-water fishes suffer far worse trouble when abruptly brought into a region of diminished pressure; and the crew of the French vessel *Talisman*, which brought back so many treasures of the deep to Paris some years ago, hauled some fishes from the greatest depths to which their baited hooks would reach, in which, as the fish came to the surface, the dilated air-bladder was shot out of the mouth.

The Nostrils.

The nostrils of fishes are only pits in the snout, and do not, like our own, communicate with the throat. This does not, however, impair the power of smell, for they must certainly be in touch with sensitive nerve-centres that convey their sensations to the brain. It has been argued

* See Ridewood, *Journ. of Anat. and Physiol.*, January, 1889, pp. 228-242, and Harman, *ibid.*, October, 1899, pp. 1-36.

that the fact of congers refusing stale pilchard is due to the acute smelling powers with which we know that fish to be endowed ; but some allowance should also be made for the peculiar medium in which fishes pass their existence. It is, in fact, not improbable that, although the nose may perform its share in apprising the conger of its want of freshness in the bait, oily particles may also float through the water in such manner that the conger, approaching close enough, could taste as well as smell any imperfection.

The Ear.

The ear of fishes in not an ear at all perhaps, strictly speaking, in our restricted sense of the word. At any rate, it is not visible without dissection. Within the skull, however, there are distinct and sensitive organs of hearing, together with small bones known as "otoliths," or ear-stones.* These may be found without much difficulty in the head ot any cod or haddock brought to table. These internal ears are separated from the brain of the fish by only a thin wall of membrane or cartilage, so that sound-waves must be conveyed with great distinctness. It is, moreover, probable that fishes are provided with what we may virtually regard as supplementary hearing organs in the air-bladder, as well as in the nerve-centres of the lateral line, but these are distinct from, and auxiliary to, the ear proper.

The Mouth.

The mouth of fishes varies in size and position, as exemplified in the sole (*Solea*) and angler-fish (*Lophius*), the weever (*Trachinus*) and skate (*Raia*), the gurnard (*Trigla*) and gar-fish (*Belone*). The lips are very fleshy in the wrasse (*Labrus*), and comparatively small in the bellows-fish (*Centriscus*). The tongue, which fishes are not able to thrust outside their mouth, like the higher vertebrates do, is in many cases armed with sharp and numerous teeth, and may not perhaps be endowed with any very sensitive powers of taste. Some fishes, indeed, are without tongue altogether.

* See Ridewood, "The Air-bladder and Ear of British Clupeoid Fishes" (*Journ. Anat. and Physiol.*, Vol. XXVI., pp. 26-42).

The teeth of fishes, which might, had the present volume other aims, offer material for a very interesting study in development, must be very briefly dismissed. They differ considerably in bony and cartilaginous fishes. There is, in the former group, distinct anchylosis, but it may not always be easy to determine by casual examination where the tooth leaves off and where the jawbone begins. The teeth also show much variety in the various families, and reference will be made in later chapters to the more or less successful endeavours to associate these types of fish-teeth with different kinds of food or different manners of feeding. In the sea-breams (*Pagrus*), for instance, the teeth are blunt and round ; in the wolf-fish (*Anarrhicas*), there are pointed teeth in front, for seizing living prey, and flatter teeth behind, for crushing shells. Some of our common fishes, such as the pipe-fish (*Sygnathus*) and sea-horse (*Hippocampus*) have no teeth whatever ; in others, such as the grey mullet (*Mugil*), they are exceedingly feeble ; and in a few, like the red mullet (*Mullus*), there are teeth in the lower jaw only. Some fishes, such as the launce (*Ammodytes*) and globe-fish (*Tetrodon*), have no detachable teeth, but bony or horny continuations of the jaw. The teeth of bony fishes may cover not only the edges of the jaws, but also the tongue and palate ; and in the sun-fish (*Orthagoriscus*) there is a powerful series of pointed gill-teeth. In sharks and rays (*Selachii*) the teeth are, as already indicated, really identical with the granulations on the skin, and they are moreover not connected with the jaws, as in bony fishes, by ossification, but merely lie embedded in the gums. Even in sharks, however, there are many types of teeth, those of the porbeagle (*Lamna*), for instance, having smooth, keen edges, while those of the blue shark (*Carcharias*) are slightly serrated and also differ in the two jaws. In the eagle-ray (*Myliobatis*) and some other allied forms the teeth are closely packed in the form of a pavement. In sharks the teeth lie in several parallel rows, one ready to replace the other ; but in rays those on the edge of the jaw are erect and ready ror use, while those situated further back lie flat and point towards the throat.

The Gills.

The gills, which may be regarded as dividing the head from the body, are the means by which the fish oxygenates its blood, taking in the water at the mouth and passing it through the gills. In some sharks and in all the rays, which have the gill-slits external and separate, not protected by covers as in bony fishes, the water for this purpose is also taken in through small holes situated behind the eye and called "spiracles." These must be particularly helpful to the rays, which pass most of their time lying flat in the sand with their mouth more or less buried. Most sharks (and all the rays) have five of these external gill-slits ; but one of the former, a rare visitor to our seas, has six, and a relative occurring in the Mediterranean has seven. Bony fishes have no breathing spiracle, and the gills, usually four in number, instead of opening out on the surface as distinct gill-slits, all lead into what is called a branchial chamber, strongly protected by a hinged shield in several sections known as the gill-covers, one portion of which, the "preopercle," is often furnished with a toothed or spiked edge. The teeth in the gill-covers are clearly designed to arrest foreign matter that might, without their intervention, clog the gills. Strictly speaking, they are not teeth at all, but may be regarded rather as tooth-like growths. The bars of the gills are edged with hair-like growths, which in fishes of very different groups, such as the herring (*Clupea*) and basking shark (*Selache*), lie so close as to form a very beautiful sieve arrangement, which, like the baleen of whale-bone whales, retains even the most minute organisms from the expelled water. The so-called false gills (*Pseudobranchiæ*) are the remains of a fifth gill, the use of which is restricted to the embryonic stage of the fish. Those fishes (*e.g.* herring) in which the gill-openings are largest soon die out of water ; others (*e.g.* eel) in which the gill-openings are smaller can survive a period of removal from the water without inconvenience.

The Air-bladder, or Swimming Bladder.

The air bladder, or swimming bladder, the only internal organ with which the present volume need concern itself, is in a measure comparable to the lung in the higher vertebrates; and in fact in the so-called "lung-fishes," which have living representatives in three continents, the "lung" is a special modification of the air-bladder. Whether to some extent this organ may be regarded as having the value of a lung in fishes that respire with the aid of gills is an open question. Indeed, the functions of this organ are variously estimated. Its connection in some fishes with the sense of hearing has received passing allusion. It is also associated with the only recognised "voice" in fish, little more than a grunting, such as might be produced by the expulsion of air. Matthias Dunn's view, that the "singing bubbles" sent to the surface by pilchards are an effort of voice on the part of those fish,* has not been confirmed.

Undoubtedly, however, one of its chief uses to the fish must be as a balancer, adjusting its specific gravity, enabling it without further effort to rise or sink in the water, the fish being, in fact, able to change its volume according to the depth and pressure. Many fishes (*e.g.* all flat-fish) that lack the air-bladder in the adult stage possess it in the larval form.

The Food of Fishes.

The food of fishes is a subject that will necessarily be reverted to in the chapters that follow. Something has already been said on the species that find their food by scent and those which seek it by the aid of their eyesight, and it will generally be found that the latter devour living prey. The very minute foodstuffs on which many fishes feed, either in the larval stage or throughout life, often escape our notice. It is related that the German naturalist Meyer all but lost a number of larval herrings from starvation, owing to the water being admitted to their tank through a strainer. This anecdote will give some idea of the exceedingly small size of the organisms on which the young herrings must feed, for as

* See *Records of the Falmouth Polytechnic Society* for 1892.

soon as he removed the strainer (which had been introduced to keep out enemies) and allowed the water to flow in direct, he found that the larvæ underwent rapid recovery.

There is often considerable difficulty in determining the exact food of any fish. This difficulty arises from three causes. First, there is this habit, in many, of feeding on minute copepoda and similar small organisms. Secondly, many fishes have very rapid digestion, those which pass much of their life swimming at high speed near the surface of the sea being most remarkable in this respect, so that it is unusual to find any trace of food in a newly caught herring or mackerel. Some of the larger ground-dwelling fishes, on the other hand, like the torpedo and angler-fish, appear to feed and digest more after the fashion of pythons, devouring a large victim at a meal, and then lying quiet to digest at leisure ; at least, we know that bass and other fish have been recovered from their inside, often, more particularly perhaps in the case of the electric torpedo, having sustained such trifling injury that they are fit for sale. The third reason for the difficulty of determining the substance on which a fish has recently fed is the habit that so many have of throwing up their last meal when hooked or taken in the nets. Whether they do this in pain, in terror, or in some hope of throwing over ballast when struggling for their life and liberty, we can only surmise, but the habit is very familiar to fishermen and anglers. Over and over again the writer has known a bass or pollack throw up as many as three or four tiny sand-eels when hauled into the boat, and the boat's "well," into which the fish are thrown, often contains a score or more of these small disgorged fishes, more or less damaged by the teeth of their captors.

While on the subject of the food of fishes, a word may perhaps be said, by an easy transition, of fish as food. Leading authorities differ in a remarkable degree as to what exactly constitutes a "food-fish." Cunningham is perhaps nearest the mark, yet he excludes the weevers and says little of the rays ;

while, on the other hand, he devotes some attention to the suckers and rocklings, which no one would ever dream of eating, save as an alternative to starvation. McIntosh and Masterman, again, include the weevers and gobies, but practically omit the rays. Some allowance must probably be made, not only for the relative importance of certain groups in the district with which each writer is best acquainted, but also for difference in taste. Thus, whereas with the Norwegians the so-called little ling (*Molva abyssorum*), or "*birkelange*," is a favourite article of food, Holt mentions a case of a seal which refused to eat it! * A word may here be said on the subject of *rigor mortis*. It is that stiffening of the muscles which ensues at some variable period after death. It may follow in a few minutes; it may delay many hours: this depends on circumstances. Likewise, the condition may endure a short or a long time, also according to the circumstances attending death. A spent salmon would behave quite differently from a fresh-run fish. Professor Cossar Ewart † has shown that rigor sets in later in a fish in which the brain has been destroyed. In a hare that has been chased, in a fish that has been played on the hook, rigor sets in rapidly and is of only short duration. Dr. Ewart's investigations in the matter take a very practical turn, since they enable him to demonstrate the fact that fish intended for preservation should be treated just after rigor sets in, and also that putrefaction occurs somewhat sooner, other conditions being equal, in trawl-fish than in those taken on the hook. He altogether distrusts the housewife's empirical clues to freshness, such as smell, colour of the gills, or brightness of the eyes.

At the same time, it would not be desirable to limit our studies to only the comparatively few fishes that we use as food. For centuries man has gathered the treasures of the deep without any thought of harvesting. The harvesting has

* *Proc. Zool. Soc.*, 1894, p. 415.
† *Proc. Roy. Soc.*, June, 1887, p. 443.

been left to the twentieth century, for the last quarter of the nineteenth witnessed only the barest inception of practices and economies that may eventually result in placing the fisheries and agriculture on the same footing. It has of late years been increasingly apparent that a sounder knowledge of the fishes themselves, of their growth, their food, their migrations, and their reproduction, is the first condition of useful legislation. The strongest evidence of a general acceptance of this view in intelligent circles is the reception accorded during the past five years to such admirable volumes on the life-history of our food-fishes as those by Professor McIntosh, Mr. Cunningham, and others. Not alone, as shown above, do the few market-fish occupy their attention, but also the majority of the rest, some too small, others too huge, for consumption. Many of these commercially "useless" fishes, moreover, frequent the same grounds as those of greater economic importance. Thus the proximity of cod is, as the fishermen well know, unmistakably indicated by abundance of the bergylt (*Sebastes*) and poor cod (*Gadus minutus*). So that a careful study of the forms which furnish food to those which we ourselves eat may throw valuable light on the life-story of the latter.

Migrations and Distribution.

The migrations and distribution* of fishes may be briefly considered in this place. With the exception of some of our smaller gobies and blennies, and one or two of the flat-fish group, almost all of our sea fish are, even from their larval and post-larval stages, endowed with the wandering instinct, and even those which become to all intents and purposes stationary in later life, begin their career as travellers. When we think for a moment of the vast extent of their watery home, and of the comparatively few restrictions put upon their progress, it would be surprising

* These remarks on distribution of sea-life are largely based on two invaluable German works, *Die Verbreitung der Fische*, by J. Palacky, and *Grundzüge der marinen Tiergeographie*, by Arnold Ortmann.

were things otherwise. Beyond assuming, however, that the majority of fishes wander considerable distances, either along our coasts or to and from the deeper water outside, we know comparatively little that is certain of the precise season, object, and direction of these journeys. The mackerel, for instance, and the herring were formerly thought to travel round our islands and off to Arctic seas with a most complicated itinerary. Later observers, with far more statistical material at their disposal, have come to the conclusion that these migrations are by no means so extensive as was then supposed, and that the fish merely move into deep or shallow water for spawning purposes. Something will be said later on the subject of the kinds which prefer deep water for the purpose and, on the other hand, those which repair to the shallows. There are other reasons for migration than spawning. A change in the temperature of the water, sudden or normal at given seasons, will cause the shoals to move from one part of the sea to another. Food, too, may be the motive of these journeys. An instance of this is on record, in which numbers of hake appeared suddenly off the Cornish coast in pursuit of a small and rare species of gadoid, and will be duly related in the chapter on the cod family. All shoaling fishes must be continually on the move, on account of this same food problem, for only solitary kinds, like the weever and angler-fish, could possibly find supplies for a long period in one place. Fish do not consume a great quantity of food during the spawning season, so that the shoals are then less restless.

A good deal of unnecessary mystery has been allowed to invest this shoaling habit in some fishes. So far as we have any reason to suppose, it is not materially different from the parallel habit of flocking in some birds. Suitable conditions of food and temperature take the members of each species to certain neighbourhoods, and those of the same size, being unable to devour each other, swim in company. This is why we find the broods of one "class"—that is to say, hatched at approximately the same time—in one shoal. They are not, of course, the offspring of the same parents, but have simply joined forces from a preference for company. Not all fishes go thus in shoals. The angler may sometimes catch a single dory among a hundred fishes of two or three other species. The sun-fish is generally described as solitary, and, in the writer's opinion, the same may be said of most of the larger sharks in our seas, though the smaller "hounds" undoubtedly hunt, like their namesakes on land, in packs. Even mackerel and pilchards only gather near the surface in shoals during some parts of the year, and the pilchards even disperse during the summer nights to feed separately, with their heads pointing away from the land ; hence, as will be explained in the next chapter, the rationale of the drift-net. The break-up of the mackerel shoals, too, and the subsequent capture of the fish on leaded ground-lines, is an annual experience with the fishermen, and corresponds approximately with the break-up of the summer weather.

It can hardly be contended, unless instinct is more at fault than usual, that the habit of shoaling in fishes is associated with any notion of protection, for a moment's reflection will show that the mackerel or pilchards would be infinitely safer singly than they can possibly be in shoals, far less likely to attract the attention of their enemies, far less vulnerable by the bills of sea-fowl, the jaws of porpoises, or the nets of man. It has certainly been said, and by no less an authority than the late Matthias Dunn, that a dense shoal of mackerel has been all but known to suffocate a grampus that had inadvertently plunged into the midst of the crowded fish, but such an episode must be very rare. The writer has repeatedly seen both grampuses and thresher sharks busy among very large shoals, and never with any result beyond, so far as could be judged, the destruction of an immense quantity of the fish.

The distribution, or geography, of our sea fish is an immense subject, and one that might well occupy a chapter, if not indeed a volume, to itself. A brief summary of the first principles is all that can here be attempted.

The student of the distribution of land animals, beasts, birds, reptiles, or fresh-water fishes, has at once a simpler and more complex task before him than if his theme were the fishes of the sea. In the first place, the subject has been fully worked by many naturalists, and the zoo-geographical zones are, with some little modification here and there, satisfactory for all such purposes. If we take the case of a land mammal, like, for instance, the camel, we know, with a little research, that, apart from the teachings of palæontology and the artificial transplanting by man (as in South Australia and Italy), the camel is an Asiatic animal which the Arab has taken into Northern Africa. We know also that the New World has not, at any rate to-day, any animal of the same species; but we find in the llama, vicuna, and huanaco of the Andes region what are known as "vicarious" species—that is to say, closely allied animals, sprung from a common ancestor—which may be said to replace the camel on that side of the Atlantic. In the case of most mammals, at any rate, save perhaps flying bats and swimming porpoises, a mountain range or a deep sea will form a sufficient hindrance to progress, and in this way the fauna of some islands has, from long isolation since the older land barriers were swamped beneath deep waters, arrived at a remarkable stage of types peculiar to very small areas of the world's surface—that is to say, found nowhere else at the present day.

With the fishes of lakes, which are, so to speak, the converse of islands, there may be a similar isolation, and we know, in fact, that the chars of some countries, possibly even of our own Welsh lakes, differ in their characters from those of other parts of the world.

In the case of sea fish there is obviously no such straightforward course of study. Indeed, when we consider how apparently easy it is for a fish to swim on and on without hindrance, the wonder is rather that almost all our sea fish are not of cosmopolitan distribution. We know, however, that such is far from being the case, and that not only do the fishes of Australia, some of which have been already referred to, differ materially from those of the northern hemisphere, not only do the sea fish of the eastern and western shores of the North Atlantic differ in an almost equally surprising degree, but actually that there are fishes, like the torsk (*Brosmius*), which occur in Scotch waters, but are not found in the English Channel.

The case of three of our smallest and least known British flat-fishes, the topknots (*Zeugopterus*), may be taken as conveniently illustrating the peculiarity of an overlapping range. One of these (*Z. punctatus*) is found from the most northern waters of Europe to only as far south as the Bay of Biscay. Another (*Z. unimaculatus*) does not range farther north than Shetland, but, on the other hand, it is met with as far south as the Mediterranean. A third (*Z. norvegicus*), with apparently the most restricted range of all, extends only from the English Channel to the Norwegian fjords. Now, why one or other of these topknots should never, at any rate in sufficient numbers to occur in the trawl of commerce or in the dredge of scientific expeditions, wander out of these well-defined bounds, is a question that it would not be easy to answer offhand. The mere question of temperature will not, as may be seen by reference to the latitudes in question, suffice as an explanation.

Cases of irregular distribution are not, as might be expected, uncommon, an unusual supply of food being probably responsible in most cases. The case of quantities of hake * (*Merluccius*) appearing one summer on the Cornish coast has been explained on the ground of their pursuing into those waters numbers of a small fish of the same

* For another case of irregular occurrences of this fish see *Scandinavian Fishes*, p. 519.

family. Less easy of explanation are one or two other cases that may here be quoted. Pilchards, for instance, were common on the east coast of Scotland during the early years of the nineteenth century, but have been very scarce there ever since. The silvery blade-fish (*Trichiurus*) was common, according to Dunn, on the coast of Cornwall every winter from 1865 to 1875, but scarce in those waters both before and since that decade. Similarly, the red band-fish (*Cepola*) was common in Devon for two years, 1838-9, but never since.

Now, in considering the distribution of our sea fish, we have to distinguish them under four heads—fishes of different seas, fishes of different characteristic grounds, fishes of deep or shallow water, and fishes that pass their lives near the bottom or close to the surface.

These four categories call for brief explanation.

I. The fishes of different seas are mainly, so far as our list is concerned, distinguished as either northern or southern forms. To the latter belong the bass (*Labrax*), breams (*Pagrus*), and surmullet (*Mullus*), all of which flourish in the Mediterranean. To the former belong the cod (*Gadus*), halibut (*Hippoglossus*), and torsk (*Brosmius*). Just as the birds of northern and southern latitudes find, during their migrations, a convenient resting-place in these islands, so do the fishes of vastly different seas meet on our coasts. A further similarity between the movements of the two classes may be suggested. As the wildfowl and waterfowl of the northern ice flock to our estuaries and lagoons in winter-time, while the more gaily coloured birds of Africa and Southern Europe come to us in summer, so are the northern fishes more plentiful and of superior quality in our markets in the cold months, while those of southern origin are conspicuous with us only in summer.

II. The distinction between the fishes of characteristic grounds is of somewhat more practical interest and importance, seeing that the fisherman must be guided by such empirical knowledge when desirous of capturing a certain kind of fish for which there is a brisk demand at the time. The angler knows quite well the difference between, for instance, rock-fish and those which dwell, or at any rate seek their food, on sandy ground. This is the simplest, and also the most important, distinction of the kind. To the rock-fish belong, to quote a few familiar examples, the conger (*Conger*), pollack and pout (*Gadus*), rocklings (*Motella*), wrasses (*Labrus*), breams (*Pagrus*), sticklebacks (*Gasterosteus*), gobies (*Gobius*), and suckers (*Lepadogaster*). These are only a few of our rock-fish, and many more might have been cited.

As equally familiar examples of sand-dwelling fishes we may take the flat-fish (*Heterosomata*), of which the aforementioned topknots (*Zeugopterus*) are regarded as evincing a preference for rocky ground more than any of the rest, the sand-eels (*Ammodytes*), the gurnards (*Trigla*), whiting (*Gadus*), skates (*Raia*), and weevers (*Trachinus*). Many of our commonest fish, like the bass (*Labrax*), most of the sharks (*Selachii*), cod (*Gadus*), and dory (*Zeus*), are found on both rock and sand, and one or two fishes that keep almost entirely to the rocks by day seem to wander out in search of food on the sand by night. There are, as a matter of fact, other characteristic localities for some of our sea fish besides this distinction of rock or sand. Some of them, like the bass and grey mullet (*Mugil*) are particularly partial to estuaries and even the lower reaches of tidal rivers. Others, like the pout and wreck-fish (*Polyprion*), are found in the neighbourhood ot wreckage, the former fish being associated with sunken wrecks of some age, the latter with floating timber from recent disasters.

III. The fishes of our seas considered in the present volume practically belong without exception to what would be called shallow water, since the term "deep-sea fishes" has been restricted by general consent to those extraordinary luminous and other forms that are from time to time brought up from the uttermost depths by specially equipped scientific expeditions. At the same time, a measure of distinction may be permitted, sub-dividing these shallow-water forms according to the depth at which they live. We can, for instance, draw a line between the shore-haunting gobies (*Gobius*) and the deeper-water halibut (*Hippoglossus*). This, in fact, seems to be the utmost that is attained in the very interesting chapter on the distribution of sea fish in Dr. Günther's great work.* In the case of non-migratory fresh-water fishes he was able, as might be expected, to lay down principles and to find his illustrations with almost the same facility as if he had been dealing with a group of land mammals, for the salt water is in all cases a bar to progress outside of the defined range, even in the case of fishes inhabiting tidal rivers. So long as he defined the "Fishes of Brackish Water," though there is necessarily a vagueness about the limits of such a region, and later the "Fishes of the Deep Sea," Dr. Günther was fairly sure of his ground, and those chapters consequently make most useful reading. When, however, we come to his two intermediate groups, the "Shore" and the "Pelagic" fishes, we find continual contradictions, for it seems quite hopeless to attempt, save on the broadest lines and with an infinite patience with the exceptions that are certain to present themselves, any fixed definition of these groups. Even with reference to the demarcation between sea and fresh-water fishes, Dr. Günther himself admits that there is a constant interchange of species.

It is only, therefore, on broad and not arbitrary grounds that we may venture to distinguish between the shore-haunting forms and those which live for the greater part of the year at a moderate distance from the land, say outside of the ten-mile limit. Even here, it will be understood even from what has gone before, there is a continual mingling, for some of the forms from the deeper water come inshore for spawning purposes, while a still larger number will repair to the shallows

* *An Introduction to the Study of Fishes*, pp. 255-295.

after the spawning is over in order to find fresh supplies of food to satisfy their ravening appetites. The shore-haunting kinds may more particularly be classified under the two categories already named, sand-fish or rock-fish, and it will be found on investigation that the majority of them are, in view of the aforementioned risks of the shallow and disturbed water, capable of affixing themselves when threatened with dispersal. Of the rock-fish, the suckers (*Lepadogaster*, *Liparis*, *etc.*), and in a lesser degree the gobies (*Gobius*), illustrate this power; while, among the others, we have the flat-fish (*Heterosomata*) and weevers (*Trachinus*), which lie half-covered by the sand, or even with only the eyes and gills protruding, and the sand-eel and launce (*Ammodytes*), which burrow beneath it.*

IV. Equally unsatisfactory in many respects is any attempt to separate the surface-swimming from the ground-dwelling fishes, for here also there is an even greater interchange than between those inhabiting coastal and more open waters. It is matter of common knowledge, as already stated, that the shoals of mackerel, which during the greater part of the year are encountered at, or near, the surface, break up and sink to the bottom at the end of summer. At the same time, bearing in mind these difficulties, we can, of course, distinguish, if it so please us, between the characteristic surface-fishes of our seas—the mackerel (*Scomber*), herring (*Clupea*), bass (*Labrax*), grey mullet (*Mugil*), and so on—and those which, on the other hand, pass the greater portion of their existence close to the bottom, such as the angler-fish (*Lophius*), skates (*Raia*), weevers (*Trachinus*), ling (*Molva*), and others. It will, moreover, be found that it is more usual for the normally surface-fishes to spend a period at the bottom than for the pronounced ground-dwellers to appear in any numbers or for any consider-

* See an interesting article by Hunt and Jeffreys in the *Journ. Linn. Soc.*, 1885 (pp. 262-274, and particularly pp. 270-271), entitled, "On the Influence of Wave-currents on the Fauna inhabiting Shallow Seas."

able time at the surface, the explanation being simply that their swimming and possibly also their breathing apparatus do not qualify them for such an effort. A further confusion, however, arises in any scheme for differentiating between the surface and the ground fishes. Not alone do the former, as mentioned, habitually go to the bottom, either at fixed seasons or under stress of temperature or weather, but the young forms, larval and post-larval, of many ground-dwelling fishes are strictly pelagic, passing all their early days in the surface water.

The great abundance and variety of fishes in British seas have already been noticed in connection with the migrations of northern and southern forms, and Forbes long ago remarked on their convenience as a kind of half-way house for these wanderers. Palacky points out that a few typically northern forms are either very rare—as *Sebastes*, *Cottus quadricornis*, *Gobius nilssoni*, and *Lumpenus lampetriformis*—or altogether wanting, as *Cottus liljeborgi*, *Onos** *reinhardti*, and *Stomias ferox*.† On the other hand, by way of compensation, he remarks on the southern forms that find their way to our seas, such as *Holocanthus tricolor*, *Peristethus cataphractus*, *Dentex*, *Box*, *Luvarus imperialis*, *Lichia glauca*, *Centriscus scolopax*, *Fierasfer dentatus*, *Balistes capriscus*, *Muræna helena*, *Pristiurus melanostoma*, *Pagellus bogaraveo*, and others. More on the subject of these rare British fishes will be found in a chapter (XIV.) which it has been thought desirable to devote to them, rather than to introduce them in the order that should strictly be theirs, distributed over the other chapters on the different families.

The study of animal distribution always presents itself in one of two aspects. Either we may investigate the geographical range of a given form, or we may determine the number and variety of forms that inhabit a given area, seeking their affinities

* I.e. *Motella* (rocklings).

† All of these, together with *Gadus esmarkii*, have since been taken by Murray on the west coast of Scotland.

and their original home. In the case of British seas, it may be pointed out that certain families of fishes show very marked superiority in the number of their representatives. Such, for instance, are the cod family (*Gadidæ*) with nearly a score, the sharks and rays (*Selachii*) with only one or two less, the flat-fish (*Heterosomata*), the blennies (*Blenniidæ*) and gobies (*Gobiidæ*), the breams (*Sparidæ*), the bull-heads and gurnards (*Cottidæ*), the pipe-fishes (*Sygnathidæ*), the herrings (*Clupeidæ*), the mackerels (*Scombridæ*), the horse-mackerels (*Carangidæ*), and the perches (*Percidæ*) and perch-like fishes. On the other hand, quite a number of our sea fish stand in a family by themselves, isolated representatives, with no near relative in this part of the world at all. Of these mention may be made of the dory (our only representative of the *Cyttidæ*), angler-fish (belonging to the *Pediculati*), black-fish (*Stromateidæ*), sword-fish (*Xiphiidæ*), maigre (*Sciænidæ*), red band-fish (*Cepolidæ*), bellows-fish (*Centriscidæ*), and file-fish (*Sclerodermi*). River anglers are familiar with a somewhat analogous contrast in the isolation of the pike, or jack (*Esox*), as the sole representative of the *Esocidæ*, among the many members of the two great families of game-fish (*Salmonidæ*) and coarse-fish (*Cyprinidæ*).

A special interest attaches to those species which are not found outside of a prescribed region, and are known as "peculiar" or "endemic." It is very difficult to say whether our seas have any such species. A small flat-fish (*Solea greenii*), first brought to light in the 1891 Irish surveys, and one of the gurnards (*Triglops murrayi*), supposed to occur only on the coast of Scotland and nowhere beside, have been suggested as "peculiar" British sea fish; but it is more than likely that further dredging expeditions will yield examples of both from other parts of the North Sea or Atlantic. When we come to consider that even many of the lake chars, which were for a long time fondly claimed as peculiar to Wales or the Lake District, have since been identified in Continental

Europe, the probability of any sea fish keeping so close to our coasts as not even to occur on the opposite coast of Holland or Norway seems too remote to bear serious examination. All that can with safety be affirmed is that, for some reason or other, scientific investigation has so far failed to discover these forms in neighbouring waters.

The converse of these real or alleged "peculiar" or "endemic" fishes are, of course, those with almost cosmopolitan distribution, such as many of the sharks—blue (*Carcharias*), porbeagle (*Lamna*), spur-dog (*Acanthias*), tope (*Galeus*), smooth hound (*Mustelus*), thresher (*Alopias*), hammer-head (*Zygæna*), and monk-fish (*Rhina*)—the conger (*Conger*), some of the herrings (*e.g.* the sprat), one or two of the mackerel family (as the remora), the dory (*Zeus*), horse-mackerel (*Caranx*), sword-fish (*Xiphias*), and greater weever (*Trachinus draco*).

Passing reference has already been made to the presence of some southern forms on our south coast only, and of these the chief are some of the perches (*Serranus* and *Polyprion*), some of the wrasses (*Acantholabrus* and *Coris*), the muræna (*Muræna*), and the trigger-fish (*Balistes*). On the other hand, a few northern forms do not come, in the ordinary way, as far south as the English Channel, but remain in Scotch waters, or at most extend their range to the north-eastern counties of England, such as the bergylt (*Sebastes*), lumpsucker (*Cyclopterus*),* wolf-fish (*Anarrhicas*), viviparous blenny (*Zoarces*), torsk (*Brosmius*), long rough dab (*Hippoglossoides*), and Greenland shark (*Læmargus*).

The scope of the present volume does not, however, permit of any further attention to this matter of distribution. What has to be borne in mind, and what has perhaps been shown in these few pages on the subject, is that the fish fauna of our seas is a blend of Arctic and Mediterranean forms, some few

* The lumpsucker occurs in the Channel more commonly than the majority of genuinely northern forms.

of which appear to roam around our coasts irrespective of their origin, while the majority confine themselves, as the case may be, to the southern or northern portion of our seas. As a general rule, it will be found that the Arctic forms, being the most vigorous, provide the most valuable and varied forms, while those from the south are more attractive in their colours and general appearance. The writer has had some opportunity of comparing the fishes of British seas with those of three other very different areas of water—the Baltic, the Mediterranean, and the South Pacific in the neighbourhood of Sydney, New South Wales. The Baltic was immeasurably inferior in the matter of variety, though the abundance of such comparatively few table fish as found their way to the inshore waters in North Mecklenburgh was amazing, owing in great measure to ineffectual methods of fishing. The Mediterranean, on the other hand, shows immense variety, but a serious falling-off in large fish. The practice of catching swarms of young—not what we should call undersized merely, but those which have just struggled out of the post-larval stage and measure perhaps an inch or two in length—in the *bilancia* net for a "*frittura*" is, while often helpful to the student, fatal to the fish supply. In Australia there is a great wealth of excellent fish; but at the time when the writer was in the colony named, Mr. Farnell was only just inaugurating his trawling experiments, so that it is too early to talk seriously of the Australian trawling industry.

Reproduction, Growth, and Development.*

In contrasting the bass and the tope as the types of the bony and cartilaginous sub-classes respectively, allusion was made to the fact of the latter bringing forth living young, whereas the bass deposits floating eggs, which are fertilised in the water, and subsequently hatch out. There are other forms of reproduction among

* The remainder of this chapter is based on the admirable account contained in the first six chapters of the *Life Histories* by McIntosh and Masterman.

fishes. Thus, the rowhound (*Scyllium*) deposits large horny capsules, each containing an embryo rowhound, and moored by tendril-like processes at the four corners to any convenient anchorage of rock or weed. During this period the embryo is undergoing development to the comparatively advanced stage at which it breaks through the walls of its prison. Even among bony fishes there is more than one way of maintaining the supply of the species. The eggs of different groups of fishes behave differently. Broadly, they are divided into eggs which float, like those of the plaice (*Pleuronectes*), and eggs which sink, like those of the herring (*Clupea*). The former are known as buoyant, or pelagic; the latter as demersal. While, however, the eggs of the plaice float separately, those of the angler-fish (*Lophius*), also of the buoyant kind, float in immense sheets, just as we see the spawn of frogs floating on inland ponds. A similar distinction is noted among demersal, or sinking, eggs, for whereas those of the herring lie at the bottom in adhesive masses, clinging to stones or other substances, those of its relative, the shad, lie on the bottom of rivers separately. Both the bony and the cartilaginous fishes, moreover, number some that bring forth living young, known as "viviparous" fishes. Among the cartilaginous we have already seen this habit in the tope. Among the bony fishes of our seas, it is remarked in the bergylt (*Sebastes*) and in one of the blennies (*Zoarces*)—fishes, be it noticed, of very different groups. Some of the rays, too, are viviparous, but the majority, at least of the smaller, commoner kinds, deposit large egg-cases or capsules, not unlike those of the rowhound, but unprovided with tendrils. Among the sharks, on the other hand, the viviparous habit is far commoner, and only two sharks in our seas (*Scyllium*) are ovo-viviparous. The late Matthias Dunn suggested that the egg-cases of the rays, lacking the useful anchoring tendrils, were provided in lieu thereof with a glue which, being insoluble in sea-water, serves the same purpose.

This has not perhaps been quite satisfactorily proved, the obvious difficulty being that these egg-cases are generally recovered only when they have been washed up after a storm, and have consequently been exposed for some time to the sun or atmosphere, which doubtless destroys the natural glue.

The larger rays mostly bring forth living young, like the sharks, and it is now generally recognised that the large egg-case attributed by Couch to the eagle-ray (*Myliobatis*) belonged to one of the genus *Raia*, known as the "typical" genus. Among the vipiparous kinds are the sting-rays (*Trygon*). Their embryo does not appear to have been an object of special study by anatomists in this country, but with regard to that of an Indian species (*T. walga*), taken in the Godaveri delta, there is an interesting communication from Messrs. Alcock and Wood-Mason in the archives of the Royal Society (November, 1901). According to this memoir, the new-born fish had the upper surface quite smooth and devoid of the usual tubercles of the adult, and whereas the latter has, in that species, two spines in the tail, the young fish showed only one. In addition, however, it had a fold of skin on the tail, which apparently disappears with age. The authors of the memoir regarded this fold of skin as a survival of the vertical system of fins.

The very young forms of fishes hatched from spawn differ from their elders in a considerably greater measure than those which are born alive. The tiny fish, as it emerges from the egg and for the first few days of its existence, is known as the "larval form," or larva, and at that stage it has a yolk-sac containing nourishment for the first few days of its existence, for it is born without an open mouth, and cannot at once seek its natural food. The yolk-sac may last it for a few days only, or for as long as a couple of weeks, according to the species, and perhaps also according to conditions of temperature, though our knowledge on this is still rather circumscribed. At last, however, the yolk-sac is used up, and the little mouth opens, and the little teeth develop, just at the right moment for the fish to start out foraging on its own account. It is now in what is known as the "post-larval" stage. As both of these terms will necessarily recur constantly in the following pages, it is quite important to have a clear understanding of what they mean.

Some of the larval and post-larval forms of fishes differ from the adult not less than the caterpillar and chrysalis differ from the perfect butterfly. McIntosh, for instance, describes the larval stage of the grey gurnard as "one of the most grotesque little animals which one meets with; its long, angular snout, large greenish eyes, huge pectoral fins, and numerous little spines, all adding to its unique appearance. The huge pectoral fins form a drapery for the entire body when folded back, only the tip of the tail extending beyond them."

Even after the post-larval stage the young fishes often differ considerably from what they will be when full-grown. Thus, whereas the adult coal-fish has only a small barbel and its lower jaw only slighter longer than the upper, young examples have the barbel comparatively long and the lower jaw conspicuously protruding. It has also been remarked, with much evidence in support of the view, that characters acquired comparatively late in the evolutionary history of a species are generally developed late in the post-larval stage. Conversely, it may be inferred that characters present in the larval form or new-born young (as the fold of skin in the tail of the young Indian sting-ray), and lost at a later stage, indicate features which were possessed by some ancestor of the species, but which it was found advantageous to drop. This theory must not, however, be pressed too far. For instance, it is thought that the protruding lower jaw indicates predatory habits. Now, the larval stages of practically all bony fishes show a protruding lower jaw. This does not, however, indicate that the ancestors of all bony fishes were in consequence of predatory habits; but the explanation lies rather in the fact that the post-larval stages of even vegetable-feeders among fishes live by chasing and devouring tiny living creatures so minute that only the high-power microscope reveals them to the human eye.

The eggs of fishes show considerable variation in both size and shape. As a general rule, the bony fishes lay round eggs, but that of the anchovy (*Engraulis*) is oval, and that of the garfish (*Belone*) has long filaments which serve as anchor-ropes, like the tendrils on the egg-cases of the spotted dog-fish. The anchovy's egg, unlike that of the allied herring, floats in the water, but that of the gar-fish probably sinks, the filaments securing it to weed-clumps or other convenient rests.

Attempts have with praiseworthy ingenuity been made to trace the influence of a floating or demersal egg on the after-history of the fish hatched from it, but these have signally failed, as may be shown by a few familiar examples of both. The most striking contradictions are, perhaps, the herring (*Clupea*) and angler-fish (*Lophius*). The herring, hatched from a sinking egg, which develops at the bottom of the sea, spends most of its after-life swimming at the surface. The angler-fish, on the other hand, which emerged from a floating egg, lives when older on the ground, there lying in wait for its victims. It has also been suggested that fishes hatched from pelagic, or floating, eggs are less given to wandering in after-life, since the species is already dispersed in the egg stage. Obviously, the heavy, clinging eggs of the herring, hatching out as they do close to the spot in which they were in the first instance deposited, must tend to restrict the distribution of that fish. On the other hand, the eggs of the mackerel (*Scomber*), which float hither and thither on the surface and are dispersed by every normal current or incidental storm, must carry that fish over wider areas. Yet who would care to describe the mackerel as less of a traveller in after-life than the herring? The flat-fish have also been quoted as illustrating this stationary habit in a group already sufficiently dispersed in the egg. But on the one hand we have the wandering cods (*Gadus*), which also begin life in floating eggs, and on the other we have the bull-heads (*Cottus*), gobies (*Gobius*), and suckers (*Liparis*)—interesting small forms to which a subsequent chapter is devoted—which, although hatched from heavy eggs, are little, if any, more endowed with the migratory instinct than the flat-fish themselves. Not only does the floating egg tend to spread over a greater area during the interval which elapses before hatching, but it may also escape certain dangers, such as possibly the trawl, and certainly spawn-eating fishes, like the cod and haddock. It might, therefore, have been thought that Nature would have provided against such extra risks by producing a greater supply, and that the herring would deposit more eggs than another fish of like size, say the whiting, the spawn of which floats in the sea. But Nature knows her own business best, and we find that whereas the number of eggs in an average herring would not exceed thirty thousand, those in a good-sized female whiting may easily reach ten times that number, or three hundred thousand. In support of Nature's view, moreover, it must be borne in mind that even the floating eggs run some risks to which those which develop at the bottom are not subjected. They may, for instance, be thrown ashore or otherwise destroyed by storms, and they may also be consumed, along with other food, by all manner of surface-feeding fishes, particularly those, like the herring (*Clupea*) and basking shark (*Selache*), provided with straining gill-rakers, which allow nothing, however small, to escape. On the whole, however, their very independence one of the other (save in a few cases like that aforementioned of the angler-fish) must in a measure secure their safety, on the same principle as that which governs the forming of open order in battle. Facts, too, are better than theories. So long as we find the herring, with its poor little achievement of only thirty or forty thousand eggs, crowding each of twice as many nets in the season of 1902, in numbers as appalling as those captured in half the number twenty years ago, we cannot seriously condemn the demersal egg as constituting a danger to the survival of the species. Touching the above-mentioned influence of the floating egg on the distribution of the species, it cannot be denied that the range of a fish which is of sedentary habits in later life may be appreciably extended by floating ova and free-swimming young, just as the young barnacle travels far and wide, while the old one is a fixture.

In addition to their small size—the eggs of many of our important food-fishes measure in diameter less than $\frac{1}{12}$ in., and that of the dab (*Pleuronectes*) is less than $\frac{1}{25}$ in.—the eggs of the majority of fishes are transparent, or rather translucent, and all but invisible in sea water, particularly those which float separately. That of the sole (*Solea*), however, has several oil-globules and a segmented yolk, both of which conditions tend to render it conspicuous; and that of the pilchard (*Clupea*) is more easily seen that it would otherwise be on account of the wide space between the yolk-membrane and the surrounding envelope, technically known as the "perivitelline" space. It must not be thought that the size of the egg has always a direct relation to the size of the fish. In members of the same family more particularly there is great risk of error in such an assumption, for the egg of the turbot (*Rhombus*), for example, is smaller than that of the plaice (*Pleuronectes*).

The unfertilised eggs of a fish, which for table purposes we call "hard roe," are the product of the female. The "soft roe" of our herrings and other fishes is the milt of the male. Fertilised eggs—that is to say, those which, having been deposited in the water by the female, are acted on by the milt of the male—are of course never available as food for man. The milt of a single male fish is capable, under favourable conditions, of fertilising the ova of several females on encountering them in the water, and a knowledge of this fact is utilised in a suggestion for rough-and-ready fish-culture at sea, some account of which will be found at the end of Chapter II. This milt, however, is exceedingly small in some fishes, particularly in the sole, in respect of which Cunningham, a great authority on the species, suggests that, "until a few years ago," not only fishermen, but others (presumably meaning scientific men) believed in the hermaphroditism, or double sex, of each individual.* This fact, that the milt of a single male can fertilise the eggs of several females of the same species, is a useful provision in view of the numerical superiority of the females in most fishes, as in ourselves and most other higher vertebrates. In addition to their usually superior number, the females have also, as a rule, the advantage in size, a character in which they agree less perhaps with many other vertebrates than with spiders and some other creatures without backbone. Dr. Wemyss Fulton, the able Secretary of the Scotch Fishery Board, has investigated these relations of the sexes in both size and number, and with very interesting results. Thus, to take an example, the female of the long rough dab (*Hippoglossoides*) exceeds all the other fishes tabulated by him on these grounds, and in both size and numbers as compared with the male, the proportion in numbers being more than 5 to 1, and in size nearly 4 to 3. As a contrast, the female angler-fish (*Lophius*) is not only smaller (practically 17 to 20) in proportion to the male than in any other fish on Dr. Fulton's list, but is also, with one exception (a tie), fewer in proportionate number (1 to 4). On the other hand, in case any might feel the inclination to generalise from only two cases, it may be added that in the lumpsucker (*Cyclopterus*) the females, while numbering only 1 to 4 of the males, are more than half as long again. It is questionable whether, until at any rate we have figures based on a larger series of observations than those recorded

* *Marketable Marine Fishes*, p. 74.

by Dr. Fulton, and taken over a wider area comprising very different localities, there can be any advantage in making deductions from the available data.

The unaided spawning of fishes in captivity is always interesting, particularly where a valuable food-fish is concerned. The common sole, for instance, spawned in the tanks of the Marine Biological Association at Plymouth for the first time in the year 1895, nor, up to the time of writing, have brill and turbot naturally spawned in tanks. The eggs of the one have, it is true, been artificially fertilised with the milt of the other, but that is quite a different matter. The first to achieve this was Mr. Scott, of the Scotch Fishery Board, and the episode is fully described by McIntosh and Masterman.* This suggests a few remarks on the subject of hybrids generally.

The fishermen have somewhat remarkable notions on the subject of hybridisation in fishes. The Little Ling (*Molva abyssorum*), for instance, known to Norwegians as the "birke-lange," they regard, of course erroneously, as a cross between the ling (*Molva*) and hake (*Merluccius*). Even scientific writers differ in their view of hybrids, and examples which Day considered to be hybrids between, for example, the herring and pilchard have been regarded by Bateson † as mere varieties with scales abnormal in both size and number, and rather more gill-rakers than in the type forms, or those forms from which the types were severally described.

In the flat-fish (*Heterosomata*) real or alleged hybrids are not uncommon. The egg of the brill has been artificially fertilised with the milt of the turbot and also with that of the dab, and what is done in the laboratory may possibly be done also in nature. The Grimsby fishermen, for instance, often catch a peculiar-looking flat-fish, which they firmly believe to be a hybrid between the brill and turbot, and so high an authority as Mr. Holt is inclined to agree with them, having found that

* *Op. cit.*, p. 338.

† See *Proc. Zool. Soc.*, 1890, p. 586, and 1894, p. 164.

a careful diagnosis of the characters revealed too marked a tendency towards the typical characters of either to enable him to pronounce the fish a mere "sport" of either brill or turbot, which would be the only alternative if the theory of hybridisation were rejected.

The spawning-time of fishes will be found, on reference to the writings of our own and continental authorities, to be a matter of much difference of opinion. The explanation of this divergence is clearly that our northern and southern waters differ in this respect. As a familiar instance, the common plaice spawns at Grimsby as early as January. Still farther north, in the Firth of Clyde, this fish does not commonly spawn until the month of April. When the spawning-time begins in any locality early in the year, it also ends early; and whereas in the Plymouth district the spawning of plaice is finished by the end of March, it lasts in more northern waters until nearly the end of May. A fish is known as "ripe" when it has spawn ready for shedding, and it is important to remember, in view of individual variation, that the spawning-time of a species is the whole period during which ripe fish are encountered with their eggs or milt still undeposited. As some fishes spawn over a considerable period in the same locality, for two, three, or even four, months, it will easily be understood that, the rate of growth being approximately equal, their progeny must also come to maturity at different times. Moreover, the temperature in any given year may be so abnormally high or low as to accelerate or retard the spawning-season of a species; but it may be said that such departures from the normal season, due to weather conditions, are on the whole neither general nor pronounced.

The spawning-grounds are of great importance, as will be surmised, in all questions of legislation against promiscuous trawling, and it is to be hoped that the international scheme of North Sea Investigation, on which this country is now embarked, may throw fresh light on the mystery of the spawning-grounds of valuable species, particularly of the plaice, in that area. We want to know the spawning-grounds in order that we may avoid them and induce others to do likewise. Only a few general facts have been so far ascertained, and even these must be regarded as subject to any rebutting evidence that may possibly be brought forward. We know, for example, that some fishes approach our coasts for spawning purposes, but that the majority repair to deeper water. Those which spawn in deep water may come inshore as soon as the spawning is over—when they are technically known as "spent"—but that is in order that they may recoup their lost strength with abundant food. Many of the valuable fishes, such as the plaice (*Pleuronectes*) and pilchard (*Clupea*), deposit their spawn at a considerable distance from the land, and pilchards with roe are notably far less common than herrings in the same condition. Others, on the other hand, like cod and whiting, spawn near the shore. In the case of the herring, it is thought that the distinct summer and winter "races" of that fish, which will be explained in a later chapter, have different preferences in this respect, the former spawning out in deep water, while the latter choose the brackish inshore water for the same purpose. Among the smaller, comparatively valueless fishes the inshore spawning habit is very common. The eggs of the father-lasher (*Cottus*), for instance, lie partly exposed among the weeds at low water, and the same may be said of those of the lump-sucker (*Cyclopterus*). In sticklebacks (*Gasterosteus*) the eggs are sheltered in a seaweed nest among the inshore rocks. It is quite evident that these small shore-loving forms are compelled in self-preservation to produce heavy, or demersal, eggs, else these would, if they were to float, have no chance in the shallow, broken water. In this instance, at any rate, the object of the demersal egg is not difficult to understand.

The terms "larval" and "post-larval" have already been explained. After the end of the post-larval stage, and when the fish has practically assumed the general characters of the adult, all further changes are for the most part in size or colour. In fact, the metamorphoses are to all intents and purposes at an end, though in some fishes there may be further change in the length of the fins, together with other trifling alterations of like nature. The size of an adult fish is, unlike that of a beast or bird, no exact or reliable index to its maturity or reproductive powers, for it appears to continue growing almost indefinitely, so long as the supply of food is maintained. We have already seen how the eggs of some fishes sink, while those of others float; but these two categories, instead of, as would seem, being abruptly demarcated, show a large series of gradations. Some of the sinking eggs, for instance, are only a little heavier than the sea-water, and are in consequence (*e.g.* the eggs of the wolf-fish, *Anarrhicas*) easily disturbed by under-currents; while others, like those of the herring, are not only much heavier, but also adhesive, so that they develop where they are deposited. Some of the floating eggs, again, having a low specific gravity when shed, rise rapidly in the water, while others rise much more slowly. Dead eggs of the buoyant kind sink; but healthy, buoyant eggs from the deeper water outside may likewise sink if suddenly introduced into the less dense brackish water of estuaries, yet without at once suffering destruction. The oil-globule, which is found in many eggs of different families of fishes, such as those of the hake (*Merluccius*) and ling (*Molva*) among the cod family, and those of the brill and turbot (*Rhombus*) among flat-fish, also in those of the red and grey gurnards (*Trigla*), of the bass (*Labrax*), of the mackerel (*Scomber*), and of many other fishes, may possibly have the object of keeping the egg floating with one end uppermost—acting, in fact, as a float. On the other hand, the eggs of the sole (*Solea*) and others of the same genus, as well as those of the lumpsucker (*Cyclopterus*) and stickleback (*Gasterosteus*), have a number of oil-globules so generally distributed that they could not serve to float any particular part of the egg uppermost more than another. In the eggs, moreover, of such outwardly different, though anatomically allied, forms as the plaice (*Pleuronectes*) and cod (*Gadus*) there is no oil-globule whatever. In any case, therefore, since these last are both eggs of the buoyant type, it is not the oil-globule which causes the floating of the egg, though it may keep a particular part of it uppermost in the water. Nor does the floating of eggs in sea water appear to be a question, as Professor Huxley thought might be the case, of temperature.

The time occupied in hatching varies, as might be expected, however, with this same condition of temperature, so that figures are, unless all the attendant circumstances be carefully noted, of little use. As some indication, however, and with the reservation that such results are necessarily based on observations conducted in the artificial surroundings of the aquarium, it may be mentioned that the eggs of the plaice developed at a temperature of 53° F. in from ten to twelve days, while those of the cod took twelve days at 45° F.* It must further be borne in mind that the eggs of many kinds of sea fish show considerable range in size, and also that large eggs are found to take longer in developing than small. It is also interesting to remember that, providing the water has so large a percentage of salt that it cannot freeze, the eggs of many northern fishes are capable of hatching out at a temperature below zero.

The little larva, having at last, in a varying period, burst the capsule of the egg, emerges in the sea a helpless being, without, in the majority of cases, either red blood or an open mouth. To change from this very rudimentary condition to the perfect state, irrespective of size, may be the work of a few weeks or of many months, according to the state of advancement when hatched. Just as the naturalist in Australia is confronted by a most remarkable contrast in this respect in the almost embryonic new-born kangaroo and the young brush-turkey, which does not escape from its native mound until practically

* Cunningham, *op. cit.*, pp. 216, 284.

capable of looking after itself, so in our fishes some leave the egg little more than animated threads, while others (hatched in most cases from heavy, adhesive eggs—*e.g.* the gobies) have from their first days of freedom both red blood and an open mouth.

In sharks, the eggs and development of which differ in so many respects from those of bony fishes, the young fish emerges in a comparatively advanced condition. On the other hand, it must be borne in mind that the young shark has been a long time developing in the egg. Thus, whereas the eggs of some bony fishes hatch out in a few days, the young of the black-mouthed dog-fish (*Pristiurus*) is about nine months in the egg; that of the rowhound (*Scyllium*) about seven.* Consequently, as might be expected, the baby shark has, by the time it succeeds in rupturing the tough egg-capsule, acquired all the characters of the adult, and it remains only for it to increase in size and come to maturity.

Far more wonderful in some respects is the early development of young bony fishes, which may hatch from the egg in four days, a transparent and helpless creature, measuring perhaps $\frac{1}{8}$ in., yet may acquire all the characters of the adult while still less than $\frac{1}{2}$ in.† The yolk-sac, large and conspicuous, and generally globular at the time of hatching, rapidly dwindles day by day and disappears in less than a week, by which time also the mouth has appeared and the fins are outlined. Spots and dashes of colour-pigment may appear during the first few days, and these will rapidly increase and spread. The special metamorphoses of young flat-fishes, including general twisting of the head and the passage of one eye either over the ridge of the head or through its soft tissues, together with the disappearance of colouring matter from the side bereft of its eye, will be more appropriately alluded to in the chapter on that group of fishes.

* *Cf.* Bashford Dean, *op. cit.*, p. 217.

† *Ibid.*, p. 225.

A very important point in the study of the growth and development of important food-fishes is the size at which they become sexually mature. The fruitful source of discussion whether flat-fish should be protected by Parliament from the trawler, or at any rate from the salesman, until they are full-grown or have attained to their extreme length—whether, in fact, it is for the freedom of the undersized or immature that the legislator is called upon to provide—arises in every conference on the subject. There seems to exist in some quarters a vague notion that the two terms have but one meaning, but this is quite erroneous. As already pointed out, fishes, unlike birds and mammals, are capable of growing much larger long after they are sexually mature. In other words, the quantitative changes are independent of the qualitative. It is not easy, unless an immense series of mature and immature fish of a species be examined and very carefully measured, to establish exact sizes at which fish from any given locality (this is important) are first mature. Roughly, it has been computed by so high an authority as Dr. Wemyss Fulton* that, irrespective of sex, plaice on the Scotch coast are first mature at 12 in., dabs at 6 in., turbot at 18 in., and cod at 20 in. As a rule, also, the males of bony fishes become mature at a smaller length, and probably earlier, than the females.

* McIntosh and Masterman, *op. cit.*, p. 108.

CHAPTER II

OUR FISHERIES: THEIR PRACTICE AND THEIR CONTROL

UNFORTUNATELY it is no longer possible for us to exult with Yarrell (Preface to his edition of 1837) over the large and constant supply of excellent food "obtained from the seas all round the coast by moderate labour and expense." It may be questioned whether such hopeful phrases were still applicable on the publication of his second edition; but sixty years later, at any rate, neither the capital nor the labour involved in supplying our markets with sea fish could be properly so described. No one who has spent a night on board a pilchard drifter or watched the wonderfully equipped herring-fleets cleaning up in our east-coast ports would dream of employing such a word as "moderate" in connection with either the outlay or labour entailed.

The reasons for prefacing the following short histories of our different coast fish with a chapter on the methods of fishing are two. In the first place, frequent allusion will, in the course of these pages, have to be made to the means by which different fish are captured, for the method often throws interesting light on the life-story of the fish caught. There is, for instance, in some of the Swiss lakes a small salmonoid—in fact, a degenerate char—known as the "*Beisser*," or "biter," because it is caught only by biting the soft meshes of the nets used for other chars. It is evidently a gregarious fish, for a hundred or so are generally caught at a time; but all of them, without exception, are held fast in this extraordinary fashion by the teeth being embedded in the soft cotton mesh, and the fishermen, having long known this habit, do not organise any special fishery with small-meshed nets, although the fish commands a good price in the hotels, because, they say, the fish catches itself and saves them the trouble.

We have not on our coasts any fish of such suicidal habits as this inhabitant of the inland waters of Switzerland ; but, as will be shown in the following pages, many of our food-fishes have a most interesting life-history, and the fishermen have not been backward in turning their more curious habits to account. Thus, the construction and employment of the drift-net for pilchards on the Cornish coast—which will be more fully explained later—argues a very long and close acquaintance with the singular habit of pilchards in congregating to feed about sunset, and the principle of the fine mesh slipping inside the gill-cover and thus holding the fish prisoner is extremely sound. The first obvious reason, then, for including the present chapter as a legitimate departure from the immediate subject of the volume is that the reader may have an intelligent understanding of the various engines of destruction—the trawl and trammel and the rest, mentioned hereafter. The second, not less important, reason is that he may also, if desired, be in a position to grasp the significance of some of the problems of fishery legislation which from time to time crop up in the Parliamentary programme, and which are, apart from the more academic enthusiasm of the laboratory biologist, the chief end and aim of marine biological investigation. The obsolete optimism of the remark already quoted from Yarrell has increasingly troubled those who take an interest in the safe-guarding of great industries and, more particularly, of great sources of national food supply. As we shall see in the later chapters of this book, there are a number of important round migratory fish, such as the cod and mackerel, which cannot in all probability be exhausted, or even seriously lessened, by human agency, for the very good reason that for a part of the year they swim far from our coasts and out of our ken, and no form of net yet constructed seems to encounter them on the grounds ordinarily worked. The ocean is wide, and not even the increased facilities for steam-carriage and ice-packing will be able to keep up with extended winter migration on the part of the fish. On the other hand, we shall also find a number of more or less stationary flat-fish, such as the sole and plaice, which are very severely menaced by the fishermen, since at no period of their career are they exempt from toll being levied on their numbers by one form or other of net commonly in use. The writer had the honour of giving evidence before Mr. Marjoribanks's Committee in 1893, when his object was to bring evidence from Dr. Heincke, of Heligoland, proving Germany's aloofness from international restrictive measures until the German fisheries had developed considerably beyond the position which they then held. Again in 1901 he gave evidence before Sir Herbert Maxwell's Committee on Ichthyological Research, and on that occasion it was his endeavour to illustrate, by evidence from every port between Brixham and St. Ives, personally collected during the previous summer, the immediate need of a centralisation of authority, and the manner in which the fishermen generally distrust the local fishery district officials. It is quite useless to mince matters in discussing these somewhat delicate difficulties of local government. Those who serve on the fishery boards are not always disinterested in the disposal of the local vote, and the interest of the trawler will weigh more or less than the interest of the seine-man or hooker to an extent that would be quite impossible if a central department took over direct control. Advocacy of such a Fishery Board cannot reasonably be construed into any vote of want of confidence in that overworked congeries of departments the Board of Trade; and as proof of the fallacy of such criticism of the critics, it may be urged that most of these would be satisfied by the bodily transference of the present inspectors and other officials, usefully reinforced perhaps by competent scientific advisers who had duly qualified at Plymouth, St. Andrews, Piel, or some other of our marine laboratories, under their own roof, and subject to their own President. That Scotland should have a Fishery Board and Ireland a Fishery Officer, while England has only an Assistant Secretary, with most of his attention required for other business, seems hardly credible. Yet so it was ordered until the recent removal of the Fisheries Department to the Board of Agriculture. Great things are expected of Lord Onslow, who now, as he puts it, has control of the fishes as well as of the loaves; but there has not yet been time for a critical estimate of the work that he and his colleagues may be able to perform.

Further light on our ignorance touching the life-histories of our sea fish, a more thorough knowledge of the remaining secrets of their migrations, their food, their rate of growth, and their spawning-grounds, will alone enable Parliament to legislate usefully. It cannot be said that the average Member of Parliament, even representing maritime constituencies, and thus the spokesman of the fishing population, knows very much about these matters. The writer recollects many years ago being called upon to explain to a legislator not uninterested in our east-coast fisheries the difference in principle and practice between the antiquated beam-trawl and the newer "otter" pattern, and the experience has not been forgotten. Perhaps the worst error commonly made by public men not specially initiated in the freemasonry of the seashore is to regard all the fishermen as an agglomeration of unskilled labourers, as so many men who make a livelihood by getting fish out of the sea by any means handy, netting or hooking, and selling them in the best market. No view could well be more fallacious or more prejudicial to a proper understanding of the problems that call for solution. Not only are the drifters and trawlers, the seaners and liners, the crabbers and the trammel-men to all intents and purposes separate castes, but each method of fishing is actually characteristic of certain parts of our coasts and practically unknown in others—a sure sign of skilled labour. Thus, whereas, with the single exception of the pilchard-seans of St. Ives, the drift-net is all-important in Cornwall, in Devon, the neighbouring county, or duchy, on the east, the drift-net already loses importance and gives place to the trawlers of Plymouth and Brixham. On the east coast, again, of both England and Scotland the drift-net for herring is of first importance in summer-time, while in winter all the ablest hands are away line-fishing for cod on the Dogger, or on still more northern haunts of halibut and haddock. The Scotch are practically ignorant of trawling as practised at Brixham: what they call "trawling" is in reality seaning, which, as will be seen presently, is a very different matter. Strictly local fisheries, such as the use in the Thames and a few other estuaries of the huge stow-net for sprats, are rather a development of local conditions; nevertheless, these also accentuate the skilled nature of fishing labour. It is necessary to lay great stress on this recognition of fishing as skilled labour, because herein lies more than half the difficulty of legislation. If it were unskilled labour only, there could be no serious question of the conflicting interests of different classes, since a transfer of energy would be simple. The fact is, however, that it would in many cases be easier for the hand on the trawler to take to agricultural work or the quarries than to earn his living with hook and line.

Further knowledge, then, both in and out of Parliament, is what is needed before we can hope effectually to protect the fisheries. More has been done in the right direction during the last fifteen years than during the preceding fifty. The researches of McIntosh, Günther, Boulenger, Cunningham, Holt, Garstang, Herdman, Meek, Allen, and others in this country, and the contributions of Hensen, Sars, Dannevig, Heincke, Hermes, Dohrn, Delage, Raffaele, Grassi, Giglioli, Calandruccio, Agassiz, to mention only a few, from other seas have bridged many of the widest gaps in our knowledge as it was when Day wrote his laborious and still standard work; but full as many mysteries await explanation. The man who knows most best appreciates the extent of his own ignorance, and the interesting communications to the Journals of the Marine Biological Association, and similar publications, are not only one long cry for further research, but breathe a spirit of doubt and reservation that we seek in vain in the positive pronouncements on migrations and development in the books of fifty years ago. The older writers knew; the modern investigator thinks: the more enquiry proceeds, with all the facilities afforded by modern tow-nets and apparatus for dragging the secrets from the greatest depths of ocean, the more scientific men will say they only think, but the more in reality they will know.

The exhaustion of our fisheries, more particularly the sensible depletion of the inshore grounds and consequent need of going further and further from home to supply the market, increasingly occupied the attention of politicians, biologists, and men of commerce during the last decade of the nineteenth century, but a satisfactory solution of the difficulties has been left for the twentieth. Thoughtful studies have been published embodying a divergence of opinions. In his *Resources of the Sea*, Professor W. C. McIntosh, whose joint work with Mr. Masterman* has been one of the chief sources of information in the preparation of this volume, practically endorses the *laissez-faire* views of Huxley, who saw in the sea a large source of supply with as good (and apparently also as many) fish in it as ever came out of it. On the other hand, Mr. E. W. L. Holt, who has given much attention to these matters, tells us in his study of *The Grimsby Trawl Fishery and the Destruction of Immature Fish* that the North Sea is

* *The Life-Histories of the British Marine Food-Fishes.* Where reference is made to these authors, this is the work referred to.

being emptied of its fish life, and that the only conceivable remedy is to impose a size limit of saleable plaice as high as 13 in. This, he thinks, would at least have the effect of keeping the trawlers off the inshore grounds that yield only the smaller classes of fish. Without such a measure to accompany it, he considers that a close season, such as has from time to time been proposed, as ineffectual. The extension of the three-mile limit, within which trawling is already, though in some parts only nominally, prohibited, he regards as impracticable, chiefly on account of international complications. As to artificial culture of sea fish, on which subject Mr. R. B. Marston says something in Chapter XVI., Mr. Holt is clearly of opinion that the practical difficulties outweigh the theoretical advantages. The rearing of the fry through the surface-swimming stages—a phrase that will be better understood on reference to the short accounts that follow—is at least as important as the hatching of the eggs; and even if the fry were reared to that point—a costly and difficult undertaking—Mr. Holt thinks that it would also be necessary to legislate for the protection of the young after turning them loose amid the perils of the sea. Before making further reference to the leading fishery questions of to-day, it seems desirable to describe the different nets and lines in use on our coasts. We must, in short, give our attention to the practice of our fisheries before considering the ethics of their control.

Two main principles are involved in the capture of sea fish: either the fish are lured with a baited hook or into a baited trap, or else they are bodily taken in a net, either moving or stationary. Although, that is to say, netting and hooking are widely separated modes of fishing, the crab-pot (which incidentally takes many fish along with the crustaceans for which it is ostensibly intended) is nearer in principle to the hook and line than it is to the trammel or trawl. Between netting and hooking there is an intermediate mode of fishing, with the spear or grains. This must have developed from an earlier practice of spearing land animals, and the idea of netting fish probably emanated in the brain of some Asiatic from the older practice of netting birds. All fishing originated in all probability in inland waters, river or lake, for, so far at least as concerns the use of boats, there is some evidence to show that mankind took ages of familiarising with the treacherous sea before trusting to its waters. Whereas the modern settlers in Australia are only just now reaping the results of the extensive introduction of salmonidæ and other European and American fishes into the rivers of that continent, and have hitherto angled only in the sea, it was not so with the aboriginal inhabitants, and the writer has seen ancient traps and fish-passes which testify to a considerable degree of fishing skill on the part of the inventors of the boomerang, the most wonderful implement of war and the chase ever devised by untaught savages. The Japanese and Malays have also been great sea fishermen for countless ages, while the more stay-at-home Chinese, on the other hand, have won a reputation rather for their inland fish culture. So far as Europe goes, Britain has to-day the greatest stake in the fisheries of the North Sea, but there was a time in which she was certainly surpassed by Holland and equalled by France.

The use of hook and line is a more or less simple manner of fishing that needs very little explanation. With local variations, it resolves itself into capturing the fish on a barbed hook hidden in some kind of bait, natural or artificial, calculated to attract the particular fish sought. The hook is used on hand-lines or long lines, the latter, which may carry a couple of thousand hooks, being laid either across a bay or estuary, or in deeper water, on the sand. There is a heavy leaden sinker at either end, with a buoy-line and corks with small flags, so that the owners may pick up either end without difficulty and haul the line on board. Such a line is baited with squid, pilchard, herring, whelk, or lugworm, and the baiting of a long line with two thousand hooks might, when bait is scarce and fresh mackerel have to be bought, cost many sovereigns. By day these lines, carrying small hooks and baited with mussel or worms, catch whiting and flat-fish, gurnard and bass. By night, with larger hooks and either fish or squid for bait, they take conger, ling, or skate.

Hand-lining is another method. In this case not more than two hooks are used on each line, generally on some pattern of spreading wires; but a skilful fisherman will control half a dozen lines single-handed. Whiting just before dawn, pollack and bream during the day, and conger and hake at night are the chief fruits of the hand-line, and it has the advantage of being used from small craft and without calling for any heavier investment of capital than a year or two of little economies may contrive.

There is one other method of hooking in use among professional fishermen—no account is taken in the present chapter of angling methods—and that is known as railing, whiffing, or plummeting, in which the bait, usually a small bright strip of skin from the side of a mackerel's tail, is drawn swiftly through the mackerel shoals in the wake of a sailing boat. Heavy catches, of scores of mackerel per tide, are made in this way, and on our south-west coast quite a considerable number of men engage in this style of fishing during July and August.

Netting fish is a more complicated matter, more costly, more laborious, and certainly more profitable on most parts of our coasts, though the small hookers, their own masters, owners of their boats and all the gear that therein is, may be regarded as, on the whole, the most enviable class among the fishing community.

Netting fish, as practised on our coasts, must involve one of four principles. The fisherman may set a trap to catch fish singly—*i.e.* the trammel. He may drag it, corked above and leaded below, round a shoal of fish previously seen and bring these either ashore or alongside his boat—*i.e.* the sean, or seine.

Thirdly, he may set it upright in the waters, letting it drift at right angles to the direction in which he knows the shoal to be moving, and thereby catching the fishes by the gills—*i.e.* the drift-net. Lastly, he may sweep the sea-bed and snatch up everything, animal, vegetable, and often mineral, that lies in the way of the net—*i.e.* the trawl. Some attempt will now be made clearly to explain the construction and use of these four types of net in the order given, for it may safely be asserted that between them they account for quite four-fifths of the fish brought to market.

The trammel is a most ingenious contrivance, a self-acting fish-trap that takes a great variety of fish, such as red mullet, bass, and other fish, as well as large lobsters, the last by no means unfrequently. It consists of three walls of netting set one alongside the other, the middle one about twice the length of the others, but gathered into the same length, so as to leave much slack line. It should further be mentioned that the mesh—*i.e.* the size of the square hole between the strands—of the two outer nets is much larger than that of the middle one. The net being set up and down with the tide, and not across it (this of the greatest importance, and yachtsmen often ruin their chances at trammelling through their fatal preference for setting the nets across the tide, in some vague hope that the latter may drive the fish against it), it is not difficult to see what happens. A fish strikes against one of the outer nets, and the next forward stroke carries it through the large mesh and against the small-meshed net within. It then dashes forward, carrying the fine net through the larger mesh of the third net the other side, and it is now hopelessly caught in a kind of purse of its own making, every struggle only tightening the coils. Such, roughly, is the principle on which the trammel works, though in practice there are various details to be considered: the nice adjustment of the cork buoys on the upper edge and of the leaden weights on the lower, the choice of spot at which to "shoot" the net—setting a net is called "shooting" by the fishermen, just as they also talk of "breeding" nets, and not making them—and the best time for taking it up. For red mullet the trammel is usually laid on soft ground close to rocks just before sundown, and is taken up again just after sunrise. A trammel is a somewhat cheaper net than most, one of 50 fathoms and 6 ft. in depth, with a $2\frac{1}{2}$-in. mesh for the middle net and a 12-in. mesh on both the outer, would be worth, roughly, about £10, or £12 if 8 ft. in depth instead of only 6 ft. As a matter of fact, the lesser depth is the more manageable, particularly in a strong tide. A Cornish boat would work a "fleet" of trammels, numbering perhaps ten, each of them 40 fathoms in length and $1\frac{1}{2}$ fathom deep. (Note.—A fathom is equivalent to 2 yards, or 6 ft.)

There are other fixed nets in use on our coasts, but none of the importance of the trammel. There are single walls of netting, identical with the "gill-nets" used on the American coast for cod, which catch the fish by strangulation—surface-fish, such as hake and herring, and ground-fish, such as cod and turbot. Then, again, there are the long stake-nets used for plaice on the Lancashire coast, a yard in width and as many as 300 yards long, the maximum length now fixed by statute. This net, unlike the trammel, is set across the tide, and is stretched on stakes driven into the sand, the fish caught in its meshes being removed at low water. Hedge baulks, long wicker walls with a trap between, are also very fatal to plaice alongshore; but the stream-nets, once so destructive in Lancashire estuaries, are now illegal. Another somewhat special fixed net, only known in a few localities, such as the mouth of the Thames and the waters inside the Isle of Wight, is the stow-net, used to catch sprats in winter. It is to all intents and purposes an immense funnel, 60 yards in length, and with an opening 25 ft. square or more. This mouth is kept wide open by wooden spars, and the net is set in the tideway close to the boat that works it. When the tide has nearly finished ebbing, the mouth of the net is closed by hauling the spars together on board, and the net is hoisted, the sprats being shot into the hold a few bushels at a time.

The sean, or seine, works on a totally different principle. It is also a somewhat more costly apparatus than the trammel, as one measuring 50 fathoms in length and 2 in depth would, with ropes and leads complete, cost about £15. There are two ways of using the sean. That in use for sand-eels in estuaries, such as that of the Teign, alluded to in a subsequent chapter, is a simple ground-sean, shot on ground that the fish are known to frequent at a particular stage of the tide, and then hauled ashore. In order to set such a net, it is taken in a half-circle on a row-boat and quietly dropped over the stern, the rope fastened to one extremity having been left ashore. The boat, its half-circle completed, is again beached, the occupants jumping out with the stake and rope attached to the other end. The two gangs of men, each hauling on an end of the net, then approach on the beach, so that the ends of the net are drawn together, all exit closed, and the small-meshed centre "bunt," in which the catch presently accumulates, hauled high and dry.

Such a mode of seining is simple and of secondary importance in comparison with the annual gathering of pilchards in St. Ives Bay between the last days of July and Christmas. Those who know that picturesque spot, even when this interesting fishing is not in progress, invariably notice, from the train window, the long line of tarred sean-boats drawn up on the beach. These boats are 32 ft. long, and take a crew of eight men, six to row, and the other two to work the net. When fishing, each is accompanied by other two boats with the "stop-net," and there is a fourth boat, known as the "lurker," from which the captain directs strategic operations. The long sean would measure about 160 fathoms in length, and is about 8 ft. deep and 6 ft. at the sides, or wings. The stop-net measures 70 or 80 fathoms, and is deepest in the bunt.

The simpler method of seining sand-eels at Teignmouth consists, as already mentioned, in shooting the sean on a sand-bank, and making a greater or smaller catch of the fish. With the pilchards, however, the fish are located first before any attempt is made to encircle them in the sean, and, as the range of vision is very limited at sea-level, the services of look-out men, known as "huers," are enlisted on the cliffs overlooking the bay. These men, who receive about £3 per month for their assistance, in addition to a small percentage (about one per cent.) of the catch, notify the town of the approach of a shoal of pilchards, and also, by a most complicated system of shouting and signalling with special implements, every movement of the teeming fish. Fortunately, the colour-protection of the green pilchard in the green water is not quite so striking in nature as some writers make believe, and the shoals impart a reddish hue to the sea, which betrays their presence to those watching for them. The St. Ives pilchard fishery, which has its fluctuations, its good and its bad years, like most other industries, is of some antiquity, and very stringent laws, endorsed by Act of Parliament and by the approval of the fishermen themselves, are in force for regulating the operations of the boats, the bay being mapped off into six "stems" (*i.e.* fishing-stations worked in rotation) for the purpose. As has been already mentioned, the Scotch know the sean under the name of "trawl."

The drift-net is another important method of catching pilchards in the west country, though less characteristic of the locality in past times than of the herring fisheries in Scotch waters and on the east coast, from which it probably reached Cornish seas. The writer has always regarded the drift-net as the most scientific of all, depending for its success on strategy and on a knowledge of certain curious habits of the fish for which it is set rather than on mere chance, like the trammel, mere force, like the trawl, or merely seeing fish and then catching them, like the sean. It has, of course, its limitations, chief among which is its inability to catch any but surface fishes—herring, pilchard, or mackerel. On the other hand, it can be used in any depth of water, an advantage over any of the other nets previously described. It is a moving, not a fixed, net, and in fact it combines in itself the principles of the sean and trammel aforementioned, more particularly the simpler form of "gill-net." There are many such compromises between two different forms of net, particularly in other seas than ours. The *gangui*, used in the Mediterranean capelan fishery, is a combination of sean and trawl, and the Norwegians have a sort of sack-net, a square sean worked by four boats on the rise-and-sink principle, like the smelt-nets at Cowes, or the *bilancia* used in Italian lagoons and estuaries. There is, however, no space to describe foreign fishing apparatus in the present volume, which, moreover, deals only with the fish and fisheries of our coasts.

It has been said above that the drift-net is the most scientific of all those used in the capture of our sea fish, and the reason for this statement was the fact of its successful use depending on a knowledge of the habits of pilchards and such fish towards sunset. Then it is that, perhaps dreading their many voracious enemies less in the gathering darkness, the pilchard shoals spread out a little in the great waters, yet keeping their heads all one way, so that they may readily reassemble at dawn, and feed greedily on the minute copepoda and other organisms that supply their nourishment. They all head away from the land, so the nets meant to strangle them are spread in rows parallel to the shore. Such a net, for pilchards, would measure 40 fathoms in length and 4 in depth, and has 40 meshes to the yard; and each boat uses a "fleet," as it is called, of sixteen nets. The "fleet" of mackerel nets, on the other hand, used aboard the largest-sized drifters, numbers no fewer than eighty, but each net is much smaller, having a length of only 20 fathoms in length and 16 ft. in depth, and having, of course, a larger mesh, 28 to the yard.

Lastly, the east coast and Scotch drift-nets for herring are some 30 fathoms long and 9 deep; whereas in Cornwall the herring drift-net is 40 fathoms long, $4\frac{1}{4}$ deep, and with 36 meshes to the yard. A "fleet" of such herring nets (in Cornwall) would number from sixteen to twenty.

In use, then, the drift-net is a moving wall of small-meshed netting, corked above and leaded below, so as to keep it perpendicular. It is shot to windward of the boat, and they drift together, the mainmast being lowered in a crutch, and a small mizzen sail being set to keep the lugger head to wind. The whole fleet of Mevagissey, numbering half a hundred boats or more, can thus fish in close proximity, and the writer has been out more than one night on board the *Foam* in the midst of a score of other boats, all fishing the same ground, all drifting parallel, without the slightest fear of entanglement. Sometimes care is taken to see the whereabouts of the shoals first, the movements of the gulls and cormorants and porpoises helping in this before the light is gone from the waters, the phosphorescence of the summer seas coming to the fishermen's aid after night has fallen; and if there is no sign of fish on a usually productive ground, the men stamp loudly on the deck, which sometimes has the effect of causing the frightened pilchards to show themselves. The boats leave harbour, according to tide and wind, about four or five o'clock in the afternoon, shoot their nets in various parts of the bay, and take them up again towards eight or nine in the evening, a little earlier or later according to the state of the tide and wind. The hauling of the nets, however, and the removal of the fish, which are torn from the meshes and thrown on deck, takes a considerable time, so that the boats may not be back in harbour until after midnight. While the net is being brought on board, the so-called "phosphorescent" effects—these have no connection, by the way, with the element known as phosphorus, but are the result of emission of light by Protozoa and other small animals —are very beautiful. The buyers are waiting on the quay when the boats get back, the factory at Mevagissey purchasing the bulk to make into "sardines," while the rest is bought up for export to Italy, or by the "jowders," or inland fish-hawkers. A curious exchange of Mediterranean and Channel fish is seen in the pilchard and sardine industry. These are, of course, one and the same fish in different stages, but, whereas the fishermen of southern Europe catch the smaller "sardine" and cure it in oil for consumption in cold northern cities where oil is appreciated, we pickle the older fish in salt for use in the towns of the south.

As already mentioned, the use of the drift-net is characteristic of Cornwall and the east coast, though it is also employed in other parts of the Channel. Trawling, on the other hand, is the chief method of netting fish in Devon and on the coasts of Sussex and Kent, as well as on the flat coast of Lancashire. Drift-net fishing for mackerel is much practised, also, at the eastern end of the Channel, at Hastings, as well as small trawling in Rye Bay, and the old "hog" boats, a local development arising out of the special conditions of the sloping shingle foreshore of Sussex, are familiar to all who know that corner of England. The long-distance trawling out of Hull and other ports on the east side can hardly be included in fishing on the English coast.

Trawling is, however, the most important mode of fishing in our seas. It is also the most destructive, as will be readily understood when the construction and working of the trawl are explained. The trammel catches only such passing fish as enmesh themselves in its slack netting, and even the drift-net waits for the fish to destroy themselves in its strands. With the trawl, however, it is a case of the mountain going to Mohammed, and this deep and yawning purse tears its way over the sandy ground, scooping up everything that lies in its path. It is towed, with the tide, for preference, in a light breeze, the net being allowed to drag lightly over the ground. Contrary to what the uninitiated would be inclined to think, it is less difficult to haul the trawl in a swell than in quite smooth weather, for the rocking of the boat in an unsteady sea slacks the ropes at every lurch, and these can then be wound on the winch with very little effort. A large trawl cannot be brought on board in less than an hour, so that the labour involved is in any case considerable. There is some local variation of the time in which fishing is conducted ; whereas, for instance, the Brixham trawlers keep their nets down mostly at night, seeking soles and plaice for their market, the Plymouth men, knowing that the cheaper kinds, such as rays and conger, will sell best at the Barbican, trawl for preference during the day. The so-called " prime " trawl fish include red mullet, dory, mackerel, bass, turbot, brill, sole, and halibut. The cheaper fish taken in this way include rays, cod, haddock, hake, gurnard, conger, ling, and some others.

It will thus be seen that the victims of the trawl include representatives of widely different kinds of sea fish, those which pass a great portion of their life near the surface, such as bass, grey mullet, and mackerel, being taken together with the true ground-feeding kinds. There are two patterns of trawl : the older " beam " trawl and the newer " otter " trawl, the latter having superseded the other on many parts of our coasts. The beam-trawl, briefly described, is a large conical bag, the mouth of which is kept open by a beam of wood shod at the extremities with irons that lie on the ground. Behind the beam drags the foot-rope, a stout rope which keeps the net well out. The trawl-warp, nowadays made of strong steel wire, is made fast to the bridle ropes. When the haul is finished, the trawl is brought on board and the contents are released at what is called the "cod" end—that is to say, the pointed end farthest from the beam. In Lancashire waters the beam measures from 18 to 50 ft., and sailing trawlers are there allowed to work within the three-mile limit—that is to say, at a distance less than three miles from the land. Steam trawlers are, however, compelled to keep at least three miles away, and the same restriction applies on some parts of our coasts, nominally at any rate, to all trawlers, irrespective of their motive power. A beam-trawl of 20-ft. beam would be worth about £12 or £13, with all the gear complete, and this is the size that amateur yachtsmen sometimes use. It is a pity that they use any. If they want to net fresh fish for the table, it would be far better for them to keep a set of trammels and catch plaice and red mullet. The trammel is a quiet piece of tackle that can be set near the yacht's moorings for the night without disturbing any one. The trawl, on the other hand, gets in the way of all manner of craft, and there are quite enough trawlers earning their livelihood without wealthy amateurs contributing their share towards the depletion of the inshore waters.

The otter-trawl dispenses with the cumbrous beam, the mouth of the net being kept open with boards that fly asunder on the principle of kites, as was long ago pointed out by Mr. Holdsworth, a great authority on our sea fisheries. One edge only of these boards rests on the ground, and iron plates are sometimes screwed to their sides to give added weight, a fathom or two of galvanised chain being also used between them and the end of the bridle, giving a more direct pull on the trawl. It is said that the otter-trawl catches more fish, and it is certainly easier to put down, tow, and haul, for in the last-named operation the boards come automatically together, and in that position offer far less resistance than the less accommodating beam. The "wings" of a 28-ft. trawl, 10 ft. square at the mouth, would measure about 36 ft. An otter-trawl measuring 90 ft. across at the mouth would cost complete about £30.

The Spaniards, by the way, have a primitive form of trawl, with which they nevertheless make very good catches, in which both beam and otter-boards are dispensed with, the mouth being kept wide open by working the net between two sailing boats.

We may now appropriately revert to the contentions of depletion of the sea, because it is to the trawl that most of the damage is attributed, often by those who not only have no interest in trawling, but are concerned with the profits from other styles of fishing. It is urged that the trawl destroys vast quantities of undersized, immature fish before they are of any real value for purposes of food, and before they have even once been able to spawn, and also that it tears up the nurseries of the young fish. The critics of the trawl used to add that this villainous net also destroyed vast quantities of valuable fish-spawn, because the few demersal fish-eggs, often lying in masses on the foreshore, as will be seen later, attracted attention much sooner than the majority of floating eggs. When it was found that of all our valuable food-fishes the herring alone deposits heavy, sinking eggs, opinion veered round, and the trawler was declared perfectly acquitted of all blame. Later still, however, some one discovered that the cod and haddock repair in immense numbers to the spawning-grounds of herrings to gorge themselves on the ova, and it was also found that the trawler, knowing this perfectly well, also took his nets there and caught the cod and haddock at their meal. It is extremely doubtful whether, even if the trawl were to go over such beds of herring-spawn as those on the Ballantrae Bank, where herrings have deposited their heavy, clinging eggs as long as men remember, much damage would accrue to the spawn, for it sticks to stones and weeds, and is thrown back with them when the *débris* from the trawl is heaved overboard. It is very doubtful, also, whether the sea is being emptied quite so rapidly as some would have us believe. That there is some ground for apprehension in the rapidity with which combines and capital are possessing themselves of the fishing industry, as of most others—though in this case they do not come from over the Atlantic—can hardly be denied; but this is a grievance that calls for remedy by the political economist and not from the laboratory. When we consider how infinitely vast is the sea, and behind it its greater self, the ocean, we may surely take heart when folks would tell us that the supply of fish is reaching a low ebb. It may be that certain inshore grounds, which represent only a very narrow strip of water, contain less fish than they did ; it may be, indeed it must be, that a hundred fishing-boats to-day catch less fish per boat than did ten half a century ago. When we bear in mind that Dr. Hjort and Dr. Knut Dahl have recently discovered the presence in the cold northern surface waters of myriads on myriads of young gadoids, too small for any besides purely scientific tow-nets to interfere with them, we may rest assured that the cod family, at any rate, is in no danger from over-fishing. On the other hand, it must be admitted that no one ever asserted that the round-fish were in danger at all. It is to the flat-fish that the fears of the pessimists are restricted ; and it must be apparent to all that, so far as the inshore waters are concerned, the flat-fish, particularly the plaice, show a serious falling-off in the matter of both size and numbers.

We shall presently find a very marked difference in the life-history of the flat and round fish, one that has direct bearing on this question of their exhaustibility by over-fishing. The migratory mackerel and the stationary plaice will serve to illustrate this difference. There are seasons of the year, varying in duration on different parts of our coasts, in which the mackerel vanish completely from our ken. No man knows where they are or whither they journey, and none are during that period taken by any method of fishing with either hook or net. It is true that investigations conducted at Plymouth and elsewhere are yearly throwing fresh light on this mystery of the mackerel, and almost any day we may receive information of the whereabouts of that prolific and capricious fish during the cold months in which it absents itself from our coasts. Whether the publication of that knowledge will be an unmixed benefit is very doubtful. Even if the trawl or drift-net, as now used, proved impracticable in the deeper ocean water to which these fish are supposed to migrate about Christmas-time, it is conceivable that the ingenuity of man might devise other engines wherewith to pursue the mackerel shoals even to the farthest limits of their wanderings. Were this successfully contrived, the shoals would not have the two or three months of respite which they now enjoy. They would, in fact, be brought under the same conditions as the plaice. At no time of its life, at any rate after leaving the egg, is that flat-fish secure from man. At no stage—larval, post-larval, or adult—does it find an asylum for ever so brief a portion of the year outside of the zone fished by man. The undeveloped forms are destroyed in the shrimp-trawl ; the undersized and immature fish are killed in the stake-nets ; the trawl destroys it at all ages, both fit and unfit for sale.

The mackerel may therefore, particularly in our present uncertainty as to its wanderings, be regarded as a practically inexhaustible fish. Its only natural habit which strongly prejudices its survival in numbers is that of gathering and moving in immense shoals, which naturally form a more vulnerable object of any fishery than if the fish were to roam singly or in small bands. All round-fish fall more or less under this same condition ; but in the case of those, like the dory, which which do not congregate in such conspicuous shoals, there is even less cause for apprehension.

By those who regard the gloomy view of our fisheries as unwarranted by the facts, it is often urged that man and his engines are powerless to make any impression on the hordes of fish in the ocean. That, of course, is perfectly true. The whales and sharks that still prowl through the oceans, the huge fish-eating lizards, long since extinct, must among them often have consumed more fish in a day than man's paltry trawls account for in a year. Yet the exhaustion of the ocean is hardly the practical problem. Every year the machinery of transport in ice is improving, yet there will always be remote parts of the ocean from which fish, however plentiful, cannot be profitably brought to market. When mankind reaches that limit—if he ever does—then the fisheries may finally, so far as he is concerned, be regarded as exhausted. Even if it were possible, with new improvements in refrigerating apparatus, to bring the fish in fresh and saleable condition from those very distant grounds, the expense involved might be so great that the sale of the fish would not leave a fair profit. Such a state of affairs is, needless to say, purely imaginary at present, and the hypothesis is admitted only in order to illustrate the true meaning of exhaustion of the fisheries as differentiated from the total extermination of sea fish irrespective of locality.

A long series of interesting experiments has been conducted on various parts of our coasts with a view to ascertaining, if possible, the damage done by the trawl, the percentage of undersized and immature fish captured at various depths and at every season, and the possibility of returning the smaller fish, unfit for market, alive to the sea that they may have another chance. The Scotch Fishery Board even closed a large and important inshore area against commercial trawling, and made a number of experimental hauls, the results of which were carefully summarised by Dr. Wemyss Fulton. Yet it has always seemed to the writer that too little allowance is made for the wide difference between these delicate scientific experiments, with fine gear and generally in fine weather, and the rougher trawling for the market in all weathers and over some of the worst ground on which trawls can possibly work—ground on which the valuable apparatus belonging to our marine laboratories would not, as a rule, be risked.

As to the damage done by the trawl, we may perhaps safely say that the flat-fish suffer less than the round, for they are able to shut their gills down more tightly, and thus escape suffocation, while their flattened shape, adapted as it is to bear pressure without inconvenience, probably stands them in good stead when they are being dragged along in the *débris* of the trawl. There can be no doubt about the larger trawls destroying vast quantities of ridiculously small fish. The offence of the smaller-meshed shrimp-trawl is even worse.

Mr. Frank Cole, in the course of his valuable memoir on the plaice,* which is quoted in a later chapter, mentions a catch on the Lancashire coast that included, with only about twenty quarts of shrimps, upwards of 250 soles; an even larger number of plaice, all but six of them under 8 in. and the majority only 2 in.; 896 dabs, all but two of them under 4 in.; 285 whiting, averaging 5 in.; and 18 skate only 7 in. across the body. This most destructive catch, in which shrimps, the ostensible object of the haul, played a very small part, was made in the month of August by a 25-ft. shrimp-trawl with ½-in. mesh. Professor Herdman† also mentions over 10,000 plaice of only 4 in. at one haul of a shrimp-trawl off the Mersey estuary. Such instances could be almost indefinitely multiplied, but this would only take up space without serving any useful purpose. What is of importance is this: that if a single shrimp-trawl in the hands of scientific investigators makes such frightful havoc among the undersized flat-fish on a few occasions, the hundreds of shrimp-trawls in the hands of fishermen occupied in supplying the markets all round our coasts are doing the same almost every day of the fishing-season.

Let it, then, be assumed that the falling-off in the size and numbers of plaice in our inshore waters is a proved fact. Unfortunately this assumption is not far from the truth, so far, at least, as many districts are concerned. The remedies so far proposed may be resolved into those aiming at prevention and those aiming at cure, and it looks almost as if prevention, though proverbially better than cure in most affairs of everyday life, were in this instance impossible. Remedial measures are necessarily based on the nature of the evil that calls for remedy, and this, in the case of our plaice, is known to be the wasteful destruction of immature fish. As the plaice is, particularly in the continental markets of the North Sea, saleable some time before reaching maturity (corresponding

* *Report on the Lancs. Sea Fisheries Lab.*, 1901.

† *Fishes and Fisheries of the Irish Sea*, p. 53.

to a length of about 13 in.), legislation is, it will readily be seen, very difficult. What is, in fact, required is a measure that, without throwing a large section of the fishing population out of work, shall check this massacre of the innocents. Were there any other channel into which the specialised labour of these men could temporarily be diverted without loss to themselves, there would be no great objection to giving the plaice a period of rest, for it is not among the most popular of table fish, and the public could well do without it for a time.

To protect the plaice, however, until it has had an opportunity of spawning will probably be found impracticable, so that some half-measure, protecting undersized fish, yet allowing the capture of those just under the size corresponding to sexual maturity, will be found the only compromise. Small size-limits of 8 or 10 in. have been proposed, though such a limit would be of little practical benefit as long as French markets admit plaice of only 5 or 5½ in. In any case, international concord and co-operation on the part of all the nations engaged in the North Sea fishing are essential to success. Without them, restriction in one of the countries could only hamper its fishermen, compelling them to seek neighbouring markets in order to dispose of their contraband, without doing the fish any good.

The chief remedies that have so far come up for consideration before various Conferences and Commissions are as follows :—

Prevention.

I. Closure of inshore areas to trawlers, either for some months in each year or for some years entirely.

II. Extension of the three-mile limit.

III. Increase by statute in the mesh of the trawl.

IV. Prohibition of sale or landing of undersized (or immature) plaice.

Cure.

V. Artificial culture of sea fish.

VI. Inducing the fishermen to return the spawn of newly caught ripe fish to the sea.

VII. Destruction of competitors, such as black-backed gulls, cormorants, porpoises, sharks, etc.

Each and all of these measures, preventive or otherwise, may be regarded as open to criticism.

I. The closure of inshore areas is subject to three serious objections. In the first place, there is insufficient policing as it is, and whenever any suggestion is made for utilising gunboats for the purpose, naval men raise an outcry that it is beneath the dignity of His Majesty's Navy to protect flat-fish. Again, even if trawlers were debarred from these inshore areas, the ground would be simply covered with long-lines, which are at present kept away solely by fear of the trawl tearing up and entangling their gear. There would be nothing to prevent them using much smaller hooks than they do at present, and thus catching many of the small flat-fish that now die uselessly in the trawl. Lastly, it is found by experience that inshore grounds closed to trawling are, after a few years, ruined as fish nurseries by the accumulation of rubbish and *débris* of every kind. A familiar instance of this result of prohibiting trawling may be found in Plymouth Sound, where, thanks partly to the mud-hoppers which, quite against all rule, deposit the dredged mud only a short distance from the breakwater, there has of late years been so great an accummulation that the water is yearly more and more shallow, the young fish are choked by the mud, and there is a most unpleasant ground swell which was unknown there twenty years ago.

II. The extension of the three-mile limit would not merely increase the difficulty, already too great, of efficient policing, besides being open to both the other objections cited in the foregoing paragraph, but it would be a dead letter unless supported by the other Governments concerned. Nay, it would, as has been strikingly illustrated in the case of a wide zone closed to Scotch (but not, of course, to foreign) trawlers by the Fishery Board of that country, be exceedingly unjust to our own men. Unless, that is to say, the French and Dutch and Norwegian Governments concurred in this extension of "territorial" waters, for fishing purposes at any rate, we should simply debar our own fishing fleets from the harvests of waters which foreign fishermen would continue to gather for their own benefit.

III. A statutory increase in the mesh of the trawl looks at first sight a perfectly reasonable and effectual remedy for the evil of catching undersized fish, and it has long attracted many who take a theoretical interest in the protection of our fisheries, and even some few of a more practical turn. It looks so simple. The trawl, as at present constructed, catches not only large plaice, but also very small ones, of no use for the market. If, then, the law provides for a minimum size of mesh, it may be possible to allow of the smallest fish escaping unhurt. So indeed it might, but for the peculiar behaviour of cotton meshes when subjected to the great strain of being towed in a stiff breeze through the water. If the net were of wire, with rigid meshes, then this provision might possibly go some way towards remedying the evil. Unfortunately, however, it has been found that the square or oblong mesh assumes, under the immense strain and pressure, a parallelogram of very different form, its sides drawn much closer together, so that, however large the original mesh, within practicable limits, the small fish would have very little more chance of escape. With a very large mesh, such as has been used in certain scientific experiments, it might conceivably be possible to let most of the undersized flat-fish go free, but the mesh would have to be of such size that many of the mature examples of some fish would be lost as well, and such a statute would be too serious a handicap to the trawler to admit of its being entertained for a moment.

IV. The prohibition of the landing or sale of either undersized or immature flat-fish seems, on the whole, the most reasonable suggestion that we have yet considered. Yet it is not less objectionable, on at least two counts, than those that have gone before. The international difficulty, for instance, is as important as it is in the proposed extension of the three-mile limit. Clearly, it would be almost futile to forbid our fishermen to bring undersized plaice to Dover if they knew that there was a ready market for them at Calais. If Grimsby is to be shut to immature fish, while the buyers of Scheveningen or Bergen receive them with open arms, little good is served beyond the slight extra labour given to our men in disposing of the forbidden wares. Almost as important, however, as this objection on the score of international complications is the great difficulty of fixing satisfactory size-limits. The bulk of our fish, as already stated, are marketable long before they are sexually mature, and by marketable is meant in this instance not only lawfully saleable, but even sought after by buyers. A few kinds, however, are sexually mature while yet too small to be of much use as food. A third difficulty arises in the wide variation of size in sexually mature fish in different parts of our seas. A mature plaice at Plymouth is not, for example, the same size as one that spawns for the first time in the neighbourhood of Grimsby. As matters stand at present, we protect neither "undersized" nor "immature" flat-fish. It might at first sight appear that if a fish has been allowed to spawn at any rate once, it might fairly be caught and consumed. On the other hand, as has already been suggested, some fish are capable of spawning while still small, and it seems wasteful not to wait for these to grow heavier before capturing them for the market, particularly as in most cases the larger fish fetch proportionately far more per pound.

One obvious advantage in prohibiting the sale or landing of fish below certain fixed measurements—the length of any fish is a far more accurate criterion than its weight—would be the immunity from trawling operations of certain shallow bays and inshore areas, even of certain high sandbanks far from land, where the water is comparatively shallow, and which are known to shelter only small fish. If the trawling masters knew that their catch in such localities would consist, wholly or in great part, of contraband, they would refrain from putting the trawl overboard until deeper water was reached, and this abstention on their part would be far more reliable than any arising from mere prohibition of trawling within a given area, unless accompanied by adequate provision for policing the closed district.

V. Of fish-culture Mr. R. B. Marston says something in a later chapter, and it may here suffice to remark that unless the fry be reared to the point of being able to find their nourishment and evade their enemies, the mere turning out of either fertilised spawn or newly hatched embryos would seem to be of slight promise.

VI. That something might, however, be done even with the spawn from ripe food-fish is the opinion of Mr. C. E. Fryer, of the Board of Agriculture, and others, and that gentleman has made a very ingenious suggestion, that the fishermen should be induced to press the ripe milt or ova from newly caught fish and return these to the sea. The Devon Sea Fisheries Committee has also issued an extremely convenient brochure of instructions on the subject, compiled by Mr. W. Garstang, of the Marine Biological Association, which may be briefly summarised as follows :—

The fishermen should watch for fish running with spawn as soon as the trawl comes on deck. Such fish should be placed in the shade, and on their backs as much as possible (to save the spawn), in groups according to their species, the plaice in one, the turbot in another, and so forth. They may be left thus for an hour or even more. Then, when all is clear, a ripe male plaice, say, is gently squeezed into a bucket of clean sea water, after which several ripe female plaice are squeezed into the same bucket, as the milt of a male will fertilise the ova of many females. The water, with its eggs and milt, must then be stirred about for a few seconds with the hand, in order to mix the soft and hard roes, and then, after standing for five or ten minutes, the contents of the bucket may be thrown overboard, for the spawn will be fertilised, and there is some chance of a small proportion surviving. Unripe eggs, by the way, which may be known by their white and opaque appearance, are useless for the purpose, and no good will in all probability be done with the sole, even if ripe, in the male of which the milt is so small that squeezing is ineffectual. In issuing this pamphlet, Mr. Garstang boldly states it as his opinion that Nature is incapable of keeping up the supply of fish with the demands of man; and even if this be a somewhat gloomy pronouncement on not wholly satisfactory evidence, there is at the same time much to be said for this plan of re-stocking with no expense of fish-hatcheries, but rather as the farmer sows his corn before reaping it.

VII. The last of the foregoing proposals for the cure of the disease that is apparently impossible of prevention is one that must inevitably be discussed on lines not strictly economic, but rather sentimental. This is a pity, but it cannot be helped. Gradually, as the outcome of education and a general emancipation from barbarism, man has arrived at a view of his duties to the beasts and birds which, while capable of unfortunate exaggeration, is in the main very admirable. Those who find this kindness to animals incompatible with sport are apt to overdo it; but with others, not rabid in their humanitarianism, this recognition of certain claims on the part of the so-called "dumb creation" is a pleasant and improving sentiment. Between sentiment, however, and sentimentalism there is a wide gap. A sparrow may be an admirable bird viewed from one standpoint, but that is not the standpoint of the farmer whose grain the sparrow eats. The sportsman may for his own purpose prefer the presence of deer or hares or otters in a country, but the agriculturist or trout-preserver may think differently. So, too, on the sea coast, while the wheeling gannets and mewing gulls and tumbling porpoises doubtless lend a touch of the picturesque to those who ramble on the cliffs or along the beaches, it can hardly be expected that the fishermen, with whom they compete, should regard them in the same light. Any systematic war against the fish-eating beasts and birds and other fishes of our seas would, it is true, be hampered by many difficulties, but the greatest of these would in the end be the opposition of those who hold it a sin to kill any animal that they cannot devour. You may massacre young lambs and calves and chickens, the more the better; but to slay the voracious cormorant or black-backed gull is dubbed cruelty. Some official recognition, however, of the wisdom and justice of the death penalty against these rivals of mankind may be found in the express exemption of both the birds named from the county councils' schedules of protected fowl, while in the Exe estuary, at any rate, the former has a price set upon its head. Neither the shark nor the porpoise has ever been protected by law, so that it rests with the fishermen themselves to deal with these and other marauders as they think fit. When it is remembered that porpoise-oil is a very valuable article of trade, it is astounding that they do not achieve the double purpose of destroying dangerous rivals and turning them to good account. The late Matthias Dunn, whose name must necessarily recur so often in any work dealing with the fishes of our seas, always held this destruction of cormorants and porpoises to be a most valuable remedy, though the writer, who many times discussed the subject with him, cannot recall that he ever suggested any practical scheme of action. As a matter of fact, the cormorants and black-backed gulls cannot be destroyed (the former more particularly) without the expenditure of a considerable quantity of powder, and who is to provide this, and who even is to use it, is a question that does not at once answer itself. Something might possibly be done by encouraging "week-end" sportsmen, willing to find the ammunition and shoot the birds for amusement; only the fear at once suggests itself that "week-end" sportsmen are not the safest shots, and these birds would in many cases have to be shot within range of our seaside parades, or at least of other pleasure craft. In these circumstances the uninterrupted survival of every cormorant and black-backed gull at present in active existence or in the egg would perhaps be preferable, even at the risk of an accompanying diminution in the fish supply. The remedy might conceivably be worse than the evil, since there are folks who would rather do without fish for the rest of their life than spend it wandering about the world blind in both eyes.

The National Sea Fisheries Protection Association, a body over which, in succession to Sir Edward Birkbeck, Lord Heneage ably presides, takes account of these and other measures likely to improve the condition of the fisheries, and its conferences, if not immediately productive of legislation, have frequently elicited interesting and clear-sighted discussion of the various problems under review.

CHAPTER III

THE SHARKS AND RAYS

THE precise relationship of the Sharks and Rays now living is not by any means so clear as some writers pretend, and one of the most recent of these has more cautiously admitted a doubt whether the two groups are even descended from a single palæozoic ancestor.* The most ancient form in our seas would seem to be the six-gilled shark (*Notidanus*), and, with the exception of their having reduced their gill-openings by one, it cannot be said that the rest have materially departed from the type of this shark, beyond of course such specialising as might from time to time be demanded by their surroundings and mode of life. In following the usual course and treating of the Sharks and Rays under one head, this chapter merely avoids a somewhat more modern classification, in which the spur-dog (*Acanthias*) would be regarded as the transitional link rather than the shark-ray (*Rhina*), because it could not well be explained without digressing in the direction of comparative anatomy quite beyond the scope of the present volume. For practical purposes it seems more satisfactory to retain the older arrangement followed by Couch and Day, with the Sharks and Rays abruptly subdivided, while at the same time bearing in mind that the study of embryological and other affinities has lately necessitated a revision of their scheme.

There is a deep-rooted conviction in circles otherwise

* Bashford Dean, *Fishes, Living and Fossil,* p. 88.

well informed that "true" sharks, whatever the qualification may signify, are met with only in tropical seas, and are consequently absent from our own. While, beyond a doubt, both the sharks and rays find their highest development in the warmer seas of the globe, where their scavenging work is in greatest demand, it is also a fact that such immense or specialised kinds as the Greenland shark (*Læmargus*) and starry ray (*Raia*) abound in arctic seas. In British waters, too, there is a large number of both sharks and rays, and although popular consent has called the smaller sharks by the name of "dog-fish," there is no scientific line of demarcation between the two even in the matter of size, for some of the so-called "dog-fishes" grow to a larger size than some of the "true" sharks.

THE SHARKS (*Selachoidei*)

Our British sharks are seventeen in number, the latest addition being *Centrophorus squamosus*, a relative of the spur-dog long known on the coast of Portugal, but added to the British fauna by the Irish Survey of 1891, a single specimen of 4½ in. having been caught on a long line off the Mayo coast in 250 fathoms. The species is very fully described by Holt and Calderwood in the *Transactions of the Royal Dublin Society* for September, 1895.

The British sharks fall under six families, and of these it will be convenient to give a list before passing to some brief notes on each kind.

Sharks have no great commercial value on our coasts, though elsewhere, and particularly in the East, portions of them are highly appreciated as food. The smaller dog-fishes, on the other hand, find a ready market to-day at Brighton and elsewhere on the South Coast, where, twenty years ago they would have been thrown away as offal.

Family.	Common Name.	Genus.	Species.
Lamnidæ	Porbeagle Shark	*Lamna*	*cornubica*
	Thresher Shark	*Alopias*	*vulpes*
	Basking Shark	*Selache*	*maxima*
Carchariidæ	Blue Shark	*Carcharias*	*glaucus*
	Hammerhead	*Zygæna*	*malleus*
	Tope	*Galeus*	*vulgaris*
	Smooth-hound	*Mustelus*	*vulgaris*
Scyliidæ	Nursehound	*Scyllium*	*catulus*
	Rowhound	*S.*	*canicula*
	Black-mouthed Dog-fish	*Pristiurus*	*melanostoma*
Notidanidæ	Six-gilled Shark	*Notidanus*	*griseus*
Spinacidæ	Picked Dog	*Acanthias*	*vulgaris*
	Greenland Shark	*Læmargus*	*microcephalus*
	Spinous Shark	*Echinorhinus*	*spinosus*
	Centrina	*Centrina*	*salviani*
		Centrophorus	*squamosus*
Rhinidæ	Monk-fish	*Rhina*	*squatina*

The anatomy of sharks was referred to in the first chapter, to which reference should be made for an explanation of many terms used in this.

Lamnidæ

The three British sharks belonging to this family, though outwardly widely different in form and not less diverse in habits, agree in having small spiracles, wide gill-openings, and no nictitant membrane. Apart from these family peculiarities, which they share, the three British representatives of the family have little in common.

The Porbeagle (*Lamna cornubica*) is, for its size, the most unwieldy and least active of all our sharks. Anglers catch many small porbeagles on the rocky pollack grounds off the Cornish coast, small examples of 25 to 35 lb. being killed without difficulty on the rod. Monsters measuring 5 or 6 ft. from snout to tail, and weighing in all probability over a hundredweight, are also landed on the quays after the disgusted fishermen have been able to disentangle them from their mackerel nets.

The feature of this shark which must at once strike the observer is its great depth in proportion to length—in fact, its marked departure from the typical symmetry of round fishes, which explains its want of agility in the water. Only its huge relative, the basking shark, is similarly proportioned, and with that species there is little risk of confusion. Apart from this clumsy shape, it must be confessed that the porbeagle is wanting in distinguishing characters. It has no characteristic hue, like that, for instance, of the blue shark, and no spots or blotches, as are found in the nursehound and rowhound. Most other external features it shares with other sharks. The conspicuous notch in the upper lobe of its tail is equally noticeable in the blue shark, which belongs to a totally different family, and that species also has the curious pores that stud the porbeagle's snout. Its breathing spiracles are generally very minute, but so are those in the tope, by no means a close relative; and in some foreign members of this genus the spiracles are lacking altogether, which brings them nearer again to the blue shark. Few of our sharks, in fact, offer less satisfactory material for simple and not too technical description as the porbeagle. In colour it varies between many shades of grey and brown, with a lighter shade of the same beneath.

Though most familiar in the extreme south-west of the island, the porbeagle is caught on many other parts of the coast, one of the earliest British examples having been figured, described, and even named at Beaumaris. It is not, at any rate in the adult stage, one of the gregarious sharks, though the evidence of the drift-nets sometimes shows that one or two couples may hunt in company. The food that they pursue is probably of the most varied character, including smaller sharks and dog-fishes, herrings, pilchards, mackerel, and squid. The blue shark and tope of our seas have a favourite habit of seizing a bream or mackerel already hooked, but this is not observed in the case of the porbeagle, though it often takes the large bait of pilchard or mackerel intended for bass or pollack. It is also alleged, though such a statement seems to conflict with its normal laziness of habit, to bite the artificial tinned spinning baits off the "plummeting" lines, which are used from boats going under sail to catch inshore mackerel. The evidence of this habit must, however, rest on the somewhat frequent discovery of these baits in the porbeagle's stomach, together with the known fact of large fish of some kind often breaking away with them. These large fish can never be caught in the act, for the gear used for mackerel has to be so fine that a heavy fish like a porbeagle would at once sever the lower third of the line. It may be, therefore, that the porbeagle is occasionally aroused from its customary lethargy and pursues the spinning bait, particularly when the boat comes up to the wind and the progress is momentarily checked; but it seems more probable that some extra large mackerel, or even a small pollack, breaks away with the bait, and is then swallowed by a porbeagle, the tin spinner baffling the shark's digestion and remaining as evidence of its meal. This explanation is put forward with all reservation, but not without some little acquaintance with the habits of the shark in question.

The exact manner and season of the porbeagle's breeding were long doubtful, but it is probable that it brings forth living young, like the vast majority of our sharks, and that the breeding takes place during the colder months, when the shark is absent from our coasts. For the latter conclusion, the fact of no porbeagle having been caught in our seas, recently at any rate, with any trace of unborn young is responsible. Both Day and Couch appear to have omitted all reference to the very offensive odour of this shark, a scent which resides more particularly in the blood.

The Thresher (*Alopias vulpes*) is easily recognised by the immensely long upper lobe of the tail fin. This is in some examples even longer than the head and body together, and is normally as long, and it dwarfs every other feature of this shark, for its head and body, its second dorsal and anal fins, its gill-openings, its spiracles, and its teeth are all comparatively small. A thresher shark, measuring 13 ft. 10 in. (of which the tail took up close on 7 ft.), was found in the Firth of Forth in August, 1899, strangled in the salmon nets.*

As the thresher is most in evidence on our coasts during the summer inshoring of the pilchards and mackerel, it may safely be assumed that those migratory and gregarious fishes form the bulk of its food, at any rate in our seas. The thresher may often be seen thrashing the surface of Cornish bays and beating up the frightened pilchards. It is quite easy to watch the flurried movements of its victims from the cliffs, for they colour the water a deep red wherever they are massed in numbers. At intervals the thresher leaps what looks fully its own length in the air, the bright sun making burnished silver of its body and long tail, and descends in the thick of the shoal. Some miles further out, and seen only from boats, the great rorqual also hunts the pilchards, though in a different manner, for the cetacean has no long and powerful tail to help it. Therefore it swims round and round the huddled pilchards, and then, when they are sufficiently gathered in a small area, dashes open-mouthed through their midst with a roar that makes itself heard a mile away.

Like the adder, the thresher shark has been credited with swallowing her young in order to preserve them from danger. We have a somewhat analogous, but proven, case in one of the pipe-fishes, in which the young have been seen in the aquarium to take refuge in the father's pouch in which they were hatched out. Science demands an open mind in the case of both the thresher and adder, and science should have it, but

* *Ann. Scot. Nat. Hist.*, January, 1900, p. 17.

it cannot be claimed that the testimony is particularly strong in either case. There is just this much of evidence, though very indirect, in the case of the shark, which does not equally apply to the reptile, and that is that the young sharks would not, like the young adders, be safer if allowed to scatter on their own account. Other fishes, stronger swimmers than they, would certainly capture them without difficulty, whereas it is not easy to imagine any natural enemy of young adders that would be able to catch them if they were allowed to disperse quickly and unobtrusively in the grass. In their parent, on the other hand, one blow would dispose of the whole brood.

The very circumstantial accounts of the thresher shark leaping out of water, and striking sounding blows on the backs of whales have been disbelieved in many quarters, chiefly owing to the pretensions of some naturalists, who know these creatures only in the dissecting-room, to find in the shape and size of the thresher's teeth the whole explanation of its mode of life. On the other hand, most who have travelled in the southern ocean can recall at some time or other a vivid picture of one or more threshers leaping on some unfortunate whale. As it happens, too, the laboratory disbeliever is often encouraged in his want of faith by the fatal tendency on the part of travellers to embellish their accounts with additions of their own. In the present instance this already unequal duel has been complicated by the introduction of a sword-fish, an ally in this case of the sharks, which is said to keep the unfortunate whale at the surface by prodding it with its snout. Now, it is quite true that if there be not some such deterrent as a sword-fish in attendance, it is singular that the instinct of the whale should not warn it to sink under water, where the blows from the thresher's tail would be comparatively harmless. At the same time, for all we know to the contrary, its instinct may be at fault, and, as the weapon of the sword-fish has not yet been seen in the fray, there is hardly sufficient evidence to establish its presence on the occasion. All that can positively be said is that sword-fishes have occasionally been found prowling in the neighbourhood of dying whales, and the bodies of the great mammals have also been found pierced and lacerated by their snouts. This does not, however, prove any co-operation between the sword-fish and shark.

Little seems to be known of the thresher's breeding, but it probably brings forth its young alive, like most sharks in our seas.

The Basking Shark (*Selache maxima*) is the largest and least aggressive of sharks. In addition to the characters already established for the family, the basking shark is distinguished by its immense size, small examples not being met with in our seas, as well as by its large gill-openings and curiously protruding snout, which is dented with small pores. It is further characterised by large gill-rakers, with which we shall find affinities in the herrings, and which play an important part in its feeding. In colour it varies between brown, dark blue, and grey, being lighter on the sides and lower surface, and with sometimes some dull red on the snout. The tail is keeled, and has the upper (not lower, as stated by Day) lobe the longer and notched. There is also a small pit in the line of the back, just in front of the tail. Its teeth lie in seven or more rows embedded in the mucous membrane.

The size and harmlessness of the basking shark when unmolested suggests obvious analogies with the whale and elephant. With the whalebone whales, indeed, the basking shark has somewhat closer affinities, for its bone-like gill-rakers act as a sieve and strain off the water from the *plankton*, or floating food, precisely like the baleen strainers of the whale. They may, in fact, be compared with the teeth in the gill-arches of bony fishes, for, like them, they prevent foreign substances from clogging the gills. The comb-like structure is practically a grating of narrow plates. Like the majority of sharks, this species is of a wandering disposition, though naturalists have not succeeded in determining either the precise course or the exact seasons of its migrations. The fishermen, who have at any rate studied its movements more than most, believe that during early spring it leaves the warmer regions of the Atlantic for the colder, and as not a single young basking shark has yet been recorded on our coasts, the breeding is reasonably thought to take place at some distance from our shores. Whether the fish choose deeper water or the shallow bays of shores other than ours is an open question.

Though regularly hunted with the harpoon on some parts of the Irish coast only, this immense shark is not uncommon in July and August on the coast of Cornwall, where its sail-like fin (hence its vernacular name "Sail-fish") may be seen cleaving the surface of the water on fine days when there is no breeze. The least disturbance of the water seems to drive it out of sight, possibly because its peculiar manner of feeding can only be conducted in perfectly calm water. The Irish fishermen hunt it purely for the oil from its liver, wasting the rest of its huge carcase, and such an industry is in keeping with the ethics of a generation that has not scrupled to exterminate the bison for its tongue and the African elephant for its teeth. Another not uncommon name for this shark is "Sun-fish," in allusion to its habit of rolling lazily at the surface of the sea, and there would have been no objection to this had it not led to confusion with the totally different fish properly so called.

Jonathan Couch attempted to distinguish an allied genus *Polyprosopus* with two species, which he called the Rashleigh Shark and Broadheaded Gazer, but later authorities have regarded them as only deformed basking sharks, so that any detailed account of their peculiarities is uncalled for.

Carchariidæ

The second great family of sharks represented in British seas includes three of the commonest and one of the most interesting. The sharks of this family are distinguished by the presence of the nictitant membrane. Spiracles are not a constant character, for they are present in the smooth-hound and tope, but absent in the blue shark and hammerhead. Equally varying is the presence of a small pit on the back, just before the tail fin, for we find this in the hammerhead and blue shark, but not in the tope and smooth-hound. None of these sharks have spines in front of the dorsal fins, such as we shall find present in one important family with five British representatives; and their teeth are, as a rule, serrated in examples of moderate size, though not necessarily in either very young or very old individuals.

The Blue Shark (*Carcharias glaucus*) is a graceful and beautiful fish, though it unavoidably shares the prejudices against its order, and the fishermen would unanimously vote it ugly. With them it is a case of "handsome is as handsome does," and the blue shark certainly tears their nets and robs their lines more than most. It has the typical form of sharks, with its long pointed snout and five gill-openings, and the entire back and sides are of a deep blue, shading off to white below.

As already mentioned, it has no spiracles, and there is a small pit at the base of the tail, while the teeth of medium-sized examples are saw-edged, a character that is apparently not acquired until middle age and is subsequently dropped.

Only those who fish down in Cornwall can have many opportunities of watching the active movements of the blue shark in pursuit of its prey, showing an activity that we look for in vain in the prowling porbeagle; and the angler who, fortunately or otherwise, according to his aspirations, hooks one on the rod has further occasion to admire the free and supple action, the marvellous speed, the lightning turns and leaps and dives of these smaller sharks. They are less often taken in shallow water farther up the Channel, and more rarely still in the North Sea, for most of the examples recorded from the east coast have been met with during winter storms. One was, however, taken in the Firth of Forth, July, 1898. Now and then one has been on view in the tanks of the Brighton Aquarium, when the public is able to contrast the graceful appearance and active movements of these "ugly" sharks with those of the coarse-built cod, as well as with the ungainly flat-fish with its twisted face and sidelong motion. When a blue shark is firmly hooked so that its teeth cannot cut through the line, it revolves in the water with such force and swiftness as to wind the line about its body in tight coils that threaten to score its rough, scaleless skin, though whether this performance is the result of physical pain, or whether the fish does it merely to recover its liberty, we can only guess.

Like most sharks, and indeed most sea-fish, the blue shark is a migratory species, appearing on our coasts on the approach of summer and retiring again some time during the autumn, though it is sometimes cast ashore or, more rarely, taken in the nets on the east coast during the coldest months of the year. Although no study has been made, or at any rate recorded, of its reproduction, it must almost certainly bring forth living young, like its close relatives the hammerhead and tope.

The Hammerhead (*Zygæna malleus*) shows extraordinary specialisation, its hammer-like head contrasting with the shovel-shaped snout in most sharks and notably in its nearest allies. In colour it is dark brown or grey above, and lighter on the lower parts. As above noted, the eyes have a nictitant membrane, and are situated at the extremities of the hammer-like development of the head. There are no breathing spiracles, and in front of the head there is a curious groove, the object

Photo by Reinhold Thiele

1/8 Natural Size

BLUE SHARK (*Carcharias glaucus*)

of which is not apparent. The teeth are notched on the outer edge, and the fish is generally described as fierce even for a shark. It can only be regarded as a wanderer to our seas, though large examples of 12 or 13 ft. in length have been taken on the south-west coast. In Australian seas, particularly in the tropical waters of northern Queensland, the hammerhead is plentiful, and passengers on the steamers that ply inside the Barrier Reef often have the opportunity of seeing one, or even a pair, swimming close under the stern of the vessel, keeping up for an hour or two with the thirteen-knot speed, and apparently without much effort and scarcely disturbing the water in their advance. That the hammerhead feeds on substantial fare is evident when we learn that bass and thornback rays have been taken from its stomach; but its danger for man seems a matter of local opinion. The statement made in the *Royal Natural History* touching its ferocity in Indian seas may be perfectly accurate; but those who live in the coast ports of Queensland think differently, and from many enquiries made on the spot, between Brisbane and Thursday Island, the writer gathered that the hammerhead was there regarded as slower in its movements and less dangerous than most to bathers, at any rate in shallow water.

Yet there are several ground-sharks in those waters which are dreaded even in a few feet of water, so noiselessly and quietly do they glide on their victims, and Australian bathers are always careful to keep in the "white water," or that with a light sandy background, against which they can at once see the approach of a shark.

In every sea the wise man will take no risks, but will make a practice of keeping out of the water where sharks find their way. Man is a land animal of great physical limitations, and finds himself at incalculable disadvantage when compelled to fight in the water. Even the salmon-fisherman, only partly immersed and with his feet on hard ground, realises this, and loses no time in scrambling out on the bank when he has to play a heavy fish. Completely immersed, he would be helpless; and the Malay natives, who swim under water and attack the largest and fiercest sharks with only their knives, are rare exceptions, worthy of curiosity, but not of imitation. Five or six years ago the writer addressed a letter to the *Times*, in which he took occasion to warn summer bathers from the decks of yachts anchored a few miles from shore against the possibility of shark bite. He was roundly abused as an alarmist and severely taken to task (by, among others, a Plymouth correspondent!) for applying the name "shark" to mere dog-fishes. Yet, though there is no case actually on record of a bather having been attacked by sharks in British waters, there can be no doubt of the boldness and fierceness of several British kinds; and this is a case in which, while prevention is easy, cure might be impossible. The late Matthias Dunn was in the habit of relating well-authenticated instances of Cornish sharks turning savagely on fishermen who ventured too near them when captive in the nets or in the well of the boat.

The Tope, or Toper (*Galeus vulgaris*), is a dull grey shark, which grows to 6 or 7 ft. in length, and hunts in packs. It has the nictitant membrane over the eye and also small spiracles. Its teeth are serrated; there are no spines before the fins; there is no pit before the root of the tail. The skin of this shark is exceedingly rough, and it has the usual five gill-openings. It is also known, from its colour, as the "silver dog," and its more common name is presumably a corruption of "top," in allusion to its habit of following the lines to the top of the water, and there snatching off the whiting or other fish in full view of the helpless fishermen. There is a practically identical shark in Australian seas, which there treats the snapper-fisher in the same way, showing as much boldness in robbing the hooks just before they are clear of the water. Of the extent to which this shark is to be regarded as migratory on our coasts there is some uncertainty, but the largest examples are said to occur only in the warmer months.

The Smooth-hound (*Mustelus vulgaris*) is in outline something like the last, only there is no lower lobe to its tail and the upper part of its grey body is marked with indistinct light spots. Otherwise, it has the same nictitant membrane and spiracles, the same notch on the upper part of the tail-fin, and the same rough skin ; and it also grows to about 6 ft. in length. There is a closely allied shark (*M. lævis*) which is of great interest on account of a placental connection between the unborn young and the parent ; but whether this species is actually found on our coasts seems doubtful, though it would in all probability come within the British area. The teeth of the smooth-hound are flatter and blunter than those of the rest of the British members of the family, so that it may feed on shell fish. It produces living young, though there is no placental connection in the species commonly met with on our shores. It must not be forgotten that a placental connection is also noted in at any rate some species of *Zygæna* and *Carcharias*, but not in such viviparous rays as *Trygon* and *Myliobatis*.*

Scylliidæ

The sharks belonging to this family are chiefly interesting because they deposit eggs like most of the rays, which eggs take about eight or nine months to hatch out in captivity. How far this may be accepted as an index of the time taken under natural conditions is a matter of opinion, but it is always important to make some reservation. All three British representatives of the family are only small sharks, and are more or less spotted. The eye has no nictitant membrane, the teeth are small, and there are breathing

* See Alcock, "On the Gestation of Elasmobranch Fishes" (*Journ. Asiat. Soc. of Bengal*, 1890, Vol. LIX., Part II., pp. 51-56).

spiracles. The tail-fin, too, is small and less pointed than in most sharks, also lacking the characteristic unequal lobes.

The Nurse (*Scyllium catulus*) is also known as the larger spotted dog-fish, because the spots on its body are rather larger than those in the allied species. It is not commonly met with of a greater length than 3 ft. or a little more, but is said to exceed 5 ft. In colour it is reddish brown, and has large dark spots over the body. The teeth are small, and the fish feeds on both fishes and molluscs. It deposits its eggs in spring, and the young are hatched out the following Christmas, or rather sooner. The eggs are provided with tendrils at the corners, which doubtless serve to anchor them to stones, weeds, or other convenient supports under water, and in this they differ from the eggs of the rays, the corners of which bear only short, hard projections, or horns, that cannot possibly answer the same purpose. Some observers are of opinion that the eggs of the rays therefore drift at the mercy of tides and storms, but Matthias Dunn, whose theories often bore the strictest investigation, used to say that they had a sticky secretion that served them as well. More mysterious in the egg-case of the rowhound and nurse are the slits, the object of which has been much discussed, and which may perhaps admit freshly oxygenated water to the growing embryo.

The Rowhound (*S. canicula*) is a very similar fish to the nurse, but its spots are much smaller, often resembling mere punctures in the skin, and the skin itself is somewhat smoother. It is, nevertheless, rough to the touch, and the vernacular name is in fact only a corruption of "rough hound." The most remarkable property about this fish, which is more commonly caught on our coasts than the other species, is one that, within the writer's knowledge, is peculiar to itself, at least among British fishes. When a rowhound is caught and thrown in the boat's well in company with pollack, cod, or other dark-coloured kinds, the water that drips from the body, or still more the actual contact of its skin, bleaches such portions of the other fishes as are touched, leaving dull white blotches wherever the colour-pigment is destroyed. This might possibly be turned to useful account in removing ink or other stains from deal tables; and as the skin is actually used in polishing, this property may perhaps assist its roughness in attaining the desired object. Whether it is retained for any considerable period after death, and whether the dried skin would, on being moistened, recover its virtues, is an experiment that would perhaps be worth trying.

The Black-mouthed dog-fish (*Pristiurus melanostoma*), characteristically a southern form, has two peculiarities that serve to distinguish it from other of our sharks. In the first place, as its name denotes, the interior of its mouth is dark (though not always black), and in the second the upper edge of the tail-fin is serrated with rows of small spines. There is also a fold of skin on the snout, but something similar is also apparent in the nurse. In colour this shark is dull yellow (the plate given by Couch is far brighter in hue than any examples caught by the writer on the west coast of Morocco, at Casablanca), and there are black spots along the sides. It has generally been regarded as a straggler only in British seas, but several were both hooked and trawled during the Irish survey of 1890-91, in water varying from 150 to 250 fathoms, a fact which led Holt and Calderwood to regard it as possibly a deep-water shark with us, though a littoral species in the warmer Mediterranean. A female was trawled off Aberdeen, November, 1898, and the egg-case was found to have tendrils at the lower end. On parts of the Morocco coast it is common enough, examples of 2 or 3 ft. being hooked in the spring and summer in less than 20 fathoms.

Notidanidæ

In all the sharks previously noted, and in all those, and the rays, which follow, there are but five gill-openings. In the present family there may be either six or seven. The only species which finds its way from the Mediterranean to our shores has six, but there is another in that sea with seven, and this possession of more than five gill-openings may be regarded as a sign of antiquity.

The Six-gilled Shark (*Notidanus griseus*) is the straggler to our coasts, where an example of over 26 ft. and others of 6 and 11 ft. have been taken, mostly with baits. In colour it is reddish grey ; the head is noticeably small for the length of the body ; the upper lobe of the tail-fin is conspicuously the longer, though there is a distinct lower lobe. The eye lacks the nictitant membrane, and the small spiracle lies some way behind it. As a further distinguishing feature, it lacks the front dorsal fin found in all our other sharks, or rather its single dorsal fin lies back near the tail. It is said to be a voracious shark, and to produce living young; but its habits have been little, if at all, studied in our seas.

Spinacidæ

The fifth family of sharks may be distinguished by the deep, straight, generally oblique groove at the angles of the mouth. This character seems fairly constant throughout the genera, whereas the presence of spines in front of the dorsal fins applies only to *Acanthias* and *Centrina*, doubtfully to *Centrophorus* (in which the skin overgrows them), and not at all to *Læmargus* and *Echinorhinus*. All the genera have spiracles and narrow gill-openings, and all lack the anal fin, while the eye is without nictitant membrane.

The Spur-dog, or Picked Dog (*Acanthias vulgaris*), is one of the commonest sharks in our seas, where it is easily recognised, being in fact the only abundant form with spines before the dorsal fins. Its colour is some shade of grey or brown above (all these sharks vary in colour far more than the bony fishes, though the accounts given by Day and Couch often suggest certain colours as constant) and a lighter hue beneath. The spines before the dorsal fins are to be dreaded only when the fish is carelessly handled, as in removing it from the hook, when the smaller examples will writhe like snakes and suddenly whip one of the spines into their captor's wrist, inflicting a painful, though not envenomed, wound. The teeth have a cutting inner edge, with the result that these sharks bite through stouter lines than others of their size. Picked dogs grow to a length of at least 4 ft. in our seas, and at times they swarm on the fishing-grounds to such an extent that neither the nets nor long lines can be used to any purpose until their shoals have passed along the coast. Although their razor-edged teeth enable them to bite through even gimp snooding, it is noticeable that the picked dogs take the hook without hesitation, showing none of the tope's ingenuity in removing the baits. They are found in the cooler seas of both hemispheres, but are said to be absent from the warmer, though this is a statement that we may look to see corrected by the results of future investigations. They bring forth living young, and Dunn thought that they had no fixed breeding season, but that also would be somewhat contrary to the rule among our fishes, both elasmobranchs and telesoteans. It is more commonly eaten by both men and fish than most of our sharks.

Centrina salviani is a rare wanderer from the Mediterranean, and only one or two examples have been recorded on our coasts. Specimens are, however, occasionally brought to our ports from remote grounds, and Mr. Calderwood, then of the Plymouth Laboratory, has figured and described one that was trawled off Vigo Bay.* Its rough skin was a character of the example in question, and there is an interesting difference in the dorsal spines ; for whereas both of those on the spur-dog point towards the tail, only the back spine of *Centrina* points in that direction, the front spine pointing to the head. Like the rest of the family, *Centrina* has deep

* See *Journal of the Marine Biological Association* for November, 1892.

grooves at the corner of the mouth, and the eye is large, with an elliptical pupil, a feature also noticed in *Centrophorus*. Unfortunately, the stomach in both this and another example also examined by Mr. Calderwood in the summer of 1892 was quite empty, so that there was no clue to its food or mode of living ; but he regarded it as a ground shark, and thought the flattened lower surface might be taken to indicate a habit of lying on the bottom and for some time in one place.

The Greenland Shark (*Læmargus microcephalus*) is an immense shark from Arctic seas, a few examples of which have been taken in the nets on the Scotch and Yorkshire coasts, the largest being about 14½ ft. It has no spines before the dorsal fins ; the snout projects ; the mouth is deeply grooved at its angles. The skin is covered with fine tubercles, and is uniform grey. The capture of this shark on our coasts is, of course, purely accidental ; but there is a regular line fishery for it on the coast of Iceland in moderately deep water for the sake of its liver, and the bait in common use is a seal's head.

The Spinous Shark (*Echinorhinus spinosus*) has still stronger tubercles all over its body, which is also marked with reddish patches. It has occurred on our coasts much more commonly than the last ; indeed, it can hardly be regarded as a very rare fish. It is a shark of southern habitat, however, so that the greater number of records come from the south-west coast, the largest measuring about 8½ ft. One of the latest records is from Plymouth (1896), where one measuring 6 ft. 6 in. was taken on a long-line in shallow water. It is a voracious fish, and does not apparently despise even spur-dogs as food.

Centrophorus squamosus, long known in Southern Europe, was added to the British list on the strength of a single example caught on the Irish coast in May, 1891, in 250 fathoms, off Blackrock, Mayo, on a long line. This is the

"Arreghonda," of the Portuguese, who catch it for the sake of the skin, liver, and flesh. The Irish example measured $41\frac{1}{2}$ in., and was of a mahogany brown, with strong spines before the dorsal fin, which are said, however, to be included within the skin in some species of the genus.

Rhinidæ

The sole existing species of this family is the Monk-fish, or Angel-fish (*Rhina squatina*), which may be regarded as a form of considerable antiquity, one of the earliest branches, in fact, of the great group of sharks, and retaining almost unaltered the form and peculiarities that characterised it in bygone ages. This is probably the more correct view than to regard the fish as a transition between the sharks and rays, for in the first place it belongs considerably more to the former group than to the latter, and in the second the transitional characters would have to be traced back to the spinous family, of which the spur-dog is our common representative.

The monk-fish is familiar on most parts of the coast, and is a frequent object of unintentional capture on the long-lines, as well as in both trawl and drift-nets. In form it suggests the rays, but in all its important characters it follows the sharks, as also in its manner of bringing forth living young. The feature that will strike the observer as most aberrant is the rounded snout, and in this, as in the torpedo among rays, we have a departure from the more general shovel-shaped snout of elasmobranchs. Moreover, though the pectoral fins are enormously expanded, so as to have suggested the wings of an angel or the cowl of a monk, they are not joined to the head in the manner that forms the disc in rays, and the mouth being situated at the front of the head, and not below, as in rays, gives a further sharklike appearance. Small fringes of skin in front of the snout suggests the possibility of the fish lying in ambush like *Lophius*, and attracting small fishes within reach of its mouth, but this has not been verified by actual observation in the aquarium. It is taken on our coasts measuring over 5 ft. in length, and small examples of from 12 to 18 in. are common in many south coast estuaries, notably at Teignmouth, where a few are brought ashore almost every week during May in the sand-eel seines worked just outside the bar. Flat-fishes are said to form the favourite food of the monk-fish, and it is also said to feed on lobsters and whelks. Its teeth, which lie in several rows, are sharp enough to catch the former, though hardly adapted, it would seem, to crush the latter. It must be a slow-swimming fish, for its fins are spineless and comparatively small, and the anal fin is lacking. The eye lacks the nictitant membrane found in many sharks, but is capable of being closed by a somewhat different arrangement of skin. The monk-fish is also thought to possess a keen sense of hearing, and there are rudimentary external ears. In colour it is dark brown or dark grey above, with variable spots or blotches, and white beneath.

THE RAYS (*Batoidei*)

The rays now regarded as British are fourteen in number, and to these also, as to the sharks, an addition was made in recent years by the recognition of *Raia blanda* as a species (distinct from *R. maculata*) by Holt and Calderwood in 1895.

The following list of British rays is given for convenience to correspond with that of the sharks on page 86. It is impossible to assign distinguishing characters to the rays with any degree of satisfaction, for the colours, body tubercles, teeth, and other characters of this group are subject to considerable variation, and any attempt to establish constant features must in many cases, more particularly in the typical genus (*Raia*), end in failure.

Family.	Common Name.	Genus.	Species.
Raiidæ	Common Skate	*Raia*	*batis*
	Thornback	*R.*	*clavata*
	Shagreen Ray	*R.*	*fullonica*
	Long-nosed Skate	*R.*	*oxyrhynchus*
	Painted Ray	*R.*	*microcellata*
	Sandy Ray	*R.*	*circularis*
	Sharp-nosed Skate	*R.*	*alba*
	Starry Ray	*R.*	*radiata*
	Homelyn	*R.*	*maculata*
	Blonde	*R.*	*blanda*
Torpedinidæ	Torpedo	*Torpedo*	*nobiliana*
Trygonidæ	Stingray	*Trygon*	*pastinaca*
Myliobatidæ	Eagle Ray	*Myliobatis*	*aquila*
	Ox Ray	*Cephaloptera*	*giornæ*

Raiidæ

Much of the confusion which has arisen between the species of *Raia* is due to the great difficulty of diagnosing from constant characters. Even in their colouring, which the older writers describe with the utmost precision, individuals of a species differ widely, particularly if we examine a series of different sexes and ages. Similarly, those features that have long been regarded (and rightly, in a measure) as secondary sexual characters, such as the form and number of the teeth, abundance and distribution of tubercles on the skin, or degree of curve in the fore part of the disc, are subject to almost endless variation and quite unreliable as indications of species unless accompanied by full particulars of age.

The exact relationship between the existing sharks and rays is not, as already remarked, satisfactorily determined, and we can only at present regard them as descendants from a common stock.

While it seems unnecessary to treat all the species of *Raia* in detail, a few notes on each may be of use.

The Common, or Grey, Skate (*Raia batis*) is a pale grey species with black spots; the under surface is nearly white and is speckled with black. It has two spineless dorsal fins on the tail, as well as three rows of thorn-like tubercles. It feeds on both fishes and crustaceans, and deposits its purses in early summer. Large examples of this skate are sometimes taken on our coasts, and one of 224 lb. has, in fact, been caught on the Irish coast.

The Thornback (*R. clavata*) will better serve as a typical ray, and it has been more studied and observed than the last. The vernacular name of this species is not particularly happy, as, with one exception, all rays have some equipment of spines and tubercles on the upper surface, and the present species is even less formidably covered than the Starry Ray. In general colouring, and allowing for the aforenamed variation, the thornback is dark and mottled on the upper surface and white beneath. Abnormally coloured thornbacks are, however, not very rare, and one was figured and described some years ago by Professor Traquair.* In his example, the upper side was white and had blotches of dark grey and small black spots. On the under side the colouring was normal. Dr. Traquair regarded this as a case of partial albinism, but his conclusion that such colouring could not afford protection against any known kind of sea-bed is hardly supported by a reference to his figure. The spiny growths on this species are mostly confined to a single row down the middle of the back and continuing to the tail, and four other patches, one at each extremity of the wings and one on either side of the back of the head. There may also be a few close to the eyes.

The thornback inhabits moderately shallow water, and is often hooked in less than 8 fathoms on the inshore grounds of Cornwall. There is an idea in that part of the country that this ray, instead of passing most of its life at the bottom like

* *Annals of Scottish Natural History*, January, 1893.

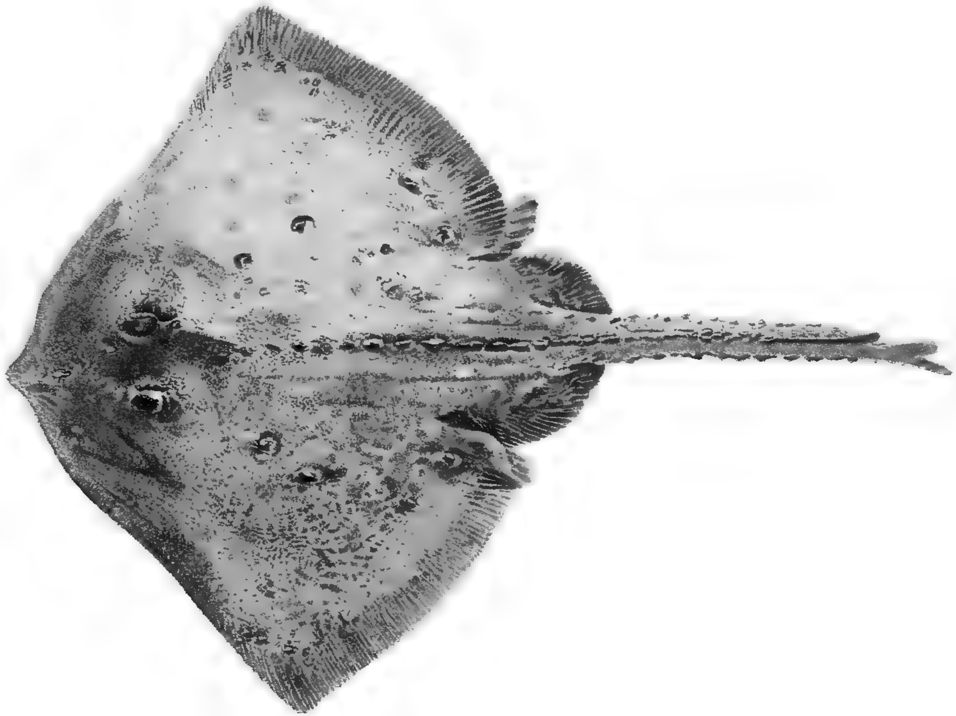

Photo by Reinhold Thiele

$\frac{1}{7}$ Natural Size

THORNBACK *(Raia clavata)*

the rest, is in the habit of rising to the surface in warm weather and chasing the pilchards, more after the manner of sharks. This may or may not be true, but it is easy to account for the belief on the ground of confusion between two separate facts. On the one hand, large thornbacks are certainly seen from time to time at the surface of the sea, and this is most probably connected with either some sudden atmospheric change with which we are unacquainted, or it may even have something to do with the breeding arrangements. On the other hand, pilchards have undoubtedly been found inside thornbacks. The two statements, taken separately, are above suspicion, and the danger only arises when they are associated as cause and effect, and some one then infers that because the thornback sometimes swims at the surface, and because also it sometimes devours pilchards—therefore it must have captured those pilchards at the surface. Not only do we know for a fact that pilchards, though commonly surface-feeders, are in the habit of swimming close to the bottom, near the ordinary haunts of the rays, in certain conditions of weather and temperature, but this shark-like method of preying on surface-swimming forms is absolutely contrary to what might be expected of the thornback's structure and ordinary mode of life. To make the positive assertion that this ray could not, taking into consideration the position of its mouth, capture a pilchard swimming at high speed and close to the surface, would be to fall into a dogmatic habit that has already, in the case of the whale and thresher story, been deplored. At the same time, in the absence of ocular evidence of rays chasing surface-fish, some doubt may be allowed to rest on the theory.

Like most rays, the thornback deposits oblong egg-purses, and allusion was made on an earlier page to their lack of anchoring threads, such as we find in the eggs of the nurse and rowhound, and to Mr. Dunn's theory of the compensating adhesive substance.

The Shagreen Ray (*R. fullonica*) is a rough-skinned species with, as a rule, no spots on its brownish-yellow back. Below, it is normally pure white. The tubercles are in two rows along the sides of the tail; also at the extremities of the wings and near the end of the snout. The dorsal fins are small, and lie near the end of the tail. It is a rather deep-water ray, and has been caught measuring 3 ft. on the Devon coast.

The Long-nosed Skate (*R. oxyrhynchus*) has the upper surface of the disc almost smooth; but the under surface is rough, except on the claspers, and is of a pale grey, with small black dots. This is a large and somewhat active skate. One trawled during the 1891 Irish survey measured 53 in. in length and weighed 32 lb., and a second measured 63 in.

The Painted, or Owl, Ray (*R. microcellata*) has rough tubercles both above and below, but their distribution is subject to great variation. In colour, also with variations, it is brown above, with purple spots and lines on the edges, and there are pale blotches on the abdomen, which is otherwise white. It was not known to occur in Irish waters previous to 1891, and may be regarded as an inshore fish there, as fourteen examples were taken, all in water from 5 to 19 fathoms.

The Sandy, or Cuckoo, Ray (*R. circularis*) was divided by Couch in two species, he having been misled into regarding as a constant character the black and yellow spot on the wings found in some individuals, but not in all. The egg-purse of this species has extremely long tendrils.

The Sharp-nosed Ray (*R. alba*), the "Bottle-nosed Ray" of Devon fishermen, is the largest species in our seas, examples having been taken of 7 or 8 ft. in length and 500 lb. in weight. It has rows of tubercles on the tail and "wings," also behind the eyes, and on the edge of the lower surface. This is the owner of the large "purse," which Couch attributed to *Myliobatis*.

The Starry Ray (*R. radiata*) is more formidably covered with tubercles than any other of our species. The claspers of the full-grown male are also of greater length than in any other ray. This is the most decidedly northern of our rays, being common on the coasts of Iceland and northern Norway, but not occurring with any regularity on our own, except in Scotland.

The Homelyn (*R. maculata*) has, as a rule, its upper surface dull brown, with a number of darker spots, and the lower surface white. The snout projects only slightly and is conical in form, sharpest in old males. The spiracles are large, and there are rows of tubercles on the tail and one along the back. Tubercles also, in some individuals, line the edges of the "wings," and there are a few before the eyes.

The Blonde (*R. blanda*) is distinguished from the last by Holt and Calderwood * on the ground of its paler ground-colour and more even distribution of spots, as well as by its smaller and more numerous teeth, and by the border of closely set tubercles along the anterior margin of the under surface.

Torpedinidæ

The Torpedo (*Torpedo nobiliana*) is in some respects the most interesting ray in our seas, showing in the highest degree that electric power which is, in fact, shared by all the foregoing. Their electric organs are in the form of either discs or cups, only, as in the colour changes of the chameleon, shared by many lizards, the torpedo has monopolised the reputation of being able to paralyse its enemies or victims with discharges from its cells.† It shows the same rounded head as is seen in the monk-fish, a very unusual formation in elasmobranchs, nearly all of which, both sharks and rays, have a shovel-shaped snout, which is commonly associated

* *Transac. Roy. Dub. Soc.*, September, 1895, p. 395.

† See Professor Cossar Ewart on "The Electric Organ of the Skate" (*Proc. Roy. Soc.*, February 25th, 1892, p. 474).

with the habit of digging up crustaceans or flat-fish from the sand. The torpedo is, however, a sluggish fish, and has other resources in the pursuit of its prey, for it doubtless lies in ambush and numbs any fish that may come in contact with its disc. Its eye has the same sensitiveness as that of all the rays; and Mr. Bateson, who some time ago conducted some very interesting investigations on the sense-organs of fishes, has recorded* that the pupil of the torpedo's eye is circular by night, but that by day the lower limb of the iris comes up over it so as to leave only a horizontal slit. In the common skate, on the other hand, it is a descending shutter which protects the pupil in the daylight, and this is drawn away when darkness falls upon the waters. Mr. Bateson was able to demonstrate these wonderful arrangements with the aid of a flash-lantern, which he suddenly turned on the fishes in the aquarium tanks at night. The practical aim of his enquiry, it should perhaps be mentioned for the benefit of those who think that such an institution justifies its existence only as long as it is "sternly practical," was connected with the all-important bait question, it being very necessary to ascertain which fishes find their food by scent, and which, on the other hand, trust to sight. The rays he assigned to the former category, and with them the sole; all the rest of our important food-fishes he regarded as hunting by sight.

The torpedo does not grow to a great weight, though an example of 82 lb. weight is on record, and it occurs on most parts of our coasts. It may easily be recognised by the rounded head. Its colour, however, is no sure guide, for both the ground shade and the spots vary in almost every two specimens. That it procures its food with the aid of its fibrous, disc-like, muscular electric organs and swallows its victims whole is obvious from the poverty of its teeth and the fact of fish as large as 5-lb. salmon having

* *Journal of the Marine Biological Association*, April, 1890.

been taken intact from its stomach. Dubois * has observed that the female torpedo gives shocks while the young are still unborn, but abstains from doing so as soon as they are born and so long as they remain near her. These facts perhaps warrant three inferences : that the shock is a voluntary act ; that the fish knows the danger to which her young would be exposed ; and that she has maternal affection.

Trygonidæ

The Stingray (*Trygon pastinaca*) has a yet more formidable weapon than any of the foregoing, in the shape of a long serrated dagger carried on the tail. Stingrays of 80 lb. have been taken on our coasts, and in such a fish the dagger, if intact, would measure half a foot or more. Whether this frightful spike is provided, like the fangs of some snakes, with venom does not appear to have been satisfactorily determined ; but such provision would scarcely seem to be necessary, since it is in any case capable of inflicting a very serious lacerated wound.

In the stingray, the wing-like pectoral fins of the order are still more highly developed than in most, completely enveloping the head, which is merely distinguished by standing above the body. The spiracles are large and lie behind the eyes, the latter being rather small. The teeth are small and lie in several rows. The tail is long and whip-like and has no fin, but there is a fold of skin at the base of the spine. It is said that the latter is replaced after injury by others that lie behind it. The body is smoother than that of most rays, though there may be a few tubercles on the disc. In colour the upper surface is similar to the sand or mud on which the fish resides. It probably lies for some time in the same spot ; at any rate, the writer has seen pits left by its body in the muddy banks of Queensland rivers.

* *Ann. Soc. Linn. Lyon*, 1899, p. 80.

Myliobatidæ

The two great rays of this family which find their way to our seas are stragglers from the warmer waters of Mexico and Florida.

The Ox Ray (*Cephaloptera giornæ*) is easily known by the horn-like processes in front of its head, which are said to be used in setting up currents in the water and bringing food to the creature's mouth. Its teeth are small and flat and lie in over 150 rows, and the particular food in question is supposed to consist of minute animals. These great rays are not, on the rare occasions on which they visit our seas, as active as in their warmer homes, where they are often seen to hurl themselves high in the air in order to throw off the remoras that persecute them. The head stands clear of the disc and is square in front. The spiracles are small. A feature of this ray is the immense length of its tail—three times that of the body, and armed with a serrated spine. Only one example has been taken in our seas ; it was caught on the south coast of Ireland, and measured 45 in. across the disc.

The Eagle Ray (*Myliobatis aquila*) is distinguished from the last by its pointed snout, shorter tail, and absence of the "horns." It also has a serrated spine in the tail ; sometimes two spines are present. Examples have been taken on many parts of the English coast, from Berwick to Cornwall, the largest, measuring 34½ in. across, having been recorded from Torbay. Like the last, it is viviparous, and the "purse" attributed to it by Couch and others belonged to a *Raia*.

These, then, are our British rays, which have been likened to the vultures of the air, the sharks supplying the place of the eagles. The swimming of the larger rays, as seen in the aquarium, is suggestive of the flight of large and sluggish birds. The enormous development of the pectoral fins, the attenuated, sometimes whiplike, tail, and the fringed eyelids distinguish them from other elasmobranchs, while they have the cartilaginous skeleton, the rough skin, the open gill-slits, and the breathing spiracles in common. They are slow swimmers, but this is compensated by various weapons, such as have been mentioned above.

CHAPTER IV

THE BASS, BREAMS, AND RED MULLET

In this chapter we must consider a number of more or less perch-like forms, including some very common, and one very valuable, food-fish. These are as follows :—

Family.	Common Name.	Genus.	Species.
Percidæ	Bass	*Labrax*	*lupus*
Sparidæ	Common Sea-bream	*Pagellus*	*centrodontus*
	Axillary Bream	*P.*	*owenii*
	Pandora	*P.*	*erythrinus*
	Spanish Bream	*P.*	*bogaraveo*
		P.	*acarne*
	Couch's Sea-bream	*Pagrus*	*vulgaris*
	Gilthead	*P.*	*auratus*
	Old Wife	*Cantharus*	*lineatus*
	Bogue	*Box*	*vulgaris*
Mullidæ	Red Mullet	*Mullus*	*surmuletus*

Percidæ

The Bass (*Labrax lupus ; Morone ; Boccus*)

The Bass, one of our handsomest sea fish, is separated on anatomical grounds from the true perches in Mr. Boulenger's new Catalogue of Fishes in the British Museum, but it was long regarded as a sea perch, and has, indeed, considerable affinities with that family. In colour the adult fish is either green or greenish brown, with silvery scales ; the younger fish

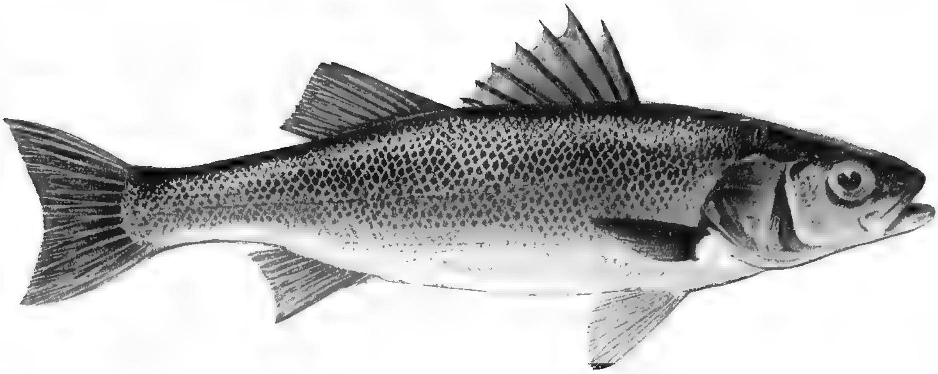

Photo by Reinhold Thiele

¼ Natural Size

BASS *(Labrax lupus)*

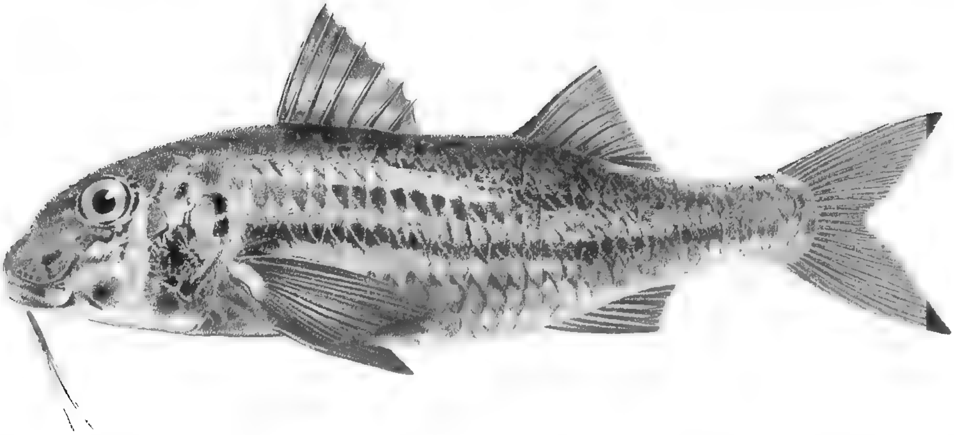

Photo by Reinhold Thiele

⅓ Natural Size

RED MULLET *(Mullus surmuletus)*

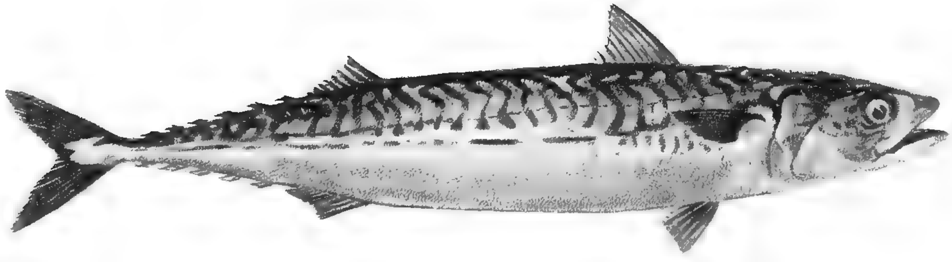

Photo by Reinhold Thiele

½ Natural Size

MACKEREL *(Scomber scomber)*

rarely show the brown tints, being a bright sea-green, and are more silvery than the adult, being spotted in their early months of full development. Willoughby had drawn attention to this spotted character in the young, and was wrongly corrected by Couch, who seems, curiously enough for one with so many opportunities of seeing young bass in the Cornish seine nets, to have overlooked that phase. The spotted or striped condition of young animals in contrast with their elders is common enough among fishes (*e.g.* cod, allis shad, etc.). It is even found in other classes of animals and may have ancestral significance. Even in the full-grown stage the bass retains a single large dark spot on the gill-covers. Its front dorsal fin has nine spines (as against twelve or fourteen in the perch), and is carried by the fish like that of the river perch, though lacking its red tints. There are also sharp spines before the other fins and on the gill-covers, which make the bass a difficult fish to handle. The greatest weight to which the fish grows is probably about 24 lb., but larger bass seem scarce of late years, possibly owing to the increased popularity of sea fishing for sport, and the consequent attention now given to the capture of a fish that is not commonly fished for by professional fishermen in a systematic manner. Records of even 12 or 15 lb. bass are much rarer than they were ten or fifteen years ago, and a fish of 10 lb. nowadays attracts attention. The Devon Teign is a favourite river with bass fishermen, and the largest fish caught (by myself) in its waters during the year 1902 weighed just $11\frac{1}{4}$ lb. The account here given of the habits of bass in the Channel is entirely the result of personal observation during several successive summers spent in pursuit of the fish in the estuary of that river, supplemented by reference to such residents as Mr. G. H. Johnson, who have made a study of the fish in that locality over a considerable period of time. It is, in fact, to those who fish for sport that much of our present knowledge of the bass is necessarily owing, for, being only seined in such estuaries as those of the Teign and Exe, and not otherwise occupying the attention of the regular fishermen, the bass has been little studied, particularly in reference to its habits, by economic writers like McIntosh, Cunningham, and Holt, while even Couch and Day have left very meagre accounts of the movements and daily behaviour of the shoals.

In the Teign, then, bass first put in an appearance during the first week in April, a little earlier or later according to the weather and temperature for the year. These are, for the most part, small shoal fish, varying in length from 4 to 9 in., but a few larger and more solitary fish appear to make their way up the river a little later, for amateurs occasionally capture these as early as the first half of May, but not earlier. Local opinion even has it that some of the largest old bass remain on the rough ground in the deeper portions of the estuary, about a quarter of a mile from the bar, throughout the winter; but it is impossible to ascertain by the most careful enquiry on what evidence this theory rests. The local fishmongers never have these large bass for sale during the colder months of the year. There is, on the other hand, no means of disproving the assertion, short of dynamiting the rocks, for the winter bass, if present in that part of the Teign, are equally immune from the prohibited salmon-nets and from the operations of anglers unable at that season to procure the living sand-eel, the only reliable bait in those waters.

The smaller shoal, or school, bass, which arrive in April, make their way up on each flood tide to within a mile of Newton Abbot (some five miles from the sea), and to all appearance return with the ebb. Anyone in a boat can in the early mornings during spring tides watch as many as half a dozen different "schools" pass the Ness in the course of an hour or two, the splashing brit and also the crying gulls plainly indicating the movements of each, while an interval of perhaps 50 yards of calm water intervenes between the shoals. Each of these is, as a rule, composed of fish of a "class"—that is to say, of approximately the same length and age. The bass in one shoal will average a pound, those of another half a pound, those of a third will weigh five to the pound, and so on. To this there are, however, exceptions, for anglers sometimes catch two or three fish of different weights from the same shoal. The manner in which these small bass behave during their ascent of the river is subject to much variation, and seems directly associated with the atmospheric conditions. Without any endeavour to establish a close correlation, it may, generally speaking, be asserted that the fish play more freely at the surface on bright, warm mornings, though they are sometimes more easily captured, particularly on the artificial fly, when the sky is overcast and a light, cold breeze blows downstream from the moors.

Another fact, which may unhesitatingly be recorded, even at the risk of being discredited in some quarters, is that for hours before the bursting of a thunderstorm the bass will touch no bait, and will rarely, indeed, show themselves at the surface. Thunder does not, as a rule, influence the biting of ground-feeding fish in moderately deep water some distance from the land; indeed, whiting-pout are commonly thought to bite with uncommon eagerness just before a storm. Of its effect, however, upon the appetite of such surface-feeders as bass and mackerel there can be no doubt.

It is also noticeable that the "play" of these fish at the surface is of two distinct kinds. When really hungry, the small bass jump clear of the water, snapping the brit, and showing continued activity throughout their progress up the middle of the stream, for they seem to keep in the middle in order to avail themselves to the full of the assistance of the flowing or ebbing tide, which is slacker under either bank. At other times, however, there is noticeable, particularly in the larger fish, a lazy, rolling action, suggestive rather of playing or bodily exercise, and without any apparent desire to feed. This view is corroborated by the fact that a "rolling" bass will not take a bait as a rule, though this is purely anglers' evidence, for a fish may often be feeding on its natural food, and yet decline baits that at other times prove attractive, and, on the other hand (*vide* a since qualified Report of the Scotch Fishery Board), it may take the fly or worm when not feeding at all.

How far, in an account that treats mainly of its life-history under more natural conditions, it is legitimate to discourse of the behaviour of a fish when hooked is open to question. It may, however, in passing, be mentioned that the tactics of a large bass in difficulties show evidence of much cunning. It is generally accounted a stupid fish in taking the bait, but an exceedingly skilful one in escaping the results of its folly. Much of its wariness in the first instance must certainly depend on the state of the water. In the clear, still waters of Cornish bays it is often possible, from a vantage point on the overhanging cliffs above, to watch large bass routing around the baits on set lines, smelling the hook, taking the bait between their lips and blowing it out again. If they take a baited hook without these preliminary enquiries, it can only be when, as in swift and muddy rivers, the water is thick and they themselves are hungry. It is not, of course, possible to watch the behaviour of the fish in dirty water, and the fisherman's only clue to the conduct of the fish is the behaviour of the line. When a large bass takes the bait, the line moves off slowly and hesitatingly at first, until the hook is struck home, and then of course the fish, maddened by the pain, makes a dash for liberty. It always makes, in a river, for the deepest water, and invariably gets out into the strong sluice tide that swirls beneath a bridge or round a moored buoy, and salmon hardly show more intimate acquaintance with such characters of the water as they can turn to account than does a large bass. Every movement of the fish in avoiding the shallows or heading for the posts of a bridge points to previous knowledge of the water, and as this is observed quite early in the season, it does not seem unreasonable to conclude that the bass has been in that estuary the previous year, and remembers the conditions. The very small fish show, as might be expected, a lack of experience and cunning, taking the bait with a headstrong indifference to the risks.

Another remarkable fact remains to be recorded in the life-history of these bass shoals, and that is their avoidance of the river on certain days and their preference for the rocks just outside the bar. As an extended series of journal entries entirely fails to connect this avoidance of fresh water with any particular condition of weather or temperature, their conduct can only be associated with irregular food supplies. The hatching out of some fish or other marine animal among the rocks might conceivably keep the bass in the vicinity; but there, at any rate, they remain on certain days, hot or cool, wet or fine, calm or boisterous. An easy explanation of this remarkable behaviour would present itself if we found that the little brit, the chief food of estuarine bass, also kept out in the open water on the same days. Actual observation, however, has shown that this is not the case, for on two or three separate occasions, when the bass were playing outside and to all appearance absent from the river altogether, the river was teeming with brit, some of which, captured by tying a piece of mosquito netting in the landing-net, proved to be young sand-eels and apparently little rocklings of some species. The absence of bass, however, from the same grounds was obvious not less from the fact of the baits being untouched than from the listless, leisurely manner in which the brit drifted past the boat, instead of, as usual, leaping and hurrying in frantic escape from their enemies. Sometimes the bass do not see the brit as readily as might be expected. I was enabled to witness a striking example of this from the viaduct at Barmouth on the longest day of 1903. Hundreds of fine bass were ascending the Mawddach on the further side; myriads of sand-eels gamboled unmolested not a hundred yards from them.

The foregoing illustrates in all probability the general principles of the existence of bass in estuaries during spring and early summer, though allowance must necessarily be made for variation in local conditions. In the Sussex Arun, for example, only the larger fish seem to find their way to the fresh water, where they are caught even above Arundel, several miles from the sea, though within the tidal portion of the river; and the shoals of smaller fish do not apparently play at the surface as they do in most Devon rivers. After August the smallest bass absent themselves from most parts of the coast, particularly from the rivers, though here and there the seines take immense quantities on the foreshore, and this as late as Christmas. During autumn a few fish, mostly of 5 lb. and upwards, are taken in the river; but most of the large bass caught in September and October occur in the surf at various coast resorts farther up Channel, and notably at Bournemouth, Brighton, Hastings, Dover, and other towns similarly removed from the outfall of any considerable stream. These larger bass come inshore after breezy weather, when the water is still perturbed and discoloured, and rout among the weed and débris for food, much of which is probably in a state of decay. At any rate, fishermen find that partly putrefied ray's liver is then the best bait, and the large bass are frequently taken in the fall of the year in the lobster pots, when the baits are stale, owing to the inability of the men to pick up the pots for days together.

The distribution of the bass presents no great difficulties. On our coasts it is most abundant south of the Thames on the east side and the Bristol Channel on the west, though it is regularly caught in the Menai Strait and in the Liverpool district. In Irish waters it is also, with few exceptions, confined to the southern portion of the island. Apart from this preference for the southern waters, the bass may be regarded as more plentiful on our west than on our east coast. It is very common in most parts of the Mediterranean, in which sea the writer has caught it at Gibraltar, Tangier, Leghorn, Naples, and Palermo, and has met with it in almost every fish-market visited, including those of Marseilles and Algiers. Its claim to rank as a table fish is variously accepted. As a general rule, it may be said that while the smaller bass, of a pound weight or less, are agreeable eating, the fish of several pounds are woolly and insipid to the taste. The bass spawns apparently in July and August and deposits floating eggs.

Sparidæ

The Sea-Breams

There is also something obviously perch-like about the Sea-breams, which should not be confused with the cyprinoid breams of our lakes and rivers. The river-bream is a green and yellow fish with some red on the fins and no spines in the dorsal. The sea-breams are blue or red and silver, with sharp spines in the fins; they dwell in shoals among the rocks, and, as remarked of the bass, fish of a "class" shoal in company. This holds good both north and south of the Equator; and in Australia, as at home, there are three names for three different stages of the red bream, though the precise stage to which each should apply seems variable in both countries. At Plymouth the smallest red bream is called "chad," the largest is a bream, and the intervening stage a "ballard"; at Sydney these three ages of the red bream are respectively "red brim," "squire," and "snapper." It is not here claimed that the fish are specifically identical in the Atlantic and Pacific, but the younger stages are not easily distinguished by the fisherman, particularly as he sees only one at the time. Cornishmen have no notion of the origin of the term "ballard," and one can only regard it as a possible contraction of "bald-head," a term of opprobrium; Australians are equally ignorant of the precise application of "squire," though the appropriateness of "snapper" for the larger fish is beyond all doubt. British sea-breams do not approach in weight those of our colonies, for whereas a snapper of 10 lb. is not an uncommonly heavy fish, even to-day, among the less-fished reefs on the coast of New South Wales, a bream of half that weight would be a good fish in Devon. It cannot be said that the sea-breams take high rank as food-fish, for only one, the common sea-bream, or adult form of the chad, is caught in considerable numbers for the market. Although a southern form, the sea-bream finds its way to all parts of the coast, but it is abundant only in the south and south-west. The group may be regarded as characteristically Mediterranean, in which sea the writer caught, during four months of 1891, at least seven distinguishable species.

The Common Sea-bream (*Pagellus centrodontus*) has the usual appearance and habits of the family, so that much of the foregoing account will apply to it. In colour it is bright red, the adult fish having a conspicuous black spot on the shoulder. Its scales are large. The front dorsal fin has sharp spines, and there are three spines in the ventrals. The teeth of the sea-breams show on a smaller scale the same variety as those of the wolf-fish, for the jaws have pointed teeth in front for seizing prey and flat teeth for crushing shells farther back; but *Pagellus* has mostly the flat teeth, and its food consists in fact less of other fishes than of crustaceans and echinoderms. Cunningham has not examined the eggs, but concludes that they are similar to those of the pandora (*P. erythrinus*), which were found at Naples to float separately at the surface. The common sea-bream, though for the most part a ground-feeder, is said at some seasons to swim in shoals at the surface; but this is not generally corroborated, and can, at any rate, not be a common phenomenon.

It is in connection with this fish that, with the aid of Matthias Dunn, Mr. Garstang, of the Plymouth Marine Laboratory, was able to offer a most interesting explanation of the malformed fish so common in Plymouth Sound and neighbourhood. If every discovery and theory in connection with the life-history of our sea fish for which the late Mr. Dunn was answerable were brought together under one cover, what a marvellous record of first-hand observation and ingenious deduction we should have! and how favourably his credentials would compare with those of many who, on the strength of a polite education, which he lacked, have taken far higher rank among marine naturalists! Any student of our sea fish must continually be struck not only by the acknowledgments of every marine biologist, from Couch to Cunningham, but also by the notes and articles which that remarkable man, who served his time on a pilchard boat, published in the *Transactions* of scientific societies. To the writer, who enjoyed the rare pleasure of his acquaintance during the last eight years of his life, his death, in the summer of 1901, brought added grief, for on the last occasion of their meeting Dunn had promised to think seriously of writing a great work on British fishes. Such a volume would have been a worthy successor to Day's standard work; but Dunn, unfortunately, had much other business to engage his time and was never able to get beyond the preliminary ground-work. His theory on the subject of malformed bream was published in the following circumstances. Mr. Garstang had long been puzzled by the continual recurrence in Plymouth waters of peculiarly deformed bream, which had to all appearance lost their upper jaw, and thus gave the impression, when viewed in profile, of being short-nosed or tube-mouthed. Mr. Dunn offered a very simple explanation of this phenomenon. He told Garstang that the pollack fishermen, increasingly impatient when they find hook after hook robbed by chad, the latter being too small-mouthed for capture on a pollack-hook, often give their lines a terrific jerk, more in helpless anger than with any hope of hooking the chad. The result of this impetuous movement is that every now and then, when a small bream happens at the moment to be sucking at the bait which is too large for it to swallow, the upper jaw of the fish is torn away, and in the course of years these maimed bream—which are not debarred from finding nourishment, henceforth living on soft food by a process closely resembling suction—grow, and are finally caught in that neighbourhood. The interest of this explanation is not confined to its accounting for the deformed mouth in these bream. It also shows, since we know the breams to be migratory, at any rate to the extent of leaving our shores in winter, either that the individuals thus handicapped prefer to remain in the neighbourhood rather than wander with their whole fellows, or else that the breams generally, though wanderers, return year after year to the same neighbourhood. In accepting this almost legitimate deduction, it should, however, be borne in mind that in all probability the fishermen of other districts, say on the south coast of Ireland, are equally impatient, and tear the jaws of bream in precisely the same way as is done in Cornwall, so that these malformed bream taken at Plymouth might have received their wounds elsewhere.

Whether the prickly little chad is to any great extent preyed upon by pollack, the fact remains that one side of a chad is an excellent bait for that fish. It is always used when the chads themselves meet the descending hooks a few fathoms below the surface and remove the soft pilchard baits before they have reached the lower level at which the pollack are feeding. At other times the reverse happens, and the baits go too far, passing the pollack in mid-water, only to be robbed by the chads below.

The breams of our seas fall under four genera. Of the typical genus the Common Sea-bream is an example, and its allies are the Axillary Bream (*Pagellus owenii*), which lacks the black spot on the shoulder; the Pandora, or King of the Breams (*P. erythrinus*), which is red, with blue spots; the Spanish Bream (*P. bogaraveo*), a smaller fish also spotted with blue; and a fifth and rare species, *P. acarne*. In the second group we have Couch's Sea-bream (*Pagrus vulgaris*), which is our closest ally of the aforenamed Australian snapper, and which has been taken in our waters weighing 10 lb., and the equally rare Gilthead (*P. auratus*), so-called from the crescent-shaped yellow mark between the eyes. The third and fourth genera have but one British representative apiece, and these are the Old Wife (*Cantharus lineatus*), a silvery grey bream, with longitudinal yellow bands on the body and dark spots on the fins; and the Bogue (*Box vulgaris*), a bronze fish with a brown spot on the pectoral fins. It is rare in our seas, though the writer has caught scores off Leghorn. An example of the old wife, which is usually described as a moderately deep-water fish, was taken in shallow water in the seine-nets at the upper end of the Hamoaze, Plymouth, in July, 1897. It is of importance, when studying American works, to bear in mind that their "common sea-bream" (cf. Bashford Dean, *Fishes, Living and Fossil*, p. 225) is a wrasse (*Ctenolabrus*).

Mullidæ

The Red Mullet

The Red Mullet (*Mullus surmuletus*) is a small red fish with from three to five longitudinal yellow bands, large thin scales, and two barbels on the lower lip, which lie back in grooves when not in use. Its teeth are small and blunt, and there are none in the upper jaw, but some are also found on the palate. There is a plainer form of this fish, whether species or variety has not yet been determined by zoologists, which lacks the yellow stripes, and is somewhat smaller in size.

It is plentiful enough in the fish-markets of Mediterranean coast towns, but is rarely, if ever, seen in our shops. When it is remembered that Cunningham has, with all his opportunities, never seen the plain form at Plymouth, and that neither Couch nor Day described the fish from actual observation of British-caught examples, it looks as if its right to be included in the British fauna is somewhat doubtful.

The red mullet does not grow to a great weight. A couple of pounds, with a corresponding length of about 15 in., would be considered a good weight in Cornwall, where some of our finest are caught for the London market. In all countries it commands a high price for the table, though comparatively inexpensive in Italy and the southern ports of France. At Marseilles, for instance, it is a common ingredient in the famous *bouillabaisse* soup. The name given to this little fish by the Moorish fishermen of Tangier—"Sultan-el-hout," or the "Emperor of Fishes"—is probably a tribute to its brilliant colouring, particularly as red is the royal colour in Morocco, for that would appeal to the Oriental eye sooner than its delicate flavour to the Oriental palate.

The red mullet is caught chiefly in the trammel, which is set on soft ground near the inshore rocks, and it is taken at night, the nets being taken up in early morning. To some extent also it is taken in the trawl, and the writer has seen many scores landed from the trawlers at Brixham. There is no regular hook fishery for red mullet, though rare instances of its capture by amateurs have been recorded at Brighton, Shoreham, Bournemouth, and elsewhere. Still, it does not commonly take the hook; and the writer, after fishing for years close to its haunts on the coasts of both England and Italy and catching none, took two within ten minutes in Tangier Bay in April, 1899, and never one since. Soft food lying on the sand suits the mullet's teeth and manner of feeding, and it is probable that if any angler were to lay himself out to capture the fish in suitable localities during the summer months, he would meet with success. The already beautiful pink of the large scales during life is intensified by the fishermen, who remove them before *rigor mortis* has set in, though not invariably, as formerly thought, while the fish still lives.

It is a shore-haunting fish, of gregarious habits, and it feeds on the bottom. The tank-house of the Plymouth Laboratory generally has a very attractive shoal of these fish, and Cunningham has aptly compared their movements in the water to that of a flock of birds in a field, alternately soaring to the higher levels, then settling down and seeking for food. This they do by turning over the gravel with their stiff and sensitive barbels, which are tucked out of the way when the fish are exercising themselves in mid-water, as gulls stow away their legs when flying high.

The spawning of the surmullet has been studied by Italian biologists, but not, so far, by our own. Raffaele found the fish spawn in the Naples Aquarium in early spring, the eggs being transparent and floating on the water. The larvæ are hatched out in three or four days, and have a curious appearance, from the position of the yolk, which protrudes in front in a manner that McIntosh likens to the prow of a vessel. By the end of summer the little red mullet had their barbel, but were still silvery, and had not assumed the pink livery of their later life. Their head was, with its barbel, more like that of a cod, though the characteristic form of head in the adult fish was not long in appearing.

With reference to the relations of the plain and striped forms, Günther apparently follows Gronovius in regarding the latter as the female, and the former as the male, of one and the same species; and it is somewhat curious that, with the analogy of the male and female of *Callionymus*, they should not have accepted the more general rule, and assigned male sex to the more ornate form. What ground Dr. Günther has for this view is not explained in his book,* where he merely says, "*M. surmuletus* being probably the female." This sexual view of the two forms of red mullet does not, however, appear to have received later support, for the striped form appears to have bred by itself in a tank at Naples, and to have produced larger eggs and young than the other.

Of the actual food of the red mullet we do not know much, and it can only be surmised that the fish feeds on soft substances, since its teeth are exceedingly feeble, and its manner of routing in the gravel or mud with its barbels suggests such material. Günther mentions that some of the family enter brackish water to feed on the animalculæ in the weeds, but whether specific allusion is made to our fish is not quite clear from the context.

* See *Introduction to the Study of Fishes*, p. 404.

CHAPTER V

THE MACKERELS, HORSE-MACKERELS, AND ALLIED FORMS

WE now come to a large and interesting group, or rather several related groups, of fishes for the most part residing at the surface of the sea and in the neighbourhood of land, at any rate during a portion of the year. One or two of the larger species, on the other hand, keep out in the deeper water, only wandering occasionally within the littoral waters, while in the dory we have a fish that lives and feeds close to the sea bed. The larger tunnies and bonitoes, which, although periodically taken on our shores, must be regarded as stragglers from the Mediterranean by way of the open Atlantic, are more appropriately enumerated in the chapter on "Rare and Uncommon Fishes"; and in the present chapter account will be taken only of the commoner kinds and their close relations, these being :—

FAMILY.	COMMON NAME.	GENUS.	SPECIES.
SCOMBRIDÆ . .	The Mackerel Spanish Mackerel	*Scomber* *S.*	*scomber* *colias*
CARANGIDÆ . .	Horse-mackerel Boar-fish	*Caranx* *Capros*	*trachurus* *aper*
CYTTIDÆ	John Dory	*Zeus*	*faber*
SCOMBRESOCIDÆ .	Gar-fish Saury Pike	*Belone* *Scombresox*	*vulgaris* *saurus*

Scombridæ

The Mackerel

The Mackerel (*Scomber scomber*) is the type of all these fishes, commercially the most important, and certainly the most beautiful. It is a familiar fish enough, blue, with very small scales and irregular black bands down its sides, the latter, as well as the under surface, showing a beautiful pink metallic sheen and silver reflections. The colouring of the mackerel is subject to much variation, and while some races have spots and scribbled lines between the bars, or in their place, there are individuals (see *The Zoologist*, July, 1897) with neither spots nor bands nor markings of any kind, but of uniform blue or green. There is a small keel on each lobe of the tail, and there are five or six finlets behind the second dorsal fin, the first dorsal having from eleven to fourteen spines. The mouth is well provided with small, sharp teeth, which cover both jaws, as well as the tongue and palate.

Few of our sea fish are, in fact, of greater importance than the beautiful mackerel, for which there are distinct and regular hook and net fisheries, according to the season. The cod and herring may occupy the greater fleets of the North Sea; the pilchard has its restricted area in the south-west; but the great mackerel fisheries of the coasts of Britain and Ireland are of immense annual value.

Although we recognise but two species of *Scomber*, it is evident to all who have seen even the common species in different seas and markets that there are several types or races. To the unscientific observer size and the presence or absence of spots will be the determining character; but the biologist takes closer account of the number of fin-rays and transverse bars, and on this basis Mr. Garstang recently conducted a very interesting investigation of these racial peculiarities. The results of his enquiry have been ably summarised in the *Journal of the Marine Biological Association* (November, 1898). His researches not only enabled him to draw conclusions as to the migrations, about which something will be said later, but also to establish a most important anatomical correlation between abnormal development of spots and abnormal increase in the number of fin-rays, associating these as departures from the normal type. Morphologically, therefore, as well as economically, his enquiry was of considerable value.

In the mere matter of size, it is within the experience of every buyer of fish that the fish-dealer offers sometimes very large and sometimes correspondingly small mackerel. According to the season and the wares, that it is his business to sell without delay, he unhesitatingly affirms that either the large Irish mackerel is the finest flavoured in the market, or that the little "joeys" are better for table purposes than the larger, ranker class of fish. The largest race of mackerel are sometimes called "horse-mackerel" by the fishermen, particularly in the hooking season (August), when these fish are taken on fine drift-lines, and go careering round the boat, to the imminent risk of entangling all the lines over the side. The name is unfortunate, as it might lead to confusion with the horse-mackerel (*Caranx*) properly so called. Perhaps these different-sized mackerel are to be regarded as merely brigades of one great mackerel army which invades our shores at the appointed season, splitting up into roving bands of large or small fish in spring, the largest remaining in the south-west of the islands, the smaller finding their way along the south and up the east coasts. This, however, has not been satisfactorily determined, nor will be in all probability until more attention has been devoted to the subject.

Before passing to a brief consideration of the seasonal migrations of our mackerel, it is desirable to take some notice of their mode of feeding and manner of food, with the procuring of which one, at any rate, of their two great yearly movements has been associated by all modern authorities.

At times the mackerel feeds close to the surface; at other times in mid-water (by which is meant anywhere tolerably distant from both the surface and bed of the sea); and still later in the year the mackerel are busy feeding at the bottom. Two distinct styles of food appear to suit the fish in its various moods. In the one case it filters the water through its gill-rakers, just as the herrings and pilchards do, sucking in and retaining the minute copepoda, larval molluscs, or olive weed-spores (*Melanospermeæ*); in the other it chases young sand-eels, rocklings, and pilchards. At the spawning time the females, at any rate, do not seek food, and even the males display some indifference in the matter of eating, with the result that just at that season mackerel are caught almost entirely in the nets, and rarely take a bait. Mr. Cunningham satisfies himself that this accounts for the refusal of the fish to take a bait in early spring, and the "blindness" consequently alleged by the fishermen, who aver that the fish do not take the bait because they are unable to see it. Without desiring to offer any opinion with reference to this alleged blindness in spring mackerel, it yet seems right that I should add that several generally reliable Cornish fishermen have given more positive evidence in support of their belief, and have carefully described the filmy appearance of the eye at that season.

The spawning takes place, in the Channel, in the summer months, and the eggs, of which a large female will contain about half a million, float separately in the water, and are rather larger than those of the cod. According to Holt, the larva of the mackerel closely resembles that of the bull-heads, a similarity which may, according to McIntosh, indicate ancestral affinities. This, however, he regards as mere conjecture. The growth of young mackerel has not been very closely or satisfactorily studied. Matthias Dunn used to describe year-old mackerel of about 3 in. in length in the bays around Mevagissey during the month of September each year, and similarly two-year-old mackerel are thought to attain to about 8 in., and three-year-old fish to 11 in., which would be the arrival at sexual maturity.

Undoubtedly, however, the most interesting matter in the life-history of mackerel is the extent and direction of their migrations. That these great movements of the shoals will have less mystery for us as time goes on there can be little doubt, for already, thanks to the indefatigable researches of Messrs. Allen and Garstang and others in this country, and of Professor Sars in Norway, we are in a position at least to qualify considerably the confused accounts of earlier writers. Modern enquiry has, at least, had one result inseparable from scientific research. It has compelled us to interpret the possible movements and relations of the great mackerel shoals with all reservation, the confident and circumstantial accounts published more than twenty years ago no longer finding support among the more cautious zoologists of to-day. The subject is immensely interesting, and has occupied many sheets of the *Journal* of the Marine Biological Association and other ichthyological publications. Only the barest possible summary can here be attempted. Briefly, then, it seems that the mackerel appears yearly off the west coast of France (Douarnenez) at the end of January, somewhat earlier in the year than with us. Early in April the Atlantic shoals of larger mackerel approach nearer to the south-west headlands of Ireland, and in May they are caught in quantities in Cornwall and Devon, the fishery lasting throughout June and July, and falling off in August. In October there is an autumn revival; but by the following month the main body of the fish has practically forsaken the coasts of Great Britain, though a few are netted in the south-west of Ireland up to Christmas. It would seem that the surface temperature of the inshore waters is the main determining factor in these coastal movements; and Matthias Dunn in Cornwall, and several eminent ichthyologists in America, agree on 45° F. as the lowest temperature agreeable to the fish. This will better enable us to understand the otherwise seemingly capricious journeyings up the coast. This phrase, by the way, must be used with caution, for much may depend on whether it is meant to signify the progress of shoals actually working their way along, for example, our south coast, from west to east, in a course approximately parallel to the shore, or whether it indicates merely their successive appearance at points on the coast from west to east.

The importance of the foregoing distinction will be obvious when we bear in mind the extent to which modern enquiry has tended to explain fish migrations as comparatively restricted journeys between the deep and shallow water—*i.e.* in a direction either oblique or at right angles to the shore. There is a wide gap between the ichthyology of the end of the Victorian era and that of its dawn, when the first edition of Yarrell was published. We can now, for instance, distinguish with some reason between the motives of the spring and autumn movement of the mackerel, the first having for its object the arrival on suitable spawning-grounds, the second being rather connected with the movements of larval fishes upon which, in the fall of the year, mackerel are wont to feed. This distinction is confirmed by the examination of the stomachs of mackerel caught at the two seasons, those of spring mackerel being comparatively empty, while a large proportion of those captured in autumn are crammed with the young of rocklings, sand-eels, and other shore-dwelling species. The practical end and aim, over and above the intrinsic interest attaching to the elucidation of such mysteries, of these enquiries into the migrations of mackerel must obviously be the discovery of the whereabouts of the shoals when absent from our coasts. Possibly, if biological investigation does eventually throw light on the exact whereabouts of the shoals during the three months of winter, the fish will be found in a locality and at a depth such as to bring them conveniently within the operations of the nets ; and whether, even if the shoals were so located, a continuous fishery of the kind would not tend to exhaustion, is another question.

It is the business of the biologist to ascertain these facts; it is then the business of the legislator to act upon them. Certainly the problem is one that should fascinate all with opportunities for studying it. The presence of mackerel in the trawl, as well as in the stomachs of the cod and other ground-feeding fishes, points to a retreat to deep water in the winter, and this may perhaps be undertaken to avoid the extreme cold of the shallows during the months in which the sun is giving its greatest heat to the mackerel of Australian seas. The difficulty may eventually be solved by the deep-sea thermometer, which will show us the depth and distance from land at which the mackerel would be most likely to find a congenial winter residence. Little by little science is substituting fact for fiction. We have grown out of the simple faith that accepted stories of mackerel hibernating with their heads buried in Arctic mud, and we find, on comparing the two, that the truths of nature are quite as wonderful as the fables of man.

The Spanish Mackerel (*S. colias*) is a much rarer and also less important fish in our seas, being in fact only a wanderer from the Mediterranean. It resembles the ordinary mackerel in colour, but is distinctively marked with blotches and spots, and the eye is conspicuously larger. It has, moreover, an air-bladder, which the common mackerel lacks, and it shows rudimentary traces of a corselet of scales, which is more highly developed in the bonitoes. Its flesh becomes unfit for market after capture even more rapidly than that of the common species, so that commercially it is of no account. Still, it is a beautiful fish, and Dr. Bashford Dean * takes it as the type of a fast-swimming fish, with its rounded surface, tapering spindle outline, smoothly closed gill-covers—in short, as seen from the front, a small but perfect ellipse. The

* *Fishes, Living and Fossil*, p. 3.

mucous covering which extends over its body diminishes friction with the water, and inside as well as out everything is so disposed as to give the perfection of equilibrium and facilitate rapidity of movement through the water. Our common mackerel fills almost as efficiently the ideal of a swift fish, and it would be difficult to name another capable of such activity in either rough or smooth water, in the state of freedom or hooked in the mouth and thereby handicapped.

Carangidæ

The Horse-Mackerels

The Horse-mackerel (*Caranx trachurus*), or Scad, though sufficiently distinct from the true mackerels to preclude all risk of confusion, nevertheless recalls the mackerel in outline, and is always captured in its company, unless it is in a shoal of its own kind. The fish is recognisable by the row of sharp scales along the lateral line, as well as by its duller blue-grey colouring, and the presence of only eight (instead of eleven or more) spines in the front dorsal fin. In size it resembles the mackerel, a large example of either measuring about 20 in., and individuals exceeding that length being the exceptions. In weight, too, 3 lb. is the approximate limit. Its habitat is also, like that of the mackerels and their allies, southern, nor does it, from all accounts, find its way as far north as the other fish. The two swim in company on the south coast; but the scad is more commonly taken on the ground-lines, when the mackerel shoals have "broken up" and gone to the bottom, than on the surface-lines in early summer. Similarly, the scad occurs in the trawl more often than in the drift-nets. These results, therefore, seem to point to its keeping closer to the bottom than the mackerel. It is even more uncertain in its migrations, though, by reason no doubt of its commercial unimportance, these have been but little studied. In 1897, as a case in point, thousands were netted in Bournemouth Bay throughout July and August. They were called "pilchards," but they were most assuredly scad, for the writer handled scores fresh from the seines, and they have since been as scarce in that bay as they had been previous to that year.

The eggs of the scad have been described only in the unfertilised state, Holt having failed to fertilise them artificially. They are (unfertilised) transparent, and float in water. Cunningham took the young in a tow-net, from 1 to 2 in. long, in August and September, about five miles out from Plymouth. At that length they displayed all the adult characters, and may have been from two to four months old. According to Couch these young scad are the prey of many fishes. At a much earlier stage, on the other hand, Malm found them sheltering in jelly-fish and feeding on their eggs. The scad is supposed to utter a grunting sound, like that observed in the gurnards, and the Italians consequently call the fish by a name corresponding to our word "vocalist." This must be either an occasional habit or more common with scad taken in the Mediterranean, for the writer has handled hundreds of scad newly caught in the Channel without once hearing such sounds.

The Boar-fish (*Capros aper*), also known as the Cuckoo-fish, is a small, flattened, orange-red species with a tubular mouth, and having tubercles all over its skin. Its teeth are small. It rarely grows to more than 7 in., and its fins are not in any way remarkable, though there is a long thick ray in the pectorals, and the ventrals have but three spines. Matthias Dunn found it spawning on the Cornish coast in July, and Cunningham succeeded in fertilising the buoyant, transparent egg, though he failed to hatch out the young. This fish is plentiful only on our south-west coast during the summer months, and is of no commercial importance.

Cyttidæ

The John Dory (*Zeus faber*) is a much more familiar and valuable fish, though its popularity as a food-fish is undoubtedly prejudiced by ignorant dislike of its grotesque appearance. Seen from the front, as it hovers in the aquarium tank, the fish foreshortens to a mere line, which is of immense advantage to it when stalking its prey. The more familiar view of the dory, however, as seen in the fishmonger's shop, shows us a compressed, dull grey fish, with a conspicuous black spot on each side of the body, and, as seen, in at any rate the dead fish, a disproportionately small and tubular mouth. The fins have long rays which end in filaments, and at the base of the dorsal and anal there are rows of spines. The dory grows in our seas to a weight of at any rate 18 lb., and the greatest recorded length is just over 22 in. Its distribution is that of most of our southern fishes, the fish being common on the south coast, rare on the east, and increasingly scarce in northern waters. The largest examples appear not to penetrate much north of the Thames and Severn estuaries, and in the Lancashire district, for instance, most of those taken of late years have measured about 5 in.*

There are patches of bony plates on the abdomen and, as already stated, at the base of both dorsal and anal fins, and the scales generally are few and small. The small teeth of the dory lie in the jaws and on the vomer; there are none on the tongue. The curious fancy among the fishermen, associating the black blotch on each side of this fish with the thumb and finger of St. Peter when taking the tribute money, has been so frequently related as to need no more than passing mention.

The habits of the dory are more interesting than its somewhat unpromising exterior might suggest. The writer has often watched these fishes stalking their prey beneath Bourne-

* Herdman and Dawson, *Fishes and Fisheries of the Irish Sea*, 1902, p. 39.

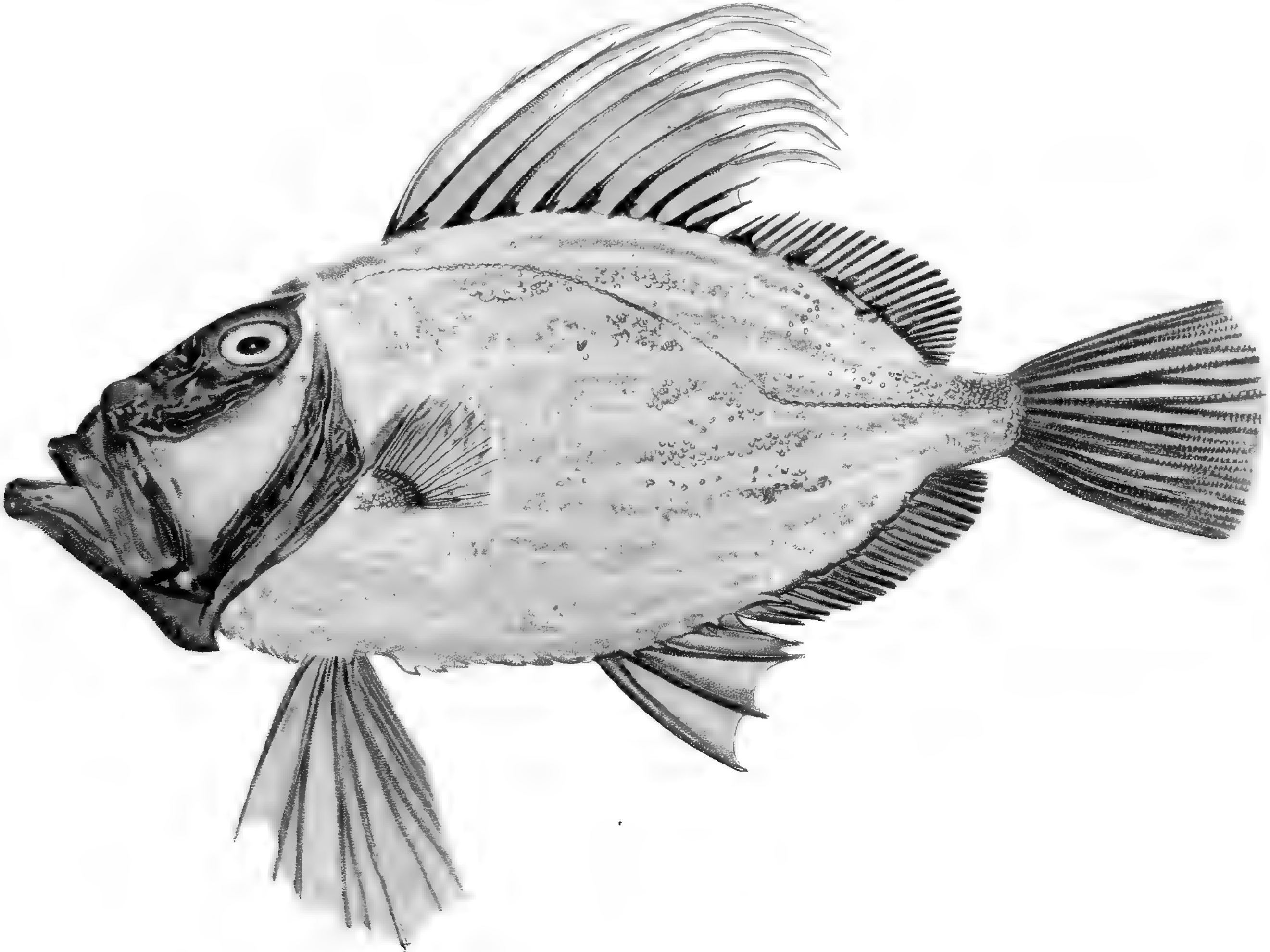

Photo by Reinhold Thiele

½ Natural Size

JOHN DORY (*Zeus faber*)

mouth Pier on calm summer mornings before the water has been disturbed by holiday traffic, and he can only confirm Cunningham's account as absolutely faithful to nature. The grotesque fish foreshortens to little more than a blurred line, and in that guise it advances with little, unobtrusive jerks, gradually approaching the sand-eels and atherines that swarm among the weed-covered piles. Then, quite suddenly, it shoots out its tube-shaped mouth like a telescope, or rather like those Japanese fishing-rods that may be blown out, joint by joint, from the hollow butt, and the nearest small fish is seized. So cleverly does the dory sometimes contrive the assault that the others continue to play unsuspectingly in its immediate neighbourhood, though it does not commonly take advantage of this to capture a second before some little interval has elapsed.

This sort of stratagem suits the dory's organisation, for it is only a poor swimmer, and much of its so-called "migration"—we know that it appears on different parts of the coast at stated seasons, so that it is rightly regarded as a wandering fish—is probably performed by drifting. A single rough day is sufficient to clear the inshore waters (for example, under the pier above mentioned) of dories for days, so that the fish is probably quite unable to hold its own in those most desirable feeding-grounds when the shallow water is stirred to its bed by rollers sweeping through the iron girders.

The breeding of the dory has apparently been little studied, and the supposed period of the dory's spawning is one of the few points on which Matthias Dunn and Cunningham disagree, for, whereas Dunn considered winter to be its breeding-time, Cunningham thinks that it must spawn in summer. The evidence in either case seems rather circumstantial, Cunningham's strongest authority being the assumption that the small dories, measuring from 5 to 7 in., which are trawled in Plymouth Sound between June and September must be one year old, and were therefore hatched from the egg between June and September of the preceding year. It may be that subsequent investigation of the larval dory and its development will confirm Cunningham's view, but he has certainly made as much of the rather meagre evidence as could have been expected.

Small dories are said to feed on gobies, which would probably imply that they hunt their food nearer to the ground than the larger individuals, which, as already stated, chase surface-swimming fishes not far below the surface.

Scombresocidæ

The Gar-fish (*Belone vulgaris*) is perhaps the most easily recognised of our fishes, having a flattened, silvery, eel-like body and a development of the jaws, the lower one the longer, that recalls the bill of the woodcock. Examined more closely, the gar-fish is found to have numerous small teeth in both jaws which at once distinguish these from the typical bill of existing birds), wide gill-openings, small scales, the dorsal fin far back, the tail forked, and large eyes. In colour the gar-fish is bluish green, with metallic reflections, and even the bones are green, both in the natural state and when cooked—a character that has, quite needlessly, prejudiced consumers against this very excellent food-fish.

There can be no doubt that the gar-fish is migratory, or that it consorts at some seasons with the mackerel shoals. The writer never caught gar-fish except when mackerel fishing, in either the Channel or the Baltic Sea. In the latter this species was abundant in summer, always in company with the mackerel, and the two are said to enter from the North Sea in May or June, with the inflow of denser water through the Skager Rack. All around our coasts this companionship between the gar-fish and mackerel seems to be remarked as something more than a coincidence in the season of their inshoring, and the gar-fish is invariably taken on the same lines or in the same nets that serve for the more important fish.

As to the method of feeding practised by the gar-fish, there is little room for doubt on the part of any that have watched them chasing the small fry with extraordinary agility close to the surface. The only difficulty arises from a consideration of the recorded instances in which they have been know to thrust their bills into pilchards or even larger fish. There can, however, be little doubt that these attacks were purely accidental, for the bill has been known to break off in a peal or other large fish, and the gar-fish could never conceivably have intended feeding on such prey. It can only be surmised that in its frenzied rushes through the water its longer jaw does occasionally strike some passing fish as large as, or larger than, the gar-fish itself, probably to the destruction of both fish, the one dying from loss of blood, the other from the accident to its mouth and subsequent starvation, for it is hardly to be expected that a gar-fish deprived of its bill could adapt itself to feeding by suction, as in the case of the maimed bream recorded above.

When hooked on a light line, the gar-fish displays extraordinary activity, leaping out of the water and apparently endeavouring to shake the hook from its jaws. The gar-fish is closely related to the flying fish, which is more appropriately described in the chapter on uncommon fishes, its presence in our seas being so uncommon, indeed, as to have cast grave doubts on its being a genuine British fish.

The spawning of the gar-fish is interesting, for we find its eggs provided with anchoring filaments that recall in a modified form the tendrils that we noticed in the eggs of two of the sharks. These threads, some of them one centimetre (or $\frac{2}{5}$ in.) long, grow all over the surface of the egg, and, as figured by Masterman,* they look as if they were capable of anchoring the eggs not alone to each other, but also to

* McIntosh and Masterman, *British Marine Food-fishes*, p. 401.

any other support with which they come in contact. It does not appear that, at any rate as recently as 1897, the eggs have ever been obtained in the natural state, so that much of this surmised function of the filaments, as well as any statement as to the egg probably hatching out at either the surface or bottom of the sea, must obviously be conjecture, even if based on analogy with the habits of kindred species more closely observed in other seas. Scandinavian authors tell us circumstantially enough, however, that the fish spawns close in shore in the spring months, April to June, and one of them is of opinion that the eggs are deposited among the weeds, since the fish is always caught among weeds during the spawning-time.

The young gar-fish is, in its early developments, as interesting as the egg, for the "beak" is an acquisition of a later stage, and in the young fish we find the ordinary jaws of any other teleostean form. Then the lower jaw begins to outgrow the upper, and at one stage it is immensely the longer, the discrepancy being far more conspicuous than in the adult. There is a gar-fish in Australian waters, plentiful in Port Jackson, and served up almost daily in the winter months (May to September) in the Sydney hotels, that retains the great disproportion between the jaws, but this belongs to a distinct genus (*Hemirhamphus*), some species of which live up the fresh-water creeks. Australians call these fish "half-beaks." There are also interesting developments in the fins of our species, but that of the jaws is more characteristic. Cunningham mentions having found young gar-fish in ground-seines in the Hamoaze (Plymouth) in September. They measured 4 in. or 5 in. in length, and were fully developed, and Cunningham regards them as over a year old. The garfish grows to about 3 ft. in length.

The Saury Pike (*Scombresox saurus*), or Skipper, is not unlike a small gar-fish, but may be distinguished by its deeper blue (and less green) colour, also by the presence of finlets along the back near the tail, by its smaller teeth, and the slighter difference between the jaws. It appears on our shores at the same time as the gar-fish, and is perhaps found more frequently among the pilchards, often hampering the netsmen by frightening those timid fish. It eggs are said to have the same filaments as those of the gar-fish, and also to develop in much the same way, and the larval forms of both are also compared; but little study appears to have been given to either. A skipper of 18 in. would be a large example, and in Cornwall one meets with more of about half that length.

CHAPTER VI

THE GURNARDS, BULLHEADS, AND WEEVERS

It is customary to associate the Gurnards and Bullheads very closely, and the inclusion of the Weevers in the same chapter will perhaps be resented for some reasons dear to the systematic zoologist. At the same time, the wide differences between the first two groups are scarcely less than those which separate either from the Weevers. In structure the gurnards and bullheads differ as completely as in habits. The disproportionately large head and the spines on the gill-covers are, in fact, their only common possessions. Otherwise the bullheads are for the most part dull-coloured, scaleless fishes, which live some distance from the bottom, or which at any rate seize baits near the surface, and lay heavy eggs that sink in the water. The gurnards are generally brightly coloured fishes, with scales, and with a row of spines along the lateral line, also with their ventral fins modified into separate rays that look and act like fingers. They keep almost entirely to the bottom, but lay floating eggs. They reach, perhaps, their highest development in the Mediterranean, whereas the bullheads are characteristically Arctic fishes.

The Weevers are among the greatest dangers to shore-bathers on our coasts. Quantities are caught in the trawl-net, and on the quays at Lowestoft the writer has seen heaps containing many hundreds, which are sold to fish-fryers at a low figure, the proceeds being divided among the crew of the smack as a perquisite.

The fishes which occupy the present chapter fall under three families. They are :—

FAMILY.	COMMON NAME.	GENUS.	SPECIES.
COTTIDÆ	Sea-scorpion	*Cottus*	*scorpius*
	Father-lasher	*C.*	*bubalis*
	Four-horned Cottus	*C.*	*quadricornis*
	Norway Bullhead	*C.*	*norvegicus*
	Red Gurnard	*Trigla*	*cuculus*
	Grey Gurnard	*T.*	*gurnardus*
	Streaked Gurnard	*T.*	*lineata*
	Sapphirine Gurnard	*T.*	*hirundo*
	Piper	*T.*	*lyra*
	Lanthorn Gurnard	*T.*	*obscura*
CATAPHRACTI	Armed Bullhead	*Agonus*	*cataphractus*
	Armed Gurnard	*Peristethus*	*cataphractum*
TRACHINIDÆ	Greater Weever	*Trachinus*	*draco*
	Lesser Weever	*T.*	*vipera*

It will now be necessary to consider these somewhat in detail.

Cottidæ

THE BULLHEADS AND GURNARDS

Something has already been said of the differences between these two groups. The habit of grunting—hence the French "*gourneau*," and the English vernacular name "piper" of one species—is commonly associated with the gurnards only; and Cunningham explains it as the sound produced by the expulsion of air from one chamber of the closed and partitioned air-bladder to the other. This is probably correct, the only objection to it being that some bullheads (hence the German name for the Baltic sea-scorpion, "*Knurrhahn*") also utter these sounds, and the bullheads have no air-bladder. It is, however, true that the noise made by the bullheads is much weaker than that of the gurnards, and it may in their case be merely the gasping expulsion of air at the gill-covers. The grunting sound made by gurnards is, on the other hand, said to be produced when these fish are still under water, though the writer is not aware of any existing record of its having been heard from fish in that position. On the American and other tropical coasts, however, the so-called "drums" utter sounds beneath the water which make themselves distinctly heard by the occupants of boats passing over fish lying at some depth.

The Sea-scorpion (*Cottus scorpius*) is, like most of these fishes, well armed, carrying spines above the eyes and on the gill-covers. It grows to a length of 15 in. in our seas, and is grey in colour on the back, with often some yellow on its white underparts; and in some examples there are red shades on the fins, but this is not apparently a constant character. It frequents estuaries, and appears to live in brackish water without inconvenience. It has no scales. Its teeth are feeble, as are those in all the bullheads and gurnards. It seems to be rarer on our south-west coast than the father-lasher; indeed, Cunningham has not found it at Plymouth at all. McIntosh says that its eggs are abundant on the east coast of Scotland in March, attached to stones, weeds, and débris. On the west coast they are apparently found about a month earlier. They are some shade of pink or red and covered with small punctures, and they hatch out at the bottom of the shallow water. The larvæ exhibit remarkable vitality.

The Father-lasher (*C. bubalis*) is a smaller species, with a longer spine on the upper portion of the gill-cover. Although the majority of individuals have the dull covering characteristic of the bullheads, purple-red examples are sometimes taken; and Cunningham thinks that these must have resided among the red weeds.

The father-lasher deposits its spawn among the weeds, often above low-water mark, and thus exposed to the air when the tide recedes.

The Four-horned Cottus (*C. quadricornis*) has four rough tubercles, in pairs, on the head, and there are also rows of tubercles along the sides. Like the father-lasher, it grows in our seas to about a foot, or a little more, in length. It is also stated to inhabit deeper water and to be a swifter-swimming fish; but the writer has caught many in the shallow waters of the Baltic without observing any greater activity than in the rest. With regard to its breeding, Scandinavian authors regard winter as the spawning-period of the four-horned cottus, and they compare its spawn to that of the perch, deposited in one mass. McIntosh is, however, sceptical, not alone as regards the alleged time of breeding, but also with regard to the comparatively large size and advanced development of the larva on emerging from the egg. While the eggs have not been obtained in our seas, the larval and post-larval forms have not been wanting on the east coast of Scotland.

The Norway Bullhead (*C. norvegicus*) is included in the list of British fishes on the strength of a single example trawled some years ago in Scotch waters, so that any account of the fish would be obviously out of place in the present work.

The Red Gurnard (*Trigla cuculus*) is the commonest of our gurnards, at any rate on the south coast, and is easily distinguished by its red back and silvery belly. The scales of the gurnards are small, and in the present species there is no ridge of sharp spines along the lateral line, but the line itself is marked by transverse plates which define it unmistakably along its whole length. There are also rows of spines along the base of the dorsal fins. The red gurnard has the finger-like rays on the pectoral fins. It leads a lazy existence, seeking its food close to the sand. Very often when a bait not too large for its mouth is allowed to rest for a moment on the sand off the Cornish coast in water of from 10 to 40 fathoms, it is instantly seized by a red gurnard, one of which seems always in readiness, so that the species must be incredibly abundant in that part of the Channel. Occasionally one will take a spinning bait that moves slowly near the bottom, and this generally happens, in fact, in pollack-fishing, when the artificial bait sinks in the water and comes almost to a standstill as the boat is making a tack.

The spawning of the red gurnard has been studied in this country, and its transparent, floating eggs have been artificially fertilised by Cunningham. The hatching took six days at Plymouth, the newly hatched larval gurnard being rather under $\frac{3}{20}$ in. Günther alludes to the sensitiveness of the three pectoral "fingers," and explains that the anterior spinal nerves are instrumental in supplying this.

The Grey Gurnard (*T. gurnardus*) is a more northern form, and has consequently been studied at St. Andrews far more than the last. Indeed, Holt never knew of a single red gurnard being caught there during his eighteen months' residence.* It is also the commonest gurnard on our east coast and in the Irish Sea, where the fishermen know it as the "knowds." It is easily distinguished from the last not merely by its colour, grey with white spots, but also by the absence of spines along the base of the dorsal fins, and, on the other hand, their presence on the lateral line. It is also a larger fish, growing to a length of 30 in. as against 18 in., the greatest recorded length of the red species. It must be borne in mind that the name "grey gurnard" is applied on parts of the Irish coast to the Sapphirine Gurnard (*T. hirundo*), a very different fish.

Its eggs float on the sea, and their hatching and the development of the larva have been described in great detail by McIntosh and Masterman.† In June, according to the authors, the grey gurnard's egg is the commonest pelagic egg on the east coast of Scotland; and as it is found in the shallow water from April until August, and only takes a few days in hatching, it may be inferred that the spawning period extends over several months. The grey gurnard comes in shore, then, to deposit its spawn ; in autumn it returns to deeper water. It has even been said that the fish spawns twice in the year, but this is generally doubted, being based

* Vide *Trans. Roy. Dub. Soc.*, July, 1893, p. 35.

† *British Marine Food-fishes*, pp. 135-143.

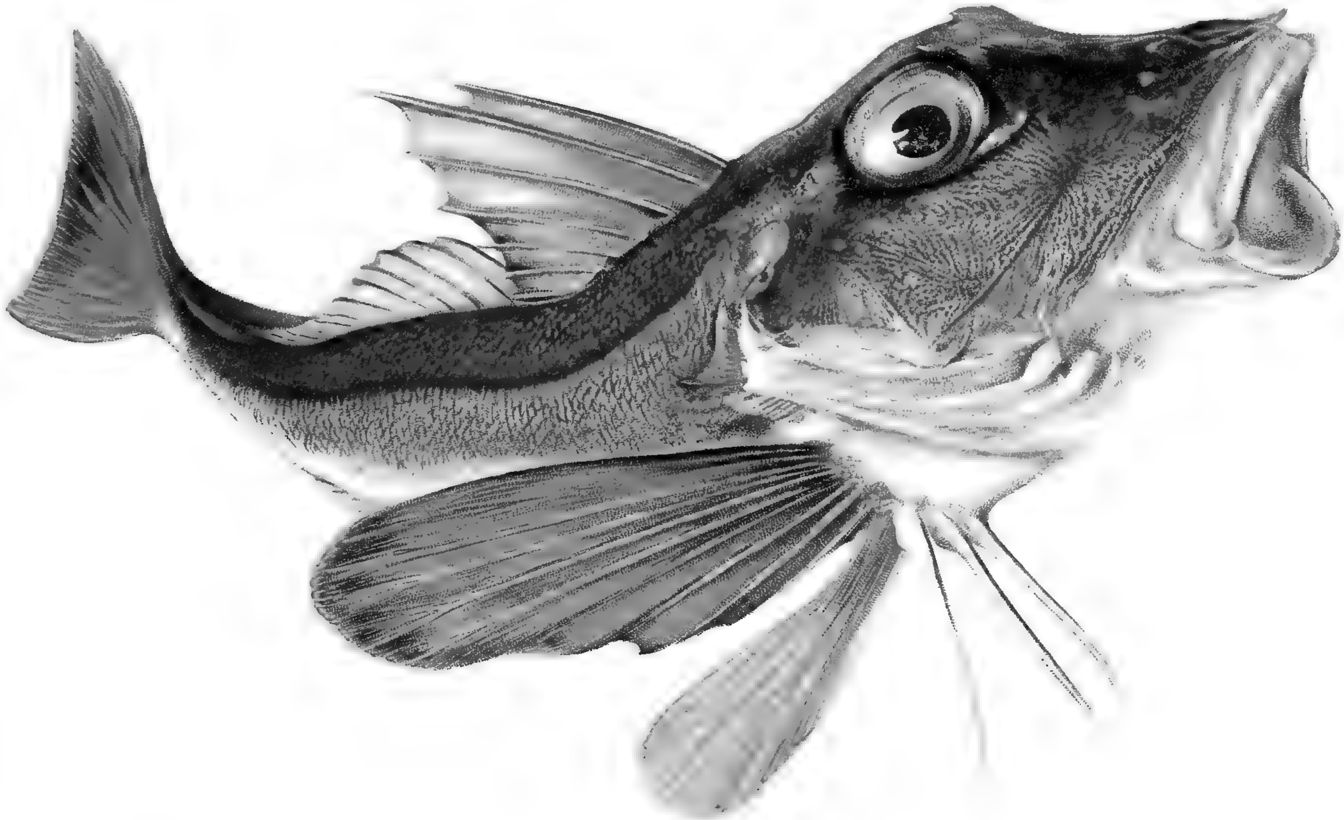

Photo by Reinhold Thiele

1/2 Natural Size

REDGURNARD (*Trigla cuculus*)

only on the occasional occurrence of the egg in January. The pectoral fins show great development in the early days, but the separation of the "fingers" is a later growth. It is thought that the ancestors of the gurnard lacked these "fingers," which have been adopted as a modified structure by gurnards now in existence. The grey gurnard is said to come to maturity during its third year, or when about 8 or 9 in. long.

The Streaked Gurnard (*T. lineata*) has slanting, raised ridges down the sides, and there are rows of spines along both the base of the dorsal fins and lateral line. It is dark red in colour, and has usually brownish blotches on the fins. It takes the hook less frequently than other gurnards, being more often trawled or caught in set nets. None of these gurnards are easily handled with impunity, but the abundance of spines on the present species makes it the most unmanageable of all.

The Sapphirine Gurnard (*T. hirundo*), or Tub, is our second largest species, and grows to a couple of feet in length. It is red in colour, and has the hinder (or upper) surface of the pectoral fins a bright blue. These it is fond of displaying when alarmed, possibly as a danger signal. Its eggs have apparently not been specially studied.

The Piper (*T. lyra*) is the largest of our gurnards, examples having been caught measuring over 2 ft. in length. It is red in colour, and has saw-edged bony plates projecting from the snout. The pectoral fins are large, but lack the brilliant colouring of those in *T. hirundo*. It seems likely that the bony projections on the head of this species may be useful in routing in the gravel for food, but this has not been actually observed in the aquarium.

The Lanthorn Gurnard (*T. obscura*), also known as the Long-finned Gurnard, in allusion to the long second spine of the dorsal fin, has, in addition to that peculiarity, a bright silver band along the sides. Otherwise it is uniform red in colour. Its scales are small, and the lateral line is marked by much the same arrangement of transverse plates as in the red kind. Like the red gurnard, too, it has rows of spines along the base of the dorsal fins. The pectoral fins are blue, but are not displayed to any extent like the larger pectorals of the tub. It is a small gurnard, rare in our seas, and reaching us from the south of Europe. The men on the Plymouth trawlers know it as the "offing" gurnard, presumably alluding to its preference for deeper water.

Cataphracti

The Armed Bullhead and Gurnard

The two fishes that follow, both belonging to a second family, are distinguished by several easily recognisable characters from the true bullheads and gurnards, but otherwise appear to have certain affinities with those groups.

The Armed Bullhead (*Agonus cataphractus*) has its head and body protected by bony plates, giving the head more particularly the appearance of a solid geometrical figure. It has two dorsal fins, and beneath the head there are many small growths like threads. In colour it is yellowish grey, with black vertical bands down the sides. It is a small fish, only 5 or 6 in. in length, and its home is in the sand, where it preys on minute crustaceans. Its teeth are weak, but the small forms on which it feeds are probably soft. Like the true bullheads, it lacks the air-bladder, whereas the next species, like the true gurnards, has that organ. The spawning of the armed bullhead was studied comparatively recently, and, although Cunningham omits all mention of it, McIntosh devotes several pages to an account of its early life-history. Its eggs, which are of the demersal kind, are deposited among weeds, and the larvæ are well developed when they emerge. They are more brightly coloured than the adult, and live for a time near the surface of the water, finally taking to a life at the bottom of the sea, like their parents. The capsule of the egg is described as tough and elastic, rebounding when pressed with the point of a needle; and the egg is extraordinarily hardy, as proved by the fact of some having survived being frozen up in ice for nearly a month, an ordeal that would have killed most pelagic ova.

The Armed Gurnard (*Peristethus cataphractum*) has also a strong bony cuirass, but it is more gurnard-like than the last, having two pectoral "fingers." There are also prominent barbels on the lower jaw; but there are no teeth, so that this fish must eat only the softest food. It inhabits somewhat deeper water than the true gurnards, and is only a wanderer to our seas from the Mediterranean. In colour it is scarlet, which gives it a further resemblance to many of the gurnards, and it grows to 18 in. or 2 ft. in length.

In addition to the foregoing characters, the armed gurnard has two curious, slightly serrated, and flattened processes growing before the eyes, and the first dorsal fin also has some very long free rays. Very little has been recorded of the habits of this fish, and its spawning does not appear to have been studied in either this or any other country.

Trachinidæ

The Weevers

We now come to two very different fishes, both of them venomous, and the smaller decidedly the most dangerous inhabitant, for its size, of any sea. Affinities have been suggested between the dangerous weevers and the innocuous dragonet, a small and interesting form that is described in a subsequent chapter; and this, if correct, illustrates a case of mimicry, just as we know that, for their own safety, some non-venomous snakes closely imitate venomous species. The weevers also recall, with some well-marked differences, the bullheads, and the resemblance, apparent in the adults, is still more marked in the larval and post-larval stages, in which the head seems equipped with an almost identical armature. As a matter of fact, the weevers take a very different place in the economy of nature; while, as regards their use to man, they are eaten in some continental countries after the removal of the offending spines, but are little appreciated by us. In the poorer quarters, however, of some large cities in this kingdom, weevers find a ready sale under various disguises. The smaller kind is the more abundant on our south coast, but the larger seems more commonly found in northern waters. They have no air-bladder; the eyes are directed upwards; the mouth opens obliquely.

The Greater Weever (*Trachinus draco*), which grows in our seas to a length of between 12 and 18 in., has curious oblique lines of scales down its body, which show a yellow shade against the grey ground-colour. The fins are mostly yellow, with some black on their margins; but the first dorsal is black, and is apparently erected as a danger-signal. It is not, to all appearance, used intentionally by the fish, as are the spines on the gill-covers. With the latter either of the weevers can strike any object with great accuracy. Couch relates how he kept a greater weever alive by throwing sea water over it, and how it struck at his stick whenever he stirred it up. The spines in these fishes are not comparable to the venom-fangs in some snakes; indeed, it is not satisfactorily demonstrated that any venom is introduced in the wound, though this seems probable. In the case of the "Fortescue," a venomous little fish of Australian seas, it is claimed that there is a direct venom-gland. At any rate, a wound from the weever's spines is sufficiently serious to have called on more than one occasion for prompt surgical operation, and it is singular that no steps are taken in this country to warn anglers and others against these fishes. One often shudders at the sight of some child, or even grown person, ignorantly handling the dangerous little fish on some pier or other in August, during which month, particularly during a spell of east wind, anglers catch many on sandy ground; whereas in Australia diagrams and descriptions of the " Fortescue " are posted on the piers and quays by the local angling societies.

The Lesser Weever (*T. vipera*) grows to only 7 or 8 in., is paler in colour than the larger species, and has a black band on the caudal fin. It is more dangerous than the other on account of its smaller size, for it can lurk in the smallest patch of seaweed in the nets, and the unsuspecting fisherman grasps the dangerous spines in his hand in his effort to throw away the weed and débris. In some of the Scotch isles the lesser weever and sand-eel are regarded respectively as the male and female of the same species, a belief for which it would be difficult to find any basis. These totally unaccountable beliefs on the part of some of our fishermen are probably derived from very early superstitions. Such, for instance, are the beliefs that shrimps are young flat-fishes, and that flounders, like Surinam water-toads, carry their eggs embedded in their back.

The spawning of the lesser weever was studied by the late Mr. Brook,* of Huddersfield, and he found the weevers spawn in an aquarium in very early morning (between 1 and 5 a.m.) in June. The eggs are of the buoyant kind; and the larvæ, which hatch out in from nine to eleven days, differ from those of other teleostean fishes in having the pelvic fins distinct before leaving the egg. The egg itself is pearly white and translucent, and has from twenty to thirty small oil-globules. These make it extremely buoyant, and even the larva floats, for some hours after hatching, on its back.

The food of the weevers probably consists in great part of worms and small crustaceans, but from the upward direction of the mouth and eyes, it seems probable that there are times at which these fishes simply lie on the sea bed with their eyes and mouth open and receive their share of the constant supplies of food that must be raining down from the disturbed surface waters.

* See *Journ. Linn. Soc.*, 1885, Vol. XVIII., p. 274.

CHAPTER VII

THE GOBIES, SUCKERS, AND BLENNIES

To those who in their superior knowledge regard the British vertebrate fauna as either worked out, or at most subject to periodic additions in the shape of straggling birds doubtfully included, it may come as a shock to learn that a new British fish has been identified during the year 1903 by Mr. Pickard-Cambridge. He, at the suggestion of Mr. Boulenger—a suggestion offered as far back as 1899 in the *Annals and Magazine of Natural History*—searched the rock-pools of Cornwall for *Gobius capito*, a species with which Mr. Boulenger had been familiar in the vicinity of Concarneau, and which, he thought, might be the abnormally long 9-inch specimens of *G. niger* mentioned by Couch and Day. This species, hitherto reckoned the largest of British gobies, never exceeds 5½ inches. In Brittany, at any rate, *G. capito*, now a British fish, is regarded as an excellent table-fish, so we may in time eat it on this side of the Channel.

Some thirty or more of these small fishes must be considered in the present chapter. Not one of these, it is safe to affirm, will ever be seen at the fishmonger's shop, or, seen there, would be recognised by his customers. To the general rule of insignificant size and commercial unimportance there are just two exceptions, the lumpsucker and wolf-fish, each of which grows to a large weight and commands a price as food in country districts. The fishes are as follow :—

Family.	Common Name.	Genus.	Species.
Gobiidæ	Four-spotted Goby	*Gobius*	*quadrimaculatus*
		G.	*jeffreysii*
		G.	*scorpoides*
	Black Goby	*G.*	*niger*
	Spotted Goby	*G.*	*minutus*
	Paganellus	*G.*	*paganellus*
	Two-spotted Goby	*G.*	*flavescens*
	Parnell's Goby	*G.*	*parnelli*
	Painted Goby	*G.*	*pictus*
		G.	*friesii*
		G.	*capito*
	White Goby	*Aphia*	*pellucida*
	Nilsson's Goby	*Crystallogobius*	*nilssoni*
Callionymidæ	Gemmeous Dragonet	*Callionymus*	*lyra*
	Spotted Dragonet	*C.*	*maculatus*
Discoboli	Lumpsucker	*Cyclopterus*	*lumpus*
	Sea-snail	*Liparis*	*vulgaris*
	Montagu's Sucker	*L.*	*montagui*
Gobiesocidæ	Cornish Sucker	*Lepadogaster*	*gouanii*
	Connemara Sucker	*L.*	*decandolii*
	Doubly-spotted Sucker	*L.*	*bimaculatus*
		L.	*stictopteryx*
Blenniidæ	Shanny	*Blennius*	*pholis*
	Gattorugine	*B.*	*gattorugine*
	Butterfly Blenny	*B.*	*ocellaris*
	Montagu's Blenny	*B.*	*galerita*
	Yarrell's Blenny	*Carelophus*	*ascanii*
	Gunnel	*Centronotus*	*gunnellus*
	Viviparous Blenny	*Zoarces*	*viviparus*
	Wolf-fish	*Anarrhicas*	*lupus*
Gasterosteidæ	Fifteen-spined Stickleback	*Gasterosteus*	*spinachia*
Sygnathidæ	Broad-nosed Pipe-fish	*Siphonostoma*	*typhle*
	Greater Pipe-fish	*Sygnathus*	*acus*
	Straight-nosed Pipe-fish	*Nerophis*	*æquoreus*
	Snake Pipe-fish	*N.*	*ophidion*
	Worm Pipe-fish	*N.*	*lumbriciformis*
	Sea-horse	*Hippocampus*	*antiquorum*

It is not to be thought that all of the foregoing families and genera are very closely related on anatomical grounds, though the first five families have much in common. The stickleback and pipe-fishes are merely included for convenience in a chapter planned to dispose of all the small shore-haunting forms found in our rock pools and filling a somewhat similar place in nature's economy. They live for the most part in very shallow water, and in some cases the eggs are even deposited and hatched above low water-mark. In most species the male parent shows the anxiety to protect the eggs, discovering parental instincts that we seek in vain among the larger and in some respects more highly developed food-fishes described in earlier chapters. Yet it is hardly commendable to take the view adopted by one writer, who cynically regrets that Nature should have implanted the most cautious habits in the least valuable fishes. In the first place, Nature does not take the fishmonger's view of what are the most and least valuable fishes, for she has uses for all quite distinct from those of the kitchen. In the second place, this strong affection for the eggs and young is in many cases counteracted by a compensating lack of judgment, as these fishes often deposit their eggs in situations on the foreshore, where they must inevitably be exposed at high tide to the violence of the surf and at low to the raids of crows and gulls.

Scales, so characteristic a covering in the majority of fishes, are not strongly developed among these small shore-dwellers, though present in some of them. In many cases the scales are replaced by either tubercles or bony plates ; in others they are absent, and there is no such substitute.

Gobiidæ

The Gobies

Interesting in their breeding habits, the Gobies are in themselves insignificant-looking, little, spotted fishes with large fins in proportion to the size of their bodies. Their eggs are deposited at the bottom of the sea in shallow water, and in all manner of strange receptacles that recall the curious nesting-sites chosen by some birds. These eggs are attached to their supports by a network of hairlike anchor ropes, and these are admirably figured by Professor McIntosh and Mr. Masterman in their work on our Marine Food-fishes. These eggs, as well as those of the blennies, are found in various shells and under stones. Like the herring, in fact, these small fishes deposit eggs too heavy to float in salt water, so that the biologist obtains them from the dredge, and not, as in the case of pelagic, or floating, eggs, in the surface tow-net. In the blennies it is the female that, as a rule, takes sole charge of the eggs, while in the gobies and suckers this duty devolves upon the male.

So small and inconspicuous are these fishes that we may reasonably expect three results from any closer investigation of their individual peculiarities. In the first place, we shall in all probability find that earlier writers confused distinct species under one name, and it looks, in fact, as if Day had confused the four-spotted goby with another species (*G. jeffreysii*), the former a common wanderer from the Mediterranean region, the latter a much rarer visitor from the Atlantic, having been taken by Herdman off the Isle of Man, and, as recently only as 1897, by Holt in the Plymouth district.

Secondly, we shall find species described in earlier works as extremely rare without being so in reality. A case in point is Nilsson's goby (*Crystallogobius*), which Day describes as a rare species of northern haunts, naming only a single British specimen, but of which, in 1891, Cunningham took no fewer than 201 specimens at a single haul of a fine-meshed shrimp-trawl in 28 fathoms of water some 10 miles from the Eddystone. Holt records the same goby a year earlier (1890) in Ballinskelligs Bay, and a year later (1892) off Flamborough Head. As Nilsson's goby is a tiny, transparent, scaleless fish, measuring when full-grown only about 1½ in. in length, it might easily be overlooked in a district for years. Although, moreover, its distribution, however local and capricious, can hardly have altered so completely since the time at which Day wrote his great work, it is only fair to that author to recollect that the occurrence of these gobies on any part of the coast is subject to sudden and unaccountable variation.

Thus another species, the white, or transparent, goby (*Aphia*), was found by Professor White in the Menai Strait in great abundance in 1897, but during the six years that have since elapsed only stray individuals have been taken on the same grounds. Prof. Herdman and Mr. Dawson mention that its numbers vary in the Lancashire district from year to year, and in some seasons it is netted in company with the shoals of young herrings.

The third result to which the further study of such small fishes may always be expected to lead is the addition of new species hitherto overlooked. Of this one case was cited above. Again, in the group under notice, Dr. Scharff described *Gobius friesii* for the first time in working out the results of the Irish surveys in 1889 and 1891; and yet more recently, in 1897, Messrs. Holt and Byrne added *G. scorpoides*, one example of which they dredged in the mouth of Falmouth Harbour among a quantity of dead shells.

From this alone it will be apparent that the gobies, though neglected by the fishermen, are of great interest to the shore-naturalist, for their haunts come within the scope of his necessarily restricted operations, and it is open to all to find the rarer kinds in a ramble among the rock pools. The rarer flat-fishes, on the other hand, and gadoids, reside out in the deeper offshore waters, and are, as a rule, discovered only by elaborately equipped scientific expeditions.

There are, as may be seen by reference to the foregoing list, twelve gobies at present named as British, though, for the reasons given above, this list may be regarded as subject to early additions.

The Four-spotted Goby (*Gobius quadrimaculatus*) is the one which Day apparently confused with *G. jeffreysii*. Neither call for detailed account.

G. scorpoides, equally rare, has just been mentioned.

The Black Goby (*G. niger*), or Rock Goby, is the largest species but one in our seas, and has white blotches on its dull brown sides. It clings to the rocks in much the same fashion as that observed in the suckers.

The Spotted Goby (*G. minutus*) is also known as the Polewig, and in the Lancashire district, where it is the most abundant of all gobies, as the One-spotted Goby. To which of its many spots this may refer, unless to the dark one on the dorsal fin, it is not easy to say. It has been observed in Colwyn Bay by Mr. A. O. Walker, one of the closest observers of these fishes, guarding its eggs in an empty *Mya* shell, which it half buried in the sand. Shrimps appear to be among the worst enemies of the gobies' eggs, and against them the male parent has to be unremittingly on the watch, besides keeping a continuous current of water circulating about the eggs, and providing them with the fresh layers of oxygenated water so essential to their healthy development.

The Paganellus (*G. paganellus*) is chiefly interesting on account of the attractive garb that the male assumes in the breeding-time. Less brilliant in this respect than the dragonet, it nevertheless displays a bright purple coat with orange yellow on the dorsal fin.

The Two-spotted Goby (*G. flavescens*) has a conspicuous black spot above the pectoral fin and a second on the tail. According to Harvie-Brown and Buckley, it deposits its eggs in mussel shells.

Parnell's Goby (*G. parnelli*) is a small goby with light bands on the back fin.

The Painted Goby (*G. pictus*) is another of the small fishes with strong secondary sexual characters, its dorsal fin displaying in the breeding-season bright blue and green metallic reflections. Mr. A. O. Walker has been a most successful collector of this handsome goby. It was he who sent Day his single specimen described in *British Fishes*, and he again secured the species at Colwyn Bay in 1894, and described it as not uncommon there as recently as 1901.*

* Herdman and Dawson, *Fishes and Fisheries of the Irish Sea*, 1902, p. 40.

G. friesii is the new goby aforementioned, named and described by Dr. Scharff in or about the year 1891. It is yellow in colour, and has numerous dark-brown spots, and the dorsal fin has sometimes, but not always, an elongated ray.

The White, or Transparent, Goby (*Aphia pellucida*), a tiny creature of not more than 1½ in., has an interest distinct from that of any other member of the family. It is thought to reach maturity, spawn, and die within its first year, so that it would be what is known as an "annual vertebrate." This statement, which owes its origin to Professor Collett, of Christiania, is one that will in all probability always be labelled "not proven." It might conceivably be demonstrated that *in the aquarium* the transparent goby dies after spawning once. Mr. Cunningham has demonstrated that female congers cannot spawn in the aquarium, and that in their efforts to deposit their eggs they die. From this we are are asked to believe that the conger spawns once and dies in nature; but many will prefer to keep an open mind in the case of both conger and goby. It may be that another generation will view the alleged short span of this goby's life in the same light in which we now, thanks to later observations in the aquarium, regard the "two-year" existence of the sticklebacks. Yarrell, Donovan, and other early writers asked the world to believe that these fishes lived only two years, and their theories have been proved wrong. Such ephemeral careers are familiar enough to the botanist and entomologist, but among vertebrates so short a life is, under normal conditions, extremely uncommon.

Nilsson's Goby (*Crystallogobius nilssoni*) has already been mentioned in reference to its distribution and abundance on our coasts. The ventral fins of these gobies show the transition to the disc of the suckers, and many of these fishes cling in like fashion to the rocks, and thus resist the force of the waves. This method of adhesion, which we shall find more highly developed in the suckers themselves, must be a great convenience to these shallow-water dwellers in rough weather, when the swirl of the surf would otherwise dash them ashore or at any rate transport them far from their eggs. Other fishes, not provided with these suctorial fins or discs, have to burrow in the sand ; * and Cunningham gives a most interesting account of an experiment by which he discovered the manner in which the topknots (*Zeugopterus*), a group of flat-fishes particularly given to a rocky dwelling, contrive to cling to the vertical glass wall of an aquarium tank. By ingeniously colouring the water with carmine particles, he was able to ascertain the nature and direction of currents in the water produced by the fish pumping water with its fins from between its body and the glass and thereby setting up enough difference in pressure to keep it in position. In order to satisfy himself beyond doubt that such was the case, he constructed an imitation topknot of indiarubber with a siphon tube, and his artificial flat-fish behaved exactly as was expected of it, falling away from the glass the moment he checked the action of the siphon. In view of what was said above of the convenience of such methods of adhesion to shallow water fishes, the top-knot's preference for a rocky ground, whereas most other flat-fishes prefer the sand, is interesting.

The most familiar foreign relatives of the gobies are the grotesque little Mudskippers of the South Pacific. Their strangely protruding, mobile eyes stare like those of the chameleon, and they jump over the wet and treacherous sand of North Australian estuaries more like frogs than fishes.

Callionymidæ

The Dragonets

Closely related to the gobies are the two Dragonets (*Callionymidæ*). As in so many of our wild birds, the male

* See an interesting paper by Hunt and Jeffreys on "The Influence of Wave Currents on the Fauna inhabiting Shallow Seas" (*Journ. Linn. Soc.*, 1885, pp. 270-271).

is much more smartly attired than the female, and in the breeding-season this is particularly conspicuous. For a long time, indeed, the male and female of *C. lyra* were regarded as two species, going by the names of the Yellow and Dusky Skulpins. "Yellow" gives but a faint idea of the beautiful wedding-coat of the male, with its blue and yellow and purple bands and pale blue spots. The male is further distinguished by long threads that grow from the dorsal fin, and that are probably erected to intimidate enemies ; and it has been seen in the aquarium to attract its duller mate by going through antics like those of farmyard fowls,* his dorsal rays streaming in the water, and his mouth protruding. The female dragonet has also been said to masquerade occasionally in male attire, much after the fashion of old hen pheasants, but this seems to require confirmation.

The Gemmeous Dragonet (*Callionymus lyra*), of which the male has been already described (the female is of a uniform brown, with spots and blotches), has a pointed mouth with small orifice, and is said to feed on molluscs. Unlike the gobies and suckers, it lays floating eggs, which are seen under the microscope to be curiously reticulated. The advantage of this structure has not yet been explained. Nor are naturalists agreed as to the object and cause of the striking secondary sexual characters aforenamed. Some are of opinion that the females would continue in each succeeding generation to mate with the best-dressed males, the latter consequently transmitting their bright hues to posterity, and the duller males dying bachelors in the course of time. Others take exception to this theory of selection, and prefer to regard the duller colouring of the female as the special departure, having for its object to ensure her safety during the breeding-time. This view, while in many respects unsatisfactory, finds

* Perhaps the most interesting account ever published of the appearance and habits of the dragonet is that contributed by Holt (with an admirable figure) to the *Proc. Zool. Soc.*, 1898, pp. 281 *et. seq.*

support in the preponderance of male dragonets taken from the inside of the cod and haddock.

The Spotted Dragonet (*C. maculatus*) has a grey body with light spots, and there are black spots on the fins. Day records only a single British example, dredged off Shetland; but Günther has since identified it from the Clyde estuary, and it has also been taken off the west coast of Ireland. One of the latest records of this species is from the neighbourhood of Falmouth, where Holt trawled it in July, 1897, in 30 or 35 fathoms of water. It is generally, in fact, regarded as a deeper water species than *C. lyra*, though even of the latter it is only the females and young males that are, as a rule, found quite close to land, the males being usually taken in the shrimp-trawl.

The large, upturned eyes and mobile mouth would distinguish the dragonets apart from any peculiarity of colouring, the mouth being thrust out in a curious fashion when they are feeding on small copepoda. One of the most noticeable habits of these fishes in the aquarium is to lie half buried in the sand, and keep the pectoral fins in rapid rotation, a motion also observed in pipe-fishes.

The Suckers

As already stated, the Suckers have developed still further the disc-like arrangement that exists in a rudimentary form in the gobies, and the adhesive organs of both the divisions of the present group act, when pressed to a wet surface, even after the death of the fish. These suckers are divided into two distinct families, the one with three, the other with four, representatives in our seas. The first includes the ungainly lumpsucker (*Cyclopterus*) and two smaller kinds, in all of which the throat-fins themselves form the adhesive disc. The second, with four species, have the disc in the form of a separate structure between those fins. As a further conspicuous difference between the two groups, the lumpsucker and its kindred have a spinous fin on the back, whereas the dorsal fins of *Lepadogaster* are without spines.

Discoboli

The Lumpsucker (*Cyclopterus lumpus*) is perhaps the most hideous and repulsive fish in our seas. The coarse head and thick-set body are enveloped in a loose, slimy skin covered with warty tubercles. There are numerous teeth in the jaws, but none on the tongue or vomer. The female is the larger, having been captured weighing over 15 lb., and is generally blue in colour, the prevailing hue in the male being red. They are known on the Scotch coasts as the cock and hen paidle.

It is not to be expected, seeing that the greenness of its bones prejudice people against so excellent a food-fish as the gar-fish, that a fish with the appearance of the lumpsucker should be in great demand as human food. In England the fish is little eaten, if at all. In some parts of Scotland it is eaten by the natives ; in others, it is considered fit for the pigs only.

Its natural enemies are, however, many and dangerous, for seals devour it in estuaries, sharks prey on it in deeper water, and crows, rooks, and gulls attack it when guarding the eggs above low water-mark. The eggs, which are heavy and sink in the water, are deposited in early spring, and lie in masses among the rocks. McIntosh points out an interesting case of protective colouring, due in part to reflection, for when such a mass of eggs is only partly covered under a rocky ledge, the eggs thus immersed are of a faint lilac hue, while those more exposed are straw-coloured. From the point of view of the species, it is to be regretted that the male lumpsucker has not a little less devotion and the female a little more judgment, for the eggs are frequently deposited on the

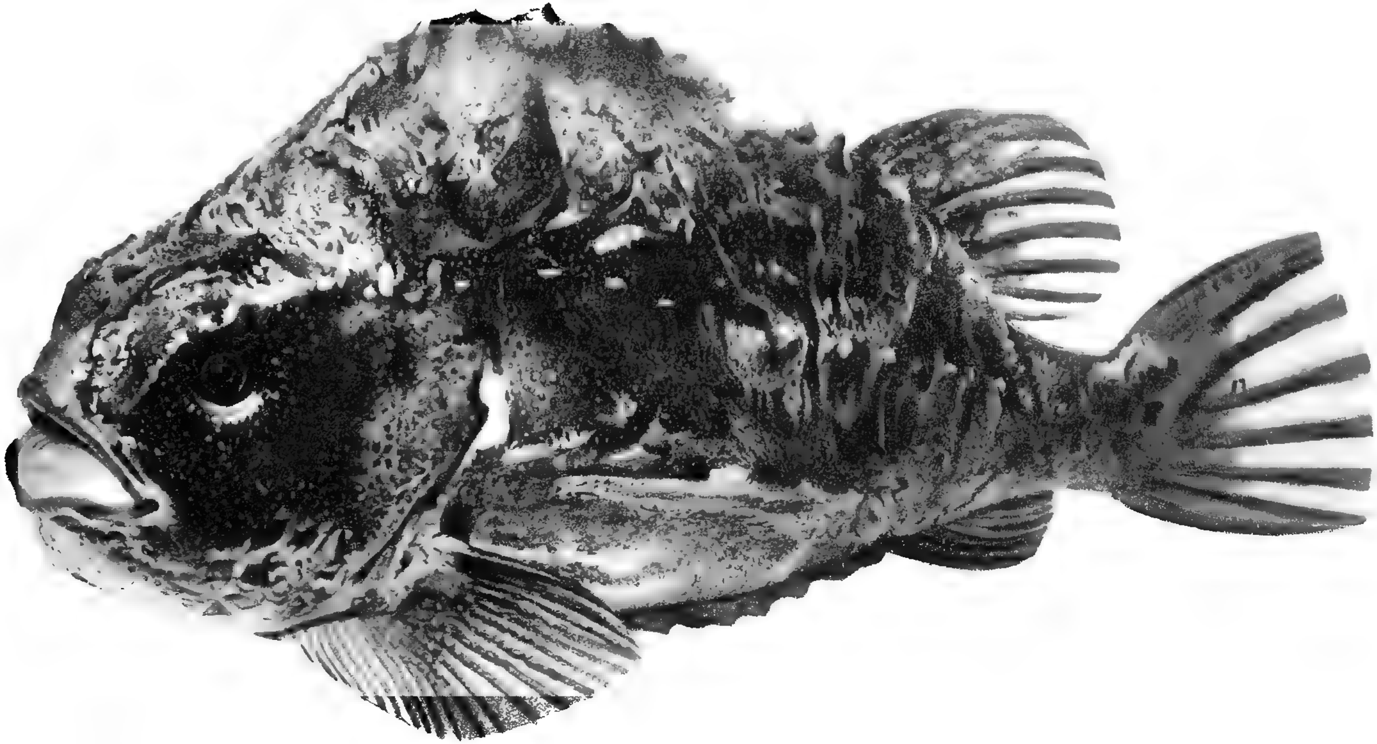

Photo by Reinhold Thiele

⅓ Natural Size

LUMPSUCKER (*Cyclopterus lumpus*)

foreshore in situations so exposed that not alone the eggs, but also their untiring guardians, are devoured by birds or rats. Many anecdotes have been related of the courage with which the male mounts guard over the eggs. It is related that one was once found lying on its side in a hot June sun in water so shallow that one side of the body and gill-covers was exposed to the air. It has also been observed that when a storm has scattered masses of these eggs, and driven the sentinels from their post, numbers of distracted males are to be seen hunting everywhere, in the succeeding calm, for their lost treasures.

Day quotes someone who observed the young adhering to the male immediately after leaving the egg, and being carried off by him to the greater security of the deeper water, but later authorities have doubted this story. It is now, indeed, generally recognised that the larval lumpsucker keeps close to the shore for some time, seeking safety among the stones and weed-roots. The imperfect little lumpsuckers are far more rapid and active than the adult, their tail-fin propelling them effectually, and even their heavy hindquarters, a hindrance to progress in later life, lending at that stage an impetus to their movements. Their colouring in these early days is somewhat remarkable, the head being light brown, with a pale blue band, the body yellow, and the base of the dorsal fins being marked by blue spots. The rough tubercles, so conspicuous in the adult, do not develop until the young measure about $\frac{3}{5}$ in., or three times the length at which they emerge from the egg. At that stage, too, the eye is proportionately much larger than in the full-grown fish.

McIntosh found the skin of the larvæ to be covered with minute leeches, while at a somewhat later stage young lumpsuckers are infested with threadworms. This identification of both internal and external parasites in fishes themselves less than an inch in length gives some idea of the extent to which, of late years, microscopic work has been summoned to the aid of marine biology.

The Sea-snail (*Liparis vulgaris*) is a small sucker that does not exceed a length of 6 in. Its skin is so loose as to give the impression of an ill-fitting coat. Herdman and Dawson have found it in the Mersey district feeding on shrimps. The eggs, which are sometimes deposited in estuaries, attach themselves in small round masses to zoophytes and red seaweeds at depths of between 1 and 30 fathoms—a range of considerable variation; and they have been mistaken for the slightly larger eggs of the herring. They are said to be very hardy, bearing transport and exposure when packed in wet seaweed better than the eggs of most other fishes. Like the lumpsucker, they have no scales.

Montagu's Sucker (*L. montagui*) is both smaller and more active than the last, and is common in the northern waters, round the Hebrides. Neither of these smaller suckers have the tubercles of the lumpsucker, but in them there is the same modification of the throat-fins to form the adhesive disc. The indirect importance of these little fishes to the student of economic forms may be gathered from their continual occurrence in the stomach of the cod and haddock.

Gobiesocidæ

The second group of suckers, with the separate disc between the ventral fins, has four species, all of which deposit their flattened, oval eggs inside the deserted shells of the scallop or razor-fish, as well as among the roots of weed tangles. Some of these small suckers are brilliantly coloured in early life, the males particularly displaying much red on the eyes and on the sides of the body. There are other secondary sexual characters besides colour. The frilled border of the disc and vent varies to a considerable extent in male and female. The names of two of these little fishes, the Cornish and Connemara suckers, illustrate the regrettable practice of earlier writers, who often bestowed place-names on new species without taking any pains to make sure that the species was either peculiar to the place or even markedly common there. The Beaumaris shark, Spanish mackerel, and Norway haddock are other undesirable vernacular names; and they may recall to collectors of birds' eggs the case of the Dartford warbler, and to moth-hunters that of the Lulworth skipper or Camberwell beauty. All of these might be sought to-day in their original localities, but they would be sought in vain.

The Cornish Sucker (*Lepadogaster gouanii*) is a reddish fish, common enough in the rock pools on some parts of the coast. It grows to a length of 4 in., and is said to feed on crustaceans, but not much seems to be known of its habits.

The Connemara Sucker (*L. decandolii*) is also red, marked with light oval spots. Its dorsal fin is shorter than that of *L. gouanii*.

The Doubly-spotted Sucker (*L. bimaculatus*), which rarely exceeds a length of 2 in., is red above and has a large dark spot behind the pectoral fins.

L. stictopteryx, the latest addition to the British suckers, was provisionally named and described by Holt and Byrne * as distinguishable from *L. bimaculatus* by the more lateral position of the eyes and squarer fore part of the head, as well as by the presence of dark spots on the dorsal and anal fins.

Blenniidæ

The Blennies

The group that has now to be described is of greater commercial importance, on account of the wolf-fish, and greater zoological interest, thanks to the viviparous blenny, than the foregoing. The former grows to a great size, and is a not unimportant article of food in the north; the latter is one of the only two teleostean fishes on our coasts that,

* See *Proc. Zool. Soc.*, 1898, p. 589.

instead of depositing eggs, give birth to living young after the fashion of most of our sharks and a few of our rays.

The chief external characters of the blennies are their elongated body and short, thick head, their smooth and generally scaleless skin, and their more or less continuous spineless fringe of dorsal and ventral fins, which edge the body above and below. One or two of them suggest in outward appearance the gadoid rocklings, but are distinguished from these by the absence of barbel. Most of the family keep close to the shore, but an exception is found in the deep-water wolf-fish, the largest of them all, so-called from its sharp teeth, its powerful bite, and its generally carnivorous tastes. For the most part the blennies deposit their eggs in deserted shells and similar convenient receptacles. Cunningham found those of the butterfly blenny (*Blennius ocellaris*) in a hollow bone brought up on a hook off the Cornish coast; while another naturalist made, not long ago, a still more extraordinary find in an enormous whelk-shell that was dredged in the neighbourhood of Plymouth. There were in the recesses of this shell two separate households, for it accommodated at once a male butterfly blenny and a male two-spotted goby, each guarding its own cluster of eggs.

Larval blennies also seem to take refuge in strange asylums, for Holt mentions having found a young shanny (*B. pholis*) in a floating dahlia off Falmouth. This incident only shows how careful collectors should be to search every likely and unlikely corner, for one can conceive of few less promising haunts for a larval sea-fish than the interior of such flotsam as a wind-blown land-flower.

The Wolf-fish (*Anarrhicas lupus*), the largest and only commercially important member of the family, is a northern form. The ventral (throat) fins, never very highly developed in the blennies, are absent altogether in this fish. Its scales are so small as to be almost invisible. Only one other blenny (*Carelophus*) has scales at all.

The most remarkable feature of this fish is its teeth. It combines in its mouth the two chief types of fish teeth, adapted for every conceivable use. It has, so to speak (though their structure is different from that of elasmobranch teeth), the pointed teeth of male rays, and the flat, crushing teeth of the females. Thus it can seize the most slippery fish and it can crush the hardest shells. It has a conical series in the jaws, and large rows along the middle of the palate. A wolf-fish of 6 ft. in length must therefore be a formidable creature, little less fearsome than a shark of similar size. Its natural diet is said to consist of crabs and whelks ; but there is abundant evidence of this either being insufficient or else being varied to suit a changing taste, for the fish is constantly tearing the nets and robbing the long lines of the Scotch and Norwegian fishermen. Now and again, indeed, it is captured on the haddock lines. In colour the wolf-fish is dull grey, with dark vertical bands down the sides and yellow stains on the marginal fins. Though commonly regarded as a dweller in moderately deep water, taken only on lines that are shot at some distance from the land, it would seem that the wolf-fish must sometimes venture close to the coast, for it is thrown ashore by storms every winter.

It spawns in the cold months, its pale yellow eggs, equal in size to those of the salmon, lying in masses on the bottom. The wolf-fish lays the largest demersal egg found in our seas, and the larva, also large, has been compared with that of the salmon. Professor McIntosh therefore tabulates the chief differences in interesting fashion, and these are the spheroid, colourless yolk, blunt snout, and continuous marginal fin of the young wolf-fish, contrasting with the elongated, reddish yolk, projecting snout, and intermittent fin of the young salmon. The differences between the adult and intermediate stages persist to a later period of growth, for whereas the adult salmon loses the bars that marked the parr stage, it is the young wolf-fish that lacks the bars which later develop in the adult.

The typical blennies (*Blennius*) of our coasts are four in number.

The Shanny (*Blennius pholis*) is the commonest of our blennies, and perhaps even of the fishes of our rock pools. In colour it is yellow, variegated with black spots. It lacks the tentacles on the eyes which occur in some of the family. The female deposits her eggs in June, and they are carefully guarded until the young hatch out. Holt describes these as extremely active, and he thinks that they would, if thrown up on the sand, have no difficulty in leaping and wriggling back to the water's edge.

The Gattorugine (*B. gattorugine*) is a scaleless fish with a tentacle over each eye. In colour it is greyish brown, with bands and blotches. There is generally a black spot on the dorsal fin, and there is another under the eyes. Some specimens also have yellow tints on the pectoral fins. It is the largest British member of the genus, growing to a length of 8 or 9 in.

The Butterfly Blenny (*B. ocellaris*) derives its trivial name from the white-rimmed black spot on its wing-like dorsal fin. It has a small fringe-like tentacle over each eye. It is not one of our commoner blennies, but occurs irregularly all round the coast. In May, 1894, the Lancashire Fisheries steamer trawled a single specimen in that district. Reference has been made above to the discovery of its eggs in a hollow bone—a most suitable, though probably unusual, receptacle for the purpose.

Montagu's Blenny (*B. galerita*) is another scaleless form, with fringes of minute tentacles over the eyes, even extending along the back of the head. The young of this species was recently fully described by Byrne.* It is the smallest of our blennies, rarely exceeding a length of 2 in., and is most active in its efforts to jump over the side of the tank or globe in which it is confined.

Yarrell's Blenny (*Carelophus ascanii*) grows to a length of at least 7 in., and has small scales. Its colouring is variable;

* See *Journal Mar. Biol. Assoc.*, January, 1902, p. 383.

indeed, colouring is scarcely diagnostic in many of these small species. It has numerous small tentacles on the head. The breeding of this species does not appear to have been made the subject of special study, but there seems reason for accepting the conclusion, with all reservation, of McIntosh, that its uniformly large eggs are demersal, like those of the other oviparous blennies.

The Gunnel, or Butter-fish (*Centronotus gunnellus*) has been studied in the aquarium by Holt. It grows to a length of nearly 12 in., the base of the dorsal fin being marked by white-edged black spots. It has no tentacles on the head. Holt found it spawning in the aquarium soon after Christmas, and the parents took turns in coiling their bodies round the eggs, probably to keep them together. These eggs have been found in the natural state in February in the rock-burrows of piddocks with the parents on guard. The egg is demersal, and the larva, when hatched out, journeys off to deeper water, returning later, like the herring and sand-eel, to take up its residence close to the shore.

The Viviparous Blenny (*Zoarces viviparus*) is biologically the most interesting of all. In place of depositing demersal eggs, it brings forth well-developed young alive. It grows to a length of 20 or 24 in., and is dark green in colour, with brown tints, spots, and curved bands like arches. There is a distinctive gap, or notch, in its dorsal fin. It seems to have been confused in some parts of the country with the burbot, a fresh-water relative of the cod, yet the only point of resemblance is the long and almost scaleless body. The prominent barbel on the lower lip of the gadoid should sufficiently distinguish the two.

The young blennies are born in winter in a well-developed state. They at once display great activity, concealing themselves from their numerous enemies by burrowing under weeds and stones. So developed, indeed, is the new-born larva, that it cannot possibly be compared stage by stage with the helpless newly hatched larva of any egg-laying fish.

McIntosh, who had opportunities of studying these young viviparous blennies in a tank reserved for their sole use, found them under these conditions stretching themselves along the horizontal branches of zoophytes, and feeding on the hydroid polyps and tiny sessile-eyed crustaceans that they found in such situations. The upward turn of the eyes is, as in the weever and some other star-gazing forms, less noticeable in the larval stage than in the adult.

Cunningham draws attention to the fact of both this and our other viviparous bony fish, the bergylt (*Sebastes*), being of northern origin. There is some doubt whether this blenny can have more than one family in the year.

Gasterosteidæ

The Fifteen-Spined Stickleback

Three British sticklebacks, with a bewildering series of varieties and races, are commonly described; but, although two of these seem equally at home in the head-waters of rivers and their brackish estuaries, one only need be seriously regarded as a sea fish.

The Fifteen-spined Stickleback (*Gasterosteus spinachia*) is recognisable by its tubular pointed mouth, its scaleless, bony-plated body (both more or less characteristic of the next group), and its fifteen short spines along the back. In colour it is greenish brown, with variable lines and spots. It is said to change its colour at will when excited, but there seems to be little circumstantial record of this phenomenon. Nor has the male been described as changing his hue in the breeding-season, though in our two fresh-water species the males become bright red when guarding their nest.

The sticklebacks have, in fact, among fishes, much the same interest for naturalists as the nightjar among birds. That species neglects to build a nest like those of the majority of its class and deposits its two eggs in well-chosen sites on the bare earth. The sticklebacks, on the other hand, instead of merely depositing their eggs in the water, like most fishes, build a beautiful nest for their reception, that of the marine form under notice making the most of the decorative possibilities of fucus and corallina, and recalling the flask-shaped nursery of the long-tailed titmice. The stickleback builds its nest among the rocks and continually adds to it, one composite nest, moreover, sometimes serving two families. When the female has deposited the eggs, the male guards them until the young appear.

Sygnathidæ

The Pipe-Fishes and Sea-Horses

The fatherly devotion noticed in the lumpsucker and stickleback is rivalled in the pipe-fishes and sea-horse, the males of which, not content with merely guarding the eggs, carry them about, till hatched, in a pouch or fold of the skin. In one species, indeed, the young have been seen to take refuge in the pouch again when threatened by danger. This is fully as remarkable as any of the stories told of vipers and thresher sharks swallowing their young, or of the angler-fish receiving them within its gill-pouches, for the same purpose, and it has the advantage of having been seen by reliable witnesses. The straight-nosed pipe-fish (*Nerophis*) and its congeners, unprovided with any egg-pouch, is said to carry the eggs in a loose fold of the skin.

The Broad-nosed Pipe-fish (*Siphonostoma typhle*) grows to a length of 12 in., and is dark brown in colour, with a variable quantity of light spots. In some localities it is said to be confused with the young of the gar-fish. Herdman and Dawson mention having taken one measuring 6 in. off the Isle of Man in September, 1894.

The Greater Pipe-fish (*Sygnathus acus*) is a striped and somewhat larger kind, inhabiting deeper water. Like the last, it has an egg-pouch. One was taken at Exmouth in 1901 with embryos in the pouch. These hatched out next day, and measured 14 mm.*

The Straight-nosed Pipe-fish (*Nerophis æquoreus*) lacks the egg-pouch, as do the two that follow. It grows to a length of 12 in., and in colour it is green, the body being covered with white blotches.

The Snake Pipe-fish (*N. ophidion*) is the largest British pipe-fish, growing to between 2 and 3 ft. in length. It is also more brightly coloured than the rest, the body being marked by attractive blue lines and bands. It is often caught in autumn on Southend Pier and at other spots in the Thames estuary, and is also a common fish at Littlehampton, where anglers catch it from boats anchored in the mouth of the Arun.

The Worm Pipe-fish (*N. lumbriciformis*) is the smallest of all, not exceeding a length of 9 in. It is familiar in the "whitebait" of commerce, in company with young sprats, herrings, gurnards, flat-fishes, and even shrimps.

All these pipe-fishes have the characteristic elongated body with bony plates and dividing ridges that give a segmented appearance not unlike that of a glued cane-rod. They are without scales, and their mouth is tubular and devoid of teeth. In view of this last disability, it looks as if the epithet "carnivorous," so often applied to these fishes, might undergo revision.

The grotesque Sea-horse (*Hippocampus antiquorum*), while obviously related very closely to the pipe-fishes, shows several marked departures from their type. These are its curved body, horse-like head, with the knobbed crest and finless, prehensile tail. The pipe-fishes drift in the water extended in a rigid line, whereas the sea-horse more often holds itself in a curved position, the tail grasping some frond of seaweed. Its

* See *Journal Mar. Biol. Assoc.*, January, 1902, p. 335.

egg-pouch has but one small orifice, through which, when ready, the young emerge. The phenomenon of protective resemblance finds even higher expression than in the pipe-fishes, for in the dim light of the submarine jungle the sea-horse must be with difficulty distinguished from its environment. Being the poorest of swimmers, it would otherwise run almost insuperable risks. So far as British seas are concerned, the sea-horse is almost entirely confined to the rocky shores of the Channel Islands.

CHAPTER VIII

THE CONGER EEL

FAMILY: Muraenidae (*Conger vulgaris*)

If it were not that the more familiar eel of our rivers has the habit of going down to the sea to breed with the same regularity as is practised by a salmon going up the river for for the same purpose, there would be little or no risk of confusion, even in name, between the two eels. Whereas the fresh-water species has a small eye and small gill-openings, small teeth and small scales, the latter embedded to all appearance in the skin, and whereas, further, its lower jaw is slightly the longer, and its dorsal fin commences some distance behind the head, in the conger all these characters are different. The eye, teeth, and gill-openings are large; scales are absent altogether; the upper jaw is the longer, though not perhaps conspicuously, and the dorsal fin commences close behind the head and is continued round the tail. The colour of the two is less distinctive, but, as a rule, the river eel has a greenish shade on the back and some yellow in the abdomen, neither of which is ever seen in the conger. The latter may, however, show great variation in hue, those trawled on the sand being known as "white" conger, and being of a uniform dirty grey, while those hooked on the rocks are called "black" conger, and are very dark on the upper parts. There is also a black edge to the fins, and there are some dull grey spots along the lateral line. In size the females are immensely superior to the males. Whereas the former grow to a length of 6 and 8 ft., Cunningham has never come upon a male conger measuring more than 2 ft. 2 in., though another biologist records one of 2 ft. $5\frac{3}{5}$ in. As to weight, which is always a deceptive and unsatisfactory basis of comparison in fishes, female congers have been caught weighing over 9 stones, but a conger of half that weight is reckoned a large fish nowadays, at least by the trade.

Congers of large size seek their food at night quite close to land. They are not only much cleaner feeders than the eels of rivers, but they also reside far from the soft mud, such as these prefer to any other environment. If they feed to any extent during the day, it must be either out in the deeper water, which seems improbable, or, more likely, on the sandy grounds. As no fisherman would ever dream of anchoring his boat for conger otherwise than on the rocks, such a habit might well remain undiscovered. It is, however, more probable that the currently accepted view of the conger feeding seriously only in the darkness is the correct one. Here and there cases are recorded of large conger taking a bait in broad daylight, but they are the exceptions. Deep water is, however, less essential than darkness; indeed, the writer has frequently taken really large conger, of 4 ft. or more in length, in 6 or 8 fathoms of water, while boats anchored farther out, in perhaps 20 fathoms, took only small fish, known as "straps" by the fishermen, who, when removing them from the hook, "strap" them over the thwarts so as to quiet their struggles. All fishermen who have had success with congers know that they absolutely refuse a tainted bait, and that only the freshest of squid or pilchard will catch them. In this way they are the opposite of the bass, which, if anything, prefers tainted food, particularly when, in autumn, foraging in the surf. This fastidiousness of conger is, however, very difficult to understand in the light of some experiments once made at Plymouth, where it was found that, although refusing baits tainted in the ordinary way, congers readily seized either squid or pilchard coated with iodoform, camphor, cheese, and even *balanoglossus*, the last named having a most offensive odour.

The conger is probably among the least migratory of our sea-fish. It is true that congers are caught with the hook only during summer and autumn, but this restriction of the fishery to only half the year is in all probability in great measure the doing of the fishermen rather than of the fish themselves. Although a stationary fish, the conger is very widely distributed in the world's seas, our own species being found in localities so far apart as Japan and Tasmania.

The conger feeds on all manner of fishes, crustaceans, and molluscs, crabs and squid being perhaps its favourite food. As to the smaller fishes on which it feeds, preference is given to those whose form favours easy digestion by a fish of this shape, and consequently smaller congers, pipe-fishes, and rocklings are among its favourite victims. It is also said to prey on flat-fish, but this may be doubted, at any rate where there is a choice of round fish, for a comparatively small flat-fish might easily, by sticking crosswise, choke a comparatively large conger. On the other hand, the conger has a few formidable enemies, among which we know of the torpedo and the various porpoises and dolphins, all of which are fond of hustling and swallowing congers. Shags and cormorants are often seen engaged in combat with congers. Doubtless they seize them in the first instance for the same reason as prompts the conger to seize the rockling—the shape is convenient. Then, however, the struggle commences; and the writer once watched a battle between a cormorant and a conger which lasted the best part of a quarter of an hour, at the end of which the eel was finally swallowed.

Undoubtedly the most interesting aspect of the conger, at least for the naturalist, is its breeding. It is unnecessary to recapitulate the many legends of other days, by which attempts were made to explain the mysterious reproduction of eels. Suffice it to say that no theory seemed too fantastic to find ready acceptance, though most of these fables related, it is true, to the river, and not to the marine, eel.

Only within the last five-and-twenty years was there even a beginning of the solution of the conger's life-history, and we are even now far from the whole truth. Indeed, when it is stated that we do not yet know the egg of either eel or conger, whether it floats or sinks, where it is deposited, and whereabouts the larval forms undergo their development, it may be thought that we know practically nothing of conger growth from the first stage. While, however, our knowledge is still extremely limited, we are yet considerably in advance of the last generation.

Three years stand out as important dates in the recent history of our knowledge of eel life. In 1880 the male conger was first identified by the Director of the Berlin Aquarium, Dr. Hermes. It is, as has been shown, much smaller than the female, and Cunningham regards it as also far inferior in point of numbers. This is not exactly proven, though there is strong reason for accepting his view. On the one hand, we know that no male conger is over 30 in. in extreme length, and the preponderance of congers longer than 30 in. which are caught by both hook and trawl is beyond question. Further, he shows that among a series of examples measuring under 30 in. only about one-third were of the male sex. This, if the series were representative of the proportions in nature, would argue in favour of an overwhelming preponderance of female fish. On the other hand, it must not be forgotten that the series might inaccurately represent the true proportions of the sexes, and also that, as regards the preponderance of female conger in the markets, it is natural that the larger sex would be more frequently taken in the trawl, as also on the hook.

A more important date in this connection, perhaps, than 1880 was 1886, when Professor Delage, of Roscoff, observed the transformation from the larval form (*Leptocephalus morrisii*) to the perfect conger; while five or six years later, in 1891 or

1892, two eminent Italian biologists, Drs. Grassi and Calandruccio, made a series of important investigations of different *Leptocephali* taken in the deep water near Messina, and identified them as the larvæ of the conger, fresh-water eel, and other murænoids.

These *Leptocephali*, little transparent eel-like forms, have long been known, though never taken in abundance, on our own shores, and the one which eventually becomes a conger has been named after Morris, who first described it. The Morris, though previously considered a distinct species, was regarded as the young of the conger, on the assertion of an American naturalist, in the early sixties, and Dr. Günther dissented from this view * only so far as to regard it as an abnormal condition of the larva in a state of arrested development. This opinion was based on the fact that he had seen small, perfectly developed congers with the adult characters smaller than the largest *Leptocephali*, and he therefore concluded that there could be no sequence. A later explanation, however, shows that the larval conger abstains from nourishment at this stage of its career, and consequently shrinks on being transformed to the perfect form, a condition with analogies in other animals.

If the credit of having first suspected the Morris to be a larval conger belongs to an American, that of first identifying the male conger to a German, that of watching the actual transformation of the Morris into the conger to a Frenchman, and that of having traced the larval form and metamorphosis of the eel to Italians, few naturalists have studied the conger in captivity more closely and carefully than Mr. Cunningham at Plymouth; and he has propounded one theory which, if open to argument, is at any rate as interesting as any of the rest. His view, briefly, is that the conger spawns once and then dies. This, as we have seen, is also thought to be the truth of one of the gobies, though it is not with the conger a case of coming to maturity, breeding, and dying all within one year.

* *Introduction to the Study of Fishes*, p. 673.

It is possible that subsequent investigations may confirm Mr Cunningham's singular proposition ; but it is certain that he argues somewhat boldly from the particular case of the aquarium to the general case of nature. The Plymouth tank-house, at which he pursued his studies, is admirable of its kind, and even the hypercritical could scarcely express anything but appreciation of the manner in which it is conducted. Yet not the Director himself would probably claim that it accurately reproduces the varied conditions of food and temperature that obtain even within the Sound, just outside its walls ; and indeed the Sound itself may be quite inadequate to the requirements of spawning conger. The same naturalist has, for instance, made some very interesting studies of the rate of growth of different fishes in the same tanks ; but his results would almost certainly call for considerable modification if they had to be reconciled to those obtaining under perfectly natural conditions. Even the spawning-season in captivity differs appreciably from that observed in the open sea. The observations made in such an aquarium as that at Plymouth must always be interesting, and may often be valuable, but they must, to be of use, be interpreted with due allowance for the influence of artificial environment. It has been observed, for instance, that congers in the Brighton Aquarium, fed on alternate days only, have come to know the feeding-time and to display no activity whatever on the intervening fast-days. This, while of interest, no doubt, to the student of animal intelligence, chiefly illustrates the extent to which artificial conditions may modify the natural habits of captive fishes.

Let us for a moment examine Mr. Cunningham's data and arguments in favour of this theory of the conger dying after its first spawning. To what, after all, do they amount ?

He has never known a female to spawn in captivity, the nearest approach to this episode having been the death of a ripe female unable to deposit the eggs. He also admits that ripe conger are never obtained from the sea, owing apparently

CHAPTER IX

THE GREY MULLETS AND ATHERINES

Both of these groups, which are closely related, have given rise to discussion as to the number of really different kinds that occur in our seas. The writer, trusting merely to a somewhat long acquaintance with grey mullet on both the English and Italian coasts, would prefer to recognise only one British species, the thick-lipped kind. Day insists upon adding the thin-lipped species, and Günther ignores the thick-lipped kind, or names it *Mugil septentrionalis*, and admits three others. The common atherine is also the only member of its family in any way familiar on our coasts, and indeed Day has some evident hesitation in admitting the second, Boyer's species. For present purposes it is thought that a brief account of the two undoubted British representatives of these groups will suffice.

Family.	Common Name.	Genus.	Species.
Mugilidæ	Grey Mullet	*Mugil*	*chelo*
Atherinidæ . . .	Sand-smelt	*Atherina*	*presbyter*

Mugilidæ

The Grey Mullet (*Mugil chelo*), or Thick-lipped Mullet, is a common fish on many parts of our coasts, particularly in the more southern waters and near harbours or estuaries.

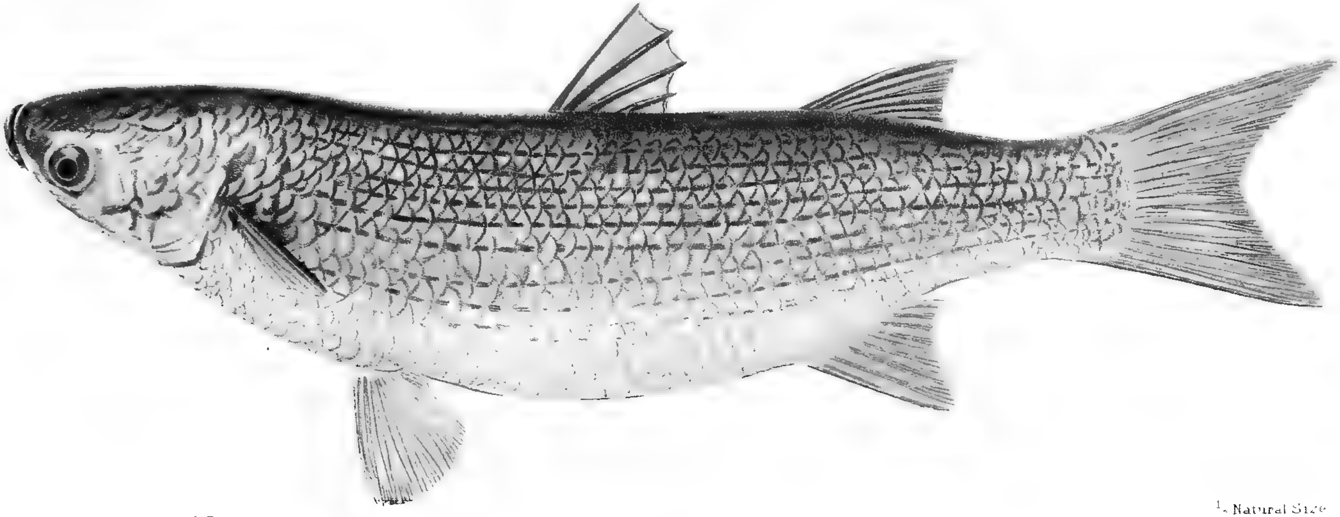

Photo by Reinhold Thiele

1/2 Natural Size

GREY MULLET (*Mugil chelo*)

Photo by Reinhold Thiele

2/3 Natural Size

STRIPED WRASSE (*Labrus mixtus*)

It can live in comfort in brackish water as well as in the open sea, but is said to spawn entirely in the latter. The teeth, when present, are so small as to be scarcely functional, and many examples lack them altogether, subsisting on soft food, and straining the water through the gauze-like sieve of their gill-rakers, after the fashion of herrings. Small worms, molluscs, and crustaceans doubtless form much of their food, but they are also regarded as partly vegetable-feeders, while ragworms are the bait found most successful by amateurs. The stomach is exceedingly muscular, and has been compared in structure to that of birds; while the folded intestine is of such immense length that one in a mullet of only 13 in. has been found to measure 7 ft. The gill-openings are wide, and this is particularly noticeable in the aquarium, when these fish are taking in gravel and expelling it every moment. The eye is small and has a thick lid. The lip is fleshy, and the writer never came across a British mullet with any other condition of the lip, though in the Mediterranean the thin-lipped kind is common.

It cannot be said that the grey mullet offers any peculiarities of outline or colouration that lend themselves to easy description. It is a typical round fish, silvery grey in colour, and some examples have darker lines along the sides from head to tail. The tail-fin is deeply forked, and there are two short fins on the back, the front one having four stiff spines. When caught in brackish water, the grey mullet is very slimy to the touch, though those taken in estuaries are regarded as better food than specimens from deeper water. This fish grows to a length of at least a yard, and there are records of specimens weighing 10 lb. or 12 lb. Large mullet are not as a rule easily induced to take the hook, particularly in the English Channel, where the bulk of those brought to market are captured in short seines. In the Mediterranean, however, perhaps because the natives of Southern France and Italy have unquestionably made a closer study of their capture with the hook, the mullet are constantly taken on the rod, and in some parts they are speared as they come to the surface to feed. It would appear as if they are not alarmed by steam traffic, for the writer once, in the summer of 1899, caught two in the course of five minutes over the side of a steamer off Mogador Island, while the anchors were coming up and numerous small craft were alongside. This experience was strangely at variance with the rule that anglers formerly observed, of rowing up to these fish with muffled oars for fear of sending them to the bottom ; but it should be added that the two referred to were only small of their kind, and larger examples might more easily have been disturbed.

The grey mullet of the Arun are noted for their great size and excellent flavour, though they are rarely in these days caught as far up as Arundel, as was formerly the case. The east works of the Littlehampton piers are the favourite spot for taking Arun mullet to-day, and there are resident enthusiasts who fish for them at daybreak throughout the summer months. The grey mullet must, moreover, be a more migratory fish than has been generally described, for nothing is seen of these Arun mullet before May or after October. The artificial culture of grey mullet in inland ponds and reservoirs has had many advocates, but Cunningham expresses the doubt whether the common marine form would spawn and develop in such surroundings.

The egg is of the floating kind, and has a simple yolk with a single oil-globule. Cunningham figures an advanced larval mullet, rather over $\frac{2}{5}$ in., which he obtained in the month of May from the late Matthias Dunn. There were no fin-rays, with the exception of a few in the tail. Very young mullet of an inch or rather less have been caught at the surface in Plymouth Sound in July and August and fed at the Laboratory, but their growth in captivity can scarcely be described as rapid, since they only trebled their length in a twelvemonth. Whether this meagre rate of growth can, however, be regarded as affording much clue to that under more natural conditions is extremely doubtful.

Until, at any rate, they get large and old, grey mullet are of a sociable disposition, and even the large examples are rarely seen singly, but more usually in couples, probably of opposite sex, though this is not recognisable in the circumstances. These fish also have a remarkable, but well-known, habit, when encircled by the seine, of following a leader in their effort to escape. The fishermen in some parts believe that one old and wary member of the shoal is the recognised pioneer in such cases; but the writer was on one occasion able to see that the first fish over the ropes was one of quite small size, and it is therefore highly probable that the rest simply follow the first fish that succeeds in finding a way out.

Atherinidæ

The Sand-smelt, or Atherine (*Atherina presbyter*), has often been confused with the true, or "cucumber," smelt, one of the salmon tribe, and even so close an observer as Mr. Cunningham says that it "resembles the true smelt in appearance and habits." In what this close resemblance in either appearance or habits consists, Mr. Cunningham does not say. The rayless adipose second dorsal fin and the spineless first dorsal fin of the salmonoid smelt should (to say nothing of its strong characteristic smell) sufficiently distinguish it from the atherine, which has spines in the first dorsal fin and rays in the second. Apart from these obvious differences, the shape of the head, and more particularly the cleft of the mouth, is distinct, and the eye of the true (salmonoid) smelt is smaller, its teeth are larger, and the broad silvery band on its sides is replaced in the atherine by a narrower stripe of pale violet iridescence. The true smelt also grows to a much larger size, examples of a foot in length being on record, whereas an atherine of half that measurement would be considered a large specimen. Nor are their habits much more alike than their appearance, since the atherine spawns in the open sea, whereas the true smelt ascends rivers for the purpose, like the salmon, and has been taken in the Thames above Richmond. The only person who sometimes persists in confusing the two is the fishmonger, and he is not wanting in excellent reasons for so doing. The two fish occur together on Breydon Water, near Yarmouth, and one or other is said to predominate in different seasons.

The lateral line, though commonly described as indistinct, and actually so in the majority of examples, is very plainly marked in a few individuals, and the writer has noticed this peculiarity rather more often in those caught in the Teign estuary than in those taken at Bournemouth and elsewhere out of the influence of fresh water. That there should be any connection between these circumstances does not appear clear, and the observation is offered indeed with every reservation, since no very extended series has been examined from both districts for the purpose of comparison. Boyer's atherine, by the way—which has been regarded, erroneously, as the young of the common species—is a Mediterranean form with a larger eye and fewer vertebræ. If it were, as alleged, the young of the atherine, its occurrence in our seas would have been more often recorded, for the atherine fry absolutely swarm some years in our south-coast estuaries in June and July, and the writer could often have caught scores of them in the Teign with a single dip of a butterfly-net.

The colour of the atherine is some variable shade of brown or green, some being coloured like the launce and others like the sand-eel (to be presently described), and there is an iridescent band along the sides which, seen sideways in the sun, has a very beautiful violet sheen. This, however, quickly fades after death, and few of our fishes, save, perhaps, the herring, die more rapidly when removed from the sea.

Atherines are fatally curious, and this leads to their being caught in great numbers in large round or square nets worked on a capstan. They are taken in this fashion near the yacht steps at Cowes, though in this case the net is worked by hand. They also take a baited hook ravenously at times, and are not merely carnivorous, but even take a fragment of another atherine often more readily than either mussel or ragworm, though the latter are usually reliable baits. They have, moreover, the true predatory instinct, for, whereas they sometimes pay no attention to a still bait, they may at once be aroused to voracious activity by merely allowing the bait to sink to some depth and then withdrawing it quickly to the surface—in fact, imparting to it the movements of a feeble creature anxious to escape. The angler soon learns that the great secret of success with bass, pollack, mackerel, and some other important fishes lies in making due allowance for such sinister instincts.

CHAPTER X

THE WRASSES

THE Wrasses are known by their brilliant colouring, which is in some species a secondary sexual character and most brilliant at the breeding-time, as well as by their smooth, slimy skin thick lips, and strong, crushing teeth. There are seven of these fishes in our seas, none of any commercial value, though the authors of the *Scandinavian Fishes* describe many of them as excellent food. The writer has tried several, out of curiosity, both on our own coasts and in the Mediterranean, without having yet found one that he would care to taste a second time. The flesh is very soft and flabby, and the bones are most difficult to avoid.

FAMILY.	COMMON NAME.	GENUS.	SPECIES.
LABRIDÆ	Striped Wrasse	*Labrus*	*mixtus*
	Ballan	*L.*	*maculatus*
	Connor	*Crenilabrus*	*melops*
	Jago's Goldsinny	*Ctenolabrus*	*rupestris*
	Scale-rayed Wrasse	*Acantholabrus*	*palloni*
	Rock Cook	*Centrolabrus*	*exoletus*
	Rainbow Wrasse	*Coris*	*julis*

In the work above named the wrasses take first place, before even the perches, and the authors remark on their resemblance in outline to some of the latter group. They also refer to the supposed monogamous code of the male, but evidence of this is wanting.

There is much resemblance between the different British members of this family, and the six genera given in the foregoing list are distinguished for the most part by inconspicuous characters determined only on close examination. One such ground of distinction is the number of dorsal spines—nine in the rainbow wrasse and as many as a score in the scale-rayed kind. Another determining character is the number of scales along the lateral line—over fifty in the rainbow wrasse and less than forty in the connor. The distribution of the teeth is also of some importance ; these lie in a single row in *Labrus* and *Centrolabrus*, and in a band in *Ctenolabrus* and *Acantholabrus*. In the last three genera (*Centrolabrus*, *Ctenolabrus* and *Acantholabrus*) there are imbricate scales on the gill-covers. Most young wrasses have a serrated edge to the front part of the gill-cover, and this character is apparently retained by the connor throughout life.

All the wrasses dwell among weed-covered rocks in either shallow or moderately deep water, usually the former. At the entrance to Dartmouth Harbour, for instance, there are some submerged rocks with very long weed, and there, many years ago, the writer used to catch very large wrasses several pounds in weight. Many of them, too, follow the crabs into the crab-pots, and are in turn made use of as excellent bait for those crustaceans.

The Striped, or Cuckoo, Wrasse (*Labrus mixtus*) is one of the handsomest of the wrasses in our seas, and affords a parallel case to that of the dragonet, for the sexes differ so strikingly in colour that they were commonly regarded, on widely separated coasts, as distinct species. The error was in the first instance corrected by Scandinavian biologists. The male was known as the blue-striped, the female as the three-spotted, or red, wrasse. The three black blotches of the female, situated on the edge of the back just before the tail, are absent from the male. As so often observed in animals that differ in colour according to their sex, the immature male follows the colouring of the female. In both sexes the ground-colour is bright orange-red, but the male has converging blue bands behind the eyes. The fins are yellow, and there is generally a blue blotch on the dorsal, while the others have blue margins. As in most highly coloured fishes, however, the tints are very variable in both intensity and distribution.

This wrasse has a large mouth, with fleshy lips, the upper one bearing numerous papillæ. The long, conical teeth are evidently suited to breaking the shells of bivalves and crustaceans. Day alludes to this fish taking the baits on whiffing lines on the pollack grounds, but the writer never heard of a single case. On the ground-lines used for pollack, on the other hand, he has frequently taken different kinds of wrasse, for the baits sometimes go to the bottom at the turn of the tide or on a change in the force or direction of the wind. On such occasions a large wrasse is almost always taken. The same authority also gives "lobworms" as the best bait, by which he presumably intended the lugworm of our shores. On the contrary, it is the ragworm of which the wrasse is passionately fond, and in seizing which it makes itself so great a nuisance to the pollack fisher. This wrasse, though rarer in the north, has been taken all round the British Islands, and apparently grows to a length of rather over a foot.

The Ballan, or Comber (*L. maculatus*), a considerably larger species, grows to a length of over 16 in. and a weight of 7 or 8 lb., though this is uncommon. Its colours, as brilliant in some examples as those of the last species, are still more variable, but they do not show the same difference in the sexes. The general body-colour is green, and there is a good deal of blue in the scales. Orange-red lines radiate on the face, and there are in some examples yellow bands along the sides and in others round yellow spots on the fins. This wrasse the French call by a name signifying "sea-parrot," and the authors of the *Scandinavian Fishes* give a very beautiful plate coloured from a living specimen. The colours fade, however, very rapidly after death.

This is one of the largest wrasses in our seas, and it is the kind to which the scientific name of *bergylta* has been applied (from the Orkney name "bergle"), already objected to as likely to lead to confusion with the true bergylt. The allusion to a pig is evidently intended in this case, for "sea-swine" is another Scotch name for the fish, probably in allusion to the thick lips. This last character has gained for all the wrasses collectively the German trivial name "lip-fishes."

The ballan wrasse feeds on small fishes, molluscs, and worms. Like most of our wrasses, it is more plentiful in the Channel than farther north, though it occurs round the Orkneys as well as in the waters of Shetland. Like the herring, this wrasse differs from the rest of its family in depositing heavy eggs, which are hatched in a seaweed nest. Mr. Matthews secured such nests from Skye, and found the spawn adhering to them.* The eggs were still alive when they reached Edinburgh, and the newly hatched larvæ, which measured about $\frac{1}{7}$ in., were extremely active, living ten days in damp seaweed. At about $\frac{1}{2}$ in. traces begin to appear of the later brilliant colouring, in the form of brown bands and white spots and patches. McIntosh alludes to the rapid movement of the pectoral fins, recalling the pipe-fishes.

The Connor, or Corkwing (*Crenilabrus melops*), is a smaller kind, which rarely exceeds 9 in. It is readily distinguished by the dark bands down the sides, as well as by the remarkable rings, with or without dark centres, on the fins. The ground-colour of the fish is some variable shade of brown or red, with green and yellow reflections. Three or four light bands pass along the cheek, that immediately beneath the eye often having a dark centre. In most examples, too, there is a black spot immediately in front of the tail-fin, but this may be wanting. The colours and markings here given will be found to answer with many specimens; but there is great variation, not merely in the colouring,

* McIntosh and Masterman, *op. cit.* p. 230.

but even in the proportion of the length and depth of the body. The edge of the front gill-cover is usually serrated in this species, but it is doubtful whether this is a distinguishing character. (Dr. Günther points out, for instance, that the young of all wrasses have serrated preopercles, which suggest a permanent ancestral character that some have dropped.) The greater number of the rays in the dorsal fin are spinous, and the anal fin has also three spines. The scales are in less than forty transverse series, whereas in the preceding wrasses they number more than fifty. The lateral line is well marked through its entire length, and it takes a more decided downward curve just beneath the second dorsal fin than in the cuckoo wrasse or ballan.

It is probable, as Day has suggested, that this wrasse is identical with the species that Couch calls "Baillon's wrasse," the condition of which it may be said to assume when its colours are faded, though there is also some apparent difference in the number of rows of scales across the cheek and under the eye.

The connor is a shallow-water fish, and is gregarious in its habits, whereas the majority of wrasses might rather be described as solitary. It occurs on all the shores of Great Britain and Ireland, being commonest perhaps in the more southern waters.

Holt has studied the eggs in summer on the Irish coast. They are colourless and have no oil-globule, and green and yellow appear to be the prevailing colours of the yolk after hatching.

Jago's Goldsinny (*Ctenolabrus rupestris*), or the Pink Brame, is a small red-and-gold kind, with a large black blotch generally noticeable on the dorsal fin, though the spots and bands are as variable as in most wrasses. In some examples that have come under the writer's notice the fins are black-edged, but this would seem to be an uncommon character.

The pink brame, which the fishermen of some parts, notably on the Irish coast, regard as poisonous, does not from all accounts exceed a length of 6 in., and is found on all parts of our coasts. The teeth are in a band on the jaws, and the dorsal fin has more than twenty rays, the majority of them prickly. The lateral line is much the same as in the connor, and there are scales on the cheeks and gill-covers. Why the name of brame, or bream, should at some of our ports have been bestowed on this fish is not very clear; but this association of two distinct families is not confined to this side of the Atlantic, for American writers also call the wrasses "sea-breams." *

This wrasse inhabits somewhat deeper water than most of the family, and it is also a less persistent biter. On one occasion the writer hooked four in the course of a morning's pout-fishing about three miles south-west of the Dodman Head; but he never at any other time, before or since, saw the fish, except in the lobster-pots.

According to the authors of *Scandinavian Fishes*, the spawning-time is from April to July, and this account agrees with what Day says on the subject. They also † refer to rows of spots which obliquely cross the lateral line, and which vanish at the will of the fish if it is handled alive, and do not return until it has recovered its equanimity. Bashford Dean figures (after A. Agassiz) the larval stages of an allied American species, with which our own probably agrees very closely. The yolk-sac is situated at the throat when the larva is first hatched, and this first stage is seen to show strong resemblance to a corresponding stage in the little sturgeon. At a week old the pectoral fins are very conspicuous, and at four weeks old the fish appears to have developed all the characters of the full-grown stage.

The Scale-rayed Wrasse (*Acantholabrus palloni*) is a southern form and one of the largest kinds found in our

* See Bashford Dean, *Fishes, Living and Fossil*, p. 225. † *Op. cit.*, p. 17.

seas, specimens of over 20 in. having been described. Its colours are very variable, but a typical example is deep orange, violet, or blue, with pink on the sides, and lighter beneath. There is a large dark blotch near the hinder end of the dorsal fin, and some examples have another blotch, somewhat smaller than the first, just in front of and above the tail-fin. The edge of the front gill-cover is strongly serrated. The dorsal fin has more than twenty-five rays, the majority of them spinous; but the peculiarity of the dorsal fin is in the presence of scales along each of the rays. There are also scales at the commencement of the tail and anal fins, a condition that we shall also find in the curious fish *Pammelas*. This is, in fact, the only British wrasse that has scales over the top of the head and on the neck.

The Rock Cook (*Centrolabrus exoletus*) is a little brown-and-yellow wrasse with blue bands and marks on the head, silvery fins, and a black line along the dorsal. The latter has more than twenty rays, most of them prickly, and the tail-fin is lighter towards the hinder edge than at the base. The lateral line is distinct, and takes a downward curve beneath the last rays of the dorsal fin. The teeth are in a single row.

This wrasse, which apparently does not grow longer than 4 or 5 in., is often taken in the crab-pots. It is, unlike the last, a northern kind, for Day gives Greenland as within its range, but it is not recorded by him as occurring in the Mediterranean. Günther, however, mentions a closely allied species from the Mediterranean.

The Rainbow Wrasse (*Coris julis*), which grows to a length of about 7 in., exhibits, though in somewhat lesser degree, the sexual colour-differences which were described in the striped wrasse. The male is distinguished by a white band with wavy edges along the sides, and also by a large black spot near the front end of the dorsal fin, the latter having along the lower half of the rays a series of faint purple or green spots. Both sexes have a small but distinct spot on the gill-cover, almost in line with the eye, and the female has a second spot, smaller in size, on the pectoral fin. She is also marked with yellow bands along the body. It cannot too often be urged that the colours of all wrasses are liable to great modification, and rarely constitute a satisfactory ground of distinction. The scales are in at least fifty rows, and are consequently of small size, and Day doubts whether the number differs according to sex, as had been alleged. As in the case of the striped wrasse and dragonet, however, the marked differences between male and female long ago led to their being described as distinct species; indeed, Günther almost inclines (1880) to this view, recognising both *Coris julis* and *C. giofredi.*

This wrasse is common in the Mediterranean, and Raffaele obtained its eggs in spring and summer. Holt found a similar egg in Irish waters in June and July, and found that the newly hatched larvæ measured about $\frac{1}{10}$ in.

These, then, are our seven wrasses, and little more has been attempted than to give some indication of their colouring and relative size. They are among the least important of our fishes, for they are neither fit for food for ourselves, nor are they appreciated by our food-fishes. Even gulls refuse them, as a rule. Whenever anglers catch a wrasse on the Cornish coast, it is thrown back in the water as soon as unhooked, for it is a slippery fish and apt to lead to accidents if left lying about in the bottom of the boat. Though often scarcely injured in the unhooking, since the steel has merely penetrated its fleshy lip, the fish is unable to descend in the water, owing to a peculiarity of the air-bladder, and remains floundering at the surface. The gulls, large and small, are at once attracted to the spot by the sight of a struggling fish, but they merely hover, as a rule, over the fish without further disturbing its struggles.

CHAPTER XI

THE HERRING FAMILY

THE fishes belonging to the present family, including the Herring, Sprat, Pilchard, Anchovy, and two Shads, are the most important in our seas. Anatomically they have a close connection with the salmon tribe, though they are widely separated by some writers.

The general characters of this family, of which our seas possess only these six species, three of them in immense shoals, are the moderately small, thin, silvery scales, which do not extend to the head, small teeth, open gills, and absence of spines in the fins. There are but one dorsal and one short ventral. The herring has no lateral line—a fact that may be borne in mind whenever there is a tendency to generalise on the connection between that character and a habit of swimming high in the water, for the herrings keep close to the surface of the sea more uniformly than the fishes of any other family in our seas. The lower edge of most of them is flattened, covered with bony plates, and varyingly sharp or serrated.

The true herrings are all small, gregarious, shore-haunting fishes of migratory habits. Dunn was of opinion that they massed in such immense shoals for safety from rorquals and other large enemies, which dare not venture among them for fear of being suffocated. He once saw a rorqual nearly suffocated in this way by coming up to breathe in the midst of a shoal of herrings. The cetacean, in desperate straits, had to dash into the air, sending up a column of herrings at the same time.*

These fishes feed, like the whalebone whale and basking shark, by straining the water through their long gill-rakers, which form a dove-tailed screen capable of arresting the copepoda. Some, like the shads, ascend rivers to breed, and even the herring itself appears to suffer no inconvenience in brackish water. The herring and shads deposit eggs that hatch out on the bottom; but whereas those of the herring adhere in masses to stones and weeds, and even to living crabs, the eggs of the shad develop separately on the river bed. The pilchard, sprat, and anchovy, on the other hand, lay eggs that float and develop close to the surface.

Professor Cossar Ewart† mentions having artificially fertilised and hatched herring spawn, which was taken adhering to stones from the Ballantræ Bank. The spawning of the pilchard, on the other hand, was first studied by Matthias Dunn, who found the fish spawning in May twenty miles from land, and pressed the eggs from one into a bucket of sea water. Each egg, he found, floated separately at the top, but soon sank, dying for want of fertilising. He also knew that the pilchard spawned about Christmas time; but whether the species spawns on our coast twice during the year, or whether there are not rather distinct summer and winter races, as in the herring, is one of the problems that the scientific experts of the Marine Biological Association at Plymouth will no doubt determine in course of time. It is, of course, because spawning pilchards keep twenty or thirty miles from land, or twice the distance fished over by the drift-boats, that we do not get pilchards, like herring, with roes for table purposes.

* See *The Migrations and Other Habits of the Herring on the Coasts of Devon and Cornwall* (reprint from *Report of the Royal Cornwall Polytechnic Society*), p. 16.

† See *Nature*, xxix., p. 538.

The spawning of the sprat has been observed in the Firth of Forth, and generally takes place nearer the land than that of other marine Clupeidæ. The spawning of anchovies has been observed in the Zuyder Zee in summer time, and its floating eggs were taken in the tow-net off Lytham (1896) by Mr. Ascroft, who hatched out the larvæ.

The spawning of shad is sufficiently familiar in many of our rivers, and is, moreover, easily studied in private hatcheries both on the Continent and in America. In the latter country the eggs are artificially hatched on an immense scale, and it has been found that the action of direct sunlight accelerates the hatching by at least twelve hours, and without apparently weakening the larvæ.

The herring, sprat, pilchard, and anchovy may be distinguished at almost any stage of their growth without much difficulty. In the adult fish, which chiefly concerns us here, the herring has the commencement of its back fin just half way between the tip of the nose and the start of the tail fin ; in the sprat the dorsal fin starts a little nearer the tail ; in the pilchard a little nearer the nose. Given the aid of a yard measure, it would be difficult to indicate a simpler means of recognition in comparing three individuals. Other differences are found in the larger scales of the pilchard, and more serrated belly edge of the sprat. The pilchard and shads also have radiating lines on the gill-covers, which are not found in any of the rest. The backbone furnishes an excellent distinction between the sprat and herring, for the former has never more than forty-eight vertebræ, and the herring has never less than fifty-six. Shads are rather like pilchards in their greenish colour, but they have smaller scales, and their lower edge is also rougher. They resemble each other somewhat closely, but the twaite shad has a line of dark spots nearly half way along the sides, and its gill-rakers are fewer, longer, and thicker than those of the allis.

FAMILY.	COMMON NAME.	GENUS.	SPECIES.
CLUPEIDÆ	Herring	*Clupea*	*harengus*
	Pilchard	*C.*	*pilchardus*
	Sprat	*C.*	*sprattus*
	Anchovy	*Engraulis*	*encrascicholus*
	Twaite Shad	*Clupea*	*finta*
	Allis Shad	*C.*	*alosa*

It now remains to add some remarks about these fishes individually.

Clupeidæ

The Herring (*Clupea harengus*) is so familiar a fish that any further description might seem superfluous. It is, however, necessary to supplement what has gone before as follows: Its colour varies between a not very pronounced green and blue. Its scales are neither strikingly large nor small, and they easily detach when the fish is roughly handled. Its lower edge is smoother and less compressed than that of the sprat, approximating more closely to that of the pilchard. Its eyes have a free fat lid, and are easily suffused with blood when the fish struggles in the nets. Small weak teeth cover the jaws, tongue, and palate, being distributed in a patch.

The herring is a cold-water fish, and develops to a larger size in more northern latitudes. In the Channel it averages 12 in.; in parts of the North Sea it exceeds this by at least 5 in. There seems, in fact, to be a regular progression in the relation between latitude and growth. Our herrings are smaller than those caught off Iceland; on the other hand, our pilchards are larger than those of the Mediterranean, and only the smaller of the shads finds its way to the rivers of southern Europe.

The Americans have made a closer study of varieties than we have, or else the races are more clearly marked, for they have their "glut," "poplar back," "may flipper," "dun belly," and other kinds. Iceland has a large, coarse herring, and there are distinct kinds in the White Sea which are netted through the ice. Even on our coasts we have the large and small herrings of the Lewes, the large race of the Ballantræ spawning-grounds, and the small, but oily, herring of Stornaway.

As regards the numbers of the sexes, the males are said to be slightly in excess ; this, if correct, is quite unusual in the animal world. They are also regarded by some as slightly longer, but this appears doubtful. The fact of the fishmonger supplying soft roes almost throughout the year does not point to an indiscriminate spawning-season, but merely to different races spawning in different months. The winter herrings frequent estuaries, while those that spawn in summer keep farther away from land.

The aforementioned fact of the herring laying heavy eggs that sink to the bottom of the sea has been of great interest in its bearing on the proposals for restricting the operations of trawlers, and the different phases through which public opinion has passed on the subject are instructive. Long ago, before the scientific world knew of the buoyant nature of most marine fish-spawn, it was known (1803) that the eggs of the herring are demersal, and it was thought that other eggs might be likewise and would certainly be disturbed, if not destroyed, by the sweeping operation of the trawl-net. Then came the discovery that only the herring, of all our important food-fishes, deposits demersal spawn, and it was said that the trawlers could damage that only and no other useful spawn. Then, again, some one discovered, or fancied that he discovered, that the herrings spawn only on ground too rough for the trawlers to work on, so the trawler was wholly acquitted as unanimously as earlier he had been condemned. Once again, however, public opinion has veered round, for Cunningham has shown beyond a doubt that the trawlers from both Granton and Grimsby were in the habit of purposely fishing these grounds in order to catch the haddocks that assemble there to gorge on the herring eggs.

The capture of herrings for market purposes is conducted almost entirely by drift-nets, and even for sport the herring is little fished for with hook and line. There are, however, times when it may be caught in numbers with a "jigger" on the Scotch coast; and Mr. C. A. Payton, H.B.M. Consul at Calais, writes, under date February 17th, 1902, that immense numbers of spent herrings came into Calais docks to recuperate in January and February, and were caught in thousands by amateurs using a local form of jigger. Mr. Payton himself caught no fewer than 1,144 between January 25th and February 16th. The proportion with either roe or milt would not have been more than 6 per cent.

The newly hatched herring measures rather over $\frac{1}{5}$ in., and is more developed than the young of fishes hatched from floating eggs. The eggs themselves are opaque, and have a thick adhesive envelope. These larval herrings have no gill-covers, and the mouth is immediately beneath the eyes and opens downwards. Silvery scales first appear when the fish have grown to a length of about $1\frac{4}{5}$ in., and the herring seems to take in all rather over two years to reach maturity, which would correspond to a length of between 7 and 9 in. The female herring contains from 30,000 to 40,000 eggs. McIntosh and Masterman give a good figure of the larval herring, showing the downward cleft of the mouth, which changes its direction in the adult. The larval herrings live on the bottom; the post-larval forms at mid-water; and when about $\frac{1}{2}$ in. long the herring becomes a surface-swimming fish. The larval pilchard and sprat, on the other hand, float with *plankton* at the surface. According to Heincke * the larva of the autumn herring differs from that of the spring race.

On the subject of whitebait much has been written, and it

* See that author's *Naturgeschichte des Herings*, a remarkable study of spring and autumn herrings, in two volumes, with diagrams (Berlin, 1893). For a criticism of it see Jenkins in *Lancashire Sea Fisheries Report*, 1903, p. 28-38.

is here merely necessary to state that it is now known to consist (with various commercial adulteration) of the young of the herring and sprat in proportions that vary according to the season, and not, as was formerly held, to be the young of the bleak, as stated by Pennant, or of the shad, as insisted by Donovan. In June and July the whitebait of the Thames estuary contains about 80 per cent. young herrings; in February and March about 90 per cent young sprats; at all times young sand-eels, gurnards, pipe-fish, and even shrimps.

The migrations of the herring in our seas have been studied to much the same extent as those of the mackerel, and in both cases the movements of the shoals are now regarded as much less extensive than would be gathered from the circumstantial accounts given by earlier writers. The modern view—which further investigations of the subject, particularly on the basis of the study of distinct races as pursued by Dr. Heincke and by some of our own biologists, will either confirm or otherwise—is that the fish leave or approach the coast, moving to and from the deeper water of the northern seas, chiefly for the purpose of procuring fresh food-supplies. These wanderings do not appear, however, to have taken the fish through the Straits of Gibraltar, for they are regarded as wanting in the Mediterranean. Now and then the summer herring mass so thick on favourite feeding-grounds on our coasts that the water is thickened by their excreta, and many other fishes shelter in this turbid area of the sea, where their enemies are unable to find them. Both pilchards, however, and mackerel, so Dunn used to say, keep away from these feeding shoals. He was also of opinion that herrings displayed above most other fishes what he called a sixth sense, for it was always observed that they were the first to leave the inshore grounds on the approach of a coming storm, and from the fact of their always moving away to leeward, it looked as if they even knew the direction from which it was blowing.

The Pilchard (*C. pilchardus*) has, as before mentioned, radiating lines on the gill-cover to distinguish it from the herring, and it also has large, loosely attached scales, a more rounded body, and a deeper green hue. Its extremely small teeth occur in the jaws only, and in some individuals they appear to be altogether wanting.

The sardine of our tables is merely a year-old, immature pilchard, masquerading under the French name. This seems to be derived from the fisheries round the island of Sardinia. Unlike the herring, the pilchard occurs abundantly in the Mediterranean.

Dunn described its floating egg as far back as 1871, and seventeen years later Raffaele thought that he had identified the similar egg of the sardine in the Mediterranean—a conclusion confirmed by Cunningham somewhat later. The pilchard is said to deposit about 60,000 eggs, and Cunningham observed these artificially fertilised for the first time in 1893. He draws attention to three very useful characters by which they can be distinguished from any other eggs that float in our seas—the great space between the egg and the surrounding membrane, the division of the yolk into irregularly shaped segments, and the presence in the yolk of a single large oil-globule. There are, it is true, other eggs with one or other of these three characters, but no other possesses them all.

The same author also gives excellent figures of the remarkable larval and post-larval stages through which the pilchard passes. It is satisfactory to learn, in an age that affects to deprecate British science, that the scientific experts of the Plymouth Marine Laboratory solved, in the course of a five years' investigation, pilchard problems which eminent French ichthyologists at Marseilles had declared to be incapable of solution close to land.

It would seem that the migrations of the pilchard are less extensive on our coasts than those of the herring. As an interesting case of irregular distribution, it may be mentioned that this fish was common on the east coast of Scotland during the early years of the nineteenth century, but has been extremely scarce there ever since.

Pilchards feed close to the land in the summer months, and chiefly at night, but they are said by the fishermen to feed with their heads all pointing away from the land, so that the shoals can easily re-form on the approach of dawn. This view is borne out by the fact that of the thousands of pilchards strangled on some nights in drift-nets set parallel with the land, the writer has often found no more than five per cent. caught on the outer side of the net, thus showing that the vast bulk of the fish struck the meshes on the land side.

The Sprat (*C. sprattus*) is a smaller fish, and rarely exceeds $6\frac{1}{2}$ in. As already shown, it is easily distinguished from the herring by its saw-edged belly and dorsal fin commencing behind the point opposite the pelvic fin. It has no teeth, and its scales are larger than in a herring of similar size. From the pilchard it is at once distinguished by the absence of radiating lines on the gill-covers.

Its relations with the "whitebait" of commerce have already been explained. It apparently spawns closer to the coast than the herring or pilchard; indeed, in such enclosed waters as the Firth of Forth its eggs are found farther from the open sea than those of any other marine fish. It is found on all European coasts, in the Atlantic, in the Mediterranean, and in the Baltic, and the chief regular fisheries of importance are in estuaries and narrow seas.

The floating egg of the sprat is found in the sea at Plymouth from the end of January until the end of April, on the west coast of Ireland from March until June, and at St. Andrews from April to July. The female deposits about 5,000, and each measures about $\frac{1}{25}$ in., is transparent, and has no oil-globule. The yolk is divided by numerous lines. Sprats' eggs are also found on the bottom in shallow, brackish water; and McIntosh suggests that these fish sometimes spawn up estuaries, so as to ensure the eggs sinking in the less dense water.

Young sprats of about $2\frac{1}{2}$ in. are known as "brit," which, with the "mackerel-midge," as the young of rocklings are called, constitute so important a source of food for surface-hunting fishes.

Sprats appear to approach our estuaries and narrow bays not so much to breed, however, as for feeding purposes. Indeed, the spawning is often carried on some little way from land, and the sprats do not commonly shoal inshore until autumn and winter, their presence at such spots as Deal being the signal for a corresponding muster of the cod and whiting.

The Anchovy (*Engraulis encrascicholus*) is less important in our seas than the three foregoing members of the family, but very large fisheries have long been established as far south as the Mediterranean, and as far north as the Zuyder Zee, where this little fish spawns every summer. The anchovy may be recognised from other Clupeids by the projecting snout and deep cleft to the mouth, which give it the look of a miniature shark. Its eye has a peculiar covering of skin, and it has a deeply forked tail, very small teeth, and a broad silver band on the sides. In colour, the back is dark green. This fish grows to a length of 7 or 8 in.

The anchovy is not known to spawn on our coasts, though it occurs regularly in the Channel during early winter, November being the month of its greatest plenty in the Plymouth district. These anchovies are looked upon as belonging to shoals returning from the spawning-grounds in the Zuyder Zee; but Cunningham shows, on the evidence of Returns in 1889 and 1890, that there is no direct relation between abundance in any season in Holland and in our own seas. Nor is there, as might perhaps be expected, a second shoaling on our coasts on the return journey.

The early development of this fish seems somewhat doubtful.

The egg differs in shape from other floating eggs, being more elongated. Its length is about $\frac{1}{20}$ in., and the yolk is covered with a network, like that of the pilchard, but has no oil-globule. It hatches out (at about 60°) in two or three days, and the larva is then rather more than $\frac{1}{12}$ in. The anchovy appears to develop rapidly, though its earlier stages have been but imperfectly studied. It is also said to spawn when two years old. Until 1896 no eggs of this fish had been obtained on our coasts.

Many attempts have been made to induce the fishermen to use finer-meshed nets to catch British anchovies, and it has even been said that these are, even if caught, not suitable for curing purposes. Cunningham mentions having sent some for trial to the celebrated dealers Messrs. Burgess, who said that those from Gorgona were far better; but that firm more recently assured the writer that the experiment had never been made on a scale sufficient for commercial test.

The Twaite and Allis Shad (*C. finta* and *C. alosa*) can hardly be omitted from this work on account of the similarity of their breeding habits and those of the excluded salmon or smelt, for they are essentially marine fishes that have taken to fresh-water breeding-haunts. There are several British rivers particularly noted for shad, among them being the Tay, Wye, and Severn. Of the last two Mr. Willis Bund, whose knowledge of the district, as Chairman for so many years of the Severn Fishery Board, is perhaps unique, writes to me (March 12th, 1902):

"Shad run up the Severn and Wye, very far up the latter. Both the twaite and allis shad run up the Severn, but the latter very rarely gets up to the fresh water, and comes in far smaller numbers than the twaite. I do not know any special law for their protection, but a smaller-meshed net is allowed in the Severn when they are in the river than is allowed at other times. The point that you suggest, whether they come under the Fresh-water Fisheries Act, has never to my knowledge arisen, and I do not well see how it can, for the fresh-water fish are almost all caught with rod and line, and the person fishing has the landowner's leave. I should say that they would not come under the Act, as it can be proved that they are not fresh-water fish, and are in the fresh water only three weeks; but it would raise a very pretty argument on the wording of the Act, which is wide enough to cover them if the words are read one way."

Mr. Willis Bund's remarks on the relative distances to which the two species ascend the Severn are of great interest, because they conflict with the observations of Ehrenbaum on the shad of the Elbe. In that river it is the allis which spawns as far up as Dresden, while the twaite remains below Hamburg.

The twaite enters every river on the Atlantic seaboard of Morocco, being called "shaval" by the Moors. The Bouregreg, at Rabat, and the Um Erbeya, at Azimur, are both visited by this shad each spring, and in the latter river the writer has bought these fish from the netsmen at the Spanish equivalent of a penny the pound.

The allis is the larger species, growing to a length of 4 ft., while the twaite is not known to exceed 16 in. Except that the latter has a row of indistinct spots along the sides and much fewer and thicker gill-rakers (*i.e.* about twenty or thirty in the twaite; sixty or eighty in the allis), the two bear a close resemblance. Like the pilchard, they have radiating lines on the gill-cover; their scales are small; and the edge of the belly is serrated. The teeth in the jaws are very small, and there are none on the tongue or vomer. They further resemble the pilchard in having the commencement of the dorsal fin nearer to the tip of the snout than to the base of the tail.

Shad feed on sprats and other small fishes, and are occasionally caught by amateurs in the Downs, near Deal. Otherwise they are netted, for the most part, in rivers, though a number are sometimes taken in the Plymouth mackerel seines.

One of the greatest feats achieved by State fish-culture in America is the transport of the shad from the Atlantic to the

Pacific seaboard, where it was naturally wanting. Artificial culture of shad, it is true, has been practised in European countries (*e.g.* on the Seine, at Elbœuf), but on a smaller scale than in the United States.

The eggs of the shad sink (in fresh water), but they lie separately on the bottom, and are not adhesive, like the demersal eggs of the herring. (The eggs of the American shad [*Alosa sapidissima*] are only a little heavier than the fresh water, and hang suspended a little above the bottom.)

Both species of shad appear to spawn in early summer, between May and July, the twaite possibly a little earlier than the other. The eggs, which measure when first deposited about $\frac{3}{50}$ in., are reticulated, like those of the pilchard, but have no oil-globule. In a temperature of 66° they hatch on the fourth day, and the newly hatched larva of the twaite measures rather less than $\frac{1}{6}$ in.

There is no comparison between the eggs and larvæ of the shad and salmon. The salmon deposits in a gravelly furrow eggs that measure approximately $\frac{1}{5}$ in. and that have many small oil-globules, and they take, under the most favourable circumstances, thirty-five days to hatch, so that, before emerging from the egg, the larva is already far more advanced towards the adult stage.

CHAPTER XII

THE FLAT-FISHES

WITH the exception of the dory and one or two of the rarer riband-like fishes inhabiting deep water, all the bony fishes hitherto considered exhibited a roundness of form, swam in the upright position, and had perfect symmetry on both sides, even to the smallest blotch or marking. In the rays, it is true, we found flattened fishes, but there was no want of similarity in the sides, for the apparent upper and lower surface of the ray is the actual back and belly of the fish, and the ray is therefore merely a compressed, or depressed, shark peculiarly adapted for residence at the bottom of the sea. That the upper surface should be coloured and the lower surface white is, therefore, only the same condition as we find in the upper and lower surface of the cod, mackerel, or gurnard. In the flat-fishes, however—the plaice and sole and turbot—we have a totally different condition. Here, what appears to be the back and belly of the fish is in reality the right and left side. The actual back and belly of the flat-fishes are the finny edges, which have become compressed out of all resemblance to the normal condition. Why, or when, the flat-fishes, as they are now known to us, developed this extraordinary shape and position, we cannot tell. They are not so when hatched from the egg, so that their ancestors in all probability swam as other fishes. But during the first few weeks of their existence they gradually lean over on one side (the left in most cases), which is henceforth pressed close to the sand and withdrawn from the action of sunlight. As a consequence, or, at any rate, as an accompanying condition, this left side is henceforth colourless. The left eye also works over to the right side, eventually taking up a position in line with the right. These remarkable metamorphoses are accompanied by a varying degree of malformation in the head of the fish, the extremes of which are perhaps marked by the plaice and halibut, the former wearing a curiously wry expression on its face, the latter, which is also the largest of the family, being, in facial appearance, little different from a round fish.

This final position of the eyes, both on the same side, clearly separates the flat-fish from all flattened round fish, such as the dory. Abnormal examples, having an eye on either side, are not very rare, and these usually have both sides similarly coloured, thus further conforming to the condition of round fishes. Mr. Holt* has, however, described an adult female sole, measuring 15 in., which had one eye on either side, but the colouring normal—that is to say, confined to the upper side. Though the abnormal eye was somewhat impeded in its action by an overgrowth of skin and by sensory filaments, there was no reason for supposing that the fish could not see with it, or that, in fact, the uncoloured side was permanently out of the sphere of influence of direct light.

Another particular in which these flat-fishes, even in a single species, show marked difference is the roughness or smoothess of the skin. Thus, the flounder has rough scales, and the turbot has no scales, but rough tubercles in their place. But there is a wide range in either species. Flounders from the Mediterranean are found to be quite smooth, while those taken from the Baltic Sea are even rougher than those on our coasts. Turbot, again, from the Norwegian fjords are far more profusely studded with tubercles than those caught in the English Channel, and often have tubercles on the lower surface as well as on the upper. The plaice is yet more

* See *Journ. Mar. Biolog. Assoc.*, October, 1894, p. 188.

variable. Holt* has described a race of dwarf Baltic plaice with spinous, or ciliated, scales—a character unknown in the plaice of our grounds ; and Cunningham † once made a detailed comparison of the different races of plaice from representative grounds between Plymouth and the Dogger Bank, in which he was able to show a great margin in respect of many distinctive characters.

Colour variation is also a common phenomenon in the flat-fishes. As has already been described, the colouring is usually confined to the upper (in reality, right or left) surface. In nature, however, all manner of changes are rung on this condition, and examples are recorded with the colouring only on the wrong side, or with equal colouring on both. Bateson ‡ describes small brill and plaice sent to him from Mevagissey by the late Matthias Dunn, as well as flounders captured in the shallow water of Bournemouth Bay, all of which had colouring on the normally white, or "blind," side. With reference to the Bournemouth flounders, the writer has, during a residence of seven consecutive winters at that town, repeatedly remarked these curiously coloured flounders in the shops, and has been given to understand that they were caught by Poole boats in the bay. In many examples the spots on the usually "blind" side coalesce in such manner as to present a considerable surface of brown colour. The most interesting record, however, with regard to the colouration of one side only in flat-fishes, and particularly with reference to the theory of the influence of light, is that of Mr. Cunningham's experiments § in the artificial colouring of flounders confined in a tank with mirrors so arranged beneath as to throw up the light on the lower side of the fish. In this way he actually succeeded in colouring the lower side of a flounder, which

* See *Journ. Mar. Biolog. Assoc.*, October, 1894, p. 194.
† See *Ibid.*, March, 1897, pp. 315-359.
‡ See *Proc. Zool. Soc.*, 1894, p. 246.
§ *Journ. Mar. Biolog. Assoc.*, May, 1893.

lived under such treatment for more than three years. The same observer records an abnormal piebald plaice with much less than the usual development of colour on the upper side. Mr. Cunningham is, in fact, one of the greatest living authorities on the present group, and his widely read monograph on the common sole, published some years ago under the auspices of the Marine Biological Association, is perhaps the most exhaustive treatise ever written on a single economic fish. Only one other account of a single flat-fish, at any rate in the English language, is worthy of comparison, that of the plaice, by Mr. F. J. Cole and J. Johnstone, of Liverpool, which appeared in far less elaborate form in the 1901 *Report on the Lancashire Sea Fisheries Laboratory*.

Wonderful as are the flat-fishes, however, as absorbing in their life-history to the naturalist as are their capture and sale to the merchant, many legends have been weaved around them that have only the slightest element of truth. By a singular lack of fairness, those who take a pleasure in manufacturing natural history always choose for their subjects not the least interesting animals, to which some such adventitious interest might be a gain, but those which are already so remarkable that any improvement on their peculiarities is superfluous. The amazing changes undergone by larval flat-fishes, already described in the sixties by Professor Traquair, were not enough, but men must add fictions of their own. According to some, they were descended from shrimps; according to others, shrimps were a mere stage in their development. Others confused their spawn with that of sea-worms; and a not uncommon disease of the flounder, which causes a local granulation of the skin, was construed into a story that the flounder, like the Surinam toad, hatched its eggs out in pits in its own back.

These flat-fishes may be divided, following Cunningham and other accepted authorities, in four groups, in the first three of which the eyes and colour are on the right side, while in the fourth they are on the left. The development of teeth in either jaw represents, however, a more satisfactory character. In the plaice, dab, and flounder, representing the first group, there is unequal development in two sides of the jaws. In the halibut, representing the second, the teeth are equally developed in both sides. In the sole, representing the third, there are teeth on one side only.

The fact that the so-called upper and lower surface of flat-fish are in reality the right and left side is at once made apparent by the presence of the lateral line along each. The terms "right" and "left," by the way, are used in respect of an observer holding the edge with the mouth and vent towards him. The dorsal fin runs along the edge farthest from the mouth; the ventral fin is long; and the vent lies close to the head.

As in the case of the cod family, one or two rarer kinds of the present group have been briefly noticed in Chapter XIV. Those described in the present chapter are as follow:—

SUB-ORDER: HETEROSOMATA

FAMILY.	COMMON NAME.	GENUS.	SPECIES.
PLEURONECTIDÆ	Plaice	*Pleuronectes*	*platessa*
	Dab	*P.*	*limanda*
	Flounder	*P.*	*flesus*
	Lemon Dab	*P.*	*microcephalus*
	Witch	*P.*	*cynoglossus*
	Halibut	*Hippoglossus*	*vulgaris*
	Long Rough Dab	*Hippoglossoides*	*limandoides*
	Brill	*Rhombus*	*lævis*
	Turbot	*R.*	*maximus*
	Megrim	*Lepidorhombus*	*megastoma*
	Topknot	*Zeugopterus*	*punctatus*
	One-spotted Topknot	*Z.*	*unimaculatus*
	Norwegian Topknot	*Z.*	*norvegicus*
	Scald-fish	*Arnoglossus*	*laterna*
		A.	*grohmanni*
SOLEIDÆ	Sole	*Solea*	*vulgaris*
	French Sole	*S.*	*lascaris*
	Thickback	*S.*	*variegata*
	Solenette	*S.*	*lutea*

During the greater part of their life, when full-grown, these flat-fishes reside close to the bottom, lying, in fact, in the sand or gravel, which often affords them a high degree of colour-protection. Cunningham gives in his monograph an admirably coloured plate of a sole lying in gravel; but an even more striking approximation of the fish to its surroundings may sometimes be seen in aquarium tanks, and the writer has seen more wonderful examples of this at the Plymouth tank-house. Allusion has already been made to the variation in colouring in this group.* As long as the flat-fish lies on the bottom, its colouring is of great service to it. Occasionally, however, even large dabs or turbot are seen swimming near the surface, and in such a position they are peculiarly conspicuous. The largest halibut and turbot prey on fish, but the rest feed on worms, molluscs, and crustaceans, which are sucked into the twisted mouth and seized in the small, sharp teeth. The fins are without spines (which is also the case in many round fish, such as cod and herring), though the plaice and lemon dab have a sharp spine before the anal fin.

All the flat-fishes of our coasts lay floating eggs, even the flounder of our rivers going down to the sea to deposit its eggs in salt water, like the eel. Here we have a converse case in respect of the habits of the salmon. That fish comes into fresh water, apart from all question of ancestral habitat, in order that its egg may sink in the shallow fresh water and lie safe in the furrows that it makes for the purpose. The flounder, on the other hand, could not possibly lay its buoyant egg in the tidal waters of rivers if it were essentially a fresh-water fish, for the eggs would inevitably be carried down to the sea, and the salt water would kill the embryos. The groups under notice must be regarded as closely related to the cod family, described in an earlier chapter.

* See also McIntosh in *Ann. and Mag. Nat. Hist.*, April, 1902, p. 291 and Patterson in *Trans. Norf. and Norw. Nat. Soc.*, 1891-2, p. 326.

Pleuronectidæ

I.—Group in which the Teeth are Largest on the Lower Side

The Plaice (*Pleuronectes platessa*) is an almost solitary exception to the general rule of a familiar fish on all parts of our coasts having a great variety of local names. Another of the genus, the lemon sole, goes by a different name at almost every port; but a plaice is a plaice in localities hundreds of miles apart. Certainly the fish is an unmistakable form, since its orange-red spots are not found in any other flat-fish of our seas. The head has an even more twisted appearance than that of most flat-fishes; the eyes are in line and on the right side, separated by a bony ridge. In all flat-fishes the eyes lie just above the sand when their owners are at rest, and to Holt is due the credit of discovering and describing a sac-like membrane, the use of which is to regulate the vertical movements of the eye. Such an apparatus must obviously be of great use to animals that pass a great portion of their existence under these conditions, and the discoverer not unreasonably looked for a similar arrangement in the weevers, which also lie with their eyes just above the sand, but the search was not successful.* The scales of the plaice, which extend to the face, are very small, so that a newly caught plaice feels slimy when handled. The lateral line is nearly straight, with only a slight curve over the pectoral fin.

In colour the plaice is deep brown, with the aforementioned orange-red spots on the right side; the left, or lower, side is pure white. Further, this white side is perfectly flat, whereas the coloured side is convex. A sharp spine points forward just before the anal fin. The dorsal fin starts above the eyes. The cleft of the mouth is narrow; the teeth are broad and somewhat blunt, largest on the white

* See *Proc. Zool. Soc.*, 1894, p. 431.

side ; on the coloured side they are both fewer and smaller. There are no teeth in the palate.

As to the size of this fish, this varies in different parts of our seas, while the Baltic produces small plaice just as it also produces small cod. Cole and Johnstone, whose memoir on this fish has already been noticed, give 33 in. as the length of the largest plaice on record, and its weight at 15 lb. Cunningham gives 28 in. as the maximum length for Scotch waters ; 24 in. for the Plymouth district ; and 26 in. for the west coast of Ireland. He makes allusion to "several inches longer than 30 in." farther north, but gives no actual examples.

The distribution of the plaice in European seas is general, though variable. It ranges to the colder waters of the north, and is found in the Bay of Biscay, but it is scarce throughout the Mediterranean. According to Cunningham, it feeds by preference on the razor-fish, particularly on its so-called "foot," and also on cockles, lugworms, ragworms, sand-stars, and occasional shrimps.

The plaice spawns in the English Channel and North Sea during the first three months of the year ; in the eastern portion of the Channel and in the North Sea possibly until May ; and in all seas at a considerable distance from land. According to Cole, the female deposits about 300,000 eggs, a smaller number than would be deposited by the average round fish of the same size. The egg, one of the largest of the flat-fish type, has a diameter of nearly $\frac{1}{12}$ in. The capsule is tough and slightly corrugated, and there is no oil-globule. The egg, being large, develops slowly, and takes, even at spring temperature, ten or twelve days to hatch. It floats near the surface, where herrings devour it along with copepoda.

The larva measures about $\frac{1}{5}$ in., and has small black and yellow spots on the body and head. The entire change, from the symmetrical round fish type, in which the plaice

Photo by Reinhold Thiele

⅓ Natural Size

PLAICE (*Pleuronecles platessa.*)

emerges from the egg, to the distorted shape of the adult, occupies about six weeks. The yolk-sac disappears in eight days, and the larva is now entirely dependent on other food, to which, however, it probably accustoms itself gradually even before nature's supply is exhausted. This early food consists of diatoms; at a later stage the little fish would be able to devour copepoda; and finally it would chase small shrimps. By the beginning of the seventh week the little plaice swims in its new position, the left eye lies alongside the right, the head is twisted out of its former plane, and the left side loses all colour. Larval flat-fishes are preyed on in these early days by jelly-fishes, and Masterman figures one (*op. cit.*, p. 56) swallowing a tiny flounder.

The rate of growth of the plaice has been much discussed. Observations are necessarily based on either examples reared under artificial conditions, or else on the spoils of the tow-net, with gaps and uncertainties that render positive pronouncements extremely difficult. As a case of actual experiment, Dannevig found that plaice on the Scotch coast grew about 3 in. in the year, most of this increment being credited to the warmer months. This yearly growth is, however, known only up to the third year inclusive.

The size at which the plaice becomes mature—that is to say, capable of depositing or fertilising ova, is of great importance (see Chapter II.) in all questions of prohibitive legislation. It would seem that the male is always mature at a smaller size than the female; but these sizes vary according to locality, and it is this variation that furnishes the chief obstacle to legislation. Thus, Cunningham gives 15 in. for the Channel; Holt 17 in. for the North Sea; and Petersen much lower sizes (10-13 in.) for the Danish coast.

The plaice is generally distributed round the British Islands, but the larger fish keep out in the deeper water, up to about 100 fathoms, outside of which line none are caught.

Cole alludes to a remarkable condition of the Baltic, which, arising out of the normally low and periodically lower specific gravity of that sea, explains the long-discussed absence from that sea of the very young plaice under 2 or 3 in. in length. About once a month, according to Hensen, the Baltic is of such low specific gravity that the plaice eggs sink; and the inference is that their development is thereby permanently checked, since floating eggs are not adapted to healthy development at the bottom of the sea. The extraordinarily low percentage of salt in that sea can hardly be appreciated by those who have neither bathed nor fished in it; but the writer well remembers, though twelve years have elapsed since he resided on its shores, the comparative difficulty of keeping afloat on its surface for one accustomed to sea-bathing in the Channel and Mediterranean, and also the curious sensation of catching, a mile or two from shore, such a medley of sea- and river-fish as plaice, pike, perch, and cod, not necessarily on the same ground, but within an area of probably less than an acre. The low percentage of salt is not difficult to account for in a sea that, having no outlet save the narrow strait that connects it with the North Sea, receives so many torrential waters from the melting snows of southern Scandinavia, besides so many slower yet broader streams from the lowlands of northern Russia and Germany. The curious variations in the salinity, however, have yet to be satisfactorily understood.

According to Cole and other observers, the young plaice follow a very general rule of inshore migration, seeking the shallows in the warmer months and the deeper banks in cold weather. The writer named also quotes a remarkable case of irregular migration on the part of large plaice, which was brought to his notice by Mr. R. L. Ascroft. A heavy storm, in 1885, washed the "sand-pipes" (*Pectinaria*) off the deep-water banks into a channel of the Ribble estuary, and there, for about four days, the sailing trawlers caught as many as

180 score of plaice apiece each day, the plaice having no doubt followed the food.

The Dab (*P. limanda*), a light-brown fish that lacks the red spots of the plaice, but has similar spots in dull brown, is, on account of its spiny scales, a rougher fish when handled. The ridge over the eyes is, however, smooth, not rough as in the plaice. The lateral line also has a characteristic abrupt curve round the pectoral fin. As in the plaice, there is a spine before the anal fin, but, unlike the plaice, the present species has scales along the rays of the dorsal and anal fins. The largest recorded dab in British waters measured 15 in., and examples of 10 in. are much more common. The females are both slightly larger and also much more numerous than the other sex.

The dab, the smallest member of the genus in our seas, is a northern fish, being absent from the Mediterranean, but occurring throughout the Baltic. It feeds chiefly on hermit-crabs and other crustaceans, as well as on sand-stars, razor-fish, and worms. It attains to maturity when 4 or 5 in. long, and spawns at a considerable distance from the land between March and June. Dr. Wemyss Fulton has reckoned that a dab of $8\frac{1}{2}$ in. deposits 128,812 eggs. The egg is smaller than that of the plaice, and, like it, has no oil-globule. It measures only about $\frac{4}{125}$ in. Cunningham succeeded in artificially fertilising them at sea in 1886, and he also hatched them at the Granton Laboratory. At a temperature of between 45° and 60° F. they hatched in three days, but at St. Andrews in May, at a much lower temperature, they took twelve. The larva measures rather over $\frac{1}{10}$ in., and has light yellow spots on the head and tail.

Young dabs, plaice, and flounders can only be distinguished with the greatest difficulty. The number of fin-rays, of which much is sometimes made, is not a very reliable character as distinguishing dabs from plaice, though it effectually separates both from the flounder. Prof. McIntosh alludes to the fact that shrimp-trawlers catch young dabs of 3 in. or less in the Thames estuary in October, and he is of opinion that the smallest of these (measuring perhaps $1\frac{1}{4}$ in.) are at least $3\frac{1}{2}$ months old, while the largest would be eight or nine months. The market price of the dab is considerably lower than that of the plaice, but it is quite equal as food to the more popular fish.

The Flounder (*P. flesus*), or Fluke, though correctly reckoned among sea fish, has a partiality for brackish or even fresh water in all but the spawning-period and finds its way a long distance up many of our rivers. According to Cunningham, it cannot, however, spawn in fresh water, for its eggs, as already explained, must float in order to develop and they would be washed out to sea and dispersed in a medium unfavourable to their development.

The flounder may be distinguished by its small, smooth scales, and by the fact of those behind the head and along the bases of the fins being rough and spinous. In colour this fish is very dark on the upper side and bright white beneath. It was on the flounder that Cunningham made his interesting experiment, already described, in artificial colouration by reflected light. The flounder has from forty to forty-five fin-rays in the ventral fin, fewer therefore than in either the plaice or dab. The largest flounder on record probably measured less than 20 in., though there is some difference of opinion as to its maximum size. Day's estimate of 8 or 9 in. as its greatest length is clearly a misprint for 18 or 19 in.

The food of the flounder consists in great part of small crustaceans and molluscs, while in the aquarium it takes worms more readily than anything else.

As usual in the flat-fishes, the female is slightly the larger sex, but, according to the calculations of Dr. Fulton, the males are considerably the more numerous, which is unusual.

The flounder, which reaches maturity at a length of 7 in. in the female and less than 5 in. in the male, spawns chiefly in the months of March and April, though in some localities it may begin to spawn as early as February, while in others it may not have finished until early in June. It is one of the fish that spawn regularly in the Plymouth tank-house, between the beginning of March and the beginning of May. The natural spawning-grounds are not more than about 10 miles from land, in water of 30 fathoms or less.

The egg of the flounder measures in diameter rather less than $\frac{1}{25}$ in., and is therefore intermediate in size between those of the plaice and dab. It is round and transparent, has no oil-globule, and floats in the water. At a temperature of about 53° F. it hatches in seven days after fertilisation. The larva measures about $\frac{3}{25}$ in., and has black and yellow spots on the head and body. These presently cover the fins and tail, the latter in a broad band. Professor McIntosh has recorded an interesting fact in the early history of the flounder. He found some years ago that the post-larval form, measuring perhaps an inch in May, is preyed on by sparrows that seize it in the shallow rock-pools left by the ebbing tide. The flounder, even at that early age, while still transparent, evidently shows that preference for estuaries and the neighbourhood of land generally which clings to it through life, save only when the demands of its pelagic egg compel it to seek the denser, deeper water outside.

The Lemon Dab (*P. microcephalus*), or Lemon Sole,* is of a warm yellow colour mottled with dark and light spots. In shape it is more exactly oval than any other British flat-fish of either the sole, plaice, or turbot group. The scales are very small and smooth, so that the lemon dab feels slimy to the touch, and they cover the entire fish, even the upper surface of the fins. The lateral line is only slightly curved behind the head. The head itself is small; the mouth also is small, and the teeth are blunt and more developed on the "blind" side.

* This must not be confused with a congener of the true sole, *Solea lascaris*, also called by this name.

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* This must not be confused with a congener of the true sole, *Solea lascaris*, also called by this name.

The number of rays in the ventral fin is about seventy-five, one or two more or less, and therefore far in excess of the number in any other British flat-fish, except the witch. As in the foregoing kinds, the eyes and colour are on the right side. The largest recorded lemon dab measured 18 in.

This fish, also known as "merry sole," occurs on every part of our coasts. It is a northern form, absent from the Mediterranean.

The lemon dab, which reaches maturity at a length of between 6 in. and 8 in., spawns over a long period, chiefly between March and May in the Plymouth district, but elsewhere from February until June. That is to say, it would not spawn through all those months in any one locality, but in some parts it might spawn as early as the first-named month, while in others it would not be done spawning until the last. Not only does the lemon dab spawn at a considerable distance from land, but is throughout life a moderately deep-water fish.

The egg, which was first studied during the 1884 Forth trawling expeditions, is small, measuring only a little over $\frac{1}{20}$ in., and is thus intermediate between those of the plaice and flounder, closely resembling both in structure, though McIntosh distinguishes in it a peculiar sheen, which he attributes to the wrinkled surface of the capsule, comparable in appearance to Morocco leather. The egg has no oil-globule, and floats in the water. The larva is slender in shape, and measures about $\frac{1}{7}$ in., showing well-developed, dull, greenish-yellow spots. It is extremely hardy, having been known to live six days in a small glass cell only $\frac{1}{2}$ in. deep.*

McIntosh and Masterman give an interesting series of figures of the lemon dab in nine stages, a July specimen showing a remarkably conspicuous blue eye. Cunningham remarks that the later larval stages had never (previously to 1896) been taken, except during the Irish survey, when they were described by Holt. That naturalist was also the first to

* McIntosh and Masterman, *op. cit.*, p. 369.

record (in 1892) young lemon dabs from the Humber estuary in autumn, previous to which they had been thought to keep out in deep water. Two years later Cunningham found the young stages in the Brightlingsea shrimp-trawls. These small lemon dabs are commonly infested with young crustaceans (*Caligi*) parasitic on their fins.

The Witch (*P. cynoglossus*), or Pole Dab, is hardly to be regarded as a Channel fish, though it does occur on our south coast. On the other hand, it is locally plentiful in the North Sea and on the west coasts of both Scotland and Ireland, while McIntosh and Masterman describe it as not uncommon on the muddy grounds of the Moray Firth. In its earlier stages, at any rate, it inhabits the deeper water offshore.

In colour the witch is a pale brown on the upper side, and there is a dull stain over the lower. The body is oval and elongated, the eyes are large, the mouth is small, and the teeth blunt and lying in one row. The lower side of the head has curious pits or depressions under the skin, first noticeable when the young fish measures rather less than 2 in. The distinguishing character of the witch, however, for easier observation lies in the extraordinarily large number of its fin-rays—over one hundred in the dorsal and often over ninety in the ventral. The scales of the upper side are somewhat rough.

In Scotch waters the witch grows to a length of about 20 in., and it feeds on worms, crustaceans, molluscs, and sand-stars. The females are slightly larger than the males and are almost double their number.

The witch spawns, in Scotch waters, between May and August, chiefly in July. The female deposits from half a million to 800,000 eggs, and the egg measures considerably under $\frac{1}{20}$ in. It is round and buoyant, and takes about a week to hatch. The larva measures rather less than $\frac{1}{6}$ in., and is distinguished from that of the dab by its very little pigment. When a couple of days old, it is slender and has more pale yellow colouring.

II.—Group with Equal Development of Teeth on Both Sides

The next two fishes represent the second group, with a much larger mouth and an equal development of teeth on both sides.

The Halibut * (*Hippoglossus vulgaris*), pronounced "Holibut," is the largest flat-fish in existence, and is said to exceed a length of 20 ft. Specimens of over 7 ft., and weighing two or three hundred pounds, have often been recorded.

The halibut is less like the typical flat-fish than any of the rest, even than the allied long rough dab.

The mouth is large, and there are teeth of equal size and number in both sides of the jaws. The skin is perfectly smooth, and the lateral line curves somewhat abruptly round the pectoral fin.

In colour, the halibut is very dark green or brown above, with mottlings ; the under side pure white.

It is a more northern fish than any of our other flat-fishes, for it does not occur, so far as is known, south of the English Channel, though common in Iceland seas, and in fact in the Arctic waters of three continents. It also inhabits deep water, up to 120 fathoms. On our own coasts, therefore, the halibut is most plentiful in the north-east. It feeds on fish and large crustaceans.

The spawning-time covers at any rate the period between April and August, and probably even longer. Mr. Holt first described the egg of the halibut in 1892. It varies considerably in size, but an average egg measures $\frac{3}{20}$ in. There is no oil-globule, and the egg is clearly of the buoyant kind, though it has not actually been seen floating in the water, Mr. Holt having obtained only dead eggs from a fish in the market at Grimsby. Dr. Wemyss Fulton subsequently

* This is the "turbot" of Scotch fishmongers, just as their "sole" is the lemon dab !

described other ripe eggs of the halibut, in which the capsule was noticeably very thin and punctured all over. McIntosh and Masterman figure a young larval halibut, after Petersen, in which the more or less symmetrical form of the grown fish is already apparent. According to the same authorities, the mixed diet of the full-grown halibut, which includes fish, is already characteristic of these early forms, which feed on shrimps and young flat-fishes.

The Long Rough Dab (*Hippoglossoides* * *limandoides*), though showing approximately the same outline as the halibut, and also having the same similarity of teeth on both sides of the jaws, is a very different fish. In the first place, it is only a pigmy compared with halibut, the largest on record not exceeding a length of between 16 and 17 in. Again, the long rough dab is, as its name indicates, a very rough fish, its scales being spinous on one edge. Its lateral line is straight, which further distinguishes it from the halibut. The colour is also lighter, and there are rarely any spots.

In distribution, the present species agrees closely with the halibut, being plentiful in Arctic seas, but absent from the more southern waters of Europe. In the English Channel it is comparatively rare.

The long rough dab feeds on crustaceans, sand-stars, fishes, worms, and molluscs, the fishes including smaller examples of it own species.

The spawning-time lasts in Scotch waters from February until May, March being the chief month. The egg, which was first found in the 1884 trawling expeditions, measures about $\frac{1}{20}$ in., though the membrane surrounding it may have a diameter of as much as $\frac{1}{12}$ in., the intervening space being considerable. The newly hatched larva is less than $\frac{1}{6}$ in. In a few days after hatching it has dark yellow bands on the tail.

* McIntosh and Masterman give preference to the generic name *Drepanopsetta* for *Hippoglossoides*.

III.—Group with Eyes on the Left Side

The following group of flat-fishes differs from the foregoing (and from the soles that follow) in having the eyes (and colour) on the left side. The teeth are equal and similar on both sides of the jaws, and there are also teeth on the vomer. The dorsal fin commences in front of the eyes.

The Brill (*Rhombus* * *lævis*) is a familiar table fish, though less known, perhaps, and certainly less excellent as food, than the turbot. It resembles the latter in shape, but has a perfectly smooth skin, devoid of tubercles, with small scales almost embedded. The colour is light brown, with mottlings and specklings, but these vanish after death, and the colour also darkens. It grows to approximately the same size as the turbot, the female being larger than the male. A large female measuring 26 in. and a large male of 23 in. are both on record.

In distribution the brill and turbot agree closely, being warm-water fish, occurring throughout the Mediterranean, but absent from Arctic seas and even rare as far south as Shetland.

The brill feeds chiefly on fishes, sand-eels being the favourite food, while in the Plymouth district it prefers the pout.

The spawning-time is from April to June, the brill reaching maturity at a length of 10 or 13 in. The egg, which measures over $\frac{1}{25}$ in., has a single oil-globule. The larva has not been satisfactorily described, though McIntosh and Masterman give a detailed account of a hybrid between brill and turbot. Raffaele describes pure brill larvæ of about $\frac{3}{8}$ in., still equal-sided, swimming upright, and having dark bands across the body. These bands seem to distinguish larval brill from larval turbot. Cunningham describes young brill hatched in the Plymouth aquarium. One of these, about six months old, measured nearly $3\frac{1}{2}$ in. Two were kept until the April

* McIntosh and Masterman give preference to the generic name *Bothus* for *Rhombus*.

following, and were then no longer than the others that had been removed in October.

The Turbot (*Rhombus maximus*) has incidentally been referred to in describing the brill. It has no scales, but in their place rough tubercles, and in some examples, those particularly from the Norwegian coasts, these extend to the uncoloured side. The body is also broader than that of the brill, and the eyes are proportionately smaller. The colour is somewhat lighter, and spots are numerous and conspicuous even after death. Colour protection is admirably illustrated in the turbot, and the writer has seen small examples lying in the shallow, calm water under Bournemouth Pier in July and August which could scarcely be distinguished until something disturbed them. The turbot has much fewer fin-rays than the brill. The recorded largest examples somewhat exceed the measurements of those of the brill, a female of 28 in. being given in Dr. Fulton's fishery reports. Like the brill, this fish is plentiful in the Mediterranean and on our coasts, but is not found in the northernmost waters of Europe.

The turbot feeds on other fish, chiefly sand-eels, though pout and small flat-fishes are also eaten, while Cunningham mentions boar-fish. Nothing but fish has been found in examinations of the turbot's stomach; but the writer has caught several on mussel bait, though sand-eel was always considered preferable when it could be had.

The spawning-time of the turbot is between April and July, inclusive, and the number of eggs in a large female of 21 lb. has been calculated at upwards of ten millions. The egg measures $\frac{1}{25}$ in., which is small, considering that the flounder lays an egg of the same size. It has a single yellow oil-globule.

The egg has been known to hatch out in nine days after fertilising; and the larva measures about $\frac{1}{12}$ in., and has reddish yellow spots. It is very active, darting about in the tank within a day or two of hatching ; and McIntosh says that actually after being exposed on a microscope slide in only a drop of water for over two hours the small turbot recovered its vitality when restored to the tank. It is also active in chasing small crustacean forms, which at that early stage furnish its principal food. It has a strong preference for living food, and chases its prey at the surface of the sea. It is a curious fact that, although the air-bladder is absent in all flat-fishes in the full-grown stage, the larval forms and transitional stages possess that organ. The small turbot would swim upright, like a round fish, until the metamorphosis of the eyes commenced ; but as soon as the transformation begins, the fish leans over to the right side, and swims henceforth with that side lowermost.

The Megrim (*Lepidorhombus megastoma*), otherwise Sail-fluke, or Whiff, is a rough-scaled, thin-skinned fish ; in colour, pale yellow above and sometimes showing dull markings on the white side. The head, mouth, and eyes are large. This flat-fish grows to a recorded length of just under 2 ft., and is plentiful on the coasts of Devon and Cornwall, less so on the shores of the North Sea, and possibly altogether absent from the Mediterranean. This very restricted range, excluding both the colder northern and the warmer southern seas, is hardly in keeping with what we know of the distribution of other flat-fish, and Cunningham offers a more likely explanation on the ground that in all probability the megrim keeps on certain coasts outside of the limit usually worked by trawlers, and may thus escape notice. Whether the results of the deep-water hauls during the Irish survey were in themselves sufficient to warrant such a theory is not clearly stated ; but this view bears on it the imprint of probability.

Like the brill and turbot, the species under notice feeds almost entirely on small fishes, particularly sand-eels.

The spawning, at any rate, appears confined to deep water,

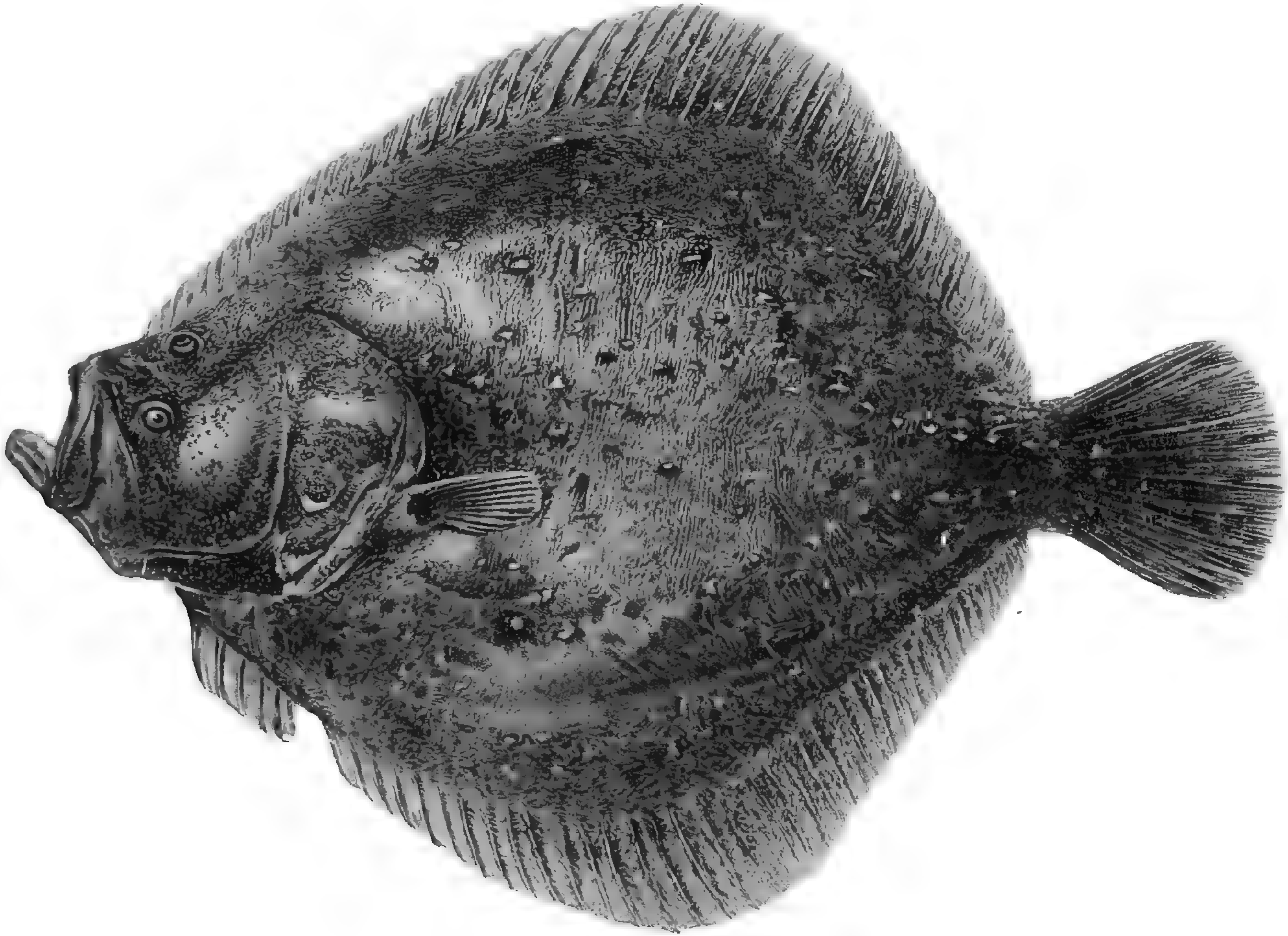

Photo by Reinhold Thiele

⅓ Natural Size

TURBOT (*Rhombus maximus*)

and takes place between March and May inclusive, a female of 18 in. having been computed to contain not far short of half a million eggs.

The egg measures less than $\frac{1}{20}$ in., and has a single oil-globule. The surface of the capsule is covered with ridges and punctures, resembling, therefore, the egg of the brill. Hatching takes place, in spring temperature, on the fifth or sixth day, and the larva is dotted with black, yellow spots appearing on the fourth or fifth day. In a fish of rather less than $\frac{4}{5}$ in. the transformation is almost complete, but there are as yet no scales. These first appear at the tail end, when the fish is rather over an inch long, and do not extend over the rest of the body until the fish is 2 in.

The Scald-fish (*Arnoglossus* * *laterna*), or Scald-back, derives its vernacular name from the scalded appearance of the body when the fragile skin is roughly handled and in consequence peels off. Even the action of the trawl, and the contact with débris in the net, suffices to produce this effect. Although the skin is so thin, the scales are rough and spinous, though in a lesser degree than those of some flat-fishes already described. This roughness is confined to the upper side, on which also the scales are larger than on the lower. This is the only British flat-fish in which there has so far been any recognition of secondary sexual characters, of which several examples have in previous chapters been given in connection with the round fish. The male has the first rays of the dorsal fin (which has in all from eighty-seven to one hunded rays) elongated; but this character is not seen, save to a very small extent, in females, and is quite wanting in young males. Nor is it actually associated in adult males with maturity, since that stage may precede it by a considerable time. The mouth of the scald-fish is almost as small as that of the plaice, the teeth being, as in the rest of the present group, equal on both sides.

* Prof. McIntosh prefers *Platophrys*.

There seems to have been some confusion in name between this fish and the last, but "scald-fish" is so descriptive that preference may be given to it. It has a wider range than many of our flat-fish, for it occurs both in the far North and in the Mediterranean. It was trawled at Plymouth in June, 1897, and its eggs were hatched in the Association's tanks. Professor Herdman * mentions it as occasionally trawled in the estuary of the Dee, and says that in that locality it attains only to a length of about 7 in. This, however, appears to be near the limit of its growth elsewhere as well, though Cunningham mentions one of 8 in. taken near Plymouth.

The scald-fish spawns in April and May. The egg is very small, measuring in diameter only $\frac{1}{40}$ in., and has a single oil-globule. According to Ehrenbaum the larva measured about $\frac{1}{10}$ in. or rather less, and showed touches of red. Holt describes young scald-fish of an inch in length with black dots irregularly distributed on the body.

The allied *A. grohmanni* was trawled at Plymouth in 1897 and 1898, and Holt describes the egg as measuring about $\frac{1}{40}$ in., with a single oil-globule, and larva as distinguished by two dark bands, one near the tail. The eggs have also been taken at the surface in the neighbourhood of the Eddystone Lighthouse.

The Topknots commonly described as British are three in number.

Müller's Topknot (*Zeugopterus punctatus*), or Common Topknot, otherwise "Browny," is a small brown fish with large dark blotches, growing to a length of 6 or 7 in The skin is very rough, owing to the spinous scales, and the fins extend right around the edge of the body, joining the tail. The head is short, the mouth large, and there are teeth in a band on the jaws and on the vomer. On the lower, colourless side the skin is smooth.

This topknot is not found in the Mediterranean, but

* *Fishes and Fisheries of the Irish Sea*, p. 52.

its range includes the most northern parts of the Scandinavian coast.

The spawning-time is said to be in spring and summer—a somewhat wide range. McIntosh quotes Malm to the effect that a nearly ripe egg measured just over $\frac{1}{25}$ in., the larva measuring about $\frac{1}{10}$ in., and having yellow dots on the fins. The egg has a single oil-globule, like the rest of the present subdivision of flat-fish. The yellow on the fins became deeper and extended to the head after a few days.

The One-spotted Topknot (*Z. unimaculatus*) is rough on the lower side as well as on the upper, a most uncommon condition in flat-fish, and only familiar otherwise in some turbot from Norwegian seas, in which the tubercles grow on both the right and left sides. As further grounds of distinction from the commoner species, we have the dark spot in the middle of the coloured side, from which the present subject takes its name, and also the greater length of the first ray of the dorsal fin. There are also gaps in the marginal fins, which is not the case in the common kind.

The distribution is somewhat more southern, for the one-spotted topknot occurs sparsely in the Mediterranean, but is said to be absent from the most northern waters inhabited by the other. Mention has already been made of the preference which these topknots have for rocky ground, and of their power of clinging to the surface of rocks. It may therefore be, as Cunningham suggests, that this has placed them out of danger of the trawl in many localities, where they are in consequence less rare than commonly described. This is a smaller topknot than the last, having been recorded to a length of no more than 5 in.

The ripe egg, taken from a fish in 1892 (which was not, however, fertilised), measured, in spirit, nearly $\frac{1}{25}$ in. On a subsequent occasion (1897) another ripe fish was taken at Teignmouth, and the eggs were in this case hatched out in the Plymouth tanks.

The Norwegian Topknot (*Z. norvegicus*), smallest of the three and mature already when only 3 in. long, is commonest in the Channel, but does not extend much farther south. It is less rough to the touch than the others, and the front ray of the dorsal fin is not long, as in the last species.

The egg measures rather under $\frac{1}{25}$ in., not $\frac{9}{25}$ in. as Cunningham gives it, an obvious misprint, since he gives the correct measurement in millimetres. (At $\frac{9}{25}$ in. the egg would be half again as large as the salmon's, rather a remarkable feat for a fish 3 in. long, and one that would make it a very kiwi among fishes !)

Soleidæ

Of the *Soleidæ*, the second family of flat-fish as at present classified, one is the most important of the whole sub-order, and three closely related forms are neither familiar nor valuable.

These fishes have several peculiarities which serve to distinguish them from all the flat-fish hitherto enumerated. In the first place, they have teeth only on the underside, and the mouth is more twisted and smaller than even in the plaice, which approaches nearest to their condition in this respect. The twist of the mouth gives the snout a curious projecting appearance, which develops in large examples into a hook. This may be seen by no more than a casual glance at the soles lying on the fishmonger's slab. As another distinction, the lower side of the head has a kind of beard, while the eyes are small, and the dorsal fin commences in front of them.

The Sole (*Solea vulgaris*) has all these characters, and is too familiar a fish to need any detailed description. In colour it is a variable brown above, with darker streaks or blotches, and white below. The upper side is, however, subject to great variation, for, as already mentioned, the sole relies in no small degree on colour protection. The largest recorded sole was 26 in. long, but nowadays a sole of 12 in. may be regarded as an average fish. The twisted mouth, the curved jaws, the absence of teeth on the upper side, the small eyes, the oval body are all characteristic of this family. The beard-like arrangement beneath the head there takes the place of scales. The most detailed and useful account of the sole, both biological and economic, ever published in the English language is the treatise, already quoted, by Mr. Cunningham, and published some years ago by the Marine Biological Association.

The sole is a native of warm and temperate seas, occurring in the Mediterranean, but absent, at any rate in quantity, from the most northern waters of Europe. It occurs throughout the English Channel, where it is wastefully overfished, and Dover soles have long been famous at the eastern extremity, while some of the fish landed by the Brixham trawlers from the south-western grounds are worth a journey to see. Most of the best sole grounds lie comparatively near land, though the spawning takes place some miles away.

Marine worms form the chief element in the sole's food, though it also devours such small molluscs as are not too hard-shelled for its fine-pointed teeth. Small shrimps and sand-eels have also been found in the stomach of this fish, and sand-stars are in some localities a favourite prey. This is one of the fish that hunt by smell and mostly at night.

The sole attains maturity at a length of 10 or 11 in., and lays rather more than 100,000 eggs, according to the size of the parent. The spawning-time is, taking into account the returns from various parts of our coasts, some period between February and June. The egg measures rather over $\frac{1}{20}$ in., and is therefore large in comparison with some others, and has a number of very small oil-globules, which effectually distinguish it from the rest. The sole has often spawned in captivity, at both Piel and Plymouth,* and the eggs are deposited one at a time. It is also noticed that the extrusion of the eggs takes place earlier in the day as the weather grows warmer. The larva, which (at a temperature of 48° to 50° F.) hatches out about the tenth day, measures about $\frac{1}{8}$ in. or rather more, and has a large amount of pale orange colouring. As in other flat-fish, there is an air-bladder in the youngest stages, and Cunningham says that it has already disappeared in fish of about $\frac{3}{5}$ in., or two months old. The same author refers to the constant risk of confusion between these very small soles and the little solenette, the smallest member of the group, which is described below. The sole at the end of its first year measures as much as 6 in. or even rather more.

The migrations of the sole, as of so many flat-fish, may in all probability be regarded as being restricted to a general movement to deeper water during the extreme cold of winter, and possibly also a food-migration into the shallows in summer time. This would not, however, include the spawning fish.

Professor McIntosh describes the egg of the sole as hardy and the larva as extremely active, and he attributes the strange fashion in which the latter rushes about in its tank to the needs of respiration, for he has observed that it darts about open-mouthed. This, he rightly points out, need not be the habit of the little sole in the open sea, but is simply a habit acquired in confinement and necessitated by the absence of invigorating currents in the tank. The breast-fins, he says, vibrate like those of the sea-horse, and there is also rapid movement in the tail.

As a single instance of what may be done by transplanting sea-fish from characteristic localities to those in which they were either rare or altogether unknown,† it may be mentioned

* See an interesting account of this by Mr. Butler in the *Journ. Mar. Biolog. Assoc.*, September, 1895, p. 3.

† See also Mr. R. B. Marston's remarks in Chapter XVI.

that about ten years ago some five hundred soles were conveyed from English waters to St. Andrews Bay by Professor McIntosh, under the auspices of the Scotch Fishery Board, and the Professor is able to say that both the adult sole and the egg have been more frequently encountered on that part of the Scotch coast since this experiment was made.

The French Sole (*S. lascaris*), otherwise Sand Sole or Lemon Sole,* is recognised by the greater development of the front nostril on the under side, as well as by the fringe of filaments adorning its edge. The scales are somewhat larger than in the sole and similarly grow on the fin-rays. These are fewer than in the sole. In colour the French sole is lemon-yellow, with brown and black spots. It does not grow as large as the sole, the longest on record being 14 in.

Although the French sole occurs in the waters of Scotland, it is to be regarded rather as a southern fish, commonest, so far as our coasts go, in the English Channel. It occurs also in the Mediterranean.

Its eggs and larvæ have not apparently been described.

The Thickback (*S. variegata*) is a red fish with five dark bands on the body, the bands extending to the fins and being darkest at their extremities. The pectoral fins are much smaller than in the foregoing. The teeth are very small. It grows to a length of 8 or 9 in.

This fish, the "bastard sole" of some ports in the Channel, is excellent eating, though small. It is a southern form, extending to the Mediterranean, but not known in our more northern waters. In the Plymouth district, on the off-shore grounds, it is by no means uncommon, but it is not trawled in shallow water. Cunningham describes the egg as measuring rather over $\frac{1}{20}$ in., and differing from that of the sole by the larger size and different distribution of the oil-globules. He figures the larva, which measures rather less

* See also Lemon dab, p. 223.

than $\frac{1}{10}$ in., and which differs from that of the sole in its lighter colouring.

The Solenette (*S. lutea*), or Little Sole, is the smallest of the family, not being known of greater length than 5 or 6 in. The pectoral fins are even more rudimentary than in the last species. The scales, proportionately larger than in the common sole, extend to the fin-rays. These rays are fewer than in the sole and are marked by black lines. The colouring of the solenette, apart from this, is a slate-grey, with spots on the upper side. The left side is white.

This very small flat-fish has a wide range, being known to the north of Scotland as well as from the Mediterranean. It is common at various stages on the coast of Devon, and is sometimes taken, along with the young of other flat-fishes, which closely approximate its adult stage in size, in the small sand-eel seines. Herdman and Dawson* describe it as exceedingly abundant in the Irish Sea, wherein it differs from both the French sole and thickback. The females are both larger and more numerous than the males, and become mature at $3\frac{1}{2}$ in., the male at 3 in.

The egg has a diameter of about $\frac{3}{100}$ in., and, as described by Holt and others, has several oil-globules. The larva, which measures about $\frac{2}{25}$ in., is as hardy and restless as that of the sole. By the time the fish is $\frac{1}{3}$ in., the left eye has worked over to the right, its passage indicated by a slight notch before the dorsal. It is considered to attain maturity at the end of its second year, or a length of $3\frac{3}{4}$ in.

The foregoing are the principal flat-fish of our coasts, and, having now summarised their appearance and habits, we are better able to appreciate some peculiarities of the group. They are singularly lacking in bright colours. The cod family, though generally characterised by dull hues, are far more richly tinted, and have not the entire lack of silver or

* *Fishes and Fisheries of the Irish Sea*, p. 56.

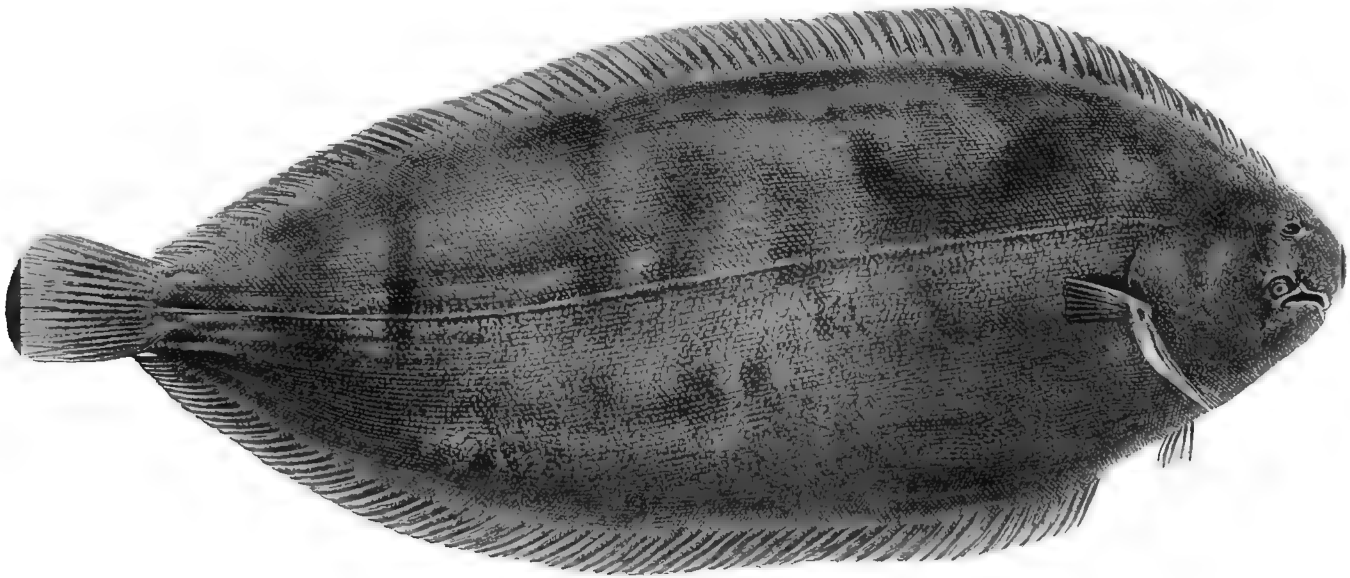

Photo by Reinhold Thiele

½ Natural Size

COMMON SOLE (*Solea vulgaris*)

burnished sheen so noticeable in the flat-fish. With the single exception of the orange-red spots in the plaice, there is not a touch of any colour other than browns and greys in any full-grown flat-fish, though the larval stages show traces of brighter tints.

Another curious point about the fish of this sub-order is the great difference in their distribution. It might have been thought that so homologous a group of animals would have been characteristic, if not of any particular locality, at any rate of cold or warm seas. In closely related flat-fish, however, we find a northern and a southern habitat side by side; and this is well illustrated by the case of the three topknots, two only of which are found in extreme northern waters, and one only of which extends to the Mediterranean, while of the first two one extends as far south as the Bay of Biscay, and the other no farther than the English Channel.

All of the flat-fish, at any rate on our coasts, deposit floating eggs, and many of them proceed for the purpose some distance from land. This can hardly be, as has been suggested, in order that the greater pressure at those depths shall assist in the extrusion of the egg,* for the sole, which in natural conditions spawns in moderately deep water, has frequently deposited its eggs in the tanks of the aquarium. The instinct which prompts these fish, then, to migrate seawards when ready to reproduce their species is far more probably one of self-defence, for they know that the spawn-eating surface fish are much more abundant in the waters immediately beside the land. Not only other fishes moreover, but also nature would be against them in the shallows, where the constant disturbance of the water by breaking waves would obviously prejudice the quiet development of the egg and subsequently of the larva, while a storm might actually have the effect of flinging both ashore.

The eggs of the turbot group, it will have been noticed,

* See also remarks on Conger spawning in captivity, p. 182.

are provided with an oil-globule ; those of the sole and its four allies have a number of these globules ; and those of both the plaice and halibut types have no oil-globule at all. As the function of the oil-globule is obviously that of a swimming-belt, to keep the egg afloat, it is not easy to understand why the ova of fish so closely related should differ so materially in this respect, and a satisfactory explanation has yet to be offered. In addition to merely keeping the egg afloat, it should be noticed that the presence of the oil-globule makes it float with that end uppermost at which this contrivance is situated, though in the eggs of the soles the small globules are so generally distributed that this consideration is eliminated.

For the most part, except when their spawning-time comes, the flat-fish live in shallow water and on sandy, or muddy, ground, two preferences that combine to put them at the mercy of man and his trawls during the greater part of their life. The only kinds that enjoy immunity from such constant danger are the topknots, which live on rocky ground, clinging to the smooth surface of the rocks with their fins in a way that has already been described, and thereby escape the sweeping trawl, which dare not work such rough ground. As there is no regular line fishery for topknots, all statements as to their geographical range, and particularly as to their scarcity in any given locality, must clearly be accepted with all reserve.

One curious habit all these flat-fish share which comes perhaps within the cognisance of the angler rather than that of the naturalist, and that is their behaviour when hooked. They immediately curve the body, the white side being the concave ; and this has the obvious result of immensely increasing the resistance of the water, so that a comparatively small plaice or dab feels enormously heavy when being hauled on fine tackle. Whether, as seems not improbable, their instinct bids them offer this increased resistance when they feel themselves being hauled through the water, or whether their conduct is only the outcome of muscular pain, can only be surmised. Another habit, to which writers on the subject have in no case drawn attention, is their extreme cautiousness when taking a bait, particularly in shallow water. It is open to any one to see this for himself, and such a pier as that at Bournemouth affords the opportunity any fine day in summer. The writer has frequently made the experiment by offering a hook not quite concealed in the bait (mussel or lugworm) to a small plaice or dab lying in the sand, only its eyes and mouth protruding, and plainly seen through the 2 fathoms of clear water. The fish would take the hook just inside its small and twisted mouth, but would at once blow it out again, sending up the sand in a cloud around the rejected morsel. After allowing a little time to elapse, the hook, properly hidden this time in the bait, would again be presented, and this time it was retained. As there is no object in catching these very small flat-fish, it may be mentioned that the experiment loses none of its interest if the barb be first filed off the hook, so that the fish, when caught, can be shaken off in the water, none the worse for its fright.

Another point in these flat-fish which must strike every angler is their great vitality beside such round fish as the bass or herring. Some years ago, as already mentioned, the writer used to catch large numbers of plaice and dabs with rod and line in the Baltic, from the piers at Warnemünde or from boats a short distance from land. He lived at the time at Rostock, about half an hour's journey by train, and on returning after the day's fishing, all the fish that had been caught during the last hour's fishing were alive and breathing, the moisture from their companions doubtless providing them with sufficient absorbed air. A pilchard, on the other hand, a sand-smelt, or even a small bass, is dead within a few minutes of capture, being apparently unable to close its gill-covers so tightly as the flat-fish, which thereby escape suffocation.

CHAPTER XIII

THE COD FAMILY AND THE SAND-EELS

DR. BASHFORD DEAN * regards the cod type as scarcely less representative among bony fishes than the more commonly selected perch, and he is also of opinion that it has developed its existing characters from a less active competition in the sea. "Heavy in body," he says, "its sluggish form has become blunted and rounded; its fins are depressed, their rays soft and yielding; its scales are reduced in size, colours less vivid; its swim-bladder loses its connection with the gullet."

These words admirably sum the leading characters of the cod family. Their clumsy build, large eyes, and soft fins distinguish them from almost all of the foregoing families. Some of their most pronounced characters disappear, it is true, after death, while others would seem to have been described chiefly from the latter condition. To the latter belong the current accounts of their dull grey and brown colouring, for no one who has caught cod, haddock, whiting, pollack, or pout, can accuse them of lack of beautiful tints. The authors of *Scandinavian Fishes*, a magnificent work already alluded to more than once, were among the first to pay tribute to the handsome colouring of some of these gadoids when living. Another feature that alters very quickly when life is extinct is the slime that covers the minute scales. There is no

* *Fishes, Living and Fossil*, p. 174.

difficulty in recognising the scales on a hake or haddock at the fishmongers; they are easily seen and are very apparent to the touch. But in life, when the fish is thickly coated with mucus, it might pass for scaleless.

There are three variations in the number of the dorsal fins. Thus, while the cod and haddock and several others have three, the hake and ling have only two, and the torsk only one.

A character found in many, but not in all, of these fishes is the beard, or barbel, on the chin; but this has no value as a determining character even in a genus, since one species will have it, while another is without. The whiting, the pollack and the hake have no barbel, while in the rocklings there is not only one on the chin, but a varying number as well on the snout, or upper lip, which might more appropriately be termed moustaches.

Some have endeavoured to show that such gadoids (*i.e.* fish of the cod family) as lack the barbel (*e.g.* hake and pollack) are particularly given to chasing fry at the surface. Such generalising, may be tempting, but it is not always safe. Thus, the coal-fish, which has a small barbel, also chases the fry, even more furiously at times than the pollack; while, on the other hand, the whiting, which has no barbel, feeds, as a rule, nearer the bottom than the surface, and is often sluggish in the extreme.

The migrations of the cod and its relatives are far less extensive, it may be surmised, than those of the herring and mackerel and their allies, and there are deep-water grounds on which they seem to be present in varying numbers throughout the greater part of the year. Near the land, however, there is abundant evidence of regular movements according to season, for the whiting are not taken on the Eddystone grounds between Christmas and the late spring, and both they and the cod approach the coast of Kent in great number in late autumn, following the sprats, and some years they practically absent themselves. Whiting, too, were for many years scarce in the Lancashire district, * but were plentiful on the Aberystwith part of the Welsh coast. It may, however, be desirable to distinguish between regular migrations with the seasons and what has more conveniently been termed "periodicity"—a habit which makes certain fishes plentiful on a given part of the coast at long and irregular periods, years often elapsing between two seasons of plenty. The hake, to quote a member of the family under notice, is in many parts regarded as a periodic rather than as a migratory fish, its movements being also largely dependent upon those of the smaller fishes, such as herrings or pilchards, on which it feeds. In the Cattegat, for instance, hakes were plentiful during the herring fishery about the year 1780; then they were rare until 1801, when they were once more plentiful until 1803.† The next good hake year in those northern waters was 1821; there was another in 1830; and in 1840 the hake had almost disappeared, though it has since been caught in quantity at various times.

On the question of whether the cod moves nearer shore for spawning purposes or farther out to sea there appears to be no agreement. Mr. Cunningham leans to the former view, while Prof. McIntosh favours the idea that they go seawards. These two authorities, on the other hand, are both of opinion that the whiting spawns in shallower water than the larger fish, since the young are destroyed in thousands by the shrimp-trawl.

A number of the rarer deep-water members of the cod family, some of which have been described and added to the British fauna only within the last few years, and the majority with a wider distribution than the forms inhabiting shallow water, will be noticed in the chapter on

* See Herdman and Dawson, *Fishes and Fisheries of the Irish Sea*, p. 47.

† See *Scandinavian Fishes*, p. 519.

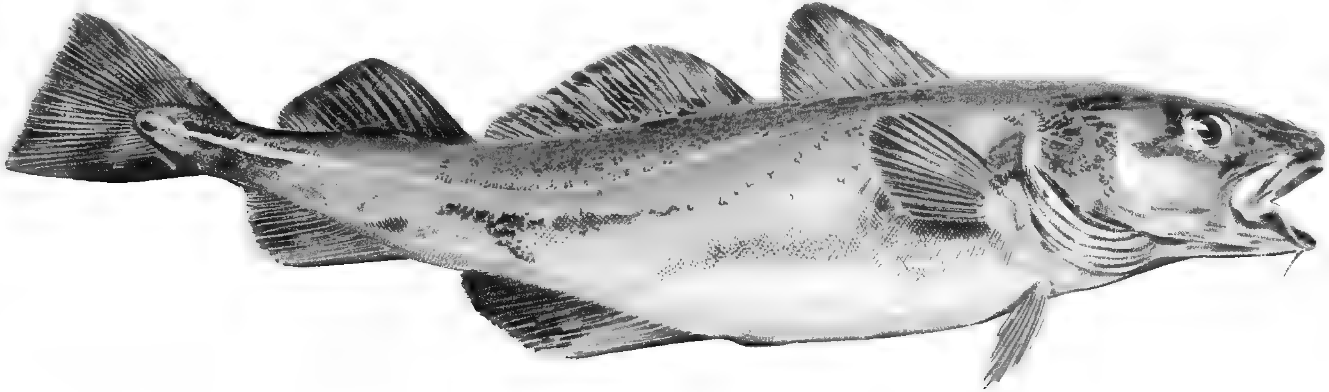

Photo by Reinhold Thiele

1/5 Natural Size

COD (*Gadus morrhua*)

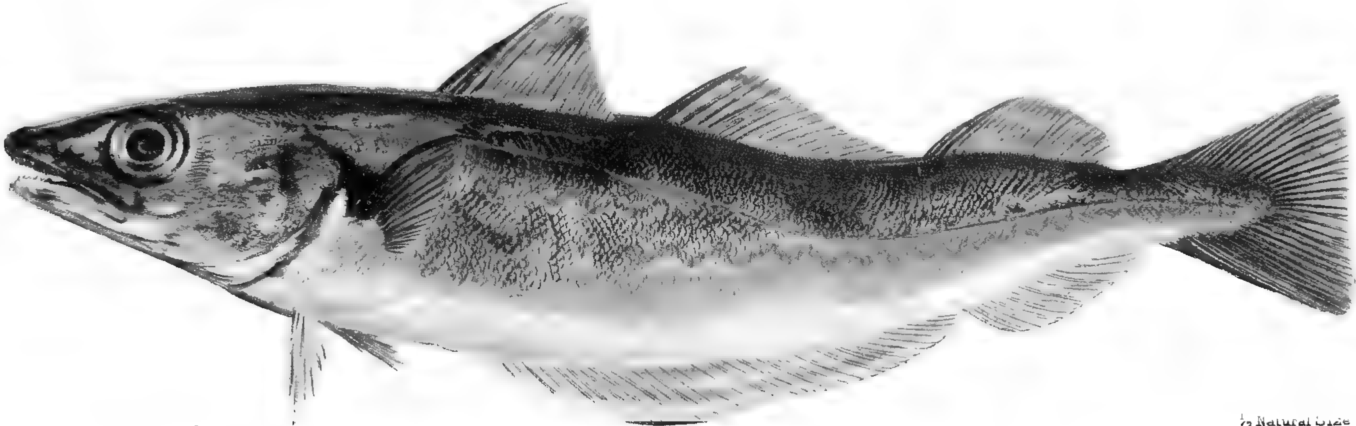

Photo by Reinhold Thiele

1/2 Natural Size

WHITING (*Gadus merlangus*)

uncommon fishes. The present chapter takes account of the following :—

FAMILY.	COMMON NAME.	GENUS.	SPECIES.
GADIDÆ	Cod	*Gadus*	*morrhua*
	Whiting	*G.*	*merlangus*
	Pout	*G.*	*luscus*
	Haddock	*G.*	*æglefinus*
	Pollack	*G.*	*pollachius*
	Coal-fish	*G.*	*virens*
	Poor Cod	*G.*	*minutus*
	Poutassou	*G.*	*poutassou*
	[All the foregoing have three dorsal fins and two ventral. The five that immediately follow have two dorsals and one ventral; and the torsk has but one of each.]		
	Hake	*Merluccius*	*vulgaris*
	Ling	*Molva*	*vulgaris*
	Three-bearded Rockling	*Motella*	*tricirrata*
	Four-bearded Rockling	*M.*	*cimbria*
	Five-bearded Rockling	*M.*	*mustela*
	Torsk	*Brosmius*	*brosme*

Our sand-eels, which have strong affinities with the cod family, are two in number, a third having been added on doubtful grounds:—

FAMILY.	COMMON NAME.	GENUS.	SPECIES.
OPHIDIIDÆ	Launce	*Ammodytes*	*lanceolatus*
	Sand-eel	*A.*	*tobianus*

Gadidæ

The Cod-fish (*Gadus morrhua*) is a sufficiently familiar fish to render lengthy description comparatively unnecessary. It is an inhabitant of cold seas, absent from the Mediterranean and other waters of Southern Europe, and finding its highest development in Arctic seas.

What was said above with reference to the rapid fading of the colours in members of the present family after death has, perhaps, less application to the cod than to most, but even it is far handsomer when first taken from the water, being brown to grey along the sides, with the belly shining white. There are sometimes spots on the grown cod, and the young, known as "codlings," generally exhibit light yellow spots on their head and body. The lateral line in the cod is white, but this, too, like the black lateral line in the haddock, is more noticeable at the fishmonger's than in the water. The fins of some examples are black-edged, and all of them are quite soft, so that the fishes of this group, unlike the bass or bream, may be handled without fear or caution. The body of the cod is less elongated than that of the hake or ling, and more so than that of the pout. Its mouth is very large, the upper jaw usually projecting; the tongue is fleshy and has no teeth on it, but the teeth in the jaws and on the vomer are many and sharp. The scales are small and easily scraped from the skin. Abnormal cod-fish with protruding lower jaws are sometimes caught in the North Sea, and are known as "bull-dogs."*

Mention was made on an earlier page of the three names applied, both on our own coasts and in Australian seas, to different stages of one of the sea-breams. The cod has also various names, according to size, in the Grimsby market,† and is a codling up to 20 in., a "sprag" from 20 to 30 in., then a "half-cod," until some indefinite final stage, at which it becomes a "cod." The "sprag" is, therefore, on the verge of maturity—that is to say, according to the accepted minimum size at which it reaches that condition.

The cod feeds close to the bottom as a rule, and is among the most voracious of fishes, though somewhat sluggish in its manner. Great numbers are taken on hand-lines and on long-lines baited with sprats or whelks. Both sea- and land-birds have been taken from the inside of large cod, and there are many stories of books having been recovered all but intact,

* The same name is applied on the Cornish coast to the streaked gurnard, in allusion to its grunting voice.

† See Holt, *The Grimsby Trawl Fishery*, p. 80.

while the cod's more natural food includes all manner of fishes, not excepting young sharks, as well as crustaceans and sea-anemones. Among it most dreaded enemies, on the other hand, are sharks and seals. Cod are also trawled, generally during the period preceding the spawning-season, when they are not taking a bait. This fish is particularly subject to the attacks of sea-lice and other parasites. The air-bladder of the cod is one of the chief sources of isinglass, though sharks' fins and other substitutes have recently been utilised.

The smaller cod of the Baltic, called "Dorsch," are larger by far than our codling stage, and doubtless form a distinct race. The writer has caught them at Christmas time off Doberan weighing 3 or 4 lb. apiece; and the German fishermen invariably called them "Dorsch," and not "Kabeljau," the name applied to larger cod of the North Sea. Günther gives "Dorsch" as the German name for young cod only, and doubtless in the general way he is correct; but the use of the word as applied to full-grown, mature fish on the Baltic coast (at Warnemünde) seems worth recording. The cod grows to a length of over 4 ft. and a weight of at least 50 lb. Three other (Arctic) cods are described in *Scandinavian Fishes*, but none of these occur in our seas.

The spawning of the cod takes place on our coasts in early spring, between January and May. Dr. Wemyss Fulton is of opinion that the females are in the majority, the male being very slightly the larger. The egg, which floats, has a diameter of rather over $\frac{1}{20}$ in. According to Professor McIntosh, the embryo hatches in April on the eighth or tenth day after fertilisation, and Cunningham allows twelve or thirteen days at 45° and twenty at 38°.

The larva, when first hatched out, is, according to Dannevig, only a little over $\frac{1}{10}$ in., while another estimate gives it as rather less than $\frac{1}{6}$ in., a considerable difference. It is recognised by two dark bands on the body, and other two on the tail. McIntosh and Masterman give coloured figures of larval and post-larval cod, as well as (*op. cit.*, pp. 74-78) a very interesting series showing the egg-development. The barbel first appears when the little fish is nearly an inch in length. Dull as are the colours of the full-grown cod, some of the later larval stages, an inch or two in length, exhibit great beauty of hue, with burnished silver reflections and iridescent eyes. Small cod, measuring from 5 to 10 in., are found in the algæ on the sea-bed, some of these being red in colour and others green, doubtless to suit their surroundings. About a year after its release from the egg the cod may measure a foot, and at that stage of its career off it goes to the deeper water outside, returning as a mature, grown-up fish in its third or fourth year, its rate of growth being in the meanwhile apparently little less remarkable than that of the salmon.

Although it cannot too often be insisted that the growth of fishes in captivity may furnish only an approximate clue to their development under the more robust conditions of nature, much interest attaches to such experiments as that conducted by Captain Dannevig at Arendal, in Norway. Here, in a large pond, he reared young cod, and studied them for six months. They doubled the length at which they emerged from the egg during the first fortnight. They doubled their new length in less than another month, and during the last four months that they were under observation they increased from a little over $\frac{1}{2}$ in. to nearly $4\frac{1}{2}$ in. McIntosh and Prince found that young cod taken at St. Andrews between the end of April and the beginning of June measured $\frac{1}{5}$ in., and the same observers also took a larger stage, about double the length, with rays beginning to appear in the fins.

Young cod are said to require longer to hatch out, conditions of temperature, etc., being equal, than those of most other bony fishes. Thus, the cod takes from thirteen to twenty days, whereas, in the same temperature, the mackerel would require only six and the herring only nine.

The Whiting (*G. merlangus*) is as familiar as its larger relative, if anything more so, since it is more generally eaten whole on our tables, whereas the portions of cod give little or no idea of the fish in life. The whiting is distinguished by its lighter colour, absence of barbel (though there is one in young whitings of an inch in length), and black lateral line, while there is a black spot near the base of the pectoral fin. The male is slightly the smaller, in which the whiting again differs from the cod, and the present species does not grow to a greater length than 24 in., or, save in very exceptional cases, a weight of more than 4 or 5 lb. The outer edge of the whiting's fins is dark ; otherwise, the fish is of a uniform greenish grey above and white below, with black lateral line, the latter being, however, less pronounced than in the haddock. There are often lighter lines along the dark upper portion of the whiting, but these fade soon after death, and are not, indeed, very marked in many living examples.

The whiting feeds on young fishes, particularly other whiting and herring, as well as on shrimps and other crustaceans. It attains maturity in all probability in its third year, or when about 9 in. in length, and the spawning-period is from February onward in the Plymouth district, and from March onward in the neighbourhood of St. Andrews. The egg, which has a diameter of less than $\frac{1}{20}$ in., closely resembles the somewhat larger egg of the cod. The young whiting, which hatches about the tenth day, a little sooner or later according to temperature, measures about $\frac{1}{8}$ in., and is therefore smaller than that of the cod, from which it may be further distinguished by the presence of yellow spots on the body, fins, and yolk-sac. Cunningham refers to the great difficulty of distinguishing the eggs and larvæ of the various members of this family, so much are they alike ; but the small whiting may be known by its bright blue eye and by the absence of bands from its sides. McIntosh further says that it attains plumpness of outline sooner than the young cod. Curiously enough, too, young cod and whiting have their own special parasite, while another species has been found in constant association with young flounders in brackish water.

The Pout, Bib, or Blain (*G. luscus*, the *Tacaud* of the French fishermen) is among the commonest fish in our seas, particularly in the English Channel, and appears to possess less of the migratory instinct than most other members of the family. At any rate, there are on different parts of the coast rocky inshore grounds on which it is to be found throughout the year. Wherever there are gulleys in the submerged reefs, at depths of from 3 to 60 fathoms (and probably more, though that may be regarded as the limit for convenient capture on hand-lines), pout are almost certain to abound, though they are found to prefer some reefs to others in the immediate neighbourhood. With all their stationary habits, however, these fish must be continually on the move, for it sometimes happens that a score of boats will anchor one evening on a favourite spot for pout—an old sunken wreck, well encrusted and weed-grown, is even better than a reef of rocks—and catch them by hundreds, until there are apparently none left to take the bait. Yet the next morning as many boats may repair to the same ground and make as great a catch as the evening before.

Though rarely exposed for sale, like cod or whiting, by fishmongers, the pout is a very familiar fish at our seaside resorts, particularly on the south coast. It is distinguished from other British members of the family by its beautiful dark bronze colour (though a similar bronze is seen in the newly caught haddock) and by the dark bands down the sides. The depth is also great in proportion to the length, and the ventral fins are conspicuously long, while the barbel on the chin is also fairly large in proportion to the size of the fish.

The pout feeds close to the rocks, even wandering during the day to sandy ground in the neighbourhood of piers, and there seizing small baits that are allowed to rest a moment on the bottom. When anxious to make a large catch of pout, the fisherman has to drop his hooks, sometimes in 150 ft. or more of water, exactly among the fish, for these will not move a boat's length to find baits dropped wide of their haunts, or, as the fishermen say, of their "berth." The reason for this is obvious to any one who knows the habits of the pout and the peculiarities of the ground they live on. The fish swim in narrow gulleys or crevices that may measure no more than a foot across, but are many fathoms deep. As pout feed close to the bottom, it is obvious that any bait lying on either ledge above their retreat is unseen by them, and there it may lie for hours, though within a few feet of the unconscious pout.

This fish, also known as the rock-whiting, or whiting-pout, is a voracious feeder, crustaceans and worms being its chief food. The best baits are mussel and lugworm, and Day is quite in error in saying that pout feed best at night, for the very best time to catch it is in August, when the tide is low and the weather calm, at midday.

The pout grows to a length of at least a foot, and a weight of 4 or 5 lb., but such a fish would be an unusual specimen.

Day says that it spawns at the end of winter, and McIntosh mentions taking a ripe female at St. Andrews on the last day of February. Ripe pout have also been taken in that month at Boulogne. The egg is large; even in spirit its diameter is over $\frac{1}{25}$ in. Young pout measuring 4 or 5 in. are killed in the Thames in October by the shrimp-trawlers.

The Haddock (*G. æglefinus*) is best distinguished from the rest by the large dark blotch on the shoulder, as well as by the strongly marked and curved black lateral line. Otherwise the fish is of a uniform grey above, with bronze reflections, and pure white beneath. This metallic lustre fades immediately after death, and the slime also dries up so as to expose the scales, which are scarcely visible in life. There are also yellow reflections near the lateral line, which likewise disappear after death. The barbel on the chin is somewhat shorter than that of the cod, and the lower jaw is somewhat the shorter, so that the snout projects. As in all the genus, there are three fins on the back, the front one being more pointed and triangular than in the cod. The scales are small, and have bronze tints.

The haddock is said to exceed 3 ft. in length and a weight of 24 lb., but specimens of one quarter that weight are rare at the fishmonger's.

The distribution of the haddock in our seas appears to be more local and less general than that of the cod, for it is, except at irregular periods, comparatively rare in the English Channel. It is most plentiful, from all accounts, on the east coast of Scotland.

The haddock has its largest teeth in the upper jaw, and it feeds mostly on shell-fish (which has, however, nothing to do with its German name of "Schellfisch"), worms, sand-stars, and small fishes, and, as has already been mentioned, it frequents the spawning-grounds of herrings to eat the spawn in quantities. The females are, according to Cunningham, nearly twice as numerous as the males, but rather smaller. The haddock, which is said to reach maturity in its third year, spawns on the Scotch coast in early spring and some miles from land. McIntosh and Masterman give the number of eggs in a fish at from 170,000 to 2,000,000, and the egg is nearly $\frac{1}{100}$ in.—larger therefore than that of the cod, and, in fact, the largest of British gadoid eggs. It is also deposited somewhat earlier in the year than the rest, though, as might be expected, the earlier eggs take longer to develop than those deposited later in the year, when the temperature is higher. Except in its larger size, the egg so closely resembles that of the cod as to be indistinguishable. The larva is also very similar, though it lacks the dark transverse bands observed in very young cod, and its eyes are somewhat blacker. Dr. Sars was able to recognise the larval haddock by its stouter shape. It is said to keep out in the deeper water at a stage at which young cod would seek the neighbourhood of land. This may perhaps account for the absence of larval and post-larval haddocks from the tow-nets of scientific expeditions, and the consequent uncertainty of biologists as to the earlier developments. Dr. Fulton is, moreover, of opinion that the young haddock hide away among the rocks, and are thus secure from the trawl, besides being too small to be taken by the hook.

The growth of young haddock must be rapid if, as McIntosh surmises, a haddock only five months out of the egg (*i.e.* in the month of August) may be as long as 6 in. The "summer haddock" of the fishermen is a fish of 8 or 9 in., a year or eighteen months old, which comes inshore in order that it may feed upon the brit and launce. Holt took small haddock of 2 or 3 in. in length in 30-fathom water, and a somewhat larger stage, from 3 to 5 in. long, in 20 fathoms 50 or 60 miles from land. The same authority * regards the haddock as practically an offshore fish. On only one occasion, when numbers of 5-in. haddocks were thrown ashore dead in the Humber estuary during a November gale (1883), did he ever hear of a haddock in such shallow water.

The Pollack, or Lythe (*G. pollachius*), is a familiar fish to the sportsman, but it is rarely seen at the fishmonger's shop, for it is not only indifferent food when fresh, but loses its freshness more rapidly than most of the family. Commonest on the Cornish coast, it is also plentiful on the west coasts of both Scotland and Ireland, more so than on the east, being a fish that develops best in open, ocean water. Thus, it is rare on the Norfolk coast, small examples only occurring on the inshore grounds. It feeds on small fishes, chiefly

* See *The Grimsby Trawl Fishery*, p. 65.

sprats and sand-eels—the former in winter, the latter in the warm season—and as a rule it hunts its prey in mid-water over a rocky bottom. Sometimes, particularly on warm summer evenings, it takes a bait close to the surface, and even on sandy ground; and the writer has caught many of 12 lb. and more in weight in less than 30 fathoms of water and within 5 miles of the Cornish beaches. Pollack, normally rather cautious fish, often bite with extraordinary fury just before a thunderstorm, and the Cornish fishermen say that the fish know beforehand the coming change in the weather, and are anxious to feed and go off to the deeper water before the squall. As no one, either professional or amateur, ever thinks of waiting to fish during the raging of the storm, the statement is one that does not admit of much criticism. Sluggish or headstrong, however, the pollack always behaves in the same way as soon as it feels the hook, for it dashes straight for the rocks beneath, trying its best to break the tackle.

In colour this fish is of a deep olive-green—in large specimens this deepens to black—along the back and upper half, shading off somewhat abruptly to white beneath, the fins having very dark margins. The lower jaw protrudes, and the chin has no barbel. The eye is large. The lateral line is curved and well marked. Like those of all the members of the family, the fins of the pollack have no spines of any sort, and the fish may therefore be handled without fear. Cornish fishermen often dispense with the gaff and dip their hand under the fish as soon as it is brought to the surface.

The spawning-time of the pollack is not very satisfactorily settled, but, as Cunningham has found small pollack measuring nearly an inch (and presumably about six weeks old) in April, March or a little earlier may be regarded as the season, so far as the English Channel is concerned. In the northern waters of both Scotland and Ireland, however, there is reason to believe that the pollack does not spawn before May.

The egg is buoyant, and has a diameter of less than $\frac{1}{20}$ in. What the authors of *Scandinavian Fishes* mean by describing the pollack as "the least voracious of its congeners" it would be hard to say, for, with the possible exception of the coal-fish, it is, in our seas at any rate, by far the most greedy, pursuing the small fry with a boldness that is hardly equalled in the blue shark.

The Coal-fish, or Saithe (*G. virens*), somewhat closely resembles the pollack in outline, but the differences that reveal themselves on closer comparison are considerable. In the first place, the colour is distinct, being a deep bluish green, with a pronounced blue quite absent from the other species. Then the lower jaw protrudes less, and in quite young examples it does not protrude at all. The chin of the full-grown fish bears a small barbel, which further distinguishes it from the pollack; and in the young coal-fish this barbel is proportionately much larger. It grows to a greater size than the pollack, and is said to exceed 40 in. and 30 lb. Though hardly an instance of what students of distribution know as "vicarious species"—*e.g.* the llama of South America and camel of Asia, or the rhea of South America and emu of Australia—the coal-fish may in a measure be regarded as taking the place of the pollack in some of the more northern waters of Britain, the pollack, on the other hand, being far more plentiful in the English Channel. The coal-fish is also said to range to greater depths.

In both its young and full-grown stage the coal-fish has an extraordinary variety of local names; but, as Day has given a very representative selection of these, as has also "John Bickerdyke" in his admirable Badminton volume on Sea-fishing, it would serve no useful purpose to compile a list here. As food the coal-fish is regarded as even less valuable than the pollack. The writer can speak from experience only of the latter, and the comparison is not flattering.

In habits the two kinds appear somewhat similar, both being of sociable disposition and banding together to chase the shoals of launce and brit. Both also show a preference for rocky ground, and the coal-fish seems, of the two, less disinclined to leave it and seek its food on the sand.

Professor McIntosh alludes to the similarity between this fish and the cod in size, structure, habits, larval development, and life-history. The coal-fish spawns in early spring, from February to April, and by June it has grown to a length of 2 in. The eggs are very numerous, a female of $23\frac{1}{2}$ lb. having been computed to contain about four millions. The egg closely approximates that of the whiting in both size and structure, and measures rather more than $\frac{1}{25}$ in. Great numbers of coal-fish are caught in the vicinity of Gairloch, on the west coast of Scotland, and from that locality were obtained the first eggs systematically studied and described. Whereas the larger coal-fish journey considerable distances from the land, the younger haunt the weed zone.

The remaining fairly common members of the cod genus are two, the poor cod and the poutassou, and they are less familiar than any of the foregoing on account of their insignificant size.

The Poor Cod (*G. minutus*), or "Power," as Cornish fishermen call it, is not unlike the pout in outline, but it may be distinguished by its smaller size, its greater length in proportion to depth, and the absence of dark bands on the sides. The largest recorded example measured $8\frac{1}{2}$ in. There is also a difference in the tail-fin, that of the poor cod being more forked, and that of the pout ending square. In colour the poor cod is greyish green above and lighter below. The eye is large; and when the fish is hauled quickly from the rocky bottom through 40 or 50 fathoms of water, the eye, enveloped in a crystalline, gelatinous rim, seems to start from the head. The writer has frequently caught this fish in company with pout in Cornwall, and has observed this peculiarity in the eyes of both, though to the greater degree in the poor cod. According to Day, the two kinds swim at different levels; but this is hardly credible, seeing how often the two come up together, a pout on one hook and a "power" on the other, the hooks moreover being fast to the same crossbar, and therefore fishing at the same depth.

The poor cod is widely distributed, being plentiful almost all around these islands, and inhabiting at once the Mediterranean and the colder waters of Northern Europe. According to the authors of *Scandinavian Fishes*, it is much commoner on those coasts than the pout. It spawns with us about midsummer or a little earlier, and McIntosh says that, like the whiting, it may deposit its eggs either at some distance from land or well up the Firth of Forth. As the spawning-period falls late, when the temperature is high, the development of the egg is rapid. The newly hatched larva measures rather over $\frac{1}{10}$ in., and is dotted with yellow. The poor cod has been known to spawn in the tanks of the Plymouth Laboratory in March, but that is not necessarily any guide to its natural breeding-time, even in Plymouth Sound.

The Poutassou (*G. poutassou*), also known as Couch's Whiting, while it cannot be reckoned among those rarer gadoid forms that have been left for notice in Chapter XIV. is nevertheless so capricious in its occurrences as to be unknown on many parts of the coast. It grows to a length of at least 15 in., Couch having obtained a Polperro example of that size. In colour it is silvery brown above and lighter below, and has yellow lines along the sides of its elongated body. The lower jaw is rather longer than the upper, and the chin has no barbel. The scales are very small. The lateral line is distinct and but slightly curved.

The Mediterranean distribution of the poutassou seems not less irregular than with us, for, while generally common on the westernmost grounds of that sea, it is in some years exceedingly rare on the Italian coast.

According to Fries, the poutassou spawns in Scandinavian waters about the beginning of the year, and our own authorities are, at any rate, agreed that it must spawn earlier than most of the family. During the Irish survey one of the ship's officers thought he saw a large squid chasing a shoal of young poutassou about 6 in. long. This was thirty-four miles off Achill Head, and some of the frightened little fish were without difficulty taken in the tow-net, and were found to be feeding on copepoda.

We now come to the second group of the cod family, represented in our seas by three fish, the Hake, the Ling, and the Lesser Ling. These are all long in the body, and have but two fins on the upper and one on the lower edge of the body.

The Hake (*Merluccius vulgaris*) is generally regarded as a surface fish, but that it can also reside at considerable depths is proved by the fact of its having been trawled at over 300 fathoms in the Gulf of Gascony and over 600 elsewhere.* As a general rule, however, it is a typical surface fish, pursuing the pilchard and mackerel and dashing among the shoals in its nocturnal raids in a manner that has a remarkable effect when heard in the darkness from the deck of a pilchard boat.

The "periodicity" of the hake has already been referred to. It is one of those fish which come and go in a given locality without any rule, or indeed without much apparent reason at times. Its distribution in our seas is, bearing this peculiarity in mind, general. In some years it has been very plentiful on the south-west coast, but it is also found in the North Sea, particularly in winter. It appears to range over the colder northern and warmer southern seas alike. Of late years, however, the number of hake on the coast of Devon and Cornwall has shown considerable falling-off. When, in the summer of 1901, the writer was engaged on

* See *Expéd. Scientif. du Travailleur et Talisman*, p. 302.

a private fishing enquiry at every village of importance on the coast between Brixham and the Land's End, he received various confirmatory reports of this falling-off of hake, particularly at Mousehole, where this fish, so plentiful ten or fifteen years ago, was said to have virtually disappeared. This result was, fairly or otherwise, attributed to the operations of Plymouth trawlers on the inshore grounds.

As already mentioned, the hake has an elongated body, and it grows to a length of at least 4 ft. and a weight of at least 24 lb. The fish is in life more silvery in appearance than most of the family, for silver pigment is noticeably lacking in both the cods and flat-fishes. The lateral line is dark and nearly straight. The colour of the hake is, as a rule, dark grey along the back, shading off somewhat gradually to white beneath. Garstang * has given an interesting account of an albino hake, which was in wretched condition. This he ingeniously attributed to the handicap of its light colouring, which would make it very conspicuous at night, its only feeding-time, and thereby hinder it in obtaining sufficient food. The scales are rather small, and cover part of the head and gill-covers. The jaws are long, and powerfully armed with two rows of sharp teeth, the interior of the mouth being, as in *Pristiurus*, of a dark hue.

The hake spawns, according to some authorities, from early in the year until late summer. Although the fish is caught in numbers on the east coast of Scotland, the egg had not, at any rate up to 1897,† been found in those waters, but it had been studied at Naples by Dr. Raffaele, who artificially fertilised it at the aquarium there in May. It measures only about $\frac{1}{25}$ in., and is therefore somewhat small for so large a parent. In the conditions alluded to, hatching took place in less than three days, for the temperature of the water was high ; but Masterman rightly suggests that it

* See *Journ. Mar. Biolog. Assoc.*, November, 1900, p. 275.

† McIntosh and Masterman, *op. cit.*, p. 274.

would in all probability require as long as seven days in our colder seas. This assumption is based on the analogous size and behaviour of the flounder's egg. The larva, like that of the poor cod, is dotted with yellow.

The Ling (*Molva vulgaris*) represents yet another type of this important family of our food-fishes. Elongated almost to the proportions of some marine eels, it has, like the hake, two dorsal and one ventral fins ; but these, with the tail fin, are less rounded than in the last, and are edged with white. The skin is even smoother to the touch, for the scales are yet smaller, and there is a barbel of moderate size on the chin. This suggests a residence near the bottom (though the coal-fish has already been cited as an exception to the rule), and, indeed, the ling is taken on hand-lines on the conger grounds, where it devours fishes, cuttles, and crustaceans, and is not found in the surface-nets with hake.

The colour of the full-grown ling is dull grey and white, but the young are more highly tinted with orange and olive bands and other markings. Its distribution in our seas seems to be general, for it is abundant, and with less irregularity than the hake, both in the north of Scotland and on the Cornish coast, though less so at some points between the two. It has been caught measuring 7 ft. and weighing 124 lb., but such fish are not often met with nowadays.

The ling is reckoned one of the most rapacious fishes of the offshore waters, eating sharks and chimæras, cod and whitings, halibut and dragonets.* As the head of the devoured fish usually points forwards, it is thought that the ling must swim swiftly and seize its victims, in their flight, from behind. Some have inferred that it may be more convenient to swallow these fishes tail first, though a moment's contemplation of the dorsal spines of, for instance, the male dragonet would seem to lead to an opposite conclusion.

The ling is perhaps the most prolific of our food-fishes,

* *Scandinavian Fishes*, p. 529.

a large specimen having been estimated to contain from sixty to one hundred million eggs. Such estimates obviously call for a little latitude; but, even granting this, there can be no doubt of the extraordinary powers of reproduction of the species under notice. The spawning-time is in early summer, between April and June. The egg has a diameter of rather over $\frac{1}{25}$ in., being about the same size as that of the pout, and is deposited at a considerable distance from land. Like that of other members of the cod family, it floats, and it is greenish in colour, and furnished with a single oil-globule. Masterman points out that this last character is not confined to eggs of the gadoid type, but is also found in the eggs of such widely different fishes as the brill and gurnard, as well as in several heavy (demersal) eggs. The capsule of the ling's egg is sensibly tougher than that of many others of the family.

The eggs deposited at the end of April hatch out in about nine days, and the larva measures about $\frac{1}{10}$ in. (or, according to Cunningham, nearer $\frac{1}{8}$ in.), and displays numerous black and yellow spots. The ling of a week old, the latest stage reared in aquarium tanks, shows a still greater development of black and yellow spots, and the eye is bluish. At that stage of its development the mouth is open. Later post-larval stages have been taken in the tow-nets and otherwise, and are described and figured by various writers. At $\frac{1}{3}$ in. the eyes are deep blue and comparatively large. At an inch, or rather less, the ventral fins are conspicuous for their length and bright yellow colour. At 3 in. there is a longitudinal brown band, with a lighter yellowish band above and two black dots on the dorsal fins. The ventral fins are in this stage much smaller, and the barbel is more prominent. At a length of 6 or 7 in., or about a year old, the longitudinal bands have disappeared, their place being taken by a series of brown blotches with intervening white spaces, and the fins have numerous dark spots. At 16 in., or about two years old, the ling is reddish brown above and white below. These remarkable colour changes have been given at some length, because few other fishes exhibit them in such a degree.

The Lesser Ling (*M. abyssorum*) was added to the British fauna by Sim, who records* ten specimens trawled (May 25th, 1897) off Rona and brought to Aberdeen market. Two had been previously caught (February, 1895) thirty miles from Shetland. It is a much smaller species than the ling, seldom exceeding 4 ft. in length. Its body is also longer for the depth, the head is shorter, the scales proportionately larger, and there are no spots on the dorsal fins. The lesser ling is regarded as a better food-fish than the commoner species. It inhabits still deeper water, for it is taken chiefly on the coast north of Bergen in 100 to 300 fathoms of water, but occasionally it finds its way into the shallower waters of the Skager Rack, and is there captured in only 35 fathoms.†

The lesser ling is a voracious ground-feeder, and the British examples contained scales that apparently belonged to some kind of wrasse. Faber erroneously held this form to be the young stage of the common ling.

The Rocklings, three in number, have not only the barbel on the chin, as in so many of the foregoing, but also additional feelers on the upper lip. A fourth, having eleven barbels, is described from Scandinavian seas, but does not occur within the British zone. McIntosh and Masterman follow Risso and the Scandinavian writers, and call this genus by the name of *Onos*, an old Greek word for cod; but *Motella* is in more common use. All our rocklings have two dorsal fins, like the hake and ling, but the front one lies in a groove, from which only one long ray projects.

The Five-bearded Rockling (*Motella mustela*) must be

* *Ann. Scot. Nat. Hist.*, October, 1897, p. 255.

† *Scandinavian Fishes*, p. 524.

regarded as the commonest kind in British seas, particularly in the western half of the English Channel, where specimens of at least 18 in. are taken. The very young examples of this and other rocklings are popularly known as "mackerel-midge," because the mackerel greedily devour them at the surface of the sea in summer weather, dashing through almost solid masses of the fry. These young rocklings have been variously named and described, like the young of some other fishes, as species distinct from the adults.

The five-bearded rockling is brown above and lighter on the under surface. As its name denotes, there are five barbels in all, the longest on the chin, the other four on the snout. The teeth in the jaws and vomer are long and pointed, and the fish probably feeds, for the most part at night, on small fishes, molluscs, and crustaceans. In its search for food it is aided not alone by the barbels, but also by the very sensitive organs of touch in the pelvic fins.

What was said on an earlier page in respect of the importance of studying the life-history and movements of some of the smaller fishes on which those of greater moment to ourselves feed is well illustrated by the rocklings. In their young, silvery, surface-swimming stage they form the food of mackerel, and at a later stage, when their residence is at the bottom of the sea, they are the prey of ling and conger.

The five-bearded rockling spawns during summer, from April to August, and its egg and development were studied by Mr. G. Brook,* who pointed out the error of Cornish in describing the buoyant egg of this fish as deposited in a coralline nest in the rock crevices. A floating egg could obviously not develop in a nest under water, yet the mistake was long accepted. According to the accurate observer named above, the egg of the five-bearded rockling measures rather over $\frac{1}{40}$ in. in diameter, is oval in shape, and so fragile that the least pressure disturbs its outline. Mr. Brook found the egg hatch out

* See *Journ. Linn. Soc.*, 1885, Vol. XVIII., pp. 298-307.

in about six days or rather less, the temperature varying between 62° by day to 51·3° at night. At St. Andrews, however, in May, these eggs took as long as ten days to hatch.

The larva, on emerging from the egg, measured less than $\frac{1}{10}$ in., and was not so developed as that of the lesser weever, of which Mr. Brook also made a study. It has three conspicuous spots of black, and at a rather later stage the lower jaw projects, the eye is a pronounced blue, there is a greater proportion of black colouring matter, and the pelvic fins are tipped with black and very long. The barbels first appear when the little fish is about $\frac{3}{5}$ in., and are all distinctly developed at 1 in., but there is apparently some variation in the degree of development at any given age. One measuring rather over 1 in. was found to have lost much of the silvery pigment and to have taken up its residence in the sand. By their first January—*i.e.* at about six months old—the rocklings of this species are about 2 in. long, and Cunningham found that rocklings measuring 1 in. their first May had grown to 5 in. by the May following.

The Four-bearded Rockling (*M. cimbria*) is the smallest and least common of our British kinds, the largest recorded example being 14 in. long. It differs from the last kind chiefly in the number and distribution of its barbels, having one on the chin, one on the upper lip, and two on the snout. As in all rocklings, the front dorsal fin lies in a groove, one long ray only showing above the line of the back. It has recently been recorded by Holt from the Bristol Channel, but it is nowhere very common on our coasts. McIntosh and Masterman describe it as not uncommon in the Firth of Forth, but only about ten were recorded in that locality between 1890 and 1900,* which does not suggest great abundance. One was picked up near North Berwick in the October gales of 1898,

* See Eagle Clarke, "Fishes of the Firth of Forth," in *Ann. Scot. Nat. Hist.*, October, 1900, p. 210.

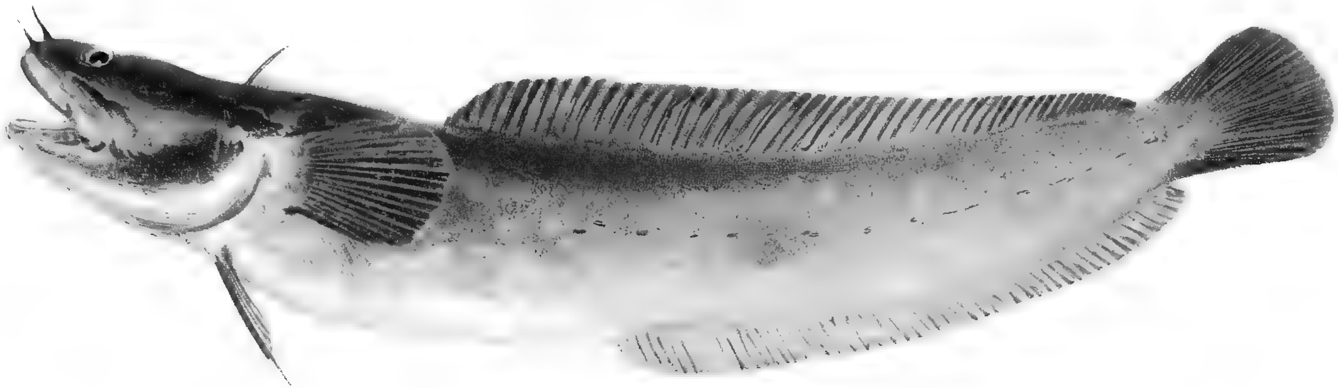

Photo by Reinhold Thiele

$^2/_3$ Natural Size

THREE-BEARDED ROCKLING *(Motella tricirrata)*

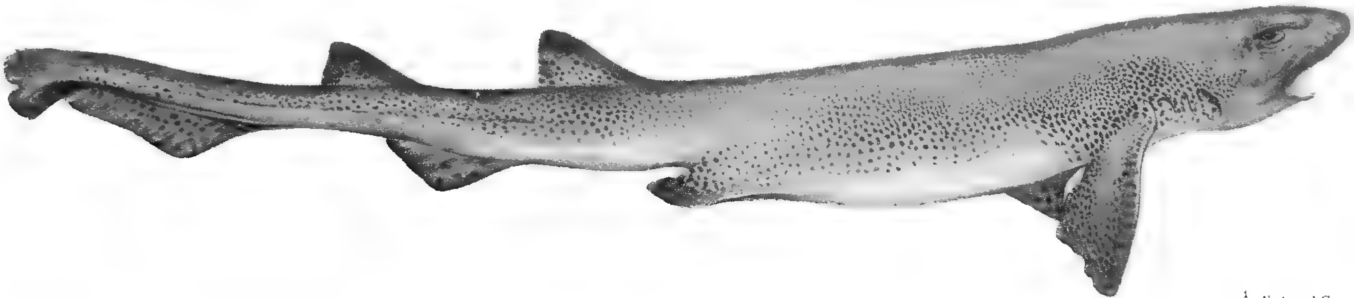

Photo by Reinhold Thiele

$^1/_5$ Natural Size

ROWHOUND *(Scyllium canicula)*

and another, measuring $13\frac{5}{8}$ in., at the same time between Leith and Portobello.

The egg is known to be distinct from that of the others, but has not been very satisfactorily described. When rather more than an inch in length, the present species may be distinguished from the last by the longer barbel on the chin and the smaller front dorsal fin. The central barbel on the upper lip appears to be of later development than the rest.

The Three-bearded Rockling (*M. tricirrata*)—the young of which is known as the "Silvery Gade," a name originally bestowed in the early years of last century by Colonel Montagu—is the largest of British rocklings, and examples have been caught which measured 20 in.

This rockling is distinguished from the rest not only by the possession of only three barbels, all of them long, one on the chin, the other two on either side of the snout, but also by black spots covering the head, body, and fins. These spots are not, however, found until the fish has grown to a length of 3 in. or thereabouts. It is found to take baited hooks lying on the bottom rather more readily than the rest, but its habits are not otherwise known to differ much from theirs.

It appears to be somewhat more generally distributed round our coasts, being fairly common in Devon and Cornwall, and yet more plentiful on parts of the Irish coast, but comparatively scarce in Scotch waters. Herdman records the species from Port Erin Bay and the Dee estuary. It is said to spawn early in the year, but neither egg nor larva has been studied in our laboratories.

The Torsk (*Brosmius brosme*), or Tusk, is the most northern member of the family, and is our sole representative of a third group, having only a single long dorsal fin. While plentiful on the north coast of Scotland and among the Shetland group, and there found in both deep and shallow water, it is not so far known in the English Channel. It grows to a length of over 40 in. and a weight of over 40 lb., but the average figures would be far below these. It is a good food-fish in Shetland waters, and is said to taste of the crabs and lobsters that form no small portion of its natural food; but it is little appreciated elsewhere, only the liver being retained, and not always even that.

In colour the torsk is grey, with bronze or yellow reflections on the upper parts, and lighter beneath, with some yellow stains on the fins, which are enveloped in tough skin. There is a barbel on the chin. The largest of its teeth are in the lower jaw and vomer. The scales are very small, and the fish has a slimy skin.

The torsk is a fish of very voracious habits, feeding on other members of its own family, as well as on crustaceans. It spawns from April to June, and the egg, first described by Dr. Wemyss Fulton, of the Scotch Fishery Board, floats in the water, measures in diameter rather more than $\frac{1}{20}$ in., and has a large reddish oil-globule. Dr. Fulton considered that the number of eggs in a female measuring 34 in. would exceed two and a quarter millions.

The larvæ, some of which hatched out on the ninth day, measured nearly $\frac{1}{6}$ in., and were distinctly marked with black bands. They have considerable vitality, and bear transport long distances in a little water. Those under observation at St. Andrews were increasingly active each day, the breast fins showing rapid vibration. Professor McIntosh regards one of 10 in., captured in February, as about a year old, which, if correct, indicates an earlier spawning-season than that usually named.

Ophidiidæ

The Sand-Eels

At almost all stages of their development a most important food for some of our principal fishes, and in the full-grown stage the very best bait for bass, pollack, coal-fish, mackerel, turbot, and many other fishes, both round and flat, the sand-eels are familiar only on certain parts of the coast where there is a special seine-fishery for them. Elsewhere their retiring habits, and the ease with which they burrow in the shifting sandbanks, make them strangers to even the average resident. One such fishery is named by McIntosh and Masterman at Elie, in the Forth estuary, and there is another at the mouth of the Teign, in Devon, close to which, indeed, within 500 yards of the nets, the writer has resided during four summers.

Both the sand-eel and launce have close affinities with the cod family, though they are referred to as a family of their own, and it is, therefore, convenient to consider these two fishes in the present chapter. They are caught at Teignmouth in varying proportions, one or the other predominating on different days, or sometimes in about equal quantities. A long series of notes on the subject, however, extending over the period named, has not enabled the writer to offer any explanation of the relative numbers in which the two are taken in the nets.

At any rate, there is no fear of mistaking one for the other, in spite of the fact that Mr. Cunningham says that they are "so much alike that it is very difficult to distinguish one from the other, but there seems to be no doubt whatever of their independence." This is amazing reading to one who has never found any difficulty in selecting the sand-eel and rejecting the launce—the latter is far inferior as bait—even in the half-light of a summer evening, and it almost prompts a doubt as to whether so careful an observer of fish can really have seen both side by side. The launce is deep or pale green, unmistakably green; the sand-eel is never green. These, by the way, are the names by which the two go at Teignmouth, where they are also collectively known as "sprats." On other parts of the coast the launce is known as the Greater, the sand-eel as the Lesser, Sand-eel.

The Launce (*Ammodytes lanceolatus*), or Greater Sand-eel, the green species above referred to, grows to a length of over 15 in. The lower jaw is conspicuously the longer, being utilised by the fish in its rapid burrowing in the wet sand. In the roof of the mouth there are two horn-like teeth, which further distinguish it from the sand-eel, which has no teeth of any kind. The horny processes referred to can hardly be regarded as teeth in the ordinary sense, for their structure is different, but they may, perhaps, do the work of teeth. The lower jaw, besides protruding, is grooved like a trowel. The tail fin is deeply forked and has some dark colouring, and the belly of the fish is silvery white. The scales are so minute that these little fishes are, when handled, almost as slippery as true eels.

The launce, when about to burrow, goes head first into the wet sand with incredible rapidity. It is a voracious fish, and the writer has often watched large examples dashing among the smaller, and seizing them crosswise, under Bournemouth and Teignmouth Piers. Its inferiority as bait has already been mentioned. Not only do the bass appreciate it less than the sand-eel, but it has not half the vitality of that species, dying on the hook in less than ten minutes, whereas the sand-eel, properly hooked, will last twenty. As food for man it is also less favoured than the brown species, being too fat and rich. Nor does it retain its activity so well when kept overnight in the "courge," a wooden or wicker contrivance used in the West Country (and originally introduced from the Channel Islands) for the proper storage of these live baits.

The spawning of the launce appears to take place in May, June, and July. The eggs, which have not been very accurately studied, are thought to be demersal, which would correspond with the general habits of the fish. They measure rather more than $\frac{3}{100}$ in., and have a green oil-globule and a thick capsule.

The Sand-eel (*A. tobianus*), or Lesser Sand-eel, has already been incidentally distinguished from the larger species. It grows to a length of only 6 or 7 in., is brown in colour, lacks the horny teeth of the launce, and has the lower jaw projecting, but shallow and pointed, not grooved like that of the launce. Day alludes to a row of teeth at the base of the tongue, but the writer has sought these in vain in many examples.

The sand-eel is commonly described as residing closer inshore than the launce, but at most places within the writer's knowledge they occur in company. The sand-eel appears the commoner, however, on the east coast of Scotland.

In that part of our seas it is said to spawn in the beginning of the year, but McIntosh and Masterman are of opinion that it spawns twice, in deep water in December or January, and in shallow water again in May. The number of eggs in the sand-eel has been estimated at from ten to thirty thousand. The ripe egg has not yet been described, but the newly hatched larva is well known, and measures rather less than $\frac{1}{7}$ in. It has been surmised, though on no certain evidence, that the early metamorphoses of the sand-eel are gone through while the fish lies securely buried in the sand, though at a later stage, and before finally settling down to its underground haunts, it has a free-swimming stage at the surface, millions occurring in the tow-nets in May. Masterman compares these wanderings with those of infant plaice. The ordering is, however, different. The sand-eel starts on its career in moderately deep water and in an asylum of sand, subsequently finding its way up into the genial influence of the sun's light and heat, growing rapidly at the surface, then returning to the depths, but not until its ranks have been sadly thinned by the attacks of birds and other fishes. The little plaice first sees light at the surface, and goes through the remarkable structural changes, that have already been described, near the top of the water. Then, having assumed its final shape, it gradually drifts inshore and finally takes up its abode, after a very different series of experiences, close to the adult sand-eels.

CHAPTER XIV

SOME RARE OR UNCOMMON FISHES

In the present chapter account must be taken of a miscellany of fishes isolated in greater or lesser degree from the foregoing, and for the most part of only accidental occurrence on our coasts. In this respect, however, they will be found to differ considerably, extreme cases being the sturgeon and *Argyropelecus*, the former occurring regularly each winter, the latter dredged on one occasion only in deep water north of Shetland. How far some of the fishes named in the present chapter are entitled to be reckoned among British forms must be largely a matter of opinion. The same difficulty arises in the cases of rare stragglers among birds ; and, on the whole, it is convenient to allow the admission of a species on the strength of even one well-authenticated occurrence under natural conditions. Whether on such a basis we can admit the single example of *Pammelas*, which was found floating in our seas in a broken wooden case, is open to doubt. For present purposes, however, no very strict investigation has been made, and in the present chapter mention will be made of every "British" fish so far named and recorded that has not been included in the earlier chapters. The following chart gives the families to which these rarities belong, and a glance at the earlier folding chart of British fishes will show more closely their approximate affinities with those of greater importance :—

FAMILY.	COMMON NAME.	GENUS.	SPECIES.
	HOLOCEPHALI		
CHIMÆRIDÆ	Arctic Chimæra	*Chimæra*	*monstrosa*
	GANOIDEI		
ACIPENSERIDÆ	Sturgeon	*Acipenser*	*sturio*
	TELEOSTEI		
PERCIDÆ	Smooth Serranus	*Serranus*	*cabrilla*
	Dusky Perch	*S.*	*gigas*
	Wreck-fish	*Polyprion*	*cernium*
	Dentex	*Dentex*	*vulgaris*
	Mendole	*Mæna*	*vulgaris*
COTTIDÆ	Murray's Gurnard	*Triglops*	*murrayi*
SCORPÆNIDÆ	Bergylt (Norway Haddock)	*Sebastes*	*norvegicus*
		S.	*dactylopterus*
BERYCIDÆ		*Beryx*	*decadactylus*
		Hoplostethus	*mediterraneum*
PEDICULATI	Angler-fish	*Lophius*	*piscatorius*
SCOMBRIDÆ	Short-finned Tunny	*Orcynus*	*thynnus*
	Long-finned Tunny	*O.*	*germo*
	Bonito	*Thynnus*	*pelamys*
	Belted Bonito	*Pelamys*	*sarda*
	Plain Bonito	*Auxis*	*rochei*
	Remora	*Echeneis*	*remora*
SCOMBRESOCIDÆ	Flying-fish	*Exocœtus*	*volitans*
STROMATEIDÆ	Black-fish	*Centrolophus*	*pompilus*
		C.	*britannicus*
CORYPHÆNIDÆ	Ray's Bream	*Brama*	*raii*
	Opah	*Lampris*	*luna*
		Luvarus	*imperialis*
CARANGIDÆ	Pilot-fish	*Naucrates*	*ductor*
	Black Pilot	*Pammelas*	*perciformis*
	Albicore	*Lichia*	*glauca*
XIPHIIDÆ	Sword-fish	*Xiphias*	*gladius*
SCIÆNIDÆ	Maigre	*Sciæna*	*aquila*
TRICHIURIDÆ	Blade-fish	*Trichiurus*	*lepturus*
	Scabbard-fish	*Lepidopus*	*caudatus*
CEPOLIDÆ	Red Band-fish	*Cepola*	*rubescens*
TRACHYPTERIDÆ	Deal-fish	*Trachypterus*	*arcticus*
	Banks' Oar-fish	*Regalecus*	*banksii*

Family.	Common Name.	Genus.	Species.
	Teleostei *(continued)*		
Centriscidæ . . .	Bellows-fish	*Centriscus*	*scolopax*
Macruridæ . .		*Coryphænoides*	*rupestris*
		Macrurus	*lævis*
		M.	*cœlorhynchus*
		M.	*æqualis*
Gadidæ. . . .	Forkbeard	*Phycis*	*blennoides*
		P.	*aldrichii*
	Lesser Forkbeard	*Raniceps*	*raninus*
	Norway Pout	*Gadus*	*esmarkii*
	Silvery Gade	*G.*	*argenteus*
		Mora	*mediterranea*
Ophidiidæ. . .		*Haloporphyrus*	*eques*
	Bearded Ophidium	*Ophidium*	*barbatum*
	Drummond's Echiodon	*Fierasfer*	*dentatus*
		Nettophichthys	*retropinnatus*
Salmonidæ . .	Argentine	*Argentina*	*sphyræna*
		A.	*silus*
Sternopthicidæ		*Argyropelecus*	*hemigymnus*
	Pearlsides	*Maurolicus*	*pennantii*
Murænidæ . . .	Murry	*Muræna*	*helena*
Gymnodontes .	Short Sun-fish	*Orthagoriscus*	*mola*
	Oblong Sun-fish	*O.*	*truncatus*
	Globe-fish	*Tetrodon*	*lagocephalus*
Sclerodermi . .	File-fish	*Balistes*	*capriscus*
		B.	*maculatus*

The Arctic Chimæra (*Chimæra monstrosa*) shows many affinities to the sharks and rays, though Bashford Dean and some other modern workers incline to separate them somewhat widely. Still, such features as the cartilaginous skeleton, the male claspers, the blood-vessels, brain, spinal cord, and organs of sight, smell, and hearing, cannot be overlooked, and all these in the chimæra are essentially sharklike. The whiplike tail, too, recalls the same organ in many rays. The most sharklike of the three surviving genera is *Harriotta*, a long-snouted fish occurring on the American coast. On the other hand, the tail of *Callorhynchus*, the elephant-fish of Antarctic seas, is almost exactly like that of typical sharks. Affinities are also seen with the lung-fishes, in the solid skull, with the jaw attached directly by its own substance.

Our own chimæra, which also occurs in the deeper parts of the Mediterranean, is the largest of surviving chimæroids. Four small ones, the largest measuring 16 in., were taken by the *Travailleur* at a depth of from 800 to 1,200 metres. It has the cartilaginous skeleton, and on each side a single gill-opening covered by a fold of skin that forms a rudimentary gill-cover, the outlet of four gills. The body is long, terminating in the aforementioned attenuated and apparently degenerate tail. There is a fringed filament over the snout, and on the head are rows of pores, the use of which has not been explained. The pectoral fins are large and fan-shaped; the tail is as long as, or longer than, the body. The adult has no scales, but the younger stages are said to possess small, tooth-like scales, locally distributed. In colour the chimæra is brown and silvery.

The chief difference between chimæroids and sharks lies in the teeth. In sharks, as we have seen, they lie in numerous rows, unconnected by ossification with the gristly jaws, those behind being ready to take the place of the others when accidental or natural causes shall have rendered these useless. The teeth of chimæroids, on the other hand, are solid-looking molars on the palate and lower jaw, with a small pair of cutting teeth in the upper jaw, on the front edge. They are clearly intended for triturating food, and it is probable that crustaceans and molluscs, rather than herrings, form the bulk of the chimæra's prey. The lateral line, sharklike, is distinct, but the air-bladder is wanting.

The breeding of the chimæra has not been studied, for the difficulties are at present insuperable. The fish has never been kept in captivity, and its natural haunts are too far removed from the eye of man for there to be much hope of an early explanation of the many mysteries of its life. We can only, from the form and position of the claspers, infer close analogies to the habits of oviparous sharks and rays. Nor has its egg-case been found ; but that of the Antarctic *Callorhynchus* is a leaf-shaped structure with fringed edges, not unlike the egg-case of rays, but lacking the horns at each corner. Portions of such an egg-case were dredged by the *Travailleur* at a depth of 615 metres in the Gulf of Gascony.*

The Sturgeon (*Acipenser sturio*) is a ganoid, and may be regarded as furnishing in a measure a link between the sharks and body fishes. Its place is, therefore, between the chimæra and the bony fishes that compose the rest of this chapter.

The sturgeons, which we associate particularly with the rivers of Russia and other Continental countries, are all river-fish, sluggish in habits, ground-feeders, spawning in fresh water (their eggs furnishing the basis of true caviare), and returning seawards in the cold months. On our own coasts, however, the fish seems to be caught during summer as often as at other times of the year.

The scales of other fishes are replaced in the sturgeon by five longitudinal rows of bony plates. The tail, like that of sharks, has a long upper lobe and short lower one. The snout is broad, pointed, and projecting, and four barbels grow from it. The jaws are highly mobile, and can be protruded by the fish when feeding in the soft mud. There are no teeth in the mouth of the adult, but larval sturgeons have conical teeth, which fall out during later development. The skeleton is cartilaginous. There is a single gill-opening, with four gills and a gill-cover (as in bony fishes), a spiracle (as in sharks), and a large air-bladder.

The sturgeon is brown on the back and lighter beneath. It grows to a length of 18 ft. It visits our shores without

* *Expéd. Scient. du Travailleur et Talisman* ("Fishes," by Vaillant) p. 80.

any regularity, and is generally caught in rivers, though a few are taken in the cold months by trawlers in both the North Sea and the Plymouth district.

The eggs of the sturgeon are small and enclosed in a viscid envelope that adheres to anything with which it comes in contact. They have but little yolk, and the young hatch out within a week. In many respects the larval sturgeon resembles the larval shark, but these anatomical affinities need not be given here in detail.

The remaining fishes, rather more than fifty in number, are all teleosteans, or bony fishes. They are given in an order that approximately corresponds with that of their nearer allies in earlier pages, but reference should be made to the chart for a more exact understanding of their place in the list. A large number of them will be found to be related to the horse-mackerels, while several are allied to the cod.

The Smooth Serranus (*Serranus cabrilla*), or Bulls, is a great percoid fish from the Mediterranean, a more exclusively marine form than the bass, since it does not travel up rivers. In colour it is yellow, having dark bands along the sides. The tail is not forked, as in the bass, but ends squarely. It lives on rocky ground, and feeds on small fishes and crustacea. Unlike the bass, it has no teeth at the base of the tongue. Occasionally this fish is hooked in our seas, but more often it is taken in the crab-pots.

The allied Dusky Perch (*S. gigas*), a wanderer from the Mediterranean and South Atlantic, grows to a weight of 60 lb. Not many more than half a dozen British examples are on record. In colour this fish is reddish above and light beneath. The lower jaw protrudes, as in *S. cabrilla*, and the tail fin is rounded, as in many of the wrasses.

The Wreck-fish (*Polyprion cernium*), or Stone-basse, which grows to a length of 5 or 6 ft. and a weight of 60 or 80 lb., but has not apparently been captured in British seas even a third of that weight, is another southern perchlike fish, ranging to Northern Europe. It has a singular habit of sheltering in floating wreckage, often in numbers, and the fishermen spear it on such occasions. In colour it is dark grey or stone hue, of clumsy build, deep and thick for its length. The fins and gill-covers are edged with sharp spines. There are teeth on the tongue as well as in the jaws. Calderwood notes two taken in Cornwall on the same day (in September, 1892), the one at Mevagissey, the other at Plymouth, the localities named being about forty miles apart by sea. They were thought to have come in from the Atlantic together, and measured respectively $19\frac{1}{2}$ and $20\frac{1}{2}$ in.

The Dentex (*Dentex vulgaris*), last of our rarer perchlike sea fish, is also a Mediterranean form. One of 56 in. has been caught in our seas, and many of smaller size. In colour it is blue and silver, with bronze reflections. It has large canine teeth, like those seen in some wrasses, and is described as a greedy biter and a powerful fighter when hooked.

The Mendole (*Mæna vulgaris*) is admitted to the British fauna by Couch, but Day thinks that the specimen thus described was a bogue (*Box*). Couch says, however, that it had pointed teeth, whereas those of the bogue are flat and notched.

Triglops murrayi, a small cottoid, was first described in 1885 from specimens taken by Dr. Murray off the Mull of Kintyre. It has since been known as "Murray's Gurnard," and has been recorded in the Firth of Forth (1890) by Mr. Thomas Scott.* It measures only 4 or 5 in., and appears to live on muddy ground in from 25 to 28 fathoms; also it is claimed as occurring in Scotch waters only, though an allied species (*T. pingelii*) from the Norwegian coast is figured in *Scandinavian Fishes*.

* See Eagle Clarke, *Ann. Scot. Nat. Hist.*, January, 1895, p. 23.

The Bergylt (*Sebastes norvegicus*), or Norway Haddock, is chiefly interesting as one of our only two bony fishes (the viviparous blenny has already been described) which produce living young. The female is said to contain fully two thousand embryos, and a celebrated Scandinavian biologist regards the male as monogamous. The satisfactory establishment of that peculiarity in the lower vertebrates must always present difficulties, since, as already suggested, the results of observations in the aquarium necessarily rest on artificial conditions, and the results of observations in the natural state are almost purely surmise.

Most of our rarer fishes are southern forms, reaching us from the Mediterranean ; but the bergylt is a cold-water fish, occurring, so far as we are concerned, chiefly on the north coast of Scotland. It is occasionally caught in the Moray Firth, and is said to be familiar in form to the Grimsby fishermen, who take it on the North Sea banks ; but one authority declares that they have no vernacular name for it. This, if correct, is an almost unique case, for it is the experience of most who have dealings with the fishing population that they seem to have devised vernacular names for even the rarest of fishes that they catch only at long intervals. That they should, therefore, have no familar name for so striking and characteristic a form as the bergylt seems almost incomprehensible, and further evidence on the subject would be desirable.

The bergylt is deep-water fish of active habits, and is for the most part taken on the cod-lines. In colour it is of a uniform bright red on the body and fins ; hence in America it is known as "rose-fish." The name "bergylt," which seems to be Norwegian for "cliff-sow," is not intelligible to our limited knowledge of its habits ; but it is at least unfortunate that *bergylta* should have been made the specific name of one of the wrasses, which are no connection whatever of the present fish. Nor is the gadoid association of "haddock" much happier, since the fish is much more like a perch.

There are spines on the gill-covers, scales over the head and body, and teeth on the jaws and vomer, but not on the tongue.

Though the adult is a deep-water fish, the embryos swim close to the surface. When first born they measure from 3 to 5 mm., or roughly $\frac{1}{5}$ in.

From all accounts the bergylt is not a desirable table-fish. Holt, however, tasted some trawled on the Iceland grounds, and compares their flavour to that of sea-bream.

The allied *S. dactylopterus*, which has been confused with *S. norvegicus*, may also be included among British fishes on the strength of one that was washed ashore in 1893 on the Yorkshire coast. It has larger scales than the commoner species, and its gill-covers open vertically instead of obliquely. It now appears that examples of this species had been captured off the Irish coast as early as 1843, but were invariably referred to the commoner species.

Beryx decadactylus has not yet been found on our coasts, though there is presumptive evidence of its occurrence there; but a single example of a near relative, *Hoplostethus mediterraneum*, a fish with a very large eye and serrated edge to the belly, was taken by Green in 250 fathoms off the south-west coast of Ireland in 1889.

The Angler-fish (*Lophius piscatorius*) is one of the least uncommon fishes named in the present chapter, but it is sufficiently isolated in both habits and appearance to be most conveniently dealt with here. This remarkable-looking fish seems generally distributed on our coasts, though nowhere very common, and the same may perhaps be said of its occurrence on the other coasts of Europe and at the

Cape. Curiously enough, while said to be not uncommon on the Pacific side of America, it is regarded as wanting from the Atlantic seaboard of that Continent.

The angler may at once be recognised by the rod-like modification of a ray of the front dorsal fin which surmounts its immense flattened head. The latter, as also the wide, gaping mouth, is fringed with tentacles. The dorsal fin has other prominent rays, but none with the forked "bait" that is carried by the first.

The body tapers somewhat abruptly to an insignificant-looking tail, and the skin has no scales. The pectoral fins are developed in a remarkable manner, so as to serve in a measure as feet, much as those of the gurnards may be regarded as answering the purpose of hands. The angler does not use them when routing for food, for this is not its mode of feeding, but it walks on the sea bed and steadies itself in strong currents or rough weather. It is a very poor swimmer, having neglected that art since its earlier and more active days and developed other talents. It lies motionless in the weeds, waving its bait and suddenly opening its mouth whenever any fish approaches sufficiently close to be carried in by the inrush of water. Even large skate and conger are engulphed in this way. The "bait" has been described by Day and others as "glistening"; but it must, if this be the case, lose its glamour with life, for the writer has examined several, fresh from the trawl, without finding any sign of glitter, even when the flag-like extremity was moistened again.

The teeth of the angler point easily backwards, towards the throat, but will not bend outwards. They lie in two rows in the jaws, and there are a few on the vomer, but none on the tongue. The lower jaw is slightly the longer. The eye is small, and is surmounted by sharp spines. There is a single gill-opening on either side with a kind of pouch, in which earlier writers said that the young find shelter when threatened with danger. McIntosh quite unnecessarily takes Day to task for holding this opinion, whereas, at any rate in *British Fishes*, Day merely quotes it as the opinion of "some authors."

In colour the angler is of a deep brown above, with dark lines and marks, and having the lower surface yellowish white. The ground-colour and markings are both, however, subject to much variation.

It is usually regarded as a shallow-water fish, but Byrne found it (1889) on the Irish coast in 200 fathoms. Though ordinarily a ground-dweller, the angler is said at times to bask at the surface, and indeed it must even seek its food there, since of the many birds that have been taken from its stomach, cormorants and razor-bills might perhaps have dived to its haunts, but gulls must have been seized at the top of the water. Its stomach can be stretched to an extraordinary extent, and its habit is probably to swallow a fish little smaller than itself at intervals, and then, like some reptiles, digest it at leisure. Holt quotes an interesting suggestion, made by a member of the Irish survey, that the fish is able to snap with great accuracy at any object that touches the "bait," so that the angler is a kind of living spring-trap. It is regarded as one of the most persistent natural enemies of the plaice, on which it is said to feed at most seasons of the year.

It is of little use, save as a curiosity for the museum, though Irish washerwomen are said to use the gall for whitening their linen, and the same organ is said to be employed in Iceland in the manufacture of soap.

The angler spawns in summer time, the eggs floating in immense sheets on the water, much like the spawn of frogs, though this is not, of course, the reason of its being called "frog-fish," a name it bore long before the spawn had been described. A sheet of angler spawn 36 ft. in length and 10 in. wide was once thrown up in July in the Firth of

Forth, and it has also been obtained in February, which points to a variable breeding-season. The eggs, pear-shaped and having a single oil-globule, measure about $\frac{1}{12}$ in. in diameter. They are adhesive, like those of the herring, only they float instead of sinking. An angler measuring nearly 4 ft. contained considerably over a million-and-a-quarter of eggs. The vast sheet in which these float on the water, one deep, is simply a gelatinous conglomeration of the egg-membranes. Black colouring matter is conspicuously developed in the larva even before hatching. The flattened form of the adult is first noticeable about fifteen days after hatching. During the early free-swimming stage the pectoral fins are enormously developed, streaming out behind the fish like long threads, and there is a later stage in which the little fish is one mass of projecting rays, and has the dorsal rays ramified like the branches of seaweeds, while the front one of all already shows the forked "bait" that is to be of so much use later.

For evidence of the rate of development after fifteen days from the egg (the latest stage observed in the aquarium) we are dependent on the harvest of the surface tow-net; but Günther, McIntosh, and Cunningham figure, between them, half a dozen distinct stages that may be usefully compared. The disproportion between the millions of eggs of this fish found floating on our coasts and the very small number of adults, and yet greater scarcity of the post-larval stage, has struck almost every writer, and the only reasonable explanation would seem to be that at an early age the angler retires to some part of the sea inaccessible to both hook and net. This view is borne out by the fact that very small adult examples are rarely met with. Young angler-fish were taken off Cape Verde Islands and off the Azores at a depth of from 500 to 700 metres. So far as the records of any county fauna go, there would of course be a tendency to enumerate only the larger examples; but, apart from this, it is known that examples of, say, 4 or 5 in. in length are very uncommon. An analogous case is found in the basking-shark, small individuals of which are never encountered, and there also the only explanation lies in some haunts far from our shores. A few quite small anglers have, however, been described here and there, and McIntosh mentions one of $5\frac{1}{2}$ in. found in an injured state on the shore, and evidently, though most of the skin was gone, brilliantly coloured.

We now come to a number of relatives of the mackerels and horse-mackerels, most of them swift ocean-going fishes, which have a wide range.

The Short-finned Tunny (*Orcynus thynnus*), the "great mackerel" of the northern fishermen, has been taken in our seas to the weight of 400 or 500 lbs. and a length of 9 or 10 ft. It is least uncommon in the late summer on our south-west coast, where it comes inshore after the pilchards that abound there at that season. In so doing, it sometimes becomes entangled in the drift-nets.

It is a large fish, resembling the mackerel in outline, the pectoral fin long and scythe-shaped, and with a conspicuous corselet of scales. In colour it is a very dark blue, the adult losing the stripes that were conspicuous in the younger fish. Both edges of the body have a number of finlets in front of the tail, so characteristic of many of these larger mackerels. A small example, measuring only 3 ft., was not long ago taken in the drift-nets at Plymouth.

The Long-finned Tunny (*Orcynus germo*) has been taken on our south-west coast, and also in the Solway Firth,* but only measuring 2 or 3 ft. and weighing from 12 to 20 lb. It is said to take a bait more readily than the larger tunny. In colour it is very like it, but it has a much longer pectoral fin, extending behind the second dorsal. There are the same

* *Ann. Scot. Nat. Hist.*, January, 1898, p. 53.

finlets on both margins of the body, but the corselet of scales is much less conspicuous. This tunny appears to be confined on the rare occasions of its visits to our Channel coast, not having found its way, like *O. thynnus*, to the more northern portions of the island.

The Bonito (*Thynnus pelamys*) and Belted Bonito (*Pelamys sarda*) are allied fishes without scales on the lower portions of the body, or indeed anywhere except on their large corselet. Both are marked with curved dark bands, which extend over the whole body in the bonito, but are confined in the belted species to the upper half, while the bonito is further distinguished by a long spinous front dorsal fin. Neither are taken in our seas of great size, from 33 to 36 in. being the greatest length. Mr. Dunn was of opinion that these bonitoes were more plentiful in our seas in former times. Both have been taken on the mackerel lines, the bonito as fär north as in the Firths of Forth and Clyde.

The Plain Bonito (*Auxis rochei*) is so called from the absence of bands. There are no scales except on the corselet, and all the fins are conspicuously small. In colour this fish is blue and silver, like most of the mackerels. The largest caught in our seas measured 18 in., and one of 2 in. less was lately taken in a mackerel-seine in Plymouth Sound.

The Remora (*Echeneis remora*), or Sucker, has been taken on the Cornish and Irish coasts, Matthias Dunn having taken one from a blue shark eighteen miles off the Deadman. It is dull brown in colour, and the front dorsal fin is so modified as to form an adhesive disc—a converse, so to speak, of the abdominal sucking disc in *Lepadogaster*. From the habit of this little fish, which clings to its hosts with the back of its head, and is therefore carried through the water with its under surface exposed to the light, a reversion of the usual conditions has resulted, and the back of the fish is lighter in colour than the belly. This is so different from what we are accustomed to see in fishes that the eye at first refuses to believe that the fish is not upside down. The disc is flat and oval, with a dozen or more transverse plates, and acts by vacuum. Remoras attach themselves to many large fishes and cetaceans, but chiefly to sharks and rays, possibly because their rougher granulated skins give a better hold. In tropical seas it is not unusual to see enormous rays hurling themselves out of the water in order to shake off these remoras, which evidently irritate them. Perhaps the most interesting occurrence of the remora in our seas was that of a head and shoulders found, during the Irish survey (1890-1), in the stomach of a picked dog-fish (*Acanthias*),* for the episode clearly shows that elasmobranchs prey on these parasites.

The Flying-fish (*Exocœtus volitans*) is doubtfully included, with a second species, in Day's *British Fishes*, but the evidence of their presence alive on our coasts is too unreliable to make a detailed description desirable.

Centrolophus britannicus and *C. pompilus*, the latter known as the "Black-fish," the former apparently without vernacular name, are two rare visitors from the Atlantic. Couch says that an example of the former was thrown ashore near Looe in 1859, and that is the only recorded British occurrence. The second species has been taken on several occasions, the first on record also coming from the neighbourhood of Looe. It is said to follow sharks. Day enumerates some seventeen cases of its capture in our seas, and a recent occurrence is mentioned by Holt, who says that six or eight were taken in a mackerel boat off the Runnstone, near the Scilly Islands. These were evidently young examples, for they measured only 12 or 13 in. They had been feeding on small pollack of 3 in. In

* See Holt and Calderwood, *Trans. Roy. Dub. Soc.*, September, 1895, p. 413.

colour they were dark grey, and showed violet and iridescent blue reflections.

Ray's Bream (*Brama raii*) is a flattened bream-like fish, its head short, the front rays of the dorsal fin conspicuously long. Its colours are variable, but blue, with bronze and other metallic reflections, and black edges to the dorsal, anal, and caudal fins are characteristic. The eye is large; the teeth are long and sharp. Though described as a deep-water fish, it may occasionally stray into the shallows, for examples are from time to time cast ashore. The Cornish specimen (Penzance) alluded to by Day as floundering in the shallows and captured in 1875 was the last seen in the duchy until the spring of 1891, when another was gaffed near Falmouth and sent by Dunn to the Plymouth Laboratory.

The Opah (*Lampris luna*) belongs to the same family, but is a much more striking fish, the most brilliantly coloured, in fact, in our seas, if not in all the world. Now and again one is on show in the window of some London fishmonger's shop, and crowds assemble to admire the silver-spotted fish with the vermilion fins and golden scales, while the sharp curve taken by its lateral line is also remarkable. Its bright colouring has gained for it a number of appropriate names, such as "king-fish" and "sun-fish," the last entailing the risk of confusion with either the true sun-fish or basking-shark so-called. It is only a straggler to our seas, and it is curious, indeed, to find so brilliant a fish evidently of northern origin, whereas we should be tempted to associate it with the hotter seas of the south. It is on rare occasions taken in the Mediterranean, but evidently does not belong to that sea. The opah grows to a great weight, and examples of between 100 and 150 lb. have been captured on our coasts at different points between Cornwall and the Orkneys. It feeds on cuttle-fish and similar animals, and its flesh is said to be excellent eating. Though a deep-water fish, like Ray's bream, it is, like that fish, never captured by either hook or net, but is always either thrown ashore or else overcome in shallow water.

A third fish of the same family, much rarer with us than the others, is *Luvarus imperialis*, the only two British examples of which were thrown ashore in Cornwall in 1866, the one near the Deadman, the other close to Falmouth. The larger measured 4 ft. and weighed 120 lb. ; the shorter measured 45 in. The truncated head and small upturned mouth of this fish give it a unique appearance.

The Pilot-fish (*Naucrates ductor*) is one of the horse-mackerels. Those who have voyaged in the warmer seas of the globe are well acquainted with the small blue fishes, shaped somewhat like mackerel, and marked down the sides with five or six dark greenish bands, that swim near the head of sharks. The dorsal and caudal fins are also tipped with white. The lateral line is clearly traced ; but, instead of being marked by rough scales, like that of the scad, the portion of it before the tail has a keeled ridge.

Though by no means a common visitor to our coasts, a number of pilot-fish have been taken, though not, as in warmer seas, in the company of sharks. The majority of these occurrences have been in Devon and Cornwall, though the preponderance of specimens of rare fishes recorded from our south-west coast may in great measure be due to the labours of such careful observers as Cornish, Couch, and Dunn. Among other localities on our shores in which the pilot-fish has occurred are the Isle of Wight, Folkestone, Margate, the coast of Suffolk, and one or two in both Scotland and Ireland. These fish generally reach our seas with some vessel from foreign parts.

The Black Pilot (*Pammelas perciformis*), another of the horse-mackerels, is a dark blue-grey fish, with dark spots on the head, and curious separate spines in place of the more commonly developed dorsal fin. Only one British example is on record, and that was picked up in a three-sided wooden case about six miles off Penzance. The conditions of its capture throw some doubt on its claim to rank among British fishes.

The Albicore (*Lichia glauca*), still another of the horse-mackerels, has only twice been recorded in British seas, in 1857 and 1878, both examples having been taken in Cornwall. It is like the last in shape, but the colours are lighter green, and there are black stains on its yellowish fins.

The Sword-fish (*Xiphias gladius*) has been taken many times in our seas, though it can only be regarded as an uncommon summer visitor from the Mediterranean and other southern waters. It grows to a great size, the larger examples taken on our own coasts having measured 10 or 11 ft., and weighed up to 300 lb. It has been caught on a baited hook and also in the drift-nets, while now and again an example has been left stranded in the shallows. Its colour is dull blue above and white beneath. The bands, visible in the young fish, disappear in the adult, but there are other changes more remarkable than this. In the very young fish of one genus (*Histiophorus*) the jaws are of equal length, and both are furnished with teeth. At that stage, too, there are spiny bristles over the eyes, and the prominent dorsal fin is absent. Somewhat later the great development in the latter begins to appear, the eyes lose their bristles, and the ventral fins grow long and threadlike. In the adult stage we find the high dorsal fin, long, swordshaped upper jaw, and absence of teeth. The scales, which were moderately strong in the young fish, are feeble in the adult.

The feeding of the sword-fish is a mystery. It is difficult to imagine what manner of food could be captured with the sword and yet devoured without teeth, unless it were possibly large cephalopods. Yet both squid and pilchards have been found in its stomach. On the whole, it is perhaps more satisfactory to regard the sword as a weapon of defence against sharks and whales, and to consider that the fish pursues its prey and swallows it whole. Clearly, there would be some difficulty in removing victims from the blade.

The Maigre (*Sciæna aquila*), or Shade-fish, has been taken on our coasts on many occasions, and one year produced no fewer than six records. That, however, must be regarded as exceptional. It has occurred for the most part in the south-west, but also in the Firth of Forth and on the Norfolk coast, as well as at Margate, Hastings, Brighton, Carmarthen, and Cork, which indicate a fairly wide range. Some of the British examples have measured over 6 ft. in length, and have weighed as much as 400 lbs. It is only a straggler from more southern seas, and seems to be identical with the jew-fish (*S. antarctica*) of Australia.

In shape it is not very different from the bass, though the tail-fin is rounded instead of forked, and the fish is somewhat longer for its depth and lighter in colour. The dorsal and anal fins are reddish, and the body is uniformly silvery, but soon turns dull after death. It is a most voracious fish, and is one of the few known enemies of the monk-fish. Like its relative the "Drum," of Florida seas, it is said to utter sounds under water that are audible above the surface, but the writer has never heard any indication of such a habit, though he has caught many of the Australian species on the coast of New South Wales.

The Blade-fish (*Trichiurus lepturus*), or Hair-tail, is a winter straggler from the tropical Atlantic, flattened and snake-like in form, with a curious scaleless, silvery covering that comes off when the fish is handled. Couch recorded the first British specimen, which measured 27 in., and was thrown ashore in 1853 near the Land's End. Most of the recorded examples occurred in Cornwall, but cases have also occurred on the Irish coast, while there was one at Swanage in 1872. The jaws are provided with sharp curved teeth, and it probably feeds on smaller fishes.

The Scabbard-fish (*Lepidopus caudatus*) is silvery, like the last, but the covering is not so easily detachable. The teeth are barbed, and the lower jaw noticeably protrudes. The ventral fins dwindle in this form to a pair of scales, but the fish is otherwise scaleless. This is the famous "frost-fish" of New Zealand, and grows to a length of 6 ft. Its weight is insignificant in comparison with its length, owing to its compressed form. It is one of the comparatively few fishes that have never been taken by either hook or net, all the examples recorded having been thrown ashore; and in New Zealand this occurs only on frosty nights.

The Red Band-fish (*Cepola rubescens*), a distant connection of the blennies, has been taken on our coasts on lines, but has more often been washed ashore, wandering to our seas in winter time from the south of Europe. The largest British example, which measured 22 in., was taken in the Exe. It is much more abundant in British seas in some years than in others, but no reason, climatic or otherwise, has ever been assigned for this. The fish is, as its name denotes, red and band-shaped. Its scales are very small. The pectoral fins are rose-pink, and there are yellow markings on the body. The dorsal and anal fins are spineless, and extend along most of the body, and the tail is pointed. The teeth are long and pointed, yet the fish is said to feed only on zoophytes and small crustaceans. If this be true, the fish has an extraordinary armature of teeth for such work.

The Deal-fish (*Trachypterus arcticus*), a northern form more commonly met with in the cold seas round Iceland, has been captured on several occasions on our coasts, the longest British example, measuring over 7 ft. in length, having been washed ashore in Donegal Bay in 1875. It and the following species have, in spite of their equally elongated and even band-like form, no connection with the foregoing. The dorsal fin runs almost the length of the back, and there is no anal; but the most remarkable fin is that on the tail, which is twisted out of the line of the body, and consists of several small rays arranged in the form of a fan. Immediately in front of the tail fin, and on the lower surface, there is a single forward-pointing spine.

This fish is said to inhabit the deeper water, but, like so many other deep-water forms, it is a poor swimmer, and occasionally wanders into the shallows, only to be thrown ashore.

Its colour is silvery, with some pink on the fins. The teeth are much smaller than in the last species. The body is scaleless, and generally in a noticeably flabby condition. The dorsal rays are less developed in the adult than in the young.

Banks' Oar-fish (*Regalecus banksii*) may be distinguished from the foregoing by the great length of the first few rays of the dorsal fin, as well as of the threadlike ventrals. There is no tail-fin.

The skin of this slender, fragile fish is silvery and easily bruised, like that of *Trichiurus*. The longest British specimen on record, captured in the Farne Islands, measured 18 ft.; and there have been less than a score of recorded occurrences, 10 ft. or 12 ft. being the average length, though one measured only about as many inches.

Banks' oar-fish must be an inhabitant of deep water, though naturalists seem unable to agree on its haunts, its range being apparently cosmopolitan. Several of our examples appear to have been taken on the coasts of Yorkshire and

Northumberland, one or two more from various parts of Scotland, and one only from the Cornwall district. It would therefore seem that these have come from northern seas.

This is a scaleless fish, but there are rough tubercles on the skin. The mouth is devoid of teeth, and Banks' oar-fish has always, possibly on this account, been regarded as a great enemy to the spawn of other fishes.

The Bellows-fish (*Centriscus scolopax*), or Trumpet-fish, has been recorded in our seas on half a dozen occasions only, visiting our seas at rare intervals from the south, and ranging, in fact, as far south as Tasmania. One measuring only 5 in. was thrown ashore near Fowey many years ago; but about the other "British" examples there seems, for various reasons, to be some little doubt.

The long and tubular bill of this fish has gained for it the name of "snipe-fish," and the species is further characterised by the long, serrated dorsal spine, which points towards the tail. There are no teeth, and the fish has been thought to probe in the mud for food, like a woodcock; but this must be mere surmise based on the structure of its mouth, for there is absolutely no evidence of its habits at first hand. The scales are small, and on the lower edge of the fish there are short, sharp spines. In colour it is pink, with metallic reflections and some silver on the sides and belly. It is regarded as a deep-water species.

Coryphænoides rupestris is one of those very rare treasures of the dredge for which no English name has been devised. It is one of the "longtails" (*Macruridæ*), deep-water relatives of the cod family, a small silvery fish with a curious truncated head, pointed tail, and long, sickle-shaped, serrated dorsal fin. The first dorsal is short; the second is long, low, and soft.

The body is covered with spiny scales, and there is a small barbel on the lower jaw. The teeth are small.

Day mentions two, the larger measuring nearly 6 in., as having been dredged in 500 fathoms in the Faroe and Shetland districts, on the outlying limits, therefore, of the British area; but there is a later record (1890) of one trawled, also in 500 fathoms or thereabouts, off Achill Head, and therefore definitely in British seas.

Allied deep-water forms, *Macrurus lævis*, *M. cælorhynchus*, and *M. æqualis*, were added to the British fauna in 1889, and 1890, by the Irish expeditions of Green and Byrne, who trawled them in 200 fathoms on the Irish coast.*

One or two rare gadoids remain for consideration.

The Fork-beard (*Phycis blennoides*), known on the Cornish coast as the "Forked Hake," is distinguished by its long, forked ventral fins. It has the dull colouring characteristic of all the cod family, and it also has the barbel on the lower lip possessed by so many of them. British examples have measured been 15 in. and 2 ft. Although it seems from all accounts to be least uncommon on our north-east coast, Holt says that it is unknown as a distinct fish to the Grimsby men, who regarded two examples caught in March, 1892, as hybrids between the torsk and haddock, both of which have been described in the chapter on the cod family.

Day describes it as rare in Devonshire, but records examples from that county. Calderwood mentions one measuring 18¼ in. taken on a whiting hook on the hard ground five miles from shore, near Plymouth. This may, however, have been in Cornish waters, from which Couch had previously recorded the species. More recently it was trawled

* For a detailed description of these rare *Macruridæ* consult Holt and Calderwood, "Report on the Rarer Fishes-Survey of Fishing-Grounds, W. Coast of Ireland, 1890-1891" (*Trans. Roy. Dub. Soc.*, September, 1895).

in both Cawsand and Kenmare Bays, and Mr. Walker found it in Rhos Weir in 1888, the third specimen recorded from that locality in the course of thirty-five years.* The allied *P. aldrichii* was added to the British fauna by Bourne in 1889.

The Lesser Forkbeard (*Raniceps raninus*) resembles one of the suckers (*Liparis montagui*) in shape, but is easily distinguished by the small barbel on its lip, as well as by the absence of sucking-disc and spots. The fins are black and edged with white. In colour the fish is brown above, with bluish tints, and white below. It does not appear to be gregarious, like the majority of the cods, and it may be small, as none of those taken on our coasts have exceeded a foot in length. It appears to occur fairly widely in our seas, being recorded chiefly from the south-west and north-east, and Holt regards it as not uncommon in the mouth of the Humber. Occasionally it is caught on lines.

The Norway Pout (*Gadus esmarkii*), which had been noted as British by Günther† in 1888, was about then included for the first time in the fauna of our seas. Harvie-Brown and Buckley‡ describe it as not uncommon in Kilbrannan Sound, and it has since then been recorded from Northumberland and from the west coasts of both Scotland and Ireland (1890-91). Until as recently as 1897 it was regarded as absent from the Channel, but Matthias Dunn identified it on the Cornish coast in the summer of that year. It came about in this way. Great shoals of hake had most unexpectedly put in an appearance in those bays, and Dunn, curious to know what might be the particular attraction, directed his son Howard to examine the contents of the stomach when the hake were opened. Howard Dunn found some small gadoids, which he took to be young whiting, but which, from his description, his father thought rather to be poutassou (*G. poutassou*). When, however,

* Herdman and Dawson, *Fishes and Fisheries of the Irish Sea*, p. 48.

† *Proc. Roy. Soc. Edinb.*, 1888.

‡ *Fauna of the Outer Hebrides*, p. 203.

some examples arrived, Dunn found them to be a species of gadoid new to him, and accordingly sent them for identification to the Plymouth Laboratory, where they were at once recognised as *G. esmarkii*. There seem to be two varieties or races, one considerably the larger. In colour the Norway Pout is dull grey on the back and sides, and paler below. Tbe latest record is from Plymouth (1900), where an example was recorded by Garstang as taken in quite shallow water.*

The Silvery Gade (*G. argenteus*) was once taken, in the Irish survey, in deep water. Another rare gadoid, *Mora mediterranea*, was trawled in 500 fathoms off Achill Head in 1890. It had not previously been recorded north of the Bay of Biscay. The largest specimen measured nearly 28½ in., and had the gadoid barbel. It has long ventral fins, and is grey on the back and silver below.

The Bearded Ophidium (*Ophidium barbatum*), of which a single British example is said to have been taken near Padstow, has small scales and a pair of barbel-like growths beneath the throat, which are a development of the ventral fins. It is a Mediterranean ally of the sand-eels, and its relationship to the cod family is thus indirect.

Drummond's Echiodon (*Fierasfer dentatus*) is an allied little snakelike fish, also of Mediterranean origin, reddish in colour, and having small spots on the sides. The vent is situated close to the throat. Two British examples only are on record, both of them taken on the Irish coast, one in Co. Antrim (1836), and the other in Co. Kerry (1852). The former measured 11 in., and the latter 8 in. Both were found dead on the beach. These little fishes are chiefly interesting on account of their habit of quartering themselves on jelly-fish and holothurians, and Bashford Dean points out that this commensal habit has resulted in their retaining their

* *Journ. Mar. Biolog. Assoc.*, November, 1900, p. 274.

elongated larval form and a number of other embryonic characters.*

Haloporphyrus eques, another rare deep-water gadoid, was dredged in the Irish survey in 500 fathoms. In length it seems to grow to 13 in. There is a barbel on the jaw, and the first ray of the dorsal fin is prolonged into a threadlike process.

Nettophichthys retropinnatus was added to the British fauna by Holt, who named a specimen trawled on the Irish coast in 144 fathoms. It is a brown, scaleless, eel-like fish with recurved teeth, and there are black edges to the fins. The single example taken was apparently immature, and measured only 5 in.

The Argentine (*Argentina sphyræna*), a marine relative of the salmon, was taken in the stomach of a skate (*R. oxyrhynchus*) in about 500 fathoms during the expeditions of the Irish survey. It was also trawled in much shallower water, of 62 to 80 fathoms.

The adult has large scales, and there is the usual rayless adipose fin of the family. In colour the argentine is olive-grey and silver, with two black spots on the head. It is said to feed on crustaceans.

A. silus, a new allied British species, was obtained in 1898 by Holt about 80 miles south-west of the Scilly Islands. It is also recorded from the coast of Ross (mouth of Lochbroom) caught on a line in August, 1896.

Argyropelecus hemigymnus is an insignificant-looking, deep-water fish, silvery in colour, and with round spots along the body which are thought, though on somewhat questionable evidence, to emit phosphorescent light. One only has been

* *Fishes, Living and Fossil*, p. 169.

dredged in our seas, and that was in a depth of over 500 fathoms, north of Shetland. It is allied to the scopeloids, also deep-sea forms.

Maurolicus pennantii, known as the Pearlsides, is an allied form, having the anterior half of the body deep and square. It has been taken somewhat often, generally in our more northern waters. The latest recorded example was taken at Yarmouth by Mr. Patterson, who found it in "some freshly thrown seaweed left by a draw-netter on the beach near the harbour mouth."*

The Murry (*Muræna helena*), a near relative of the conger, is only a rare wanderer to our seas from the Mediterranean. It differs from the conger in its mottled colouration, as well as in the front tubular nostrils and narrow gill-openings. It resembles it, however, in the absence of scales. The skin is deep brown, with yellow spots, giving a very snakelike impression.

Only three have been recorded in British seas, all on our south-west coast. Of these Day mentions two, caught respectively at Fowey and Polperro; and Holt records the third (March, 1897) as trawled off the Eddystone. It measured nearly 45 in., and had a circular wound on the tail, which had from all appearance been made by the teeth of some dog-fish.

The five fishes that complete the British list all belong to the order *Plectognathi*, a name which has reference to their twisted mouth.

They are divided in two families, the first (*Gymnodontes*) represented in our seas by the two sun-fishes and the globe-fish, the second (*Sclerodermi*) by the file-fish and a closely related form. All are more or less circular in shape and have a rough skin.

* See *The Zoologist*, December, 1897.

The Short Sun-fish (*Orthagoriscus mola*) is not a particularly uncommon fish during hot summer weather on our south-west coast, and has been taken in our seas weighing as much as 5 cwt. Like many other large fishes, however, it is inoffensive. Günther says that it feeds on crustaceans ; but it must also eat small fishes, for not only has it been known to seize a mackerel bait, but its stomach was one of the chief sources of the specimens of larval eels studied near Messina by Grassi and Calundruccio.

The skin is rough and covered with small spines. The eye is small, and is protected by a projecting ridge and provided with a kind of nictitant membrane. The mouth is small and without teeth. For so bulky a fish, the sun-fish occasionally displays extraordinary activity, and is sometimes seen to jump clear of the water. On one occasion, for instance, the writer endeavoured to shoot a very large one which was about 20 yards from his boat, but would not allow itself to be gaffed. The first rifle-ball (·303) having struck it on the back, the fish leapt three times in the air, barely touching the water each time, like a ricochetting shell, and then disappeared. In colour the sun-fish is brown, with iridescent reflections.

The Oblong Sun-fish (*O. truncatus*), which is much rarer in our waters than the last, has a smooth, tesselated skin, marked off in sections that give the surface a paved look. In colour it is said to be brighter and more silvery than the last. Not much more than a dozen species have been recorded from British waters.

The Globe-fish (*Tetrodon lagocephalus*) is a curiously shaped relative of the sun-fishes, the body having a fore-shortened appearance and being deepest almost beneath the eye. The belly is covered with sharp, four-pointed spines in its anterior portion, but not nearer the tail. When angered or excited these fishes inflate their body with air, and in this state they float at the surface of the sea head downwards, the spines offering effective protection against fishes or birds. There are no teeth, the jaws forming a parrot-like beak. The tail fin is forked, and there is a fold of skin on the lower edge of the tail. In colour this fish is deep blue on the back, and white on the sides and belly.

About a dozen British and Irish examples have been recorded. This fish and its tropical allies are regarded as poisonous during certain seasons of the year, but in our seas it is never sufficiently plentiful to rank as a food-fish.

The File-fish (*Balistes capriscus*) visits us on rare occasions when wandering from its Mediterranean home. Unlike the sun-fishes and globe-fish, it has eight large notched teeth in each jaw, and these it apparently uses to crush shell-fish, its favourite food. There are two bony plates behind the gill-opening, a somewhat unusual character. It is also known as the Trigger-fish, because the front dorsal spines, which lie in grooves on the back, move in unison, suggesting a gun action. In colour the file-fish is dark yellow.

B. maculatus is an allied dark-blue species, having lighter blue spots on the body and fins. It is smaller than the last, and only one British example has been recorded, and that under circumstances that give rise to some doubt. Its scales are rough, and it lacks the bony plates behind the gill-openings.

CHAPTER XV

THE CULTIVATION OF SEA FISH

BY R. B. MARSTON (EDITOR OF THE *FISHING GAZETTE*)

ALTHOUGH some attempts at cultivating sea fish have been made in this country, they have generally been on a small scale, and it is not possible at present to point to much, if any, success. Even in the case of the noblest of our migratory fish, the salmon (*Salmo salar*), I regret to say that I can find no *satisfactory* evidence that success has attended any of the many attempts which have been made to increase its numbers by artificial cultivation, not only in this country, but also on the Continent and in America. That all attempts to stock the rivers of New Zealand with salmon have failed is not due to any fault or imperfection in the artificial cultivation of the fish. Many thousands of salmon smolts have descended the New Zealand rivers to the sea, but they never return; and I believe still that the reason for this which I gave some twenty years ago is the right one—viz. that the swarms of voracious fish in the seas of New Zealand give the smolts no chance. Although salmon have not succeeded in New Zealand, trout have done so magnificently that if there were nothing else to point to as a justification for the science of fish-culture, the hundreds of rivers and lakes of New Zealand now teeming with grand trout would be sufficient.

CAN THE SEA BE FISHED OUT?

Under this title I gave in the *Nineteenth Century Review* for November, 1901, some account of the very important discoveries of the Norwegian marine biologists Dr. Hjort and Dr. Dahl. Speaking generally, it may be said that the discoveries of these Norwegian scientists seem to prove that there is no fear that such important fish as the cod and herring can ever become extinct or even reduced in number by man except locally; they are so prolific that what is abstracted by man merely allows for the development of a similar amount of fish life which would not otherwise have developed.

Artificial Cultivation of the Cod in Norway

It is curious to note that although the celebrated cod fishery of the Lofoten Islands, Norway, has been regularly fished for over a thousand years, there has been absolutely no indication that the fishing has prejudicially affected the supply; it fluctuates, as will be seen from an interesting and most convincing diagram given on p. 182 of the *Report on Norwegian Fishery and Marine Investigations*,* edited by Dr. J. Hjort, and published at Christiania. This table shows, for instance, that in 1872 eighteen million cod were taken; in 1878 twenty-eight millions; in 1884 sixteen millions; in 1886 thirty-one millions; in 1889 seventeen millions; in 1890 thirty millions; in 1892 sixteen millions; in 1895 thirty-eight millions; in 1898 only fifteen millions.

There can be absolutely no question of over-fishing when the results jump up and down in this way. It is certainly, as Dr. Hjort says, caused by variations in the *approach of the fish to land.* In some years the evidence seems to point to the numbers of cod-fish being larger than their available food-supply; the fish are so poor that, as Mr. F. M. Wallem tells us, it takes from nine hundred to twelve hundred fish to give

* This splendid work is in English, and must have cost hundreds of pounds to produce. It ought to be studied by every one interested in our sea fish, their food, etc.—R. B. M.

one barrel of medicinal cod liver oil, whereas in an average year four hundred fish will supply the same quantity.

It would be out of place to give a life-history of the cod here; the discovery, in 1864, of Professor G. O. Sars that the eggs float on the surface of the sea gave the first impulse to the artificial cultivation of the cod and other sea fish. In 1864 Sars found that one could take the ripe ova of a female fish and impregnate it by introducing a few drops of the milt of the male fish into the water. There is no difficulty in keeping the impregnated eggs alive until the young fish hatches out, nor the young fish itself as long as it feeds on the yolk-sac; but *once that is absorbed*, all man's efforts to rear the young cod beyond this stage have been practically useless, and in Norway and America and elsewhere, where cod are artificially hatched, all that can be done is to turn the young fish into the sea almost as soon as they are hatched. In Norway Captain Dannevig and others have taken great interest in cod-fish culture, and at the Flodevigen Hatching Establishment since 1884 many millions of cod fry have been released annually. In 1896 the number was 327 millions, and the average every year for seventeen years has been over 100 millions. This seems to be an enormous quantity; but, as compared with the natural fecundity and natural supply of the cod, it is only a drop in the ocean.

A cod of 10 lb. has a million eggs, so that a very few fish will produce naturally all that the hatchery can do artificially, and with far greater chance of success. What a drop in the ocean 100 million cod-fish eggs are will be seen from the fact that on July 26th, 1895, Professor Hensen calculated that there must be over 278 billions of impregnated cod eggs in each square Norwegian geographical mile of the surface of the Skagerrak.

As Professors Hjort and Dahl point out, to expect to increase the supply of cod by artificial means in the face of these figures can only result in disappointment. "As a business, it does not pay at present"—this is their verdict; all the same they think that the work is worth carrying on on the *experimental* scale, with a view to increasing our knowledge. Even Captain Dannevig himself is obliged to admit that "we do not know with absolute certainty whether an increase in the numbers of cod has resulted from artificial hatching or not," though he thinks there is very much in favour of the supposition that an increase has occurred.

I confess that, for my part, if we had only the evidence of these Norwegian experiments to go by, I should say that it looks like an absolute waste of money to attempt in Norway to do more than experiment with the hope of discovering how to rear the young cod as well as hatch them, but fortunately we have other and more satisfactory evidence in favour of cod-fish culture.

The Artificial Cultivation of Cod and other Sea Fish in America

For information on the work done by the United States Commission of Fish and Fisheries in connection with Sea Fish Culture, I have to thank the Acting Commissioner, Dr. Hugh M. Smith, who very kindly sent me the following letter in reply to one of mine asking for the information :—

Washington, D.C., *February 26th*, 1902.

Dear Sir,—

In reply to your letter of the 10th instant, enquiring as to the propagation of sea and anadromous fish in the United States, you are informed that the following species have received attention from this Commission :

Cod (*Gadus callarias*).
Pollack (*Pollachius virens*).
Haddock (*Melanogrammus æglefinus*).
Mackerel (*Scomber scombrus*).

Winter Flounder (*Pseudopleuronectes americanus*).
Tautog (*Tautoga onitis*).
Sea Bass (*Centropristes striatus*).
Squeteague (*Cynoscion regalis*).
Quinnat Salmon (*Oncorhynchus tschawytscha*).
Blueback Salmon (*Oncorhynchus nerka*).
Silver Salmon (*Oncorhynchus kisutch*).
Steelhead Trout (*Salmo gairdneri*).
Atlantic Salmon (*Salmo salar*).
Shad (*Alosa sapidissima*).
Yellow Perch (*Perca flavescens*).
American Lobster (*Homarus americanus*).

Of the foregoing species only the cod, winter flounder, quinnat salmon, blueback salmon, steelhead trout, Atlantic salmon, shad, and lobster are regularly cultivated. In addition to the species named, a number of others, some of minor importance commercially, have from time to time been propagated by this Commission.

With regard to the results of artificial propagation as addressed to the foregoing species, the following statements may be made :

1. The propagation and planting of cod in the inshore waters of New England have been emphatically successful, very lucrative fisheries having been established on grounds that had been entirely depleted or that had never contained cod in noteworthy numbers previous to the work of the Fish Commission. It is reported by persons outside of the Commission, and not especially interested in its work, that an increase in the shore cod catch amounting to fully 50 per cent. in ten years has attended the hatching operations of the Commission at Gloucester and Woods Hole, Massachusetts.

2. The abundance of winter flounder in the vicinity of Woods Hole, to which place the hatching is restricted, has been materially increased, as would naturally be expected in the case of a fish whose movements are so limited.

3. There is little doubt that the shad fisheries of the eastern coast of the United States are practically dependent on the artificial measures adopted by the Government. The multiplication of nets in the estuaries and lower courses of the shad streams is such that practically the entire run is caught before the fish have an opportunity to reach their spawning-grounds.

4. The value of artificial propagation as addressed to the salmon of the Pacific coast is highly appreciated by the fishing interests of that region. There is no reason to doubt that, but for the millions of young fish liberated each year by the Goverment, supplemented by smaller plants by the various states, the run of quinnat salmon in the Sacramento, Columbia, and other important streams would have been very materially reduced by the extensive fishing there carried on. It is impossible to estimate accurately just what effect our work has had on the supply, but some tagging and marking experiments conducted during the past few years have suggested the great value of our work. It has been found, for instance, that for every thousand marked fry liberated by the Commission, one ton of marketable fish have been caught by the fishermen at an interval of two or three years; in other words, at an expense not exceeding one dollar (for one thousand fish liberated) the fishermen are catching for market fish with a value of not less that one hundred dollars.

5. The planting of larval lobsters on the New England coast has not as yet been sufficiently extensive to offset the decline in the lobster fishery due to incessant fishing-operations and the disregard for restrictive laws. The Commission is now experimenting with the rearing of the larval lobsters up to the time when they assume the bottom habits of the adult; and it is expected that the perfection of a method of rearing will prove beneficial.

6. The following are the quantities of marine and anadromous fishes planted by this Commission during the fiscal year

1901. These figures include a few eggs transferred to State Commissions which planted the resultant fry :

Cod	202,871,000
Winter Flounder	44,230,000
Lobster	60,879,000
Shad	193,287,000
Quinnat Salmon	19,441,784
Atlantic Salmon	397,300
Blueback Salmon	3,834,453
Silver Salmon	300,041
Steelhead Trout	370,758
	525,611,336

Very respectfully,
H. M. SMITH,
Acting Commissioner.

Mr. R. B. MARSTON,
Editor of the *Fishing Gazette*,
St. Dunstan's House, Fetter Lane,
London, E.C., England.

SPLENDID RESULTS FROM SHAD CULTURE IN THE UNITED STATES

Shad were becoming extinct or very scarce in the rivers of New England when the late Mr. Seth Green discovered how to hatch shad eggs. His experiments were so successful that the fish, from being a luxury obtainable only by the few, is now "the best and cheapest of all American fish." "It is now 'planted' by the State hatcheries, and on an enormous scale, over two hundred and nine million shad eggs having been received by the various hatcheries in 1898; and the catch, which in 1880 was already five million fish and in 1888 was over ten millions, has now reached seventeen millions. Before 1871 the shad was unknown upon the Pacific. In that year a few thousand fry were liberated in the Sacramento

River. From this small and recent beginning shad are now to be found in abundance in all the Pacific rivers from Los Angeles to Wrangell Island, a distance of two thousand miles. The Report of the Department for 1898 states that, on the Atlantic coast alone, the value of the shad catch for 1896—thirteen million fish—was over 1,651,000 dollars, and declares that since the hatcheries were started the added value of the shad was more than sixty times the entire departmental expenditure on shad propagation. It seems, then, that Mr. Seth Green's experiments, while hardly noticed at the time, were yet destined to reduce the price of shad from a dollar per fish to a dollar per eight fish, to bring this splendid food-fish within reach of the very poorest classes of the community, and to pay the fisher folk of the eastern seaboard a very handsome revenue during the few weeks when the shad are running to the rivers."*

Many years ago I pointed out that the splendid success which has attended the cultivation of shad in America made it practically certain that there is nothing to prevent the introduction of this fish into many of our rivers. The late Mr. Fred Mather, the well-known American pisciculturist, told me that the American fish is superior as a table-fish to the European shad ; and if the experiment is ever made, it is to be hoped that it will be possible to get over the American fish. Unfortunately we have no public body like the United States Fish Commission, which does such splendid work in increasing and creating national food-supply, and indeed it seems impossible to expect any British Government to do more than publish Blue Books and appoint Commissions to take evidence as to the decay of our fisheries. As for thinking of devoting public money for the establishment of fish hatcheries, and increasing the supply of fish in our rivers by restraining over-

* Extract from a most interesting article by Mr. Moreton Frewen on "Fish Culture in America" in the *Nineteenth Century* for September, 1899.

netting, preventing river pollution and poaching, it is hopeless to think of it. What we must pray for is that some rich philanthropist like Mr. Carnegie or the late Mr. Cecil Rhodes will come forward and do for our fisheries what they have done for our libraries and universities.

The Cultivation of Flat-Fish

The plaice, sole, flounder, and other flat-fish are such universally esteemed food-fishes that it is not to be wondered at if the supply does not keep pace with the demands of our growing population, seeing that our available fishing-grounds for them are limited strictly by natural conditions which do not affect the round fish.

Judging from the experiments which have been made in Denmark, there is good ground for supposing that the stock of flat-fish in a depleted locality may be increased, not by producing just hatched fry and setting them free to be carried out to sea, but by planting young fish of some inches in length taken from some locality where they are plentiful.

As a result of its investigations, the Committee of the House of Commons appointed in 1893 to consider the state of our deep-sea and coast fisheries found that, whereas there has been no evidence of decrease of herring and round fish —mackerel, cod, haddock, etc.—there has been an appreciable decrease of flat-fish, especially of plaice and soles.

The flounder fishery in the Thames, from Teddington downwards, was an important one for centuries; but until the London sewage is treated by the bacteriological process, I fear there is no chance of re-establishing it on this river, any more than there is of stocking the river with salmon. It is quite true that the 200 million gallons poured in every twenty-four hours at Barking and Crossness are not so thick as formerly, but they are, every gallon, as poisonous. The sludge is taken out before the rest of the sewage goes into the river, and is carried in sludge boats and dumped into the sea at the mouth of the river, to be cast up on the foreshore at Southend and other places, where what used to be bright sand is now slimy mud.

One of the chief difficulties fish culture in this country has to contend with is this dumping into our rivers and into the sea round our coasts of all the noxious filth of our towns. Even where it does not make oyster culture impossible, it makes typhoid only too possible.

The Eel

Just as we pay away millions sterling for foreign hens' eggs which we might grow at home, so do we pay thousands for foreign eels, instead of looking to our own rivers. In Scotland alone more eels are produced every year than would supply the whole English market ; but the Scotch hate the sight of an eel, and, as eels are very rarely *seen*, no notice is taken of them.

In their investigations respecting the eel, the editors of the Norwegian Report already referred to comment on the ignorance of the country people in many places as to the existence of the fish in their rivers. "Only at very few places did the inhabitants know that the eel descended the rivers each autumn, and at still fewer places did they attempt to derive any advantage from the migration, possibly because most of the people regard the eel as a valueless and uneatable fish."

Most anglers in this country who know anything about eels believe that there are two kinds in our rivers, the yellow-bellied broad-nosed, and the silver-bellied, sharp-nosed ; but Dr. Petersen, of Denmark, has proved conclusively that these are one and the same fish. It is yellow with a broad head when living and feeding in our lakes and rivers ; but when its sexual organs mature and it is time for it to migrate to the sea, it assumes the glossy, silvery coat, large eyes, and pointed head. If eels breed only in the sea, what I cannot understand is that

I have caught them little longer than a lead pencil in a pond miles from any other water, in the middle of a town, and ten years after any were put into it ; and those put into it were then all four or five times the size. I confess that the life-history of the eel seems to be so well established that such a fact as this should be impossible. But it is a fact all the same.

One point in connection with the introduction of fish into waters which have previously not contained them should never be overlooked, and that is, will the fish introduced be likely to injure other fish, and will the final result do more harm than good ? For instance, it will be seen from the particulars I have given that the Atlantic shad, since it has been planted on the Pacific coast of North America, has spread for about two thousand miles. In this case there seems to be every reason to be satisfied with this wide distribution of a valuable food-fish ; but the introduction of the rabbit into New Zealand and the European sparrow into the United States are specimens of the grave blunders of acclimatisation which should never be forgotten.

In conclusion, I think that it is probable a great deal more will be done in the way of cultivating our sea fisheries by protection and regulation and investigation than by actual artificial propagation, but that the success of our American cousins proves unquestionably that there are very profitable openings for increasing our food-supply even in that direction.

INDEX

[*Specific names with small initial letter*]

Aberdeen, Black-mouthed dog-fish trawled off, 99
Aberystwyth, Abundance of whiting at, 244
Abnormally-shaped Fishes, 11
abyssorum, 46
Acanthias, 19, 37, 84, 86, 100, 284
Acantholabrus, 37, 190, 191, 195
acarne, 114, 125
Achill Head, Poutassou netted off, 258; rare gadoid dredged off, 294
Acipenser, 7, 271, 274
Acipenseridæ, 271
acus, 155, 174
æglefinus, 245, 251
æqualis, 272, 292
Africa, Lung-fish of Central, 2
Agassiz, Biological contributions of, 58
Agonus, 145, 150
Air-bladder, 23
alba, 105, 108
Albicore, 271, 287
Albinism, 9, 11, 259
Alcock on gestation of elasmobranch fishes, 97; (and Wood-Mason) on Indian stingray, 40
aldrichii, 272, 293
Algiers, Bass at, 121
Allen, Mr. E. J., 57, 133
Allis Shad, 201, 208, 209
Alopias, 7, 13, 37, 86, 88
Alosa, 210
alosa, 201, 208
America, Cod-hatching in, 302; lung-fish of South, 2; names for the herring in, 201; shad-hatching in, 200, 209, 305
Ammodytes, 21, 32, 34, 245, 267
Anarrhicas, 17, 21, 37, 49, 155, 168
Ancestral characters in larval forms, 41
Anchovy, 42, 198, 201
Anemones, 2
Angel-fish, 103
Angler-fish, 7, 17, 20, 24, 27, 34, 39, 42, 45, 271, 278
Annales Soc. Linn., *Lyon*, quoted, 111
Annals of Scottish Natural History (quoted), 9, 106, 264 f.n., 282
Antarctic *Callorhynchus*, 274
antiquorum, 155, 174
aper, 129, 137
Aphia, 155, 158, 160
aquila, 105, 110, 271, 288
Arctic Chimæra (*see* Chimæra)
Arctic forms, 37, 38, 85, 245
arcticus, 271, 290
Arendal, Cod hatched at, 248
argenteus, 272, 294
Argentina, 272, 295
Argentine, 272, 295
Argyropelecus, 270, 272, 295
Armed bullhead, 145, 150
Armed gurnard, 145, 150
Arnoglossus, 215, 231
"*Arreghonda*," 103
Arun, Bass in the, 120; grey mullet in the, 186
ascanii, 155, 170
Ascroft hatches out anchovy eggs, 200; on migrations of plaice, 220
Atherina, 184, 187
Atherine, 187; Boyer's, 188
Atherinidæ, 184
auratus, 114, 125

Australian lung-fish, 2; *Salmonidæ*, 60; sea-fish, 10, 38, 125, 135, 288
Auxis, 271, 283
Axillary bream, 114, 125
Azimur, Shad at, 209
Azores, Young angler-fish dredged off, 281

"Baillon's wrasse," 194
Balanoglossus, 178
Balistes, 35, 37, 292, 298
Ballan, 190, 192
Ballantræ Bank, Herring spawn on the, 199, 202
Ballard, 121
Ballinskelligs Bay, Nilsson's goby in, 157
Baltic Sea, Fishes of the, 10, 11, 38, 140, 147, 213, 218
Band-fish, 31, 36, 271, 289
Banks' oar-fish, 271, 290
banksii, 271, 290
barbatum, 272, 294
Barbels in fishes, 17, 127, 243
Barmouth, Bass at, 120
Barnacle, Free-swimming stage of the, 44
Barrier Reef, Sharks of the, 95
Bars on fishes, 8
Basking shark, 22, 43, 86, 91
Bass, 3, 7, 13, 16, 19, 24, 31, 32, 34, 38, 49, 114—121, 189
"Bastard sole," 237, 266
Bateson on small brill, 213; on the eye of the torpedo, 110
batis, 105, 106
Batoidei, 104
Beam-trawl, 69, 70
Bearded ophidium, 272, 294
Beaumaris, Shark named after, 87, 167
"*Beisser*," 53
Bellows-fish, 272, 291
Belone, 9, 16, 20, 42, 129, 140
Bergen, Lesser ling caught north of, 262
"Bergle," 193
Bergylt, 26, 37, 39, 172, 271, 277
bergylta, 193
Berlin Aquarium, Male conger first identified in the, 179
Berwick, Eagle-ray taken off, 112
Berycidæ, 271
Beryx, 271, 278
Bib, 250
Bichir, 3
"*Bilancia*," 38, 66
bimaculatus, 155, 167
Birkbeck, Sir Edward (first President of the N.S.F.P.A.), 83
"*Birkelange*," 25, 46
Biscay, Plaice in the Bay of, 218
Black conger, 176
Black-fish, 36, 271, 284
Black goby, 155, 158
Black pilot, 271, 286
Blackrock (Mayo), Rare shark caught off, 102
Blade-fish, 31, 271, 288
Blain, 250
blanda, 104, 105, 109
Blennies, 26, 36, 39, 167
Blenniidæ, 36, 155, 167
Blennius, 155, 168, 170
blennoides, 272, 292
Blenny, Butterfly, 155, 170; Montagu's, 155, 170; Viviparous, 37, 155, 171; Yarrell's, 155, 170
"Blind side" of flat-fishes, 213
Blonde, 109
Blue shark, 4, 19, 21, 86, 87, 93
Board of Agriculture and the Fisheries, 56
Board of Trade, Work of the, 55
Boar-fish, 129, 137
Boccus, 114
bogaraveo, 35, 114, 125
Bogue, 114, 125
Bonito, 271, 283; belted, 271, 282; plain, 271, 282
Bony fishes, 3
Bothus, 228 f.n.
"Bouillabaisse," 126
Boulenger, Mr. G. A., 57; on classification, 4; on the perches, 114; on the giant goby, 154
Boulogne, Ripe pout at, 251

Bouregreg, Shad in the River, 209
Bournemouth, Abnormal flounders at, 213; bass at, 120; red mullet at, 126; sand-smelts at, 188
Box, 35, 114, 125
Boyer's atherine, 188
Brama, 271, 285
Branchial chamber, 22
Bream (*see also* Sea-bream), Axillary, 114, 125; red, 121; Spanish, 114, 125
Breathing of fishes, 1, 2
Breydon Water, 188
Brightlingsea, Young lemon - dabs trawled at, 225
Brighton Aquarium, Conger at the, 181; sharks at the, 94
Brighton, Bass caught at, 120; maigre caught at, 288; red mullet caught at, 126
Brill, 11, 215, 228; hybrids of, 46, 228
Brisbane, Hammerhead sharks near, 95
Bristol Channel, Bass in the, 120
britannicus, 271, 284
British Fishes (Day), quoted, 159, 280
British Marine Food Fishes (McIntosh and Masterman), quoted, 38, 52, 58, 141, 148, 156, 169, 193, 203, 219, 224, 225, 227, 228, 247, 252, 259, 262, 264, 267, 269
Brixham, Trawling at, 57, 69, 126
Broad-headed gazer, 92
Broad-nosed pipe-fish, 155, 173
Brook, Mr., on the lesser weever, 153; on the rockling, 263, 264
brosme, 245, 265
Brosmius, 30, 31, 37, 245, 265
"Browny," 232
bubalis, 145, 146
Bullhead, Armed, 145, 150; Norway, 145, 147
Bullheads, 36, 43, 132, 144, 145
Bulls, 275
Bund, Mr. Willis, on shad, 208
Butler on the sole spawning in captivity, 236 f.n.
Butter-fish, 171
Butterfly blenny (*see* Blenny)
Butterfly compared with the perfect fish, 41
Byrne, Mr. L. W., adds *Phycis aldrichii* to the British fauna, 293; on *Gobius scorpoides*, 158; on *Lepadogaster*, 167; on the young of Montagu's blenny, 170; on the angler-fish, 280; on rare *Macruridæ*, 292

cabrilla, 271, 275
cælorhynchus, 272, 292
Calais, Herrings caught at, 203
Calandruccio, 58; on larval conger, 180, 297
Calderwood, Mr. W. L., on *Centrophorus*, 85; on the black-mouthed dog-fish, 99; on *Centrina*, 101, 102; on *Raia blanda*, 104, 109; on the wreck-fish, 276; on the remora, 284; on the forkbeard, 292; on rare *Macruridæ*, 292 f.n.
callarias, 302
Callionymidæ, 155, 161
Callionymus, 7, 10, 13, 127, 155, 162, 163
Callorhynchus, 272, 274
Cambridge Natural History, quoted, 4
canicula, 86
Cantharus, 114, 125
Cape Verde Islands, Young angler-fish dredged off, 281
capito, 154, 155
capriscus, 35, 292, 298
Capros, 129, 137
Carangidæ, 36, 129, 136, 271
Caranx, 9, 37, 129, 131, 136
Carcharias, 19, 21, 37, 86, 93, 97
Carchariidæ, 86, 93
Carelophus, 155, 168, 170
Carmarthen, Maigre caught at, 288
Cartilaginous fishes, 3
Casablanca, Black-mouthed dog-fish at, 99
Cataphracti, 145, 150
cataphractum, 145, 151
cataphractus, 35, 145, 150

Cattegat, Hake in the, 244
catulus, 86, 98
caudatus, 271, 289
Cawsand Bay, Forkbeard in, 293
Centrina, 86, 100, 101
Centriscidæ, 36, 272
Centriscus, 20, 35, 272, 291
centrodontus, 114, 122
Centrolabrus, 190, 191, 196
Centrolophus, 271, 284
Centronotus, 155, 171
Centrophorus, 85, 86, 100, 102
Cephaloptera, 105, 112
Cepola, 271, 289
Cepolidæ, 36, 271
Ceratodus, 2
cernium, 271, 275
Chad, 121, 124
Chameleon, Eyes of the, 18
Chars, Distribution of the, 29, 36
chelo, 184
Chimæra, 7, 271, 272
Chimæridæ, 271
Christiania, 300
cimbria, 245, 264
circularis, 105, 108
Claspers of sharks, 4
clavata, 105, 106
Closure of inshore areas to trawlers, 76, 77
Clupea, 7, 11, 22, 34, 39, 42, 44, 48, 201, 204, 206
Clupeidæ, 36, 200, 201
Clyde Estuary, Spotted dragonet in the, 163
Coal-fish, 245, 255
Cock paidle, 164
Cod, 4, 7, 10, 16, 17, 26, 31, 32, 43, 48, 49, 50, 54, 57, 69, 130, 242-248, 300, 303
Codling, 8
Cod, Poor, 245, 256
Cole, Mr. F. J., on the plaice, 75, 214, 218, 220
colias, 129, 135
Collett, Dr., on *Aphia*, 160
Colwyn Bay, Gobies in, 159
Comber, 192
Common sea-bream, 114, 122, 125
Conger, 7, 10, 14, 18, 32, 37, 176
Conger eel, 2, 7, 10, 14, 18, 32, 37, 69, 176
Connemara sucker, 155, 166, 167
Connor, 190, 193
Contemporary Review, quoted, 15
Copepoda, 24, 163
Coris, 37, 190, 196
Cork, Maigre at, 288
Corkwing, 193
Cormorants, Destruction of, 82
Cornish, Error of, 263; work of, 286
Cornish sucker, 155, 166, 167
cornubica, 86
Cornwall, Sea-fishing in, 10; hake in, 27, 30; blade-fish in, 31; drift-net fishing in, 54, 67; porbeagle in, 86; blue shark in, 93; thornback in, 106; eagle-ray in, 112; bass in, 115; mackerel in, 132, 133; boar-fish in, 137; saury pike in, 143; red gurnard in, 147; pollack in, 253; poor cod in, 256; three-bearded rockling in, 265; wreck-fish in, 276; remora in, 283; Ray's bream in, 285; *Luvarus* in, 286; pilot-fish in, 286; albicore in, 287; blade-fish in, 289; Banks' oar-fish in, 291; forkbeard in, 292
Cosmopolitan fishes, 37
Cottidæ, 145, 271
Cottus, 35, 48, 145, 147
Couch on classification, 5; on the sharks and rays, 84; on the porbeagle, 88; on *Polyprosopus*, 98; his plate of a dog-fish, 99; on the colour of sharks, 100; on the species of sandy ray, 108; on an alleged egg-purse of *Myliobatis*, 113; on the absence of spots from young bass, 116; on red mullet, 126; on young scad, 137; on the greater weever, 152; on the poutassou, 257; on the mendole, 276; his work, 286; on the forkbeard, 292
Couch's sea-bream, 114, 125

Couch's whiting, 257
Courge, 268
Cowes, Smelt-nets at, 66, 189
Crenilabrus, 190, 193
Crustaceans, 2
Crystallogobius, 155, 157, 160
Ctenoid scales, 14
Ctenolabrus, 125, 190, 191, 194
Cuckoo-fish, 137
Cuckoo ray, 108
Cuckoo wrasse, 191, 194
cuculus, 145, 147
Culture of sea fish, 76, 80, 299-309
Cunningham, Mr. J. T., on the names of fins, 5, 12; on the sole, 9; experiment on the artificial colouring of a flounder, 10; on the lateral line in herrings, 15; on "food-fishes," 24; his work, 26, 57; on the milt of the sole, 45; on the temperature at which the eggs of fishes hatch out, 50; on the bass, 116; on the eggs of the sea-bream, 122; on the red mullet, 126, 127; on the alleged blindness in mackerel, 132; on young scad, 137; on the spawning of boar-fish, 137; on the dory, 139; on young gar-fish, 142; on the sea-scorpion, 146; on the father-lasher, 146; on the spawning of red gurnard, 148; on the spawning of *Agonus*, 150; on Nilsson's goby, 157; on the spawning of the conger, 160; experiment with the topknot, 161; on the eggs of the butterfly blenny, 168; on viviparous fishes, 172; on the length of male conger, 177; on the proportion of female congers, 179; on the spawning of congers, 180-183; on larval grey mullet, 187; on trawlers disturbing herring spawn, 202; on the egg of the pilchard, 205; on anchovies, 207, 208; on racial differences in plaice, 213; experiment on colouring of flounders, 213; monograph on the sole, 214, 216; on the plaice, 218, 219; on the dab, 221; on the flounder, 222; on the lemon-dab, 224, 225; on young brill, 228; on the food of turbot, 229; on the megrim, 232; on the apparent scarcity of topknots, 233; on the egg of the Norwegian topknot, 234; on the sole, 235, 236; on the thickback, 237; on the spawning-grounds of cod, 244; on the hatching of cods' eggs, 247; on the eggs and larvæ of *Gadidæ*, 249; on the spawning time of pollack, 254; on the egg of the ling, 261; on the growth of rocklings, 264; on the launce and sand-eel, 267; on the larval angler-fish, 299
Cycloid scales, 14
Cyclopterus, 7, 37, 45, 48, 49, 155, 163, 164
Cynoglossus, 215
Cyprinidæ, 36
Cyttidæ, 36, 129, 138

Dab, Common, 215, 221
  „ Lemon, 215, 223
  „ Long rough, 45, 215, 227
  „ Pole, 225
dactylopterus, 271, 278
Dahl, Dr. Knut, 72, 301
Dannevig, 57; on cod-hatching, 247, 248, 301, 302
Dartford warbler, 167
Dartmouth Harbour, Wrasses outside, 191
Dawson (*see* Herdman)
Day, Dr., on classification, 5; on the lateral line in herrings, 15; on hybrids, 46; his work, 58; on the sharks and rays, 84; on the porbeagle, 88; on the tail of the basking shark, 91; on the colours of sharks, 100; on the bass, 116; on the red mullet, 126; on the gobies, 157, 158, 159; on the lumpsucker, 165; on the grey mullet and atherine, 184; on a wrasse

taking whiffing baits, 192; on the distribution of *Centrolabrus*, 196; on the scales of both sexes in the rainbow wrasse, 197; misprint in account of the flounder, 222; on the spawning of pout, 251; on the names of pollack, 255; on poor cod and pouting, 257; on the teeth of the sand-eel, 269; on the mendole, 276; on the bait of the angler-fish, 279; on the flying-fish, 284; on Ray's bream, 285; on *Coryphænoides*, 292; on the forkbeard, 292; on *Muræna*, 296
Day, Reasons for trawling by, 69
Deadman, *Luvarus* found near the, 286
Deal-fish, 13, 271, 290
Deal, Shad caught near, 209
Dean, Dr. Bashford, calls *Ctenolabrus* a bream, 6, 125, 195; on the outline of fishes, 12; on barbels in fishes, 17; on the pineal eye, 18; on early development in sharks, 51; on the ancestry of sharks and rays, 84; on the Spanish mackerel, 135; on a wrasse, 195; on the cod type, 242; on *Chimæra*, 272; on a result of the commensal habit, 294
decadactylus, 271, 278
decandolii, 155, 167
Dee Estuary, Scald-fish in the, 232; three-bearded rockling in the, 265
Deep-sea fishes, 32
Definition of a fish, 1
Delage, 57; on the larval conger, 179
Demersal eggs of the herring, 202
Denmark, Fish-hatching in, 307
dentatus, 35, 272, 294
Dentex, 35, 271, 276
"Dermal" sense in fish, Dunn's, 15
Devon, Blade-fish in, 31; trawling in, 57, 68; Sea Fisheries Committee of, 80; bottle-nosed ray in, 108; bass in, 116; bream in, 121; mackerel in, 133; megrim plentiful in, 230; three-bearded rockling in, 265; pilot-fish in, 286; forkbeard in, 292
Die Verbreitung der Fische (Palacky), 26
Discoboli, 155
Distribution of fishes, 28; of bass, 120; of flat-fish, 239
Dog, Picked, 86, 100, 284
,, Silver, 96
,, Spur-, 100
Dog-fish, 8, 85, 96
,, Black-mouthed, 51, 86, 99
Dogger, Cod-fishing on the, 57
Dohrn, Dr. Anton, 57
Donegal Bay, Deal-fish in, 290
Donovan on the age of sticklebacks, 160; on the nature of whitebait, 204
"Dorsch," 247
Dory, The John, 6, 129, 138
Douarnenez, Mackerel shoals off, 133
Doubly-spotted sucker, 155, 167
Dover soles, 235
draco, 145, 152
Dragonet, Gemmeous, 7, 8, 10, 13, 155, 162
,, Spotted, 155, 163
Drepanopsetta, 227 f.n.
Dresden, Shad at, 209
Drift-net, The, 54, 57, 62, 65, 66, 67, 68, 203
"Drum," The, 288
Drummond's Echiodon, 294
Dubois on the female torpedo, 111
ductor, 271
"Dun-belly," 201
Dunn, Howard, 293
,, The late Matthias, on malformed sea-breams, 11, 123; on the lateral line in the pilchard, 15; on "singing bubbles," 23; story of a grampus nearly suffocated by a shoal of mackerel, 28, 198; on the egg-case of rays, 39, 98, 107; on the need for destroying cormorants and porpoises, 82; on sharks attacking fishermen, 96; on the breeding of *Acanthias*, 101; on young mackerel, 132; on the lowest temperature suitable to

mackerel, 133; on the spawning of the boar-fish, 137; on the spawning of the dory, 139; on the spawning of pilchard, 199; on herring shoals, 204; on the egg of the pilchard, 205; on the former abundance of bonitoes, 283; on the remora, 283; sends a Ray's bream to the Plymouth Laboratory, 285; his work, 286; on the Norway pout, 293
Dusky perch, 271, 275
„ skulpin, 162

Eagle Clarke, Mr., on Murray's gurnard, 276; on the four-bearded rockling, 264
Eagle-ray, 21, 40, 112
Ear of fishes, 20, 104
Ear-stones, 20
Echeneis, 10, 271
Echinorhinus, 86, 100
Eddystone, Muræna trawled near the, 296
Eel, 22
Egg-case of sharks and rays, 39
Eggs of fishes, 38-48
Ehrenbaum on the shad, 209
Elbe, Shad in the, 209
Elbœuf, Shad-hatchery at, 210
Electric force in fishes, 109
Elie, Sand-eel fishery at, 267
encrascicholus, 201, 207
Endemic fishes, 37
Engraulis, 201, 207
eques, 272, 295
erythrinus, 114, 122, 125
esmarkii, 35 f.n., 272, 293, 294
Ewart, Professor Cossar, on *rigor mortis* in fish, 251; on the electric organ of the skate, 109 f.n.; on the spawn of herring, 199
Exe, Red band-fish in the, 289
Exocœtus, 271, 284
exoletus, 190, 196
Eye of fishes, 17, 19

faber, 129, 138
Falmouth, *Luvarus* caught near, 286; Ray's bream near, 285; shanny near, 168; spotted dragonet near, 163
"False gills," 22
Farne Islands, Banks' oar-fish in the, 290
Farnell, Mr., his trawling experiments in Australia, 38
Father-lasher, 48, 145, 146
ferox, 35
Fierasfer, 35, 272, 294
Fifteen-spined stickleback, 155, 172
File-fish, 36, 272
Fins, 1, 2, 3, 5, 12, 13
finta, 201, 208
Firth of Clyde, Plaice spawning in the, 47; bonito in, 283
Firth of Forth, Thresher in the, 89; Blue shark in the, 94; sprat spawning in the, 200, 206; poor cod spawning in, 257; fishes of the, 264 f.n.; four-bearded rockling in the, 264; sand-eels in the, 267; Murray's gurnard in the, 276; bonito in the, 283
Fish, Definition of a, 1
Fisheries, Our, 53-83
Fishes and Fisheries of the Irish Sea (Herdman and Dawson), quoted, 75, 138, 159, 232, 238, 244, 293
Fishes, Living and Fossil (Bashford Dean), quoted, 6, 12, 17, 125, 135, 195, 242, 295
Fishes of brackish water and the deep sea (Günther's definition), 33
"Fishes," So-called, 2
Five-bearded rockling, 245, 262
Flamborough Head, Nilsson's goby caught off, 157
Flat-fishes, 6, 10, 18, 23, 30, 32, 34, 36, 46, 51, 55, 211-241, 307
flavescens, 155, 159
"Fleet" of nets, 66
flesus, 215, 222
Floating eggs, 38
Floating timber, Fish associated with, 32

Flounder, 11, 212, 215, 216, 221, 222
  „ Winter, 303
Flying-fish, 271, 284
Folkestone, Pilot-fish taken at, 286
Food, Fishes as, 25, 26
Food of fishes, The, 23
Forbes on the fauna of British seas, 35
Forkbeard, 272, 292
  „ Lesser, 272, 293
"Fortescue," 152
Four-bearded rockling, 245, 264
Four-horned Cottus, 145, 156
Four-spotted Goby, 155, 158
Fowey, Bellows-fish thrown ashore near, 291; muræna caught at, 296
France, Mackerel shoals on the coast of, 133; red mullet in, 126
French sole, 215, 237
Frewen, Mr. Moreton, on fish culture in America, 306 f.n.
Fries on the spawning of poutassou, 257
friesii, 155, 158, 160
Frost-fish, 289
Fryer, Mr. C. E., on fertilising spawn, 80
fullonica, 105, 108
Fulton, Dr. Wemyss, on the proportion of sexes in fishes, 45, 46; on the size at which the plaice is mature, 52; on the experimental hauls in Scotch waters, 74; on the number of eggs in the dab, 221; on the proportion of sexes in the flounder, 222; on the eggs of the halibut, 227; on the size of turbot, 229; on proportion of sexes in cod, 247; on young haddock, 253; on the egg of the torsk, 266

Gadidæ, 36, 245, 272
Gadus, 8, 9, 10, 13, 16, 19, 31, 32, 35, 43, 50, 245, 255, 256, 272, 293, 294, 302
gairdneri, 303
galerita, 155, 170
Galeus, 3, 19, 37, 86, 96
"Gangui," 66
Gannets, Destruction of, 77
Ganoidei, 271
Gar-fish, 9, 16, 20, 42, 129, 140-142
Garstang, Mr. W., on fertilising ova at sea, 80, 81; on malformed sea-bream, 123; on racial characters in mackerel, 130; on migrations of mackerel, 133; on an albino hake, 259; on the Norway pout, 294
Gascony, Gulf of, Hake in the, 258; portions of an egg-case dredged in the, 274
Gasterosteidæ, 155, 172
Gasterosteus, 17, 48, 49, 155, 172
Gattorugine, 155, 170
Gemmeous dragonet, 155, 162
germo, 271, 282
Gestation of elasmobranch fishes, 97 f.n.
Giant goby, 154, 155
Gibraltar, Bass at, 121
gigas, 271, 275
Giglioli, Professor, 58
Gill-covers, 16, 22
Gill-nets, 63, 66
Gill-rakers, 46, 185
Gills, 16, 22, 62
Gilthead, 114, 125
giornæ, 105, 112
gladius, 271, 287
glauca, 35, 271, 287
glaucus, 86, 93
Globe-fish, 272, 297
Gobiesocidæ, 155, 166
Gobiidæ, 36, 155
Gobius, 34, 35, 43, 154, 155, 158, 159, 160
Goby (*see also* Black goby, etc.), 8, 34, 36, 43, 154-161
Godaveri Delta, Stingray from the, 40
Gorgona, Anchovies from, 208
gouanii, 155, 167
Grampus, 28
Granton trawlers, 202; egg of dab fertilised in laboratory at, 221
Grassi, Dr., on *Leptocephali*, 180, 297
Greater pipe-fish, 155, 174
  „ sand-eel, 267
  „ weever, 145, 152

Green, Mr. Seth, hatches shad's eggs, 305
Green, Rev. W. S., on *Hoplostethus*, 278; on *Macruridæ*, 292
greenii, 36
Greenland shark, 37, 85, 86, 102; wrasses, 196
Grey gurnard, 145, 148
,, mullet, 184
,, skate, 106
Grimsby, Dwarf plaice at, 11; alleged hybrid flat-fish at, 46; spawning-time of plaice at, 47; trawlers, 202
Grimsby Trawl Fishery, The, quoted, 58, 59, 246, 253
griseus, 86, 100
grohmanni, 215, 232
Gronovius on the sexes of red mullet, 127
Grundzüge der marinen Tiergeographie, quoted, 26
Gunnel, 155, 171
gunnellus, 155, 171
Günther, Dr., on distribution of fishes, 33; on the sexes of surmullet, 127; on the "fingers" of gurnards, 148; on the spotted dragonet, 163; on grey mullet, 184; on young wrasses, 194; on the rainbow wrasse, 197; on the German name for cod, 247; on young stages of the angler-fish, 281; on the Norway pout, 293; on the food of sun-fish, 297
Gurnard (*see also* Red gurnard, etc.), 7, 10, 17, 20, 32, 36, 49, 144, 145, 151
gurnardus, 145, 148
Gymnodontes, 272, 296

Haddock, 13, 16, 17, 43, 163, 245, 251-253, 302
Hair-tail, 288
Hake, 17, 46, 49, 244, 245, 258
Halibut, 31, 33, 226
Haloporphyrus, 272, 295
Hammerhead shark, 7, 37, 86, 94
Hamoaze, Old-wife in the, 125; young gar-fish in the, 142
harengus, 201
Harriotta, 272
Harvesting the sea, 25
Hastings, Drift-net fishing at, 68; bass at, 120; maigre at, 288
Hedge-baulks, 63
Heincke, Dr., on Germany's attitude in international legislation, 55; on herrings, 203, 204
helena, 272, 296
hemigymnus, 272, 295
Hemirhamphus, 142
Hensen, Dr., on the physical conditions of the Baltic, 220; on the distribution of cods' eggs, 301
Herdman, Professor (and Mr. A. J. Dawson), on the destruction of undersized plaice, 75; on the dory, 138; on a rare goby, 157; on the white goby, 158; on the painted goby, 159; on the sea-snail, 166; on the pipe-fish, 173; on the scald-fish, 232; on the solenette, 238; on the distribution of whiting, 244; on the distribution of the three-bearded rockling, 265
Hermes, Dr., 57; on the male conger, 179
Herring, 4, 7, 11, 22, 23, 24, 27, 34, 36, 37, 39, 42, 43, 44, 46, 67, 198-210
Heterosomata, 10, 18, 34, 36, 46
Hippocampus, 7, 21, 155, 174
Hippoglossoides, 37, 45, 215, 227
Hippoglossus, 31, 33, 215, 226
hirundo, 145, 149
Histiophorus, 287
Hjort, Dr., Discoveries by, 72, 300, 301
Holdsworth, E. W. L., on the fisheries, 70
Holland, 37, 60, 207
Holocanthus, 35
Holocephali, 27
Holt, Mr. E. W. L., on dragonets, 8; on hybrid flat-fish, 46; on the depletion of the North Sea, 58; on fishery legislation, 59; on the larva of mackerel, 132; on the eggs of scad, 137; on gurnards, 148; on a rare goby, 157; on the

gemmeous dragonet, 162 f.n.; on the spotted dragonet, 163; on young shannies, 168, 170; on the gunnel, 171; on the egg of the rainbow wrasse, 197; on an abnormal sole, 212; on dwarf plaice from the Baltic, 213; on the eye of flat-fishes, 217; on the size of mature plaice, 219; on the larval stages of the lemon-dab, 224; on the egg of the halibut, 226; on the egg of the scald-fish, 232; on the egg of the solenette, 238; on the cod-fishery, 246; on small haddock, 253; on the four-bearded rockling, 264; on the flavour of Norway haddock, 278; on the angler-fish, 280; on recent take of *Centrolophus*, 284; on the fork-beard, 292; on the lesser fork-beard, 293; on *Nettophichthys*, 295; on *Muræna*, 296
Holt and Byrne on a goby, 158; on a sucker, 167
Holt and Calderwood on a shark, 85; on the blackmouthed dog-fish, 99; on *Raia blanda*, 104, 109; on the remora, 284; on rare *Macruridæ*, 292 f.n.
Humber, Small haddock in the, 253
Hunt and Jeffreys, Messrs., on the influence of wave-currents, 34 f.n., 161 f.n.
Huxley, Prof., on floating eggs, 50; on *laissez-faire* in the fisheries, 58
Hybrid fishes, 46, 47

Iceland, Fisheries of, 102, 201
imperialis, 271, 286
India, Fishes of, 2, 40
Introduction to the Study of Fishes (Günther), quoted, 33 f.n., 128, 180 f.n.
Irish Survey, Fishes taken in the, 36, 85, 224, 280, 284, 292, 294
Isolated fishes, 36
Italy, Fisheries of, 66

Jack, 36
Jago's goldsinny, 190, 194
Japanese fishermen, 60
jeffreysii, 155, 157, 158
Jelly-fish, 2
"John Bickerdyke" on local names of the coal-fish, 255
John Dory, *see* Dory
Johnson, Mr. G. H., on the habits of bass, 115
Journal of Anatomy and Physiology, quoted, 19 f.n., 20 f.n.
Journal of the Asiatic Society of Bengal, quoted, 97 f.n.
Journal of the Linnæan Society, quoted, 34 f.n., 153 f.n. 161 f.n., 174 f.n., 263 f.n.
Journal of the Marine Biological Association, quoted, 9 f.n., 58, 101 f.n., 110 f.n., 130, 133, 170 f.n., 212 f.n., 213 f.n., 236 f.n., 259 f.n., 294 f.n.
"Jowder," 68
julis, 190, 196, 197

Kenmare Bay, Forkbeard in, 293
Kent, Fisheries of, 68, 243
Kerry, *Fierasfer* caught off, 294
Kilbrannan Sound, Norway Pout in, 293
"*Knurrhahn*," 145

Labrax, 3, 7, 13, 16, 31, 32, 34, 49, 114
Labridæ, 190
Labrus, 7, 9, 10, 20, 32, 190, 191
Læmargus, 37, 85, 86, 102
lævis, 11, 97, 215, 228, 292
lagocephalus, 272, 297
Laissez-faire doctrines of Huxley, 58
Lamna, 21, 37, 86
Lamnidæ, 86
Lampetriformis, 35
Lamprey, 2
Lampris, 7, 10, 271, 285
Lancashire sea fisheries, 68, 69, 75, 138, 170, 214, 244

lanceolatus, 245, 267
Land animals, Distribution of, 29
Land's End, Hair-tail near the, 289
Lanthorn gurnard, 145, 149
Larval stages of fishes, 23, 26, 40, 41, 165, 168, 169, 179, 180, 203, 219, 224, 227, 238
Lateral line, 15, 16, 246
laterna, 215, 231
Launce, 245, 267
Leghorn, Bass at, 121; bogue at, 125
Legislation, Fisheries, 54, 76-83
Lemon dab, 215, 223, 237 f.n.
Lemon sole, 223, 237
Lepadogaster, 34, 155, 164, 167, 283
Lepidopus, 271, 289
Lepidorhombus, 215, 230
Leptocephalus, 179, 180
lepturus, 271, 288
Lesser forkbeard, 272, 293
Lesser, or little, ling, 46, 258, 262
Lesser sand-eel, 267, 268
Lesser weever, 145, 153
Lichia, 35, 271, 287
Life-Histories of British Marine Food-Fishes (McIntosh and Masterman), quoted, 38 f.n., 46, 52 f.n., 58 f.n., 141 f.n, 148 f.n.
liljeborgi, 35
limanda, 215, 221
limandoides, 215
lineata, 145, 149
lineatus, 114, 125
Line-fishing, 60, 62, 88, 102, 203
Ling, 46, 49, 245, 258, 260
Liparis, 11, 34, 43, 155, 166, 293
Lips of fishes, 20
Littlehampton, Grey mullet at, 186
Liverpool, Bass in the neighbourhood of, 121
Lobster, 2, 303, 305
Lochbroom, Argentine taken in the mouth of, 295
Long-finned gurnard, 149
„ „ tunny, 271, 282
Long-nosed skate, 105, 108
Long rough dab, 215
"Longtails," 291
Lophius, 7, 13, 17, 20, 34, 39, 42, 45, 104, 271, 278
Lugworm for bait, 60
Lulworth skipper, 167
lumbriciformis, 155, 174
Lumpenus, 35
Lumpsucker, 7, 37 f.n., 45, 48, 49, 155, 163, 164
lumpus, 155, 164
luna, 271, 285
Lung-fishes, 23
lupus, 114, 155, 168
luscus, 245, 250
lutea, 215, 238
Luvarus, 35, 271, 286
lyra, 145, 149, 155, 162
Lytham, Sprats' eggs taken off, 200
Lythe, 253

McIntosh (Professor), and Masterman (Dr.), definition of food-fishes, 25; on larval gurnards, 41; on the hybridising of brill and turbot, 46, 228; quote Dr. Fulton on maturity in fishes, 52; on the eggs of gar-fish, 141; on the eggs of *Gottus*, 146; on the breeding of *Gottus*, 147; on the eggs of grey gurnard, 148; on the armed bullhead, 150; on the eggs of gobies, 156; on the eggs of the lumpsucker, 164; on parasites of larval lumpsuckers, 165; comparison between larval stages of salmon and wolf-fish, 169; on young viviparous blennies, 172; on the spawn of wrasses, 193; on the larval herring, 203; on the spawning of the sprat, 206; on the lemon-dab in captivity, 224; on the witch, 225; on the larval halibut, 227; on generic names, 227 f.n., 228 f.n., 230 f.n., 262; on the egg and larva of sole, 236; on larval cod, 247; on the eggs of haddock, 252; on the eggs of halse, 259; on the four-bearded rockling, 264; on a sand-eel fishery at Elie, 267;

on the spawning of the sand-eel, 269

[*Note: The distinction between the contributions made by each author to the work quoted has not here been drawn.*]

Mackerel, 4, 6, 11, 24, 27, 28, 36, 37, 42, 61, 73, 88, 129, 130-135, 302
Mackerel, Horse, 129, 136, 282
,, Spanish, 129, 135
Mackerel-midge, 207-263
Macruridæ, 272, 291
Macrurus, 272, 292
maculata, 104, 105, 109
maculatus, 155, 163, 190, 192, 272, 298
Mæna, 271, 276
Magnetic dermal sense in fishes, 15
Maigre, 271, 288
Malay fishermen, 60, 96
malleus, 86, 94
Malm, Prof., on young scad, 137; on eggs of the topknot, 233
Man, Isle of, Rare goby from the, 157; pipe-fish from, 173
Margate, Pilot-fish taken at, 280; maigre taken at, 288
Marine Biological Association, Work done by members of the, 46, 80, 123, 186, 199, 214, 228, 232, 235
Marjoribanks, Mr. (Committee on Sea Fisheries), 55
Marketable Marine Fishes (Cunningham), quoted, 45 f.n.
Marseille, Bass at, 121; red mullet at, 126
Marston, Mr. R. B., on fish culture, 59, 80, 236 f.n., 299-309
Mather, Mr. F., on American shad, 306
Matthews, Mr., on the spawn of the ballan wrasse, 193
Maturity in fishes, 52, 79
Maurolicus, 272, 296
Mawddach, Bass in the, 121
maxima, 86, 91
maximus, 215, 229
Maxwell, Sir Herbert (Committee on Ichthyological Research), 55
May, Isle of, Albino skate trawled off the, 9
Mayo, Rare shark caught off the coast of, 85, 102
Mecklenburgh, Fishes of, 38
Median eye of fishes, 18
mediterranea, 272, 294
Mediterranean, Fishes of the, 10, 11, 31, 37, 38, 66, 68, 121, 125, 126, 129, 137, 144, 151, 157, 183, 185, 188, 196, 197, 201, 205, 206, 218, 220, 229, 230, 232, 233, 237, 239, 257, 273, 275, 276, 277, 285, 296
mediterraneum, 271, 278
Medusæ, 2
Meek, Mr. Alexander, 57
megastoma, 215, 230
Megrim, 215
Melanogrammus, 302
Melanospermeæ, 132
melanostoma, 35, 86, 99
melops, 190, 193
Menai Strait, Bass in the, 121; gobies in the, 158
Mendole, 271, 276
Merluccius, 30, 46, 49, 245, 258
Merry sole, 224
Mesh of the trawl-net, 78
Metamorphoses of fishes, 49, 51
Mevagissey, 9, 67, 68, 132, 213, 276
Meyer on larval herrings, 23
microcellata, 105, 108
microcephalus, 86, 102, 215, 223
Migrations of fishes, 26, 54, 133, 204, 205, 243
Milt of fishes, 44, 45
minutus, 26, 155, 159, 245, 246
mixtus, 190, 191
Mogador, Grey mullet off, 186
mola, 272, 297
Molluscs, 2
Molva, 25, 34, 46, 49, 245, 260, 262
Monk-fish, 19, 37, 86, 103, 109
monstrosa, 271, 272
Monstrosities, 11
Montagu, Colonel, 265
montagui, 155, 166
Montagu's blenny, 155, 170

Montagu's sucker, 155, 166
Mora, 272, 294
Moray Firth, Witch in the, 225
Morocco, Dog-fish in, 99; red mullet in, 126; shad in, 209
Morone, 114
morrhua, 245
Morris, 180
morrisii, 179
Motella, 32, 35, 245, 262, 264, 265
Mousehole, Falling off of hake at, 259
Mouth of fishes, 20
Mudskippers, 161
Mugil, 21, 32, 34, 184
Mugilidæ, 184
Müller's topknot, 232
Mullet, Grey, 21, 32, 34, 184-187
,, Red, 7, 17, 31, 63, 114, 125
Mullidæ, 114, 125
Mullus, 21, 31, 114, 125
Muræna, 35, 37, 272, 296
Murænidæ, 176, 272
Murray, Dr., 35, 276
murrayi, 36, 271, 276
Murray's gurnard, 271, 276
Murry, 272
mustela, 245, 262
Mustelus, 19, 37, 86, 97
Mya, 159
Myliobatidæ, 105, 112
Myliobatis, 21, 40, 97, 105, 108, 112

Nannygai, 10
Naples, Bass at, 121; eggs of bream at, 122; spawn of red mullet at, 127; eggs of hake studied at, 259
National Sea Fisheries Protection Association, 83
Natural History Museum, Fishes at the, 6
Naturgeschichte des Herings (Heincke), 203 f.n.
Nature, quoted, 199 f.n.
Naucrates, 9, 271, 286
nerka, 303
Nerophis, 155, 173, 174
Nets used in fishing, 61–70
Nettophichthys, 272, 295
New South Wales, Fishes of, 10, 38
New Zealand, Frost-fish of, 289; fish-culture in, 299; the rabbit in, 309
Newton Abbot, Bass near, 116
Nictitating membrane in sharks and rays, 19
niger, 155, 158
Night, Trawling at, 69
Nile, A fish of the, 3
nilssoni, 35, 155, 160
Nilsson's goby, 155, 157, 160
Nineteenth Century, quoted, 299, 306 f.n.
nobiliana, 105, 109
Norfolk coast, Rarity of pollack on the, 253; maigre on the, 288
North Atlantic, Fishes of the, 30
North Sea, Investigation of the, 5, 47
Northumberland, Banks' oar-fish in, 291
norvegicus, 145, 147, 215, 234, 271, 277, 278
Norway bullhead, 145
,, Fisheries of, 66, 169, 300
,, Fishes of, 14, 30, 37
,, haddock, 167, 271, 277; pout, 272, 293
Norwegian topknot, 215, 234
Nostrils of fishes, 19
Notidanidæ, 86, 99
Notidanus, 84, 86
Nurse or Nursehound, 86, 98

Oblong Sun-fish, 272, 297
obscura, 145, 149
ocellaris, 155, 168, 170
"Offing gurnard," 150
Oil-globule in the eggs of fishes, 49, 50
Old-wife, 114, 125
Oncorhynchus, 303
One-spotted topknot, 215
Onos, 35
Onslow, Lord, appointed as Minister of Fisheries, 56
Opah, 7, 10, 271, 285
Ophidiidæ, 245, 266, 272
ophidion, 155, 174
Ophidium, 272, 294

Ophidium, 272, 294
Orcynus, 13, 271, 282
Orkneys, Opah caught off the, 285
Orthagoriscus, 7, 13, 21, 272, 297
Ortmann, Arnold, quoted, 26 f.n.
Otoliths, 20
Otter-trawl, 69, 70
owenii, 114, 125
Owl-ray, 108
Ox-ray, 105, 112
oxyrhynchus, 105, 108
Oyster, 2

Pacific, Fishes of the South, 161
Padstow, Bearded ophidium taken near, 294
paganellus, 155, 159
Paganellus, 155, 159
Pagellus, 35, 114, 122, 125
Pagrus, 21, 31, 32, 114, 125
Painted goby, 155, 159
" ray, 105, 108
Palacky, J., quoted, 26 f.n., 35
Palermo, Bass at, 121
palloni, 190, 195
Pammelas, 196, 270, 271, 286
Pandora, 114, 122, 125
Parasites of the lumpsucker, 165
parnelli, 155, 159
Parnell's goby, 155, 159
pastinaca, 105, 111
Patterson, Mr., on the colour of flat-fishes, 216
Payton, Mr. C. A., on catching herrings at Calais, 203
Pearlsides, 272, 296
Pectinaria, 220
"Peculiar" fishes, 36
Pediculati, 36, 271
Pelagic eggs, 39
Pelamys, 271, 283
pelamys, 271, 283
pellucida, 155, 160
Pennant on the nature of whitebait, 204
pennantii, 272, 296
Penzance, Ray's bream taken near, 285; *Pammelas* taken near, 287
Perca, 303
Perches, 36, 37
Percidæ, 36, 114, 271
perciformis, 271, 286
Periodicity of the hake, 258
Peristethus, 35, 145, 151
Petersen on the size of mature plaice, 219; on eels, 308
pholis, 155, 170
Phycis, 272, 292, 293
Pickard-Cambridge, Mr., on a new British goby, 254
Picked dog-fish, 86, 100, 284
pictus, 155, 159
Piel, Sole spawning in captivity at, 236
Pike, Isolated position of, 36
Pilchard, 15, 23, 28, 31, 46, 48, 54, 201, 204, 241
pilchardus, 201, 204
Pilot-fish, 271, 286
pingelii, 276
Pipe-fishes, 13, 17, 21, 36, 155, 173, 174
Piper, 145, 149
piscatorius, 271, 278
Plaice, 6, 7, 11, 16, 39, 47, 48, 211, 212, 217–221, 241
Plain bonito, 271, 283
platessa, 215, 217
Platophrys, 231 f.n.
Plectognathi, 296
Pleuronectes, 6, 7, 11, 16, 39, 44, 48, 50, 215, 217
Pleuronectidæ, 215
Plummeting, 61, 88
Plymouth, Pollack and whiting at, 10; plaice spawning at, 47; trawlers, 57, 69, 77; mature plaice at, 79; laboratory, 101; spinous shark at, 102; names of sea-bream at, 121; malformed bream at, 123; sea-scorpion scarce at, 146; conger studied at, 180, 181, 183; young mullet at, 186; pilchard studied at, 205; eggs of sprat at, 206; sole spawning in captivity at, 236; Norway pout at, 294
Pole-dab, 225
Pollachius, 302
pollachius, 245, 253

Pollack, 10, 24, 32, 245, 253, 302
Polyprion, 32, 37, 271, 275
Polyprosopus, 92
pompilus, 271, 284
Poor cod, 26, 245, 256
Porbeagle, 21, 37, 86
Porpoise, 2, 77
Portobello, Four-bearded rockling thrown ashore near, 265
Portuguese shark, 103
Post-larval stage of fishes, 41, 48
Pout, 19, 32, 245, 250
Poutassou, 245, 257, 293
poutassou, 245, 257, 293
Power, 256
Preopercle, 22
presbyter, 184, 187
Pristiurus, 35, 51, 86, 99, 259
Proceedings of the Royal Society, 25 f.n., 109 f.n.
Proceedings of the Royal Society of Edinburgh, 293 f.n.
Proceedings of the Zoological Society, 8 f.n, 25 f.n.. 46 f.n., 213 f.n., 217 f.n.
Pseudobranchiæ, 22
Pseudopleuronectes, 303
punctatus, 30, 215
Putrefaction in fish, 25

quadricornis, 35, 145
quadrimaculatus, 155, 158
Queensland sharks in, 95 ; stingray in, 111
Quinnat salmon, 303, 305

Rabat, Shad at, 209
radiata, 105, 109
Raffaele, Investigations of, 57, 127, 197, 205, 228, 259
Raia, 7, 9, 10, 16, 19, 32, 34, 40, 85, 104, 105, 106, 295
raii, 271, 285
Raiidæ, 105
Rainbow wrasse, 190, 196
Raniceps, 272, 293
raninus, 272, 293
Rashleigh shark, 92
Rays, 4, 5, 19, 21, 36, 40, 104, 105–113
Ray's bream, 271, 285
Records of the Falmouth Polytechnic Society, 23 f.n.
Red band-fish, 31, 36, 271, 289
,, brim, 121
,, gurnard, 145, 147
,, mullet, 7, 17, 21, 63, 114, 125
Regalecus, 271, 290
Regnard, quoted, 12 f.n.
reinhardtii, 35
Remora, 37, 271, 283
remora, 271, 283
Report on the Lancashire Sea Fisheries Laboratory, 214
Resources of the Sea, The (McIntosh), quoted, 58
retropinnatus, 272, 295
Rhina, 19, 37, 84, 86, 103
Rhinidæ, 86, 103
Rhombus, 9, 11, 14, 44, 49, 215, 228, 229
Rhos Weir, Forkbeard in, 293
Ribble, Large plaice in the estuary of the, 220
Richmond, True smelt taken above, 188
Ridewood, Mr., quoted, 19 f.n., 20 f.n.
Rigor mortis, 25
rochei, 271, 283
Rock-cook, 190, 196
Rock-fish, 32, 34
Rocklings, 17, 25, 32, 207, 245, 262–265
Rona, Lesser ling trawled off, 262
Rondelet on the eyes of sharks, 19
Roscoff, Observations by Delage at, 179
Ross, Argentine on the coast of, 295
Rostock, 241
Rough-hound or Rowhound, 39, 51, 86, 98
Round fishes, 6, 54
Royal Cornwall Polytechnic Society's Report, 199 f.n.
Royal Natural History, 95
rubescens, 271, 289
Runnstone, Black-fish taken off the, 284
rupestris, 190, 194, 272, 291
Russia, Sturgeon in, 274
Rye Bay, Trawling in, 68

"Sail-fish," 92

Sailing trawlers, 69
St. Andrews, Scientific work at, 56, 148, 221, 237, 251, 264
St. Ives, Pilchard-seans at, 57, 64, 65
Saithe, 255
Salmo, 9, 298
Salmon, 4, 210, 298
Salmonidæ, 36, 272
salviani, 86, 101
Sand-eels, 24, 32, 34, 65, 242, 245, 266-269
Sand-fishes, 34
Sand-pipes, 220
Sand-smelt, 184, 187-189
Sandy ray, 105, 108
sapidissima, 210
Sapphirine gurnard, 145, 148, 149
sarda, 271, 283
Sardine, 205
Sars, Professor, on migrations of mackerel, 133; on larval haddocks, 253; on the eggs of sea fish, 301
saurus, 129, 142
Saury pike, 129, 142
Scabbard-fish, 271, 289
Scad, 16, 129, 136, 137
Scald-fish, 215, 231
Scale-rayed wrasse, 190, 195
Scales, 1, 13, 14, 16, 156, 217
Scandinavian Fishes, quoted, 5, 30 f.n., 192, 195, 242, 244 f.n., 247, 255, 257, 262 f.n., 276
Scharff, Dr., on *Gobius friesii*, 158, 160
"Schellfisch," 252
Schnapper, or snapper, 10, 121
Sciæna, 271, 288
Sciænidæ, 36, 271
Scilly Isles, Black-fish off the, 284; Argentine taken near the, 295
Sclerodermi, 36, 272, 296
scolopax, 35, 272, 291
Scomber, 9, 11, 42, 129, 130
scomber, 129, 302
Scombresocidæ, 129, 271
Scombresox, 129, 142
Scombridæ, 36, 129, 271
Scorpænidæ, 271
scorpius, 145, 146
scorpoides, 155, 158
Scotland, Fisheries of, 57, 65; Fishery Board for, 46, 74, 77, 118, 266; fishes of, 35 f.n., 36, 37, 46, 226 f.n., 227, 286, 291
Scott, Mr., succeeds in hybridising brill and turbot, 46; on *Triglops*, 276
Scylliidæ, 86, 97
Scyllium, 4, 19, 39, 51, 86, 98
Sea-bass, 303
Sea-breams, 121-125
Sea-horse, 155, 173, 174
Sea-scorpion, 145, 146
Sea-snail, 155, 166
Seal, 2
Sean-net, 61, 64, 65
Sebastes, 26, 37, 39, 271, 277
Secondary sexual characters, 8
Seine, Shad in the River, 210
Selache, 11, 22, 43, 86, 91
Selachii, 3, 21, 32, 36
Selachoidei, 85
Selsea Bill, 10
Sense-organs in fishes, 110
septentrionalis, 184
Sergeant-baker, 10
Serranus, 37, 271, 275
Severn, Shad in the River, 208
Shad, 198, 199, 200, 201, 204, 208-210, 303, 305, 306
Shagreen Ray, 105, 108
Shanny, 155, 170
Shark ray, 84
Sharks, 3, 11, 14, 21, 32, 36, 37, 51, 82, 83-104
Sharp-nosed skate, 105, 108
Shetland, Spotted dragonet off, 163; torsk in, 266
Shoaling habit in fishes, 27, 28
Shore-fishes, 33
Shoreham, Red mullet caught at, 126
Short-finned tunny, 271, 282
Short sun-fishes, 272, 297
Shrimp, 2
silus, 272, 295
Silver salmon, 303
Silvery gade, 265, 272, 294

Sim adds the lesser ling to the British fauna, 262
Sinarapan, 11
Siphonostoma, 155, 173
Six-gilled shark, 84, 86, 100
Size of fishes, 11
Skager Rack, Gar-fish in the, 140
Skates, 9, 10, 16, 20, 32, 34, 105-108
Skin of fishes, 260
Skipper, 142
Skulpin, 8
Smell, Power of, in fishes, 18
Smelt-fishing at Cowes, 66
Smith, Dr. Hugh, on American fish culture, 302
Smooth-hound, 86, 97
Smooth serranus, 271, 275
Snake pipe-fish, 155, 174
Snipe-fish, 291
Soft roe, 44
Soft-finned fishes, 13
Sole, 4, 9, 18, 44, 49, 211, 212, 214, 215, 239
Solea, 20, 36, 44, 49, 215, 223 f.n., 234
Soleidæ, 216, 234
Solenette, 215, 238
South American lung-fish, 2
Southern forms, 35
South Pacific, Fishes of the, 38, 161
Spanish bream, 114, 125
,, mackerel, 129, 135, 167
,, trawl, 70
Sparidæ, 36, 114, 121
Spawning grounds, 47
,, in captivity, 46
,, time, 47, 227, 254
Spawn of fishes, 2
Spearing fishes, 59
Spent fishes, 48
sphyræna, 272, 295
spinachia, 155
Spinacidæ, 86, 100
spinosus, 86, 102
Spinous shark, 86, 102
Spiny-finned fishes, 13
Spiracles in sharks and rays, 4, 22
Spots in young fishes, 8
Spotted dog-fish, 98
Spotted dragonet, 155, 163
,, goby, 155, 159
Sprat, 37, 63, 198, 199, 200, 201, 206
sprattus, 201, 206
Spur-dog, 19, 37, 81, 100
squamosus, 85, 86, 102
squatina, 86, 103
Squeteague, 303
"Squire," 121
Stake-nets, 63
Starry ray, 105, 109
Stationary flat-fish, 55
Steam trawler, 69
Sternopthicidæ, 272
Stickleback, 17, 32, 38, 49, 172
stictopteryx, 155, 167
Stingray, 40, 41, 105, 111
Stomias, 35
Stone-basse, 275
Stornaway herrings, 202
Stow-net, 57, 63
Straight-nosed pipe-fish, 155, 173, 174
Strap-conger, 177
Streaked gurnard, 145, 149
Stream-nets, 63
Striped wrasse, 190, 191
Stromateidæ, 36, 271
Sturgeon, 3, 14, 271, 274
sturio, 271, 274
Suckers, 32, 155, 163-167
Suffolk, Pilot-fish in, 286
Sun-fish, 13, 21, 272, 297
"Sun-fish," 92, 285
surmuletus, 114, 121, 128
Sussex, Bass in, 120
Swiss lakes, Char in the, 53
Sword-fish, 13, 36, 37, 90, 287
Sydney fishes, 38, 121
Sygnathidæ, 36, 155, 173
Sygnathus, 13, 17, 21, 155, 174

"*Tacaud*," 250
Tail of fishes, 13
Talisman expedition, 19, 258 f.n.
Tangier, Bass at, 121; red mullet at, 126
Tasmania, Bellows-fish in, 291
Tautog, 303

Tay, Shad in the River, 208
Teeth of fishes, 15, 16, 21
Teign, River, Bass in the, 115; atherine fry in the, 188
Teignmouth, Monk-fish at, 104; sand-eel fishery at, 65, 267; topknot at, 233
Teleostomi, 3
Temperature of the sea, Effects of, 27, 50
Tetrodon, 21, 272, 297
Thames, Whitebait fishing in the, 57
Thickback, 215, 237
Thick-lipped mullet, 184
Thomson, J. S., on the periodic growth of scales, 14 f.n.
Thornback skate, 9, 10, 105, 106
Three-bearded rockling, 245
Three-mile limit, Extension of the, 59, 69, 77
Thresher shark, 28, 37, 88-91
Thunder, Effects of, 117
Thursday Island, Hammerhead shark at, 95
Thynnus, 271, 283
thynnus, 271, 282
tobianus, 245, 268
Tongue of fishes, 20
Tope, 3, 19, 96
Topknots, 30, 32, 161, 215, 232-234
Torbay, Eagle-ray in, 112
Torpedinidæ, 105, 109
Torpedo, 24, 105, 109
Torsk, or Tusk, 31, 37, 245, 265
Trachinidæ, 145, 151
Trachinus, 20, 32, 34, 37, 145, 152, 153
trachurus, 129, 136
Trachypteridæ, 271
Trachypterus, 13, 271, 290
Trammel, 59, 61, 62
Transactions of the Norfolk and Norwich Naturalists' Society, 216
Transactions of the Royal Dublin Society, 85, 109 f.n., 148 f.n., 284 f.n.
Transparent goby, 160
Traquair, Professor, on a case of partial albinism in a skate, 9, 10; on an abnormal thornback, 106; on larval flat-fishes, 214
Travailleur, Expedition of the, 273, 274
Trawling, 56, 59, 68-80; Scotch "trawling," 57, 63
Trichiuridæ, 271
Trichiurus, 31, 271, 288, 290
tricolor, 35
Trigger-fish, 37, 298
Trigla, 10, 17, 20, 32, 49, 145, 147, 148
Triglops, 36, 271, 276
truncatus, 272, 297
Trygon, 40, 97, 105, 111
Trygonidæ, 105, 111
Tub, 149
Tunny, 13, 271
Turbot, 9, 14, 49, 211, 212, 215, 229, 239, 267
Twaite shad, 201
typhle, 155, 173

Um Erbeya, Shad in the River, 209
unimaculatus, 30, 215

variegata, 215, 237
Vicarious species, 29, 255
Vigo Bay, Rare shark trawled off, 101
vipera, 145, 153
virens, 245, 255
Vitality of flat-fish, 241
Viviparous Blenny, 37, 39, 155, 171
viviparus, 155, 171
Voice in fishes, 23
volitans, 271, 284
vulgaris, 86, 96, 97, 100, 114, 125, 129, 140, 155, 166, 176, 215, 226, 234, 245, 258, 260, 271, 276
vulpes, 86, 88

walga, 40
Walker, Mr. A. O., on gobies, 159; on the forkbeard, 293
Warnemünde, Flat-fish at, 241
Weevers, 20, 27, 32, 34, 37, 144, 151-153

Welsh lakes, Chars of the, 29
Whales, 22
Whiffing for mackerel, 61
Whitebait, 203, 204
"White" conger, 176
White goby, 155, 160
White, Professor, 158
Whiting, 32, 48, 61, 243, 244, 245, 249
Willoughby on spots in young bass, 115
Winter flounder, 303
Winter race of herring, 48
Witch, 215, 225
Wolf-fish, 17, 21, 37, 49, 155, 168
Wood-Mason, Mr., on a stingray, 40
Worm pipe-fish, 155, 174
Wrasses, 5, 9, 10, 32, 37, 125, 190-197
Wreck-fish, 32, 275
Wye, Shad in the River, 208

Xiphias, 13, 37, 271, 287
Xiphiidæ, 36, 271

Yarmouth, Smelt and sand-smelt together near, 188; *Maurolicus* taken at, 296
Yarrell on the fisheries, 53; on the duration of life in gobies, 160
Yellow skulpin, 162
,, perch, 303
Yolk-sac in larval fishes, 40, 51
Yorkshire, Banks' oar-fish in, 290

Zeugopterus, 30, 32, 161, 215, 232
Zeus, 9, 32, 37, 129, 138
Zoarces, 37, 39, 155, 171
Zoo-geographical zones, 29
Zoologist, The, quoted, 130
Zuyder Zee, Anchovies in the, 207
Zygæna, 37, 86, 94, 97

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