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FISHES of the WORLD



*Overleaf : A dragon-fish (Pterois). Photograph
by Dr. Villaret.*





FISHES OF THE WORLD

by

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*with eighty photogravure plates,
thirty colour photographs,
and text illustrations*

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PREFACE

Whenever men have been terrified by the dangers of perfidious and hostile nature and frightened by suffering and the dread of death, they have created divinities to protect them and assuage their anguish. Above all else they worshipped the forces of the world; the sun and the stars, sources of warmth and light; the life-giving earth; the moving and fruitful sea and the disquieting and deadly lightning. They knelt before great trees overshadowing in their majesty the dark and rustling forest, and before fearsome animals, symbols of living power. And the peoples who dwelt close to the seas and rivers came to revere the fishes hidden in their peaceable and mysterious retreats.

Out of the primordial ocean, which existed at the origin of all things, when the sky and the earth had yet to be named, the Chaldeans raised up three great gods, of which Ea, the Oannes of the Greeks, "the Sublime Fish", possessed wisdom and perfect knowledge, for it is from the abyss that comes all learning.

The Sumerians learnt arts and crafts from him, how to build with wood and stone, to fashion clay and to forge metals. When other gods, dissatisfied with their work, wanted to destroy men, he saved them and counselled them to build a great vessel which sheltered their race and those of domesticated and wild animals when waters were loosed to submerge the earth.

In the manifold theogonies of India, Vishnu, supreme god of light and goodness in his first transformation, the Matsyavatara, assumed the form of a fish to warn the wise man Manou of an impending flood. When the waves had covered the highest mountains, he stayed under the ark, the supreme refuge of humanity and terrestrial species, so as to support it in the fearful tempest until the waters receded.

Without attaining a very elevated place in the Pantheon of Egyptian gods, Nile fishes ranked high and figured in certain towns among the tutelary divinities. In the Mediterranean, Cretan artists in 1500 B. C. decorated the Palace of Knossos with a wonderful fresco of dorados and blue dolphins. Greek genius peopled the sea with

pleasing and wanton Sirens, with disturbing breasts and harmonious voices. The chariot of Aphrodite sailed on the blue waves surrounded by a procession of husky Tritons blowing into deep-toned conch shells.

The story of Christianity began on the shores of Lake Tiberias. Jesus recruited his first disciples from out-of-work fishermen and quickened their dawning faith by the miraculous draught of fishes. With a few loaves and fishes he fed the multitude who listened to his prophecy. The symbol "Ichthus" which adorns the tombs of the martyrs doubtless has an older significance than that of a lately invented Greek monogram. The fish calls to mind the life-giving purity of water, whence comes baptism.

The Arab navigators voyaged all over the Indian Ocean as merchants, traders, pirates or slave-traders. In the entrancing travel stories which figure among the Tales of the Thousand and One Nights, they give a great place to the sea and to unknown isles and fishes. Many of these animals are kindly genii. In exchange for their liberty they lead the fisherman who has captured them into the deep, where wonderful treasures are hidden in crystalline caves.

In Hawaii, Tonga and New Zealand the Maoris honour the hero Maui, who fished for islands in the Great Ocean. Sometimes he dragged them one after the other from the bosom of the deep and so made archipelagos. But the island to the South of New Zealand was pulled out in one fell swoop: it is "Te-ika-a-Maui", the fish of Maui. The brothers of the god, against his orders, wished to dismember it and the slashes of their knives are still marked by deep valleys. The Polynesian world is bound to marine life and numerous symbols have been taken from coral fishes.

In various parts of the world primitive tribes have taken the salmon as a totem embodying both beauty and courage. It has not lost its prestige among the Indian tribes of Northern British Columbia and large, strikingly-coloured figures carved in wood still decorate the reserves in Canada. Similarly, this magnificent fish was the tutelary god of the Corisopites who lived in the Quimper region of Armorica. Breton hagiography has personified this memory in St Corentin, the first bishop of the 4th Century, who lived near a river. At meal-times the saintly man called to a pet salmon and after cutting off a slice of flesh he put the fish back in the water, when the wound immediately disappeared. One day when King Gradlon had lost his way with his retinue in the forest of Kranou, St Corentin, thanks to the miraculous fish, was easily able to feed this band of hungry hunters. In Russia, neither Christianity nor Communism have superseded rustic beliefs and in the traditional poems called bylinas, the bogatyr Volkh, the god of the Volga, changes into a great and mighty pike.

Fishes have come out of the legendary sphere, although old sailors still tell very strange tales to wile away the time on long voyages. But ichthyology has become a science and we must leave the realm of the marvellous for the reality of technical precision. To take our readers on a journey, we have given our biological remarks a geographical setting. From North to South they will pass from arctic seas to temperate and tropical regions, and having crossed the line, will become acquainted with marine life under the Southern Cross before descending into the great depths. This book is very incomplete. Many fishes find no place in it, but we have no intention of drawing up a catalogue of 30,000 known species.

Among scientific innovations, the educated public has been recently entranced by the discovery of the coelacanth in the Mozambique Channel and by the first dives of the bathyscaph. These subjects could only be dealt with by Professors J. Millot and Th. Monod, from the French Museum of Natural History. In a friendly and obliging way they have willingly presented the results of their studies and observations in this book. For this freely-given collaboration I express my sincere thanks. Professor Budker also accepted to write something about sharks. I thank him deeply for this, for he knows a great deal about the biology of these fearsome beasts, whose reputation he has discerningly vindicated.

This book had need of a wealth of illustrations to allow readers to see living fishes in their natural surroundings. We have had effective collaboration from Dr D. P. Wilson of the Plymouth Laboratory and Dr Bott of Frankfurt, who had already helped us in another work. The New York Zoological Society have supplied a remarkable series of photographs and similar help has been given by Mr. Walter Vanden Berg, Director of the Royal Zoological Society of Antwerp. Very fine photographs of the fishes of Brazil and the West Indies are the work of M. Isy Schwart. The fishes of Pacific coral reefs live in the negatives of Dr. Bernard Villaret and MM. Aubert de la Rüe, Cathala and Haas, Gunther Senft, Fraass and J. M. Baufle. And we will not overlook the contributions that Mlle Y. de Rolland and M. R.-H. Nouilles have made to this book for the fishes of France. We are indebted to Professor J. Millot for the first colour photograph of the famous coelacanth and to Dr. J. Sapin-Jaloustre for a rare photograph of antarctic nototheniid fishes. Lastly, thanks to Mr H. E. Edgerton's equipment, which was lent by the National Geographical Society to the bathyscaph F. N. R. S. III., Commander Houot has been able to take shots at great depths. He was helped by M. Pierre Dubard, who took part in the descent and to whom I am bound by memories of nearly 20 years' work in oceanography. We beg them all to accept our thanks for having made such lively contributions in calling to mind the world of fishes in all regions and in all depths of the sea.

TRANSLATOR'S NOTE

To fit in with the requirements of English readers some adaptation of the original text has been considered desirable as regards identification and nomenclature. Any reader desirous of comparing such points is referred to the French edition "POISSONS" published by Horizons de France, 39, rue du Général-Foy, Paris (8^e).



A bullhead from northern seas
(*Cottus scorpius*). Photograph
by Dr. Bott.



Above: Head of a wolf-fish (*Anarrhichas lupus*) concealed in the rocks. Its powerful teeth are only used for crushing shells and the carapaces of crabs. Photograph by Dr. Bott.

Below: The red mullet or surmullet (*Mullus barbatus*). Photograph by Dr. Bott.



CHAPTER I

SOME NATURAL LAWS

Life and laws in the ocean

A salmon leaping in a limpid waterfall; a school of tunny-fishes swimming rapidly in the open sea; the silvery glitter of a sardine shoal on the move; the rainbow pink of surface cruising mackerel; the spectral brilliance of gentle coral fishes; the slaty coat of a shark or swordfish on the prowl — all these conjure up an idea of unbounded freedom in the protean world of nature. But this colourful splendour and this power and harmony of motion are merely appearances masking an implacable determinism which rules all living beings. All are swayed by definite laws appropriate to the surroundings in which they move, feed and multiply. Countless species can only live by strictly conforming to these laws and keeping within those bounds which have allowed them to evolve and develop. When cosmic or climatic changes rudely upset this indispensable living space the animals die and extinct species swell the vast cemetery of this fossil world — this record of the piling up of geological strata since life took its place on the earth.

Each year marine fishes undertake two seasonal movements. The first is a breeding migration, when individuals of the same kind gather together in an area essential for the spawning and fertilisation of the eggs. But the extent of this movement varies from one species to another. In sedentary coastal fishes it can hardly be said to occur, although many other coastal forms move downwards to the edge of the continental shelf. On the other hand, certain deep-water fishes migrate upwards to shallower grounds. The great migratory species undertake immense journeys that may nearly span the entire breadth of an ocean.

Those species which leave the sea to spawn in fresh waters are said to be anadromous in habit. Conversely, catadromous forms are those that move down the rivers and enter the sea to spawn. Anadromous or catadromous movements can be complete, meaning that there is a complete transference from salt to fresh water, or the converse. But they may only be partial. A number of oceanic species at spawning time move upwards towards the coasts and higher grounds, while others descend to depths beyond their normal habitat.

These two ways of reproducing lead to very similar ends. Most anadromous fishes attach their eggs to the bottom (demersal eggs), while the catadromous forms lay buoyant, pelagic eggs which float in the surface waters. In both instances the eggs profit from the light and heat of the sun, so developing under favourable conditions. Whether laid in a thin layer of water near river banks (anadromous habit) or whether shed in deeper water to float upwards

to the surface layers of the open sea (catadromous habit), the all essential end is secured and the young fishes hatch out under the beneficent rays of the sun.

The second kind of seasonal movement is a feeding migration. In order to cover a wide area in their search for food a race of fishes will scatter over the entire geographical extent of its habitat. Certain kinds set out on their own to seek their chosen food, while others disperse in small schools. Finally, others, especially those that live on the microscopic algae of the plankton, keep together in dense shoals, to graze on these floating pastures.

These yearly movements are directly subject to conditions of temperature and salinity of the water masses, most species having a habitat strictly determined by precise physico-chemical laws. Concerning temperature conditions, this habitat is more often fixed over a range of several degrees centigrade, including the minimum temperature at which the species can live. With regard to salinity, the variations that can be tolerated are even slighter. Fishes submitting to these severe rules are called stenothermal and stenohaline in habits — habits that can change according to the age and sexual state of a species. But in each biological phase the rules are faithfully followed.

The sedentary, shallow-water, fishes are subjected to great seasonal variations in temperature and salinity and tolerate them fairly well. These are eurythermal and euryhaline in habit. But their resistance is limited; for very cold winters, hot summers and persistent downpours can cause a heavy mortality.

One of the consequences of a stenothermal and stenohaline habit is that fishes are inescapably confined to those water masses essential for the life of their kind and must follow such waters in movement. Their habitat is no longer geographical; it is uniquely determined by hydrological conditions — by temperature and salinity. In this way the laws directly governing a species pass into those presiding over the immense circulation of oceanic waters.

Within the limits of this book it is impossible to give even a concise summary of oceanic water movements. We can merely point out that sea-water is not homogeneous and that two great categories can be recognised: waters of polar origin; cold, not very saline (less than 35 ‰), heavy, passive and very rich in plant and animal plankton: waters of equatorial origin; warm, quite saline (more than 35 ‰), light, active, mobile and rather poor in pelagic life.

There is unceasing interplay between these waters, but they retain their individuality. As a matter of fact, the principle of immiscibility of waters, established in 1868 by the British scientists Wyville-Thomson and Carpenter, shows that waters of different temperature and salinity do not mix when in great masses. Waters of polar origin, sinking towards the depths, occupy the bottom of the ocean in the abyssal zone. Like all water masses these are influenced by the force of the earth's rotation and drift westwards to hug the continental masses. In the North Atlantic the Labrador Current, the outcome of the Arctic pack-ice, comes to skirt the east Greenland coast, to run down past the Newfoundland Banks and along the American coast as far as Cape Hatteras. In the Northern Pacific, the cold Oyashio Current emerges from the Bering Straits to fill the Okhotsk Sea and bathe the Kurile Islands and the Japanese island, Hokkaido. The Falkland Current of the South Atlantic moves north from Tierra del Fuego along the Patagonian and Argentinian coasts as far as Brazil. In certain seasons the drift of polar waters leaves a space, as it were, in the eastern part of the oceans and equatorial waters moving into this region flow northwards in the northern parts of the Atlantic and Pacific Oceans. More than 30 years ago I traced this yearly encroachment of warm salty water over waters of polar origin and gave to all such water movements the name of *oceanic transgressions*.

These transgressions stem from the tropical regions. In the Atlantic they move by Morocco in the winter, following the Iberian coast in spring to enter the Bay of Biscay in summer. Then skirting the British Isles they enter the North Sea from July to September. Continuing their northward drift, by autumn they are found off Scandinavia, while the Barents Sea is reached at the onset of the winter. These splendid, clear, deep-blue waters thus encroach on the greasy yellow-grey turbid polar waters in their own domain, seemingly bringing with them the rays of the tropical sun to the dark and misty latitudes of the northern world. Along with these waters come fine swift fishes. With iridescent gleams they swim in these azure waves and leave a luminescent wake by night.

For some months this surging procession moves northward, sporting in the summertime splendour of the sea. Then, at the end of the year, when this great movement has ceased and the Atlantic waters gradually withdraw, to regain from the tropical sun the heat lost on the way, all these brilliant animals turn on their tracks and move southward. But they never leave the waters which are their essential living space. Conversely, other fishes flee from these warm, salty waters and evade them by moving northwards or by seeking a refuge nearer the coasts. There is thus a biological distinction in the oceans between the fishes of the transgressions and the fishes of polar and continental waters.

To give some idea of the relations between transgressive waters and polar, continental and abyssal waters, imagine that the latter form an immense basin in the middle of which floats a gigantic spot of oil with ceaselessly changing outlines, a spot representing the waters of equatorial origin. These two distinct oceanic water masses do not mix with one another, and each carries its own peculiar marine fauna. Because of their stenothermal and stenohaline habits, species that live near the surface in the polar zones submerge in tropical regions in order to remain at the same temperature and salinity. Certain fishes of arctic coasts are found again in the temperate zone at about 110 fathoms, the depth of the edge of the continental shelf. At the equator they must be sought at great depths while in southern seas they reappear at higher levels. Their differing habitats are thus entirely circumscribed by the curves of the isotherms.

Other isotherms mark the journeys of migratory species, reproducing in far-away regions. These plunge into the depths, constantly following the edge of the basin formed by the waters suitable for them. In the tropics their spawning area is fixed by the lowermost point of this edge. Through such vital cause and effect, biological laws peculiar to marine species, their feeding and reproduction, are presided over by other even stronger laws. These are cosmic in order and hold the oceans in sway.

Surroundings and colours.

Fishes do not all lead the same kind of life. More often than not each species of a certain family leads an individual life in its particular environment — an environment in which it meets other forms of very different origins. In company with these it is subjected to the same changes of temperature and salinity, seeks the same kind of food and defends itself against the same enemies. Within this community, which has existed for centuries in the same "climate", remarkable resemblances have developed, due to similarity of habits. Such animals can be recognised as belonging to the same ecological type, this being apparent in external features of form and colour. There are also biological affinities.

The shore-dwelling type. Fishes of this type live in the tidal zone and extend downwards to 20 or 30 fathoms — depths marking the lower limit of their shelters, the seaweeds. In another book, "Marine life of western European coasts", I have described the habits of the dwellers in our coastal waters, but later on we shall have to conjure up the fishes of equatorial mangrove swamps and of the lagoons of volcanic coral islands. Littoral fishes are not very sensitive to heat or cold, for changes in the weather have a far-reaching effect on the shallower waters. Even if the winters are very cold or the sun burns fiercely, they rarely move far down among the algae or on to sandy banks. Some species are euryhaline and venture into estuaries, but most are confined to salt waters and cannot even tolerate sudden torrential downpours. Certain species, however, have become adapted so as to live in brackish waters or in regions around the outflow of great tropical rivers. Nearly all coastal fishes display some form of camouflage. Many bristle with spines, fleshy tags and other appendages, these blending with the disruptive outlines of seaweeds. Their colour pattern matches that of marine plants, rocks, shingles and sands, being in general brownish or greenish and overlaid with dull heavy marblings or very

dark lines. Thus we can give the fishes of the littoral zone the general name of " marbled fishes ". They are sedentary, not very active fishes, having modest food requirements and can scarcely be called voracious. Only during the mating season do they become active, this being particularly true of the males. These take on a brilliant breeding dress, fight among themselves and strive to " catch the eye " of dull and lazy females and then induce them to spawn. After this, some species guard their eggs, only regaining their liberty when their offspring have had a good start in life. This parental instinct is a particular feature of littoral fishes and is practically unknown in fishes of other ecological types. The eggs of the former are attached. Some species build a nest, others carry the eggs themselves, others again are viviparous.

The freshwater type. — There are great biological differences among freshwater fishes, differences that can be appreciated by comparing those living in mountain streams and leaping in the torrents with those of the polluted, fetid waters of equatorial swamps, where respiration becomes a problem. The freshwater type of fish comprises calm and peaceable plant-eaters, sedentary and hardly voracious in habit, and ferocious predators, carnivores with a fearsome appetite. They are markedly eurythermal, for river waters must follow the climatic changes of the continents. Many species are camouflaged and take on the colours of the bottom or the aquatic plants. Altogether they may be called " greenish fishes ". Differences between the sexes and parental instincts are often well developed.

These fishes reproduce by demersal eggs (attached eggs), some building a nest or guarding the eggs or even carrying them about. Some species are viviparous. It will be evident that in all these features the freshwater fishes are very like those of coastal waters. Yet they are more adaptable with respect to changes of salinity, for a number of freshwater species move down into estuaries or brackish lagoons. The anadromous forms are the extreme instances of this euryhaline habit : indeed these are really freshwater fishes — for the fundamental habitat of a living being must surely be defined by the medium in which it reproduces.

Among the populations of stagnant swamps or of pools which dry up when it is very hot, there is a tendency for some species to leave the water and become adapted to an aerial existence, this being evident in special modifications of the gills or swim-bladder. This struggle to breathe pure, life-giving oxygen also occurred in the far distant geological past when in Devonian times primitive fishes, which crept about on paddle-shaped fins, left the streams to become amphibians and began the conquest of the dry land.

The neritic type. — From the outer reaches of the littoral zone (where the water is some 20 fathoms deep and the great brown seaweeds and mud disappear) to the brink of the great escarpment that sweeps down from about 110 fathoms to the abyss, extends the continental shelf. This is a basal, submarine extension of the dry land. Where mountain chains border the sea and around islands and volcanic archipelagos, it is quite narrow but it may reach an immense size in continuation of low-lying coasts with gentle slopes. These enlargements of the platform, " witnesses " of bygone subsidence, are covered by the shallower waters of continental seas. In the Atlantic Ocean near the European coasts, may be mentioned : the Barents Sea, the North Sea, the English Channel and the Irish Sea. Near the American coasts there are the Laurentian Sea (Newfoundland Banks and banks off Nova Scotia and New England) and the Falklands Sea (off Argentina). In the Pacific and Indian Oceans : the Okhotsk Sea, the Yellow Sea, the Indonesian Sea, the North Australian Sea, the Andaman Sea and the Red Sea ; and near the Antarctic Continent, the Weddell Sea and the Ross Sea.

Of the fishes living over the continental shelf, some are mid-water swimmers and belong to coastal types, whilst others live closer to the bottom. These coastal swimmers are for the most part of standard form and belong to the great group of spiny-finned fishes, the dorsal and anal fins of which are provided with pointed spines set in front of the soft rays. There are groupers, sea breams and red mullets, while others, such as the gurnards, have an armoured head. Near these coastal swimmers must also be placed coral-reef fishes with their powerful



Cod (*Gadus callarias*) swimming along the bottom : above a small dog-fish.
The cod has three dorsal fins and two anal fins, while a small barbel hangs from the chin. Photograph by Dr. Bott.



A pollack (*Gadus pollachius*) among the rocks along our coasts. Photograph by Dr. Bott.

Opposite: A salmon (*Salmo salar*) leaping in a waterfall. Photograph by Ronald Thompson-Rapho.





beak-like jaws and bizarre forms. In our latitudes the modest, thicket-like structures of madreporic corals are not to be compared with the massive coral buildings of the tropical regions; but sheltering in these thickets are certain special forms. There are *Beryx* fishes with enormous eyes, looking like red sea-breems, and small, compressed boar-fishes with pointed snouts, and fin spines menacingly erected.

The coastal fishes can be grouped under the name of "red fishes". They are indeed brilliantly coloured, with a predominance of scarlets, crimsons and pinks. A few species, such as the groupers, are somewhat camouflaged, this being evident in marblings added to the general body colour typical for their species. They never move very far, having in general rather slight catadromous habits, shown by a descent to the outer continental shelf at the breeding period. On the approach of the transgressions they move coastwards, thus showing a certain tendency to a stenothermal and stenohaline habit. These animals are not particularly voracious, most feeding on small crustaceans and worms, while others, such as the gurnards, seek their food in the mud. But there is no feeding migration. Differences between the sexes are only found in certain wrasses and boar-fishes. They lay pelagic eggs which are not cared for, there being no parental instinct. In the main they are fishes much esteemed for the quality of their flesh, which plays quite an important part in human nutrition.

Demersal types. — Below coastal fishes sporting in mid-waters come the demersal fishes extending over shingle, sand or mud. Their sedentary life has involved far reaching changes in their shapes. They are flattened so as to make close contact with the ground, the rays, torpedo-rays and monk-fishes (angel-rays) being enlarged into the form of a lozenge. The pectoral fins are fused to the body, while the gill slits and the nostrils have moved to the underside of the head. Other flat-fishes, the pleuronectids, have undergone a very different evolution, for they rest on either the right or left side of the body. When the larva emerges from the egg it is symmetrical, with normally placed eyes. But when the young fish begins to lead a demersal life, the eye of the side which is to rest on the bottom would obviously not be functional, and it therefore travels in a most remarkable way over the top of the head and comes to lie not far from the other eye. In this way the eyes become placed on the same side of the fish; and very often the pectoral fin of the blind side degenerates or even disappears.

The rays and the pleuronectids are camouflaged, but in different degrees. Each of the ray species has a colour pattern harmonising in a remarkable way with the ground on which it lives, but not in any way changing during the life of the animal. On the other hand, the pleuronectids can change colour according to that of their background. The skin bears large pigment cells or chromatophores; black, white, yellow or red in colour — cells capable of expanding or retracting, becoming dispersed or concentrated so as to give a perfect match with the colours of the bottom.

While this harmonising process is rather long and laborious when a fish first moves to shingle, sand or mud, it all happens extremely quickly if the fish returns to the same ground, just as if it knew beforehand what formula of colour-cell arrangement would suit it in this previously discovered place. In addition to these remarkable ways of camouflage, rays and pleuronectids when resting on a loose, light soil can bury themselves in the sand or mud by movements of their fins, so becoming completely invisible. Only their green or golden eyes project above the surface of the bottom.

Among the demersal fishes there are also angler-fishes, weevers and rats or star-gazers. Motionless on the bottom, they seek their food by suitable guiles. The angler-fish twitches a long ray set in front of the eyes and bearing a tag of skin; the weever erects its terrible, poisonous dorsal fin, while the star-gazer in addition to this danger has a worm-shaped lure springing from its mouth. Deceived by these lures the fish approach, expecting to seize some appetising worm. At this moment the angler springs and the unwary fish disappears into its capacious mouth. (The weever or star-gazer paralyses it by an injection of venom.)

Manœuvring amid all these sedentary species are snake-like, limbless creatures (without pelvic fins) wriggling like reptiles over the mud. These are fierce and voracious conger and moray eels that may reach great lengths. The congeners are more or less camouflaged and take

on a clear colouration over sandy bottoms (white congers) or become dark on gravels or in rocky places (black congers). The morays have a tiger-coloured coat. In northern regions there are wolf-fishes, also without pelvic fins, gliding over the continental shelf and slope. These are much less dangerous, for their powerful teeth are merely used to crush shell-fishes or the carapaces of crabs.

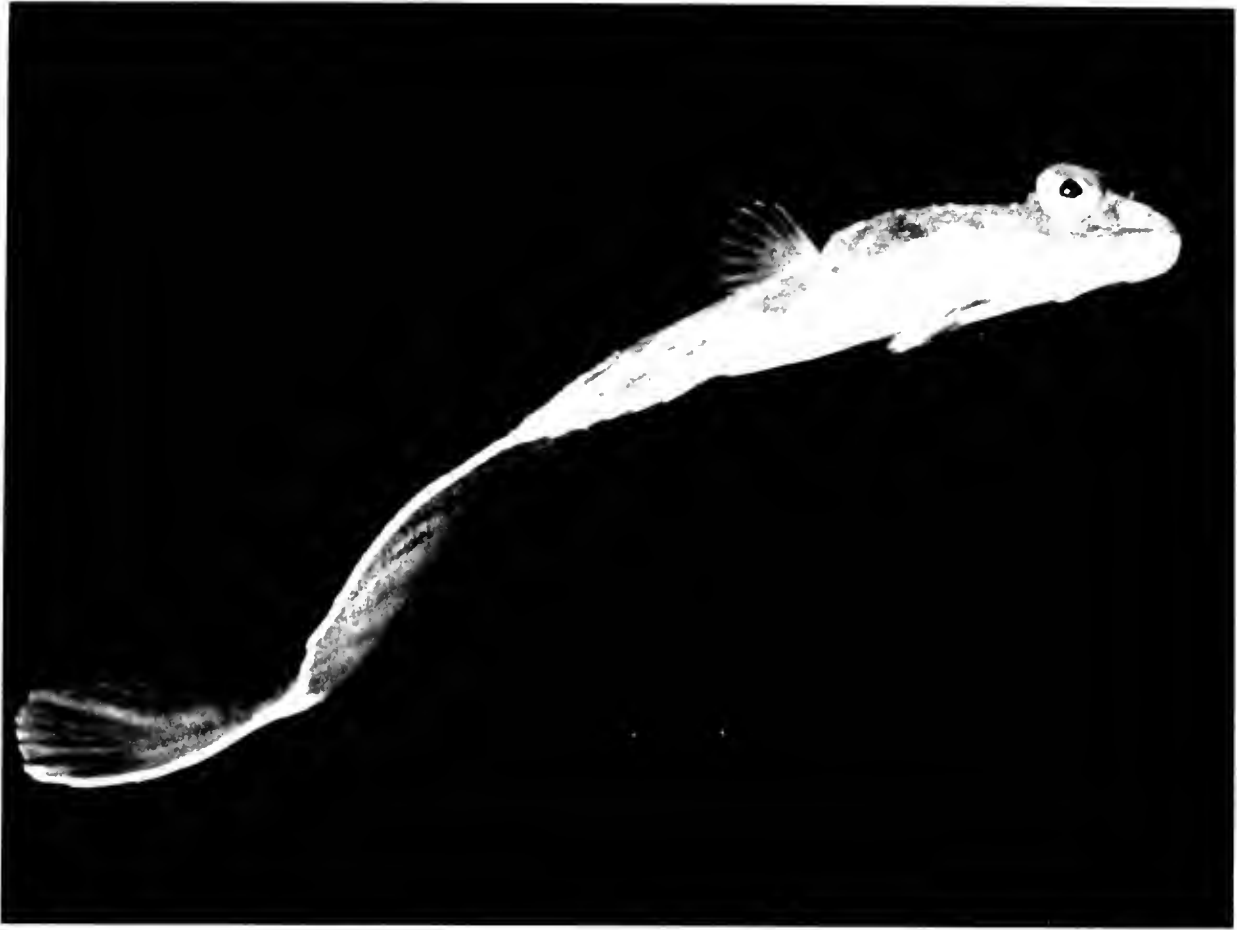
Lastly, very near the bottom, swim gadids, such as cod, haddock and hake, fishes that may be considered as semidemersal in habit. The demersal fishes can be called "white fish", after the name given to them by trawlermen. Indeed when a well-filled trawl is hauled up, the bellies of rays and cod and the blind sides of pleuronectids, which make up most of the catch, are seen as a great white patch as the trawl breaks surface. In the night hauls this whiteness appears leaden in the rays of the moon.

The bottom-dwelling fishes are sedentary and voracious, with diverse reproductive methods. The cod-like and plaice-like fishes lay pelagic eggs, while the rays produce opaque tough-shelled eggs bearing horn-like lateral prolongations that anchor them to the sand. The angel-fishes (*Squalina*), sting-rays, and torpedo-rays are viviparous. The conger-eels have a leptocephalus larva which undergoes a metamorphosis very like that of freshwater eels. Differences between the sexes are well marked in the rays and some pleuronectids but parental instincts are lacking. All these fishes are eurythermal and euryhaline, submitting to changes of temperature and salinity without much shifting of their grounds.

Pelagic types. - Pelagic fishes are creatures of the high seas. The outlines of coasts or continental shelf have little bearing on their lives, which are entirely governed by oceanic laws. From time to time the movements and changes in temperature and salinity of the water masses irrevocably bring them to the same regions; and so they form part of the life of the ocean. Gathered into countless shoals or into small schools, they move around, feeding and breeding in the light and warm, blue, tropical waters or in the cold, heavy, grey waters of northern seas. They follow the Atlantic and Pacific transgressions or retreat before them so as to keep within the bounds of temperature and salinity that fix the hydrological habitat of their kind.

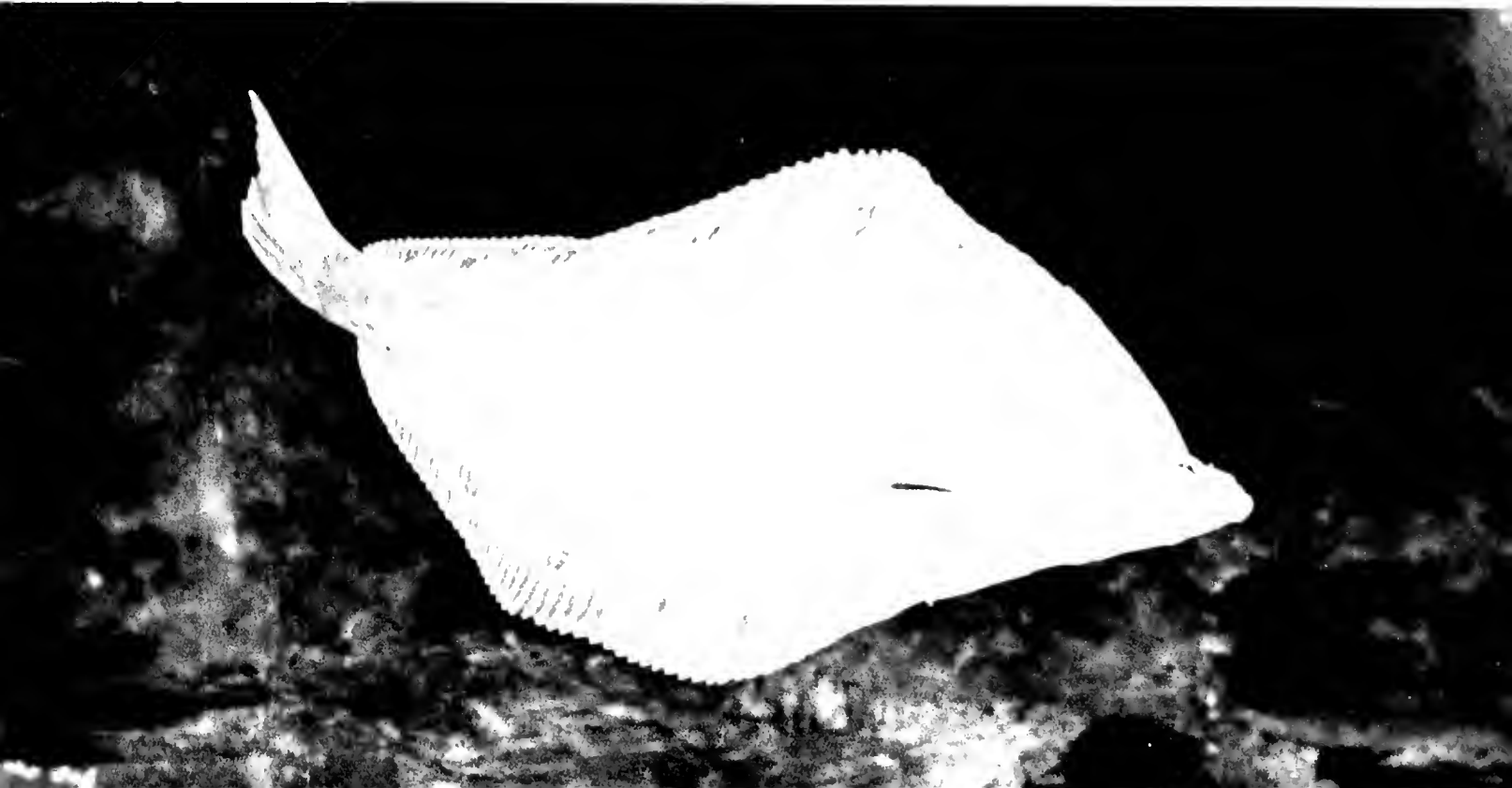
Their movements are very variable in extent. Some of them, the *seasonal fishes*, never venture seaward of the continental shelf, while others, the *migratory fishes*, undertake great journeys, swimming in the open sea. All are designed for rapid swimming. The clupeids (herrings, sardines, etc.) have long spindle-shaped bodies that are somewhat compressed from side to side. The median fins are rather reduced but keep the body on an upright keel, while the pelvic fins are set well back so as not to impede the rapid flow of water over the flanks. The scombroid fishes (mackerel and tunnies) are more highly evolved with their torpedo-shaped bodies and tapering rear section. Supported by the pectoral fins and forward-set pelvies the powerful head cuts a passage through the water for the rigid body. The very strong tail acts as a rudder and series of finlets help in smoothly leading to the rear the fierce flow of water stirred up during rapid locomotion.

All pelagic fishes have much the same kind of colour pattern and deserve the name "blue fishes". As a matter of fact, they have slaty, deep-blue upper parts, becoming lighter over the flanks and merging with a silvery or iridescent lower surface. The perfectly precise body-lines and the brilliantly simple colouring express power and beauty together. On the other hand, their gregarious kind of life leaves no room for individuality. Each fish is but a unit lost amid thousands of similar units, all forming an immense complex of close-packed schools of fishes. As if controlled by supersonic waves picked up by perfect recording devices they twist and turn with precision and speed. Arrangement in the shoals varies from species to species. Some, such as herring, swim in dense columns while others, like sardines, call to mind the arrow-head flights of wild ducks. Such variations can be revealed thanks to modern echo-sounding gear. Differences between the sexes are not found in pelagic fishes, nearly all of which lay pelagic eggs fertilised at random in the water. Parental instincts are lacking. With their stenothermal and stenohaline habits these fishes are rigorously controlled by physico-chemical conditions and perhaps by some unknown, hidden discipline ordering the "march" of the shoals.



A swimming plaice (*Pleuronectes platessa*) seen in profile.

Another plaice, on the bottom. Photographs by Dr. Bott.

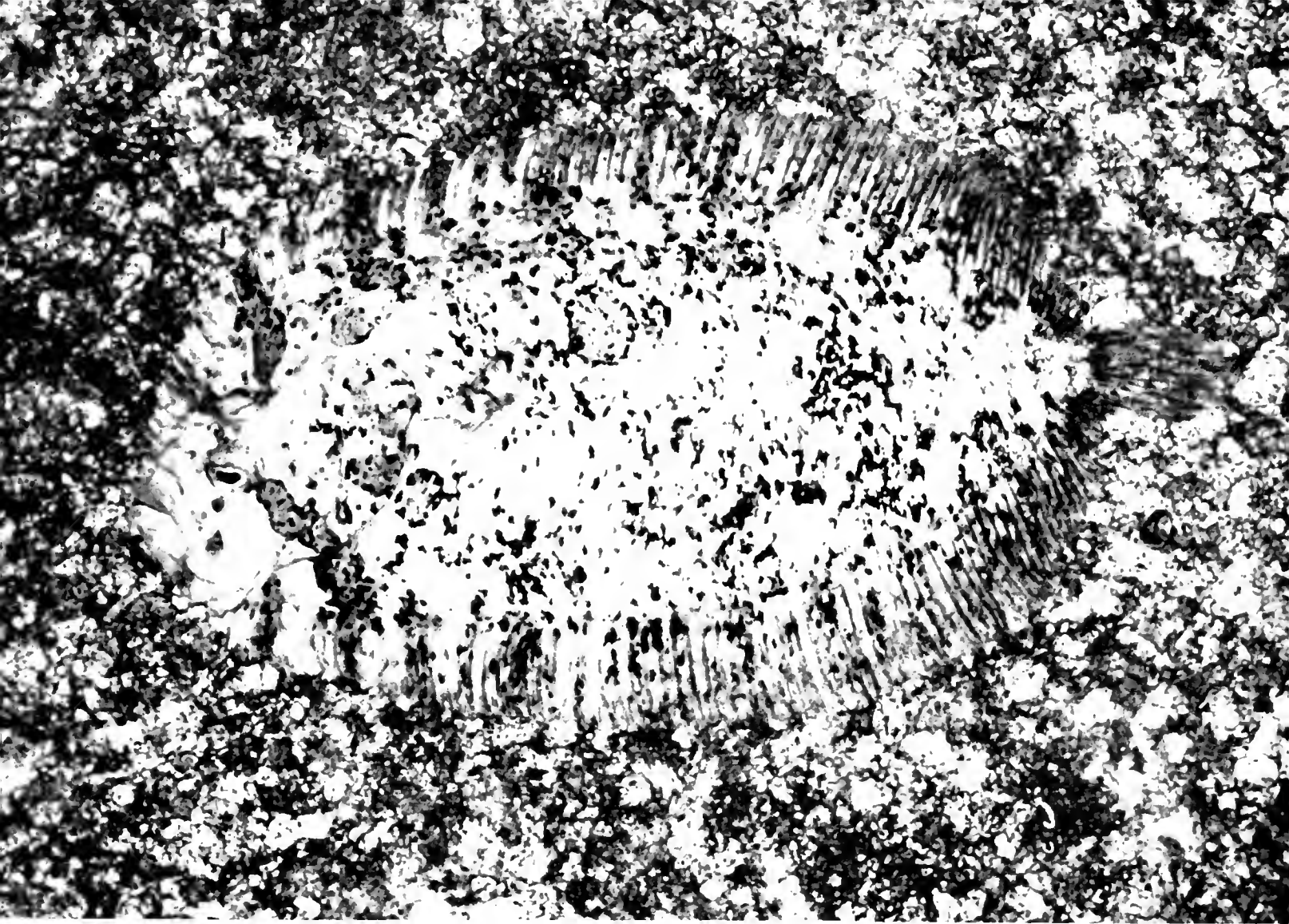




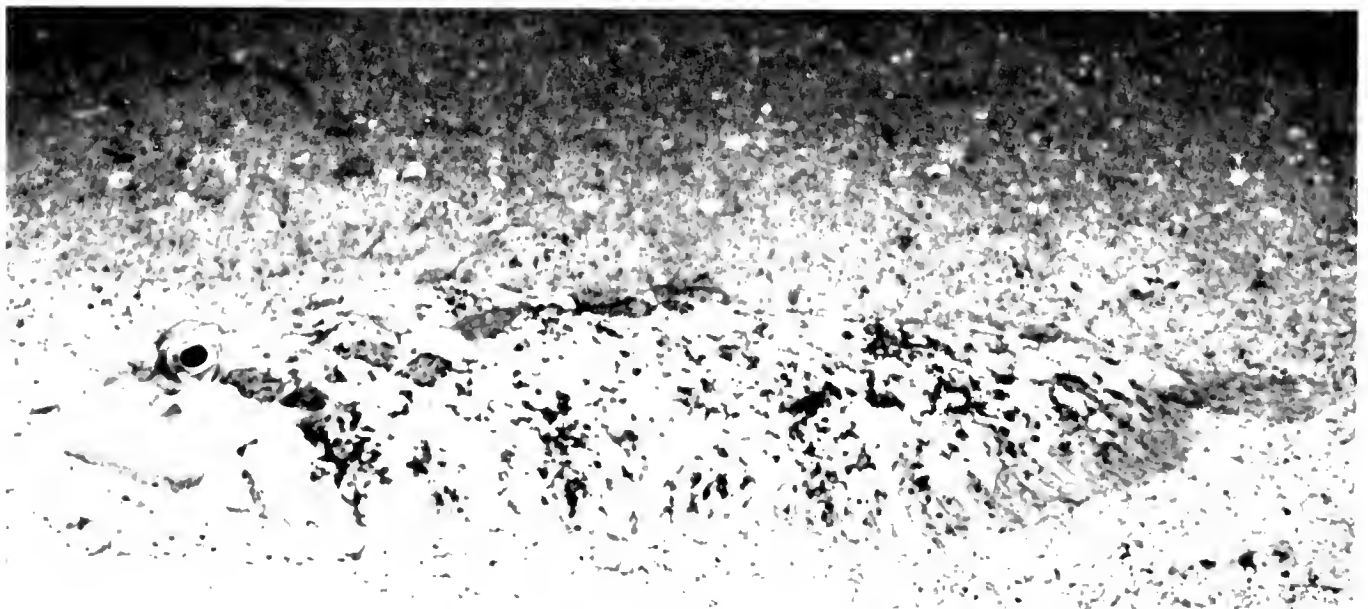
The nuptial flight of dragonets (*Callionymus maculatus*). Photograph by D. P. Wilson.



A young angler-fish (*Lophius piscatorius*) concealed on a gravel bottom. Photograph by D. P. Wilson.



A top-knot (*Zeugopterus punctatus*) camouflaged against a stony bottom.
The same fish seen in profile on a sandy bottom. Photographs by R. H. Noailles.



Bathydemersal types. — The brink of the slope leading to the abyss of the ocean has a depth of about 110 fathoms, a depth also marking the end of the continental shelf and the "mud-line" as Murray called it. Mud, the final product of marine erosion, is found at great depths over a vast area. It covers sands and gravels and, as it forms, rocky ledges are worn away. Mud gives to the vast deep-sea landscape its monotonous uniformity. Certain of the bottom-dwelling fishes of the shelf, such as pleuronectids, rays, angler-fishes and conger-eels are also to be found on the slope. Large-eyed *Beryx* fishes, more typical of the neritic zone, shelter among the coral thickets. But other fishes appear, such as chimaeras and rat-tails (Macrouridae), fishes that have a rather similar appearance although belonging to quite different groups. The robust body tapers off to end in a long rat-like tail and a pointed snout enables them to root in the mud. The mouth is set on the underside of the head, and behind the head comes a strong spine marking the origin of the dorsal fin. The enormous eyes reflect a strange greenish light, while the general body-colour is such as to suggest the name of "purple-blue fishes" for these slope dwellers.

The bathypelagic type. — Whereas the blue fishes sport in the shimmering sunlit waters, other fishes swim in dark abyssal layers. They may be called "black-fishes", for their dark colours match those of their surroundings. Down to about 1,100 or 1,600 fathoms their habits are much the same as those of the surface fishes. The lantern-fishes live in schools like herrings and sardines, sometimes in impressive concentrations. But their movements must be more restricted, for temperature and salinity conditions are less variable in the deeper waters than in those at the surface. Seeking darkness, they move down during the daytime when the sun's rays are brightest and most penetrating, but during the night they climb so high in the water that they are preyed on by tunny-fishes. The commonly held belief that deep-sea fishes explode on being brought to the surface is without foundation. The deep-living pelagic fishes are quite insensitive to changes in pressure, just as are the invertebrates. Fishes brought up in a vertical net from 1,600 fathoms can be kept for days on end by putting them in shaded containers filled with water from the open sea. Such conditions are quite unusual but they withstand them even better than herring or sardines taken along the shore.

In this darkness which is so essential for them, the black fishes are guided by their luminescent organs. These are set over the flanks like the lighted port-holes of a ship, the arrangement varying with the species. Undoubtedly such differences must mean that the lights are used as recognition signs for shoal formations. Other non-gregarious forms are provided with an individual lighting, such as, for instance, the ceratioid anglers which dangle a veritable lamp at the end of a long flexible ray placed on top of the head. In certain blind forms the loss of sight is made up for by a very marked development of long filamentous tactile organs formed from the fins.

All these abyssal animals are very voracious, some having an enormous mouth armed with formidable teeth and being perfectly capable of swallowing prey as large as themselves. The stomach is often distensible and when full bulges out enormously to double the volume of the predator.

The bathypelagic fishes have floating eggs and are entirely lacking in parental instinct. The skeleton is fibrous, due to the absence of calcium carbonate in solution in deep waters. The skin is naked and quite without scales.

This very rapid survey of the main ecological types gives but a cursory idea of the considerable changes that variations of medium and environment can bring about in the forms of fishes. In the following chapters we shall see how these types have become adapted under the influence of geographical conditions in different latitudes.

CHAPTER II

NORTHERN REGIONS

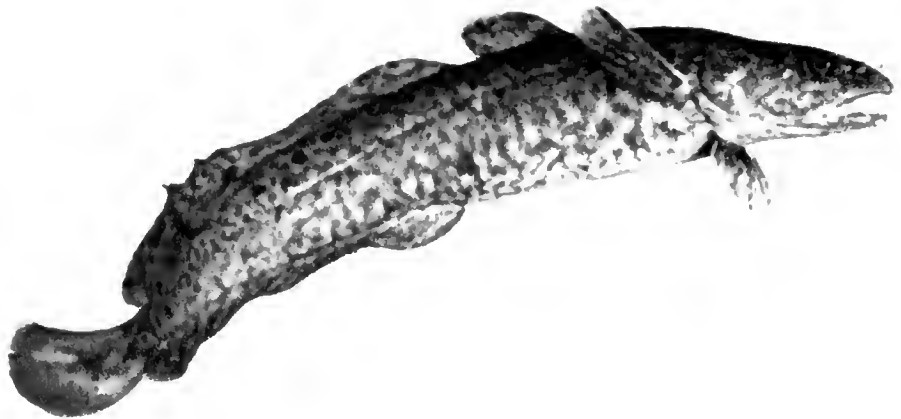
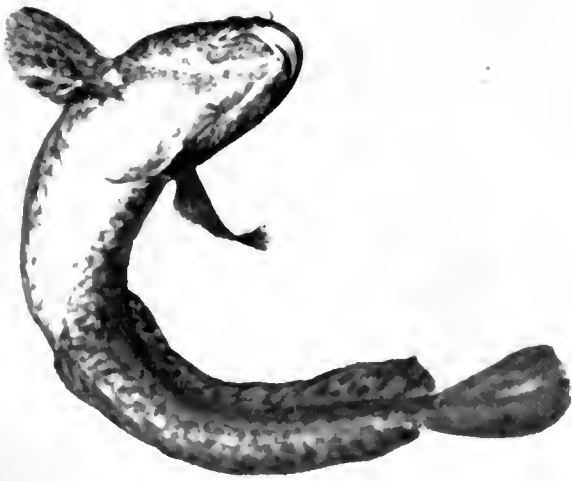
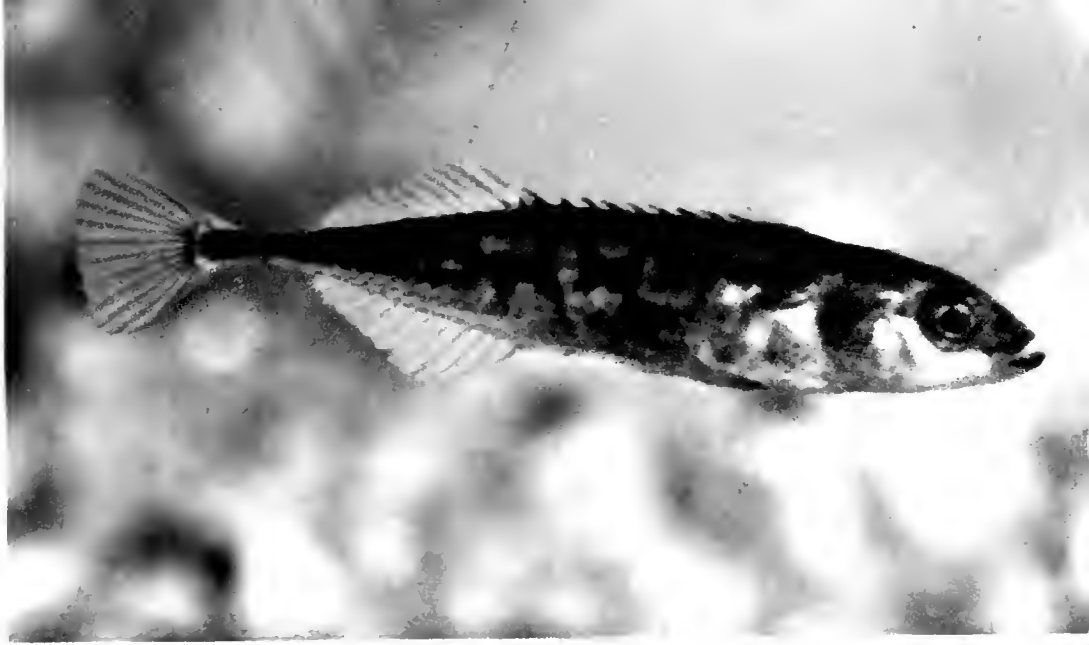
Arctic seas.

Responding to the force of the earth's rotation, the vast mass of polar pack-ice drifts from east to west as it moves round the northern world. Frozen near the New Siberian Islands not far from the pole, it enters the North Atlantic to crash against the eastern coasts of Greenland. All this was heroically shown by Fridtjof Nansen, during the epic drift of the "Fram" from 1893 to 1896.

The basin of the Arctic Ocean is surrounded by a broad continental shelf continuing upwards to the immense plains of Siberia and Canada and made up of the old Precambrian basement rocks of Angara and Laurentia, which have been levelled down during many glacial periods. Local subsidences have broken up these ancient platforms into archipelagos, such as those to the north of America; or formed shallow seas overlying the continents, like Hudson's Bay and the Barents Sea. The chaos of icebergs heaving with the tides grind incessantly against the cliffs of volcanic rock, an abrading action that has banished life from the near-shore seas. The seaweeds cannot develop nor can shell-fishes find attachments. But on the slope a grey or reddish, sticky mud contains a most abundant fauna. Here swarm the delicate transparent shells of scallops, pink and pliant comatulid sea-lilies and great comose brittle-stars ("Medusa heads") with branching arms. Amid pale, rose-coloured shrimps swim numerous fishes.

The marine millers-thumbs or cottids are predominant, whereas in our seas there are only one or two species (*Collus bubalis* and *Collus scorpius*), which live in the beds of *Zostera* grass or in pools among brown seaweeds. Their large heads, which bristle with spines, and their bulging throats give them a fearsome appearance, yet they are quite harmless animals. So are the millers-thumbs of the polar regions. The males, which are smaller and less numerous than the females, have higher and longer fins and are far more brilliantly coloured. Horns and spines look more menacing and the facial tags of skin have greater extensions. When a female is distended with ripe eggs, a male approaches, watches over her and strives to get her to spawn. No nest is built and the eggs are laid in no particular place. They may be found between stones or in large empty shells forming an irregular heap, and in the middle may still be seen the track of the egg-layer. After this, the male keeps a more or less diligent watch around his future offspring.

The commonest cottid of the arctic seas is *Icelus hamatus*, with a marbled-grey body and a lateral line set with ossicles and having four spines on the head. The gill-cover spines are



branched in *Gymnacanthus ventralis*, a fine dark-brown fish with banded fins, spotted white in the males. The four-spined sculpin *Collus quadricornis* has four projections of a spongy appearance on its head. Its greyish-green back is rather dull, but the belly of the males gleams bright red. Other species of sculpins, instead of having a naked skin like those just mentioned, are encased in an armour made of strong jointed plates and the body is polygonal in cross section. With their numerous small barbels they recall Japanese Samurais' war-masks.

These armoured sculpins are the bullheads (*Agonus cataphractus*, *A. decagonus*) that are also quite common in the North Sea. And with them may often be found a small cyclopterid about 3 to 4 inches in length, (*Eumicrotremus spinosus*) attached to a stone. Five irregular rows of spiny plates run down each side of its greyish body.

Slowly circling among these animal communities are eel-like fishes slithering agilely over the mud. Their grey or chamois-coloured bodies are edged with long, transparent fins and two long filaments set on the throat represent the pelvic fins. The head may bear small feathery tufts. These are lumpenid fishes (*Lumpenus*), which are related to the gunnels (butter-fishes) of our coasts. Other bluish or greenish fishes with a single fin encircling the body are also to be found wriggling over these coastal sea-bottoms; such being the lycodids or eel-pouts. Those species living in the shallower reaches of the arctic seas are markedly stenothermal in habit. To keep in waters with a low temperature (about 0°C.), they descend into the abyssal zone in temperate and tropical regions, to reappear at higher levels in the south. Close by the lumpenids and eel-pouts also live the wolf-fishes (*Anarrhichas lupus*).

Not far above the bottom, circle arctic cod-fishes, called "ogac", "saida" and "navaga" by the Eskimos and the Lapps. These fishes never reach any great size. Swimming close by may be another gadid, the torsk (*Brosminus brosme*) with a very long, single, dorsal fin — a fin which in other cod-like fishes is divided into two or three parts. The skull of the torsk is very fragile and if a wave hurls it against the rocks it remains for several hours in a stupefied, half-dazed condition.

Right round the Arctic Ocean, living on muddy grounds, is a flat-fish called the spiny turbot (*Platichthys stellatus*) with spiny plates instead of scales. Its eyes are generally on the left side of the head and the colour of this small pleuronectid, (which grows to a length of about 8 to 12 inches), is brown with white bands. In the arctic seas also lives the giant of the family, the halibut (*Hippoglossus hippoglossus*), which may reach a length of 10 feet and a weight of more than 600 pounds. The right side, bearing the eyes, is dark, being brownish or greenish in colour.

The halibut spends but part of its life on the bottom. At certain times, especially at night, it rears up to give swift chase to fishes and crabs. The shells of molluscs are crushed and even guillemots that have dived to within striking distance are swallowed. It lives at very low temperatures, from 0° to -1° C.

At spawning times the halibut goes down to the edge of the continental shelf. The large clear eggs, with a diameter of rather more than $\frac{1}{2}$ inch, are quite numerous, for the big females bear more than 2 million. At first placed on either side of the head, one of the eyes (the left) moves across when the larva measures about $1\frac{1}{2}$ inches. Growth is slow, the length being about 3 inches after 1 year, 18 inches after 5 years and $5\frac{1}{2}$ feet towards 20 years.

By marking experiments, the Norwegian scientists, particularly Finn Devold, have shown that these fishes can migrate over great distances. A halibut marked at Spitzbergen was recaptured after 240 days near Bergen, having covered a straight line distance of more than 1,200 miles and more than 1,600 miles if it followed the edge of the continental shelf. Halibut are fished around the island of Kadiak off the Canadian coast, where the main landing port is Prince Rupert, and on the Newfoundland Banks. The young fish move into the North Sea and the British take toll of these immature fishes. Halibut-liver oil is one of the richest in vitamins. The flesh is excellent and can equal that of the turbot.

For about sixty years there has been a marked change in the climatic and oceanographic conditions of the polar seas, following a general warming up of the Arctic. This phenomenon stems from a cosmic cycle. Every 1,800 years or so there is a minor glacial phase, but sufficient to block up the entire north. The last occurred from 1210 to 1890, during which the polar

regions were inaccessible and barred the many attempts of great explorers who strove without success to cross the passages leading from north-east to north-west. Before this icy invasion, another warming up of the Arctic in 1200 A. D. opened the northern seas and made possible the tremendous extension of the Vikings' empire, from Scandinavia to the American coasts. We are at the dawn of a similar period, for the ice is receding on all sides. The famous passages are unblocked. In three months a Russian ice-breaker made the crossing that took Nordenskjöld three years from 1876. The Canadian Archipelago is open. North of Europe, Spitzbergen, Novaya Zemlya and the Franz Josef Archipelago can be rounded by ships of a greater tonnage than those I remember seeing 40 years ago, surrounded by pack-ice even in the summer. The west coast of Greenland is open, the continental glaciers are receding and soon the great polar shield will become once more the "greenland" with fields, much as it was when Eric the Red discovered it in 982 A. D. The skies over the pole have become aerial highways and aeroplanes look down on broken-up ice-fields. Slowly drifting in the open sea are immense islands of ice, some of which may even carry the camps of courageous explorer-scientists.

More and more each year, animal life is moving back to the north. Even in winter there is scarcely any recession of the extreme waters of the transgressions, which bring with them to high latitudes species that never ventured there before. Trawlers work round Bear Island as easily as in the North Sea and go after the cod into the Barents Sea. Here dolphins play at the surface and pursue the herring, which meet in the White Sea a local race of Pacific herring (*Clupea pallasii*). A long time ago, when the Arctic was warming up, these fishes ranged along the entire Siberian coast, but caught unawares by a barrier of ice, they have remained ever since confined to the north of Russia. The conditions which presided over this ancient migration are being reproduced at the present time.

The glacial adventures of the salmon.

Although the salmonids have many features in common with the older bony fishes which were evolving in the Secondary Period (in Upper Cretaceous times) it seems that the family must be of recent origin. No fossils have been found earlier than the end of the Tertiary Period. Living in the deep sea are the related argentines also provided with a small adipose dorsal fin set in front of the tail - fishes which doubtless typify the ancestors of salmon. These large-eyed, bathydemersal animals found suitable living conditions in the cold waters of the north polar regions and evolved into anadromous fishes.

The great glacial period of Pliocene times was particularly propitious for the development and dispersal of the salmonid fishes. Then the ice-cap covered the northern lands, while the pack-ice blockaded the North American coast as far as Cape Hatteras and extended down to the British Isles. Great glaciers overlaid Scandinavia and the northern parts of Russia, Siberia and Canada. Greenland, Iceland and all the polar islands barely emerged from this gigantic covering of ice.

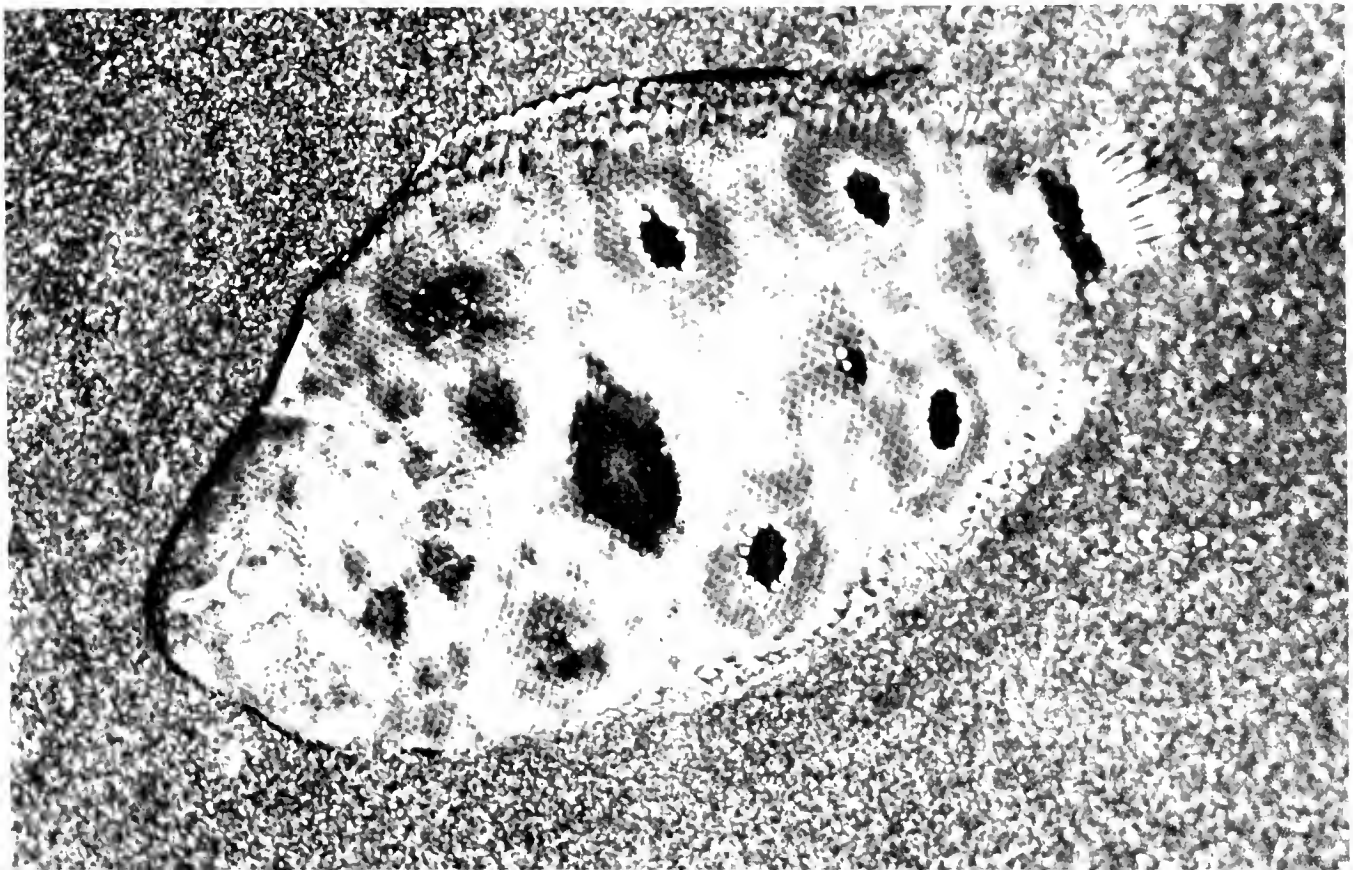
When climatic conditions changed, the ice began to melt and a vast quantity of fresh water spread over the surface of the northern seas. Great rivers which opened into the Arctic Ocean flowed freely, at least in the summer time, and there was really little difference in salinity between river and marine waters. So the salmon readily formed the habit of going from the sea to the rivers to spawn; thereafter to return to the coastal zone to feed. The Baltic, the North Sea and the Irish Sea were still immense glacial valleys, while very diluted waters from the polar regions even washed the shores of southern Europe. In the Mediterranean the melting of the glaciers of the Alps, Apennines and the Balkan and Atlas mountains lowered the salt content of the surface layers.

For salmon this was a particularly favourable period. Leaving high latitudes, they gradually moved southwards and took to frequenting all the great European rivers — not only the Atlantic tributaries but also the Ebro, the Rhône, the Po and the Algerian rivers. Much the same thing occurred on the coasts of North America and along southern Asia as far as Korea.

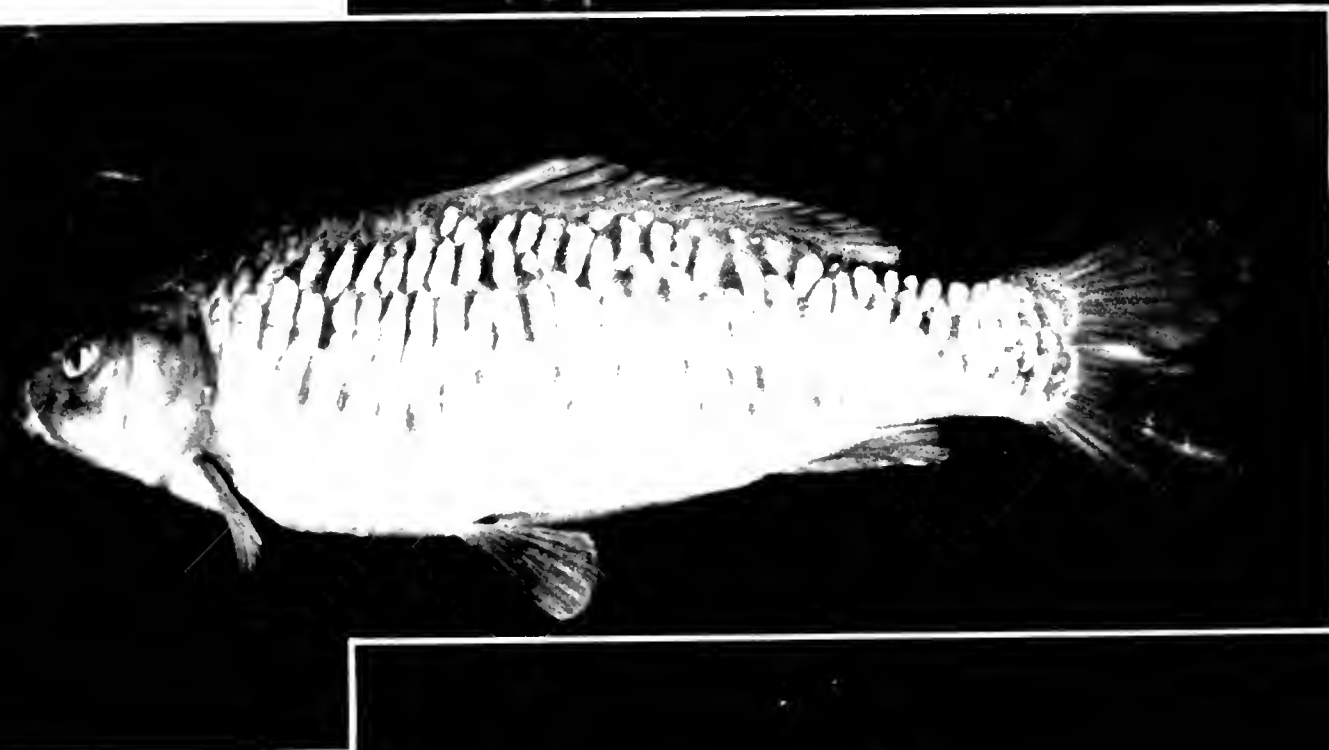
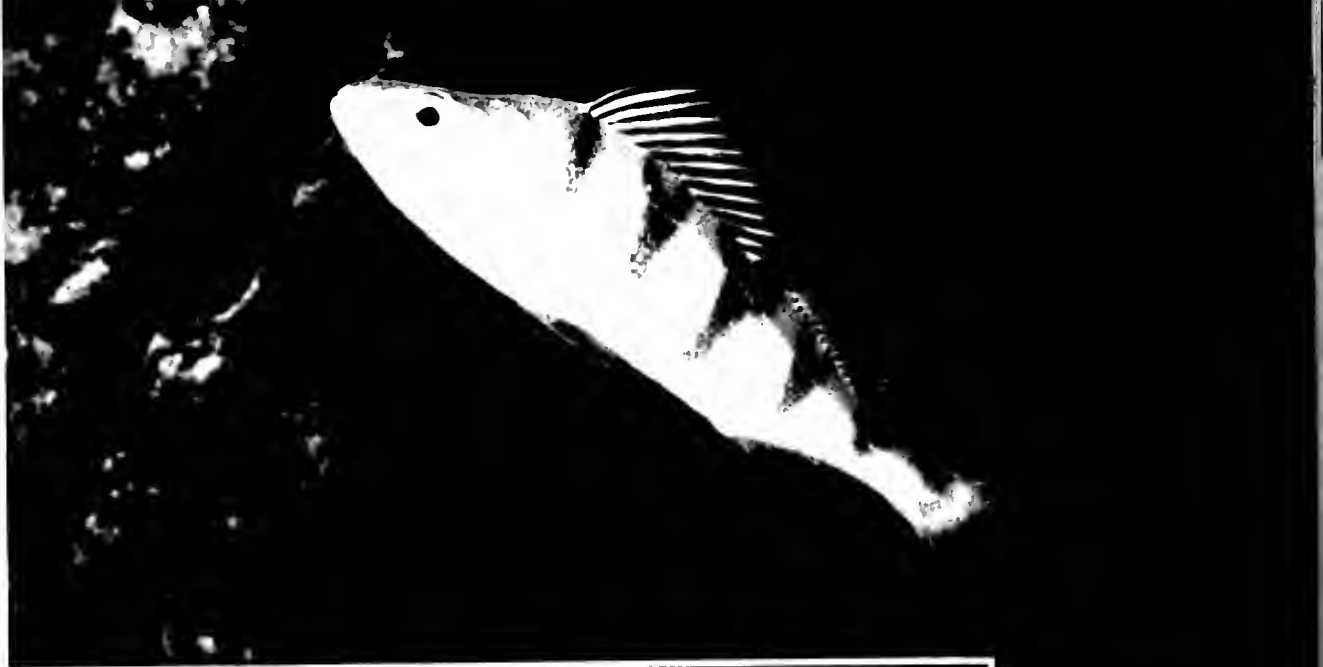


Soles on a gravel bottom : behind a young gurnard.

An ocellated sole (*Solea ocellata*). Photographs by Dr. Bott.



Some Western European fishes. Perch (*Percu fluviatilis*).



The carp (*Cyprinus carpio*).



Bream (*Abramis brama*).
Photographs by J. M. Barthe.



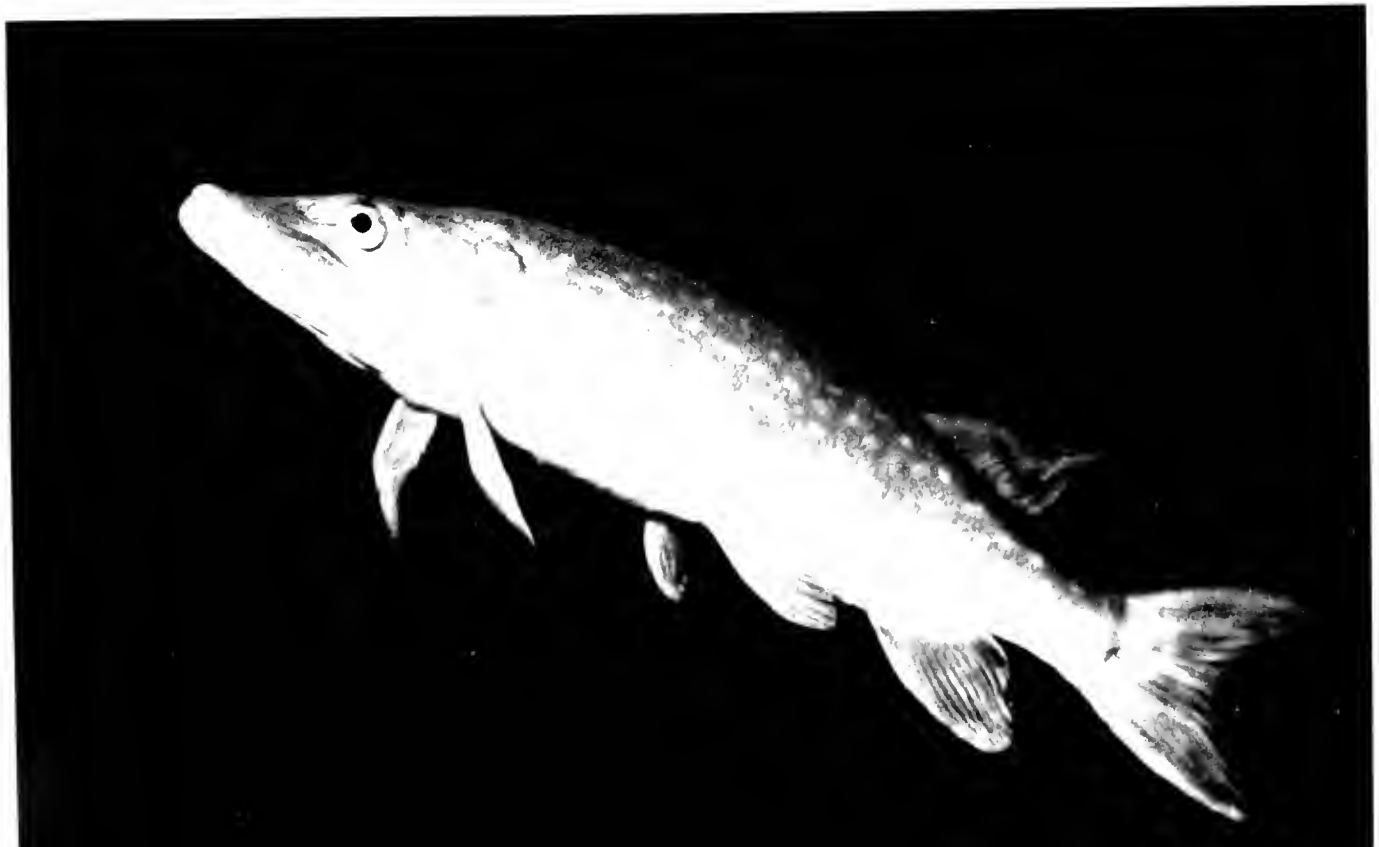
A trout (*Salmo fario*) rising to the surface.

Another trout, close to the bottom. Photographs by J. H. Baulte.





The great predator of our rivers; the pike (*Esox lucius*). Photographs by J. M. Baufle.



But this period of melting snow and ice only lasted for a while and the cold boreal water gradually receded to the north in the face of the encroachments of equatorial waters. The salmon had to become adapted to these new conditions in the temperate seas. The char (*Salvelinus fontinalis*) no longer ventured into salt water with its abundance of food organisms but became landlocked in the cold waters of Alpine and American lakes. But while they have become purely freshwater fishes in our regions, they have retained their anadromous habits in the rivers of the Arctic Ocean and on the eastern coasts of Canada and the United States. Polar features are kept in being in these latter regions by the drift of the Labrador Current which originates from the pack-ice.

The Atlantic salmon (*Salmo salar*) became more highly adapted, for it still leads an anadromous existence down to the northern coast of Spain, although at Cape Finisterre it is no longer to be found. So it would appear to tolerate waters with salinities from 34 to 35‰ but it cannot endure those from 35.5 to 36‰. It has completely deserted the Mediterranean. However, unwary fishes which had ventured into this sea at the end of the great glacial period have left some descendants in the lakes of Italy, Albania and even of Algeria. But like the Alpine char they have given up their incursions into the sea—into waters that are too warm and salty. Undoubtedly the Mediterranean is unsuitable for salmonid biology, for several attempts to acclimatise the Pacific American salmon, the quinnat, in the Rhône have not met with success. Other colonies of non-migrating salmon are still to be found in the Swedish lake Wener and in North America, where the “sebago” and the “ouananiche”, belonging to the Atlantic species, no longer go down to the sea.

Trout have had much the same kind of history. The salmon-trout or sea-trout (*Salmo trutta*), which in our latitudes is still anadromous, has retained the habits of its ancestors. From this species came river trout (*Salmo fario*). This trout has many forms, which are named after the localities or streams where they live, but all belong to the one species. Their colouration tends to match that of their surroundings. Those living in clear waters are spotted, while on gravel bottoms the black markings are X-shaped. Fishes living on mud have darker colours, which become black in caves. In the peat-bogs of Ireland the body is dusky and takes on a heavy appearance. The colours become whitish in clay-laden rivers. But a transplantation is quite sufficient to change all these characters. A young sea-trout cannot be distinguished from a young river trout and in 1907 Cligny showed they belonged to the one species.

The Pacific salmon are still anadromous fishes. Five species can be recognised and these are grouped into the subgenus *Oncorhynchus* on account of the greater number of rays in the dorsal fin. They are of considerable importance in the canning industries of Canada and the United States. The colour of the flesh varies from red to a very pale pink, in the following order: The quinnat, chinook or king salmon (*Salmo tshawytscha*); the sockeye, blue-black or red salmon (*S. nerka*); the coho or silver salmon (*S. kisutch*); the humpback or pink salmon (*S. gorbuscha*) and the chum or dog-salmon (*S. keta*). There is another species of *Salmo* living in the same regions, the steelhead trout (*Salmo gairdneri*), which is also anadromous. In lakes and rivers are other trout which do not return to the sea and of these the best known is the rainbow trout (*S. irideus*).

The coregonids or whitefishes, with compressed bodies reminiscent of those of shads have, like char, a different biology according to latitude. The vendace (*Coregonus albula*) and the lavaret (*C. fera*) are anadromous in Siberia and Scandinavia, but do not leave the deep fresh waters of the Alps. The “common whitefish” (*C. clupeiformis*) is confined to the Great Lakes of America, but keeping something of the migratory habits of its ancestors, it leaves the deeper parts of the lakes to spawn in sizeable shoals in shallow waters.

The umbers or graylings of northern lands are among the most beautiful of the salmonids, with a blue-green back, silvery flanks and a very large dorsal fin looking like a butterfly's wing. This fin is purple in colour and has four rows of dark spots. These splendid fishes live in fresh waters and they leap in the waterfalls of Scandinavian rivers in the spring, when on their way to spawn upon the break-up of the ice.

In these ways, all of the salmonids—and they are still evolving—have, as it were, a biological memory of the great glacial period which presided over their dispersal. And according

to latitude, these animals have maintained their anadromous habits or have found shelter in fresh waters.

Along the Pacific coast, from Alaska to Oregon, the mighty effort required to ascend the rivers to the spawning grounds and the misery attending the return to the sea can well be understood. The American salmon having gorged themselves in the waters of the ocean, and wearing the silvery coat of pelagic fishes, migrate towards the fresh waters. Now their appearance changes. Dark spots multiply over the skin, the belly turns pink or red and sometimes, as in the humpback, a hump of food reserves is formed on the back. The salmon then enters the great rivers of North America; the Yukon, the Skeena, the Fraser and the Columbia. They make their way into these rivers much swollen with melted snow between banks lined by centuries old conifers — into the gigantic heart of the Rocky Mountains. This journey is very long and often exceeds 1,200 miles. During this time the fishes must struggle against the currents to leap waterfalls before arriving at propitious gravel-strewn grounds in clear running water. Now they pair and the females hollow out furrows with strokes of the tail and lay their eggs in them. The males stay close to the spawn, immediately fertilise it and cover it with fine gravel. At intervals of several minutes for two whole months the pair ceaselessly renew their efforts. When these amorous gambols come to an end the salmon are exhausted. Quite inert, they passively drift down-stream towards the sea. But their battered bodies are attacked by fungal diseases and in a marked state of decay they die as they drift, their bodies piling up on the banks. Not one of them will see the Pacific Ocean again.

Only the steelhead trout escapes this miserable death, just like the salmon of our country. Renewing its strength in the sea it makes several journeys into the rivers during the course of its life.

These anadromous habits can be influenced by external causes, particularly when the fishes withdraw on the encroachment of salty water over the continental shelf. But there are also internal factors, which were revealed so clearly by Fontaine. These depend on variations in the physiological condition of the organism and this is influenced by hormones from the complex of endocrine glands.

The banks of Newfoundland and the north.

Between Nova Scotia and Newfoundland, the St. Lawrence River, the outfall of the Great Lakes, emerges into a spacious bay and hollows out a canyon right to the edge of the continental shelf. This majestic river runs in an immense valley that once held a great glacier of eastern America — a glacier which levelled down the Canadian landscape during many glacial periods. Great areas of subsidence mark the limit of ancient rivers. The outlines of high places lying under water have become "banks" separated by channels which represent fjords, and of these, the thalwegs (or valley lines) are now found at a depth of about 50 fathoms. To the west of the St. Lawrence channel extend the banks of Nova Scotia and Maine and towards the east the Newfoundland Banks cover a submarine area nearly as large as France. The most westerly bank is that of St. Peter, which carries over its northern part the islands of the old French colony, Saint-Pierre-et-Miquelon. Then come Green Bank, Whale Bank and the Grand Bank, with a summit (le Platier) rising to within 20 fathoms of the surface.

All these banks are covered by the polar waters of the Labrador Current, which arises from the melting of the Great Ice Barrier after its break-up on the east coast of Greenland. Numerous icebergs drift to the south in this current, which hugs the coasts of the United States. It is subject to strong incursions of the Gulf Stream or Florida Current, this bordering the Atlantic transgression towards the east. This antagonism of cold polar and warm equatorial waters takes much of the power from the two currents. The Labrador Current stops at Cape Hatteras and the Gulf Stream, having lost both speed and heat, dies away not far from the Azores, towards 10°W. This struggle has profound repercussions on the life of animals populating the Banks. During a number of cruises in these regions I was able to discover the hydrological conditions that are favourable or inauspicious for the cod-fishing.



The cod (*Gadus callarias*) leads a partly bottom-dwelling life. It is a fine strong fish with a heavy appearance. The fins are made of soft rays, the dorsal fin being divided into three parts and the anal fin into two. The jaws are strong, being armed with teeth powerful enough to crush shell-fishes. A small barbel hangs from the chin. The colouration blends with the nature of the bottom and is most often a clear light-brown or grey with round dark spots and yellowish mottlings. But in some regions, as in Norwegian fjords, reddish colours predominate. The lateral line is brilliantly white and stands out like a silver ribbon against the dark skin. The belly is white.

Over the Newfoundland Banks the cod move around near sea bottoms made of sand, gravel or mud. The attached fauna is rich. There are big greyish sea-anemones, hydroids of a fine clear green colour; small flattened sea-urchins, "Basque-berets" (*Echinarachnius parma*); brown holothurians blown out like balloons, "melons" (*Cucumaria frondosa*); and sac-like sea-squirts, *Boltenias* sway at the end of long, flexible stalks. Other flattened, orange-coloured sea-squirts are sufficiently thick on the ground in places to give the bottom a glazed appearance (icy bottoms). Half-covered by the sand are pitots (*Cyrtodaria siliqua*), which look like mussels with a very small shell covering only a part of the body. Sizeable patches of big whelks with extended proboscises gather around the bodies of dead fishes or the guts thrown out of the fishing vessels. The cod-fishermen call them "bulots" and in the time of sailing-ships used them to bait their lines. The bulky orange spawn of these whelks sticks to the gravel like big sponges. Pitots and whelks are among the preferred food organisms of the cod, but these are voracious fishes and go after many other kinds of animals. In the spring they take capelan (*Mallotus villosus*), marine salmonids which travel in dense shoals, drawn by their partly anadromous habits to seek their spawning grounds on coastal banks, but they never enter fresh waters. In summer cod eat cuttle-fishes which swim in the surface layers, and at all seasons take herrings and other fishes, including the young of their own species.

These gadids have a prodigious fecundity, for big females carry from 5 to 6 million eggs. They move up to shallow grounds in order to spawn and soon afterwards the larvae form part of the plankton populations of northern regions. Growth is rapid, a length of about 11 inches being reached after 2 years, 2 ½ feet after 5 years, 3 feet or more towards 10 years and about 5 feet towards 20 years. But much older cod measuring 6 ½ feet are known.

Cod are clearly stenothermal fishes. They live in waters of a definite temperature and follow the movements of the water layers they require. So their habitat is hydrological rather than geographical. The Scandinavian fishermen successfully track them down with the aid of special reversing thermometers, a method that has never found a place in the practices of French cod-fishermen. Consequently, one should not talk of cod-grounds, but rather of "cod waters". The optimum living temperatures in these waters vary according to each race.

The cod ranges over a wide geographical area, comprising the whole of the North Atlantic — from the Arctic Ocean down to the English Channel and the Irish Sea on the European side and as far as Cape Hatteras along the American coasts. In this immense sector, the researches of the Danish oceanographer Johannes Schmidt have enabled us to recognise different local races, which are distinguished by the number of their vertebrae. For numerous fishes it is possible to frame a biological rule, for the number of vertebrae increases with latitude. In other words, given the same species, the northern animals have more vertebrae than those living more to the south. Concerning the cod, the following races may be recognised; the American race (Labrador, Newfoundland and Nova Scotia) with 51 or 55 vertebrae and an optimum temperature from 0 to 2°C. The Arctic race (Newfoundland Banks, Greenland, Iceland, Scandinavia and the Barents Sea) with 52 to 54 vertebrae and an optimum temperature from 4 to 6°C.; the North Sea race (Faroes, eastern English Channel) with 52 vertebrae and an optimum temperature from 6-7°C.; and the Atlantic race (west of the British Isles) with 51 or 52 vertebrae and an optimum temperature from 6 to 9°C.

The Arctic race is that most directly concerned in the great French fishery of the Newfoundland Banks. Through varying fortunes the cod-fishers have experienced real crises, for there have been times when cod were lacking on the Banks. As early as 1922-23 I showed that these crises arise from hydrological conditions. In years when the Labrador Current

flows strongly, it girdles the east of the Grand Bank with a great cold wall which entirely resists any encroachment from the Atlantic transgression. Waters of a mean temperature from 0° to 1° C. cover all the Banks and the cod are very numerous. There is an excellent fishery. As the fishermen of the sailing vessels used to say : " An iceberg year is a cod year ".

When the volume of polar waters is reduced, the cold wall is not so compact and warm surface waters break through to encroach over the banks. But the deeper waters remain cool. The cuttle-fishes make their way over the cod who, without hesitation, dash out of the cold waters to seize this choice prey. Under these conditions the fishery is still good. But in years when the Labrador Current is feeble and when the transgressions are strong, these latter invade all of the banks or raise the temperature of the local waters. The cod run before this rising temperature to descend to the depths of the continental slope. The fishing is now unprofitable or difficult, even for large trawlers. The great transgression in 1921 had thus given rise to a " cod crisis " the effects of which were noted and the causes ascertained. In 1930 also, basing ourselves on the nine-yearly cycle of the transgression, we forecast that the fishery at Newfoundland would be bad and ship-owners were advised to seek cod more to the north, on the banks off west Greenland. There they had good fishing.

During these latter years, the warming-up of the Arctic has brought about great changes in the hydrological conditions of the northern Atlantic. The Labrador Current has decreased and the encroaching waters retreat much less in winter than they used to do. The latitudes of the Barents Sea, Bear Island and Spitzbergen are now almost continuously accessible, and the cod are moving further and further to the north, followed by the great trawlers. These vessels mainly catch the younger fishes, for the larger and older cod have not ventured so far afield but have sought deeper waters around Iceland and the Banks. Year after year, the activities of the cod-fishermen are taking them to the Arctic Ocean and very soon these wide northern seas will have taken the place of the Newfoundland Banks in this great fishery for cod.

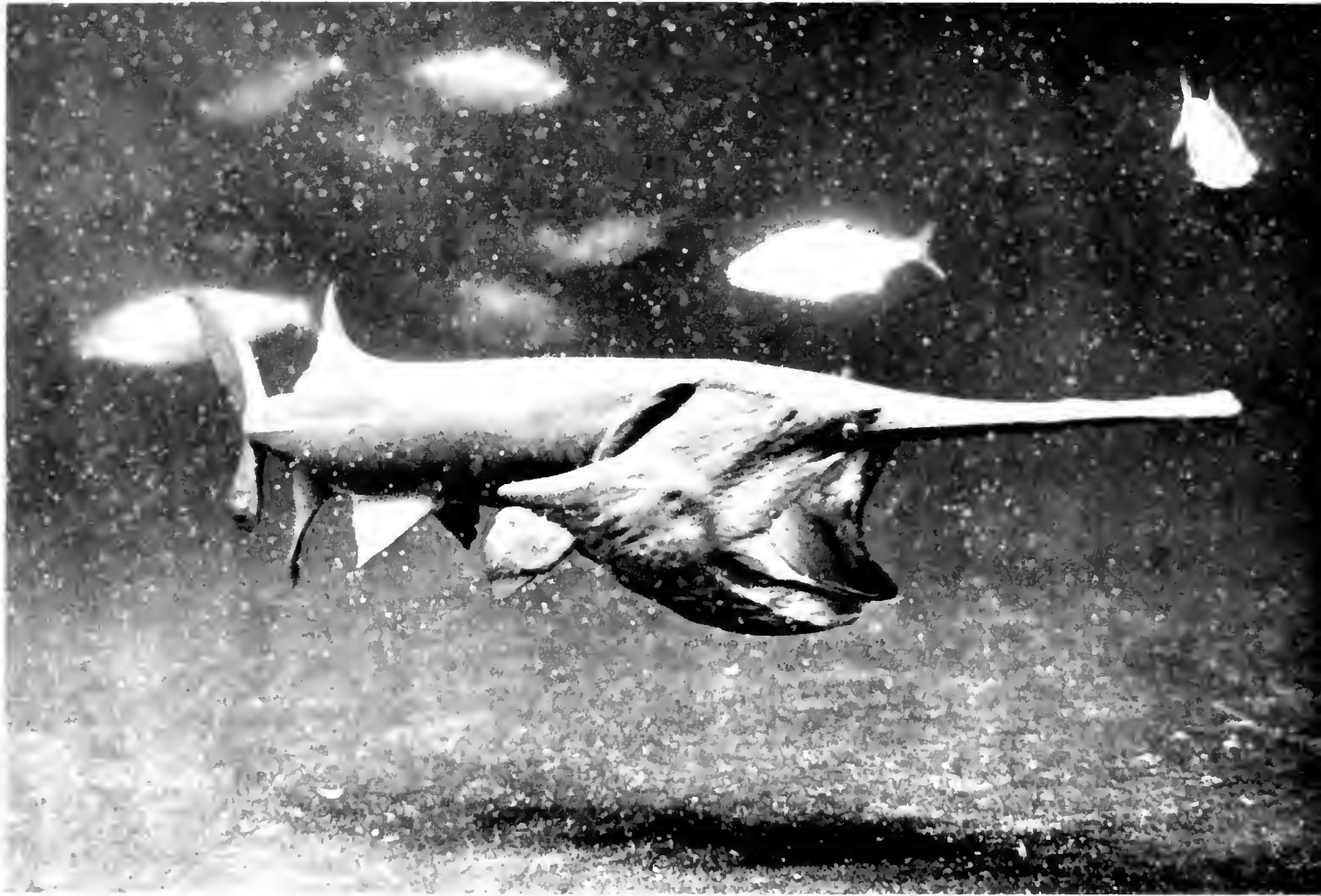
Haddock (*Gadus aeglefinus*) also live over the Banks, and the Newfoundland fishermen call them ânon. The biology of these fishes is much like that of the cod; for they are stenothermal in habit and, depending on the races, live in waters between 2° and 8° C. The haddock has a purplish-blue colour with a dark lateral line and a black spot on each of the shoulders. The fixed number of vertebrae precludes any distinction of local races. Growth is rapid at first and then diminishes : at one year they measure about 6 inches ; at 2 years about 12 inches, towards 5 years about 20 inches, at 10 years 2 ½ feet and towards 13 years nearly 3 feet. The life span does not exceed 15 years. Haddock are very voracious fishes and in the North Sea shoals of them swoop down to feed on herring spawn.

Close by the cod and haddock, living on the bottom, are the great halibut of the Arctic, finding good living conditions in the cold waters of deep channels. There are also other flat-fishes such as the long rough dab (*Drepanopsella platessoïdes*), known to cod-fishermen as " brooms ". This pleuronectid, which does not grow much beyond 2 feet in length, is a particularly sedentary species and throughout its life does not move very far from a resting-place, not even at the spawning period.

The cod is second only to the herring in economic importance to the fishing industry. Salt cod is sold throughout the world, particularly in the Mediterranean basin, in the West Indies and in South America, where it is used as lenten fare. Norwegian stock-fish, seasoned in a cold dry wind, is exported as far as central Africa. Frozen fillets of an excellent quality are prepared by the cold-storage trade and fresh cod (cabillaud) is also greatly appreciated. Salted cod's-roe is used as bait in the sardine fishery, and cod-liver oil with its rich supply of vitamins, has been known to medicine for centuries. Considerable quantities of smoked haddock are eaten, and in the British Isles " tinnau haddies " are well known on the breakfast table.

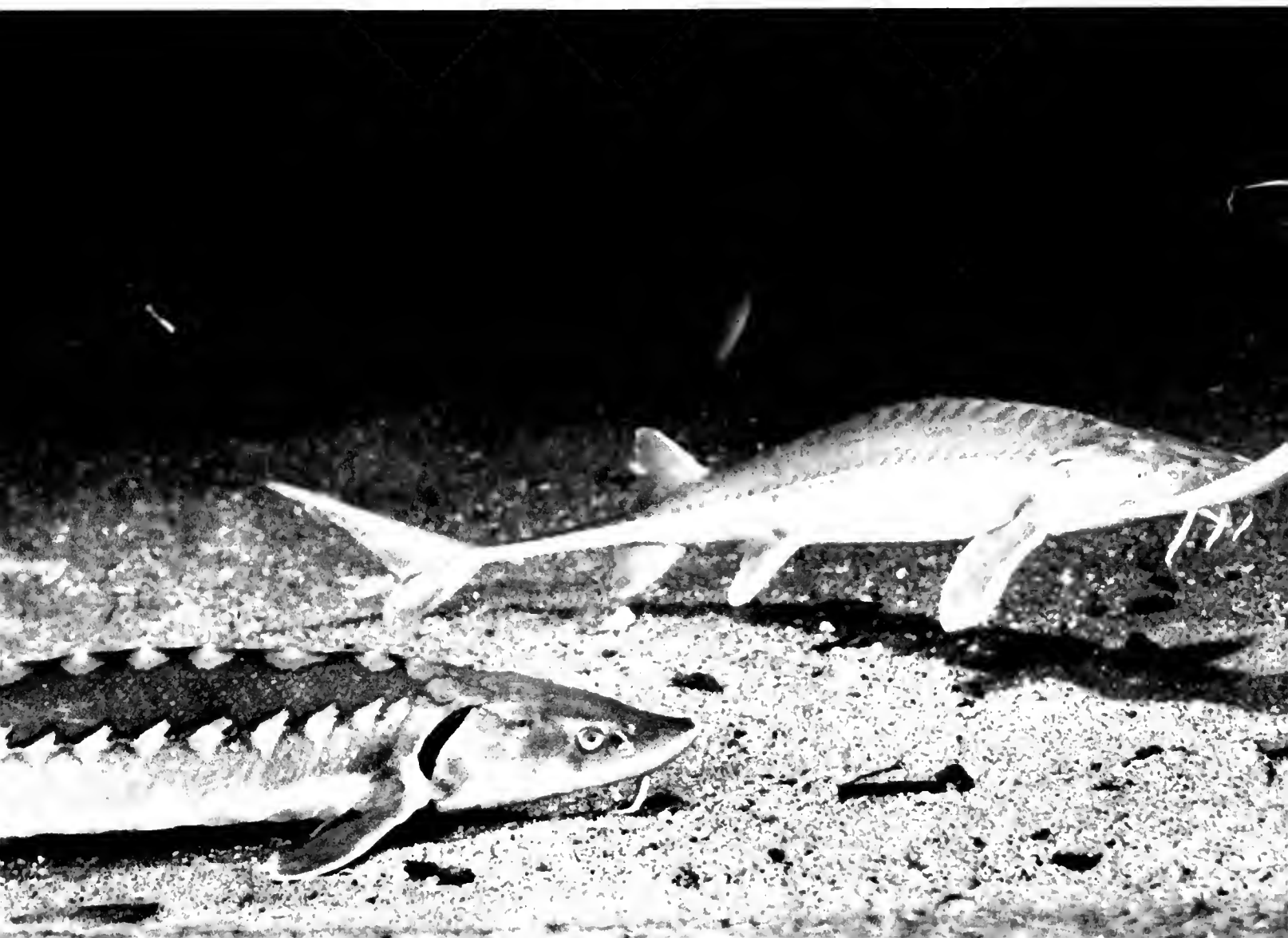
The common eel (*Anguilla anguilla*) among the plants of a fen. Photograph Popper-Atlas-Photo.





The large paddle-fish or spoon-bill (*Polyodon spatula*) from North American rivers. It can reach a length of 20 to 23 feet. The conical rostrum measures almost a third of the total length. The mouth, like that of the sturgeon, is small, but is provided with teeth. This large fish feeds on small prey detected in the mud by its sensitive rostrum. Photograph by J. G. Sheed. Aquarium Rapho.

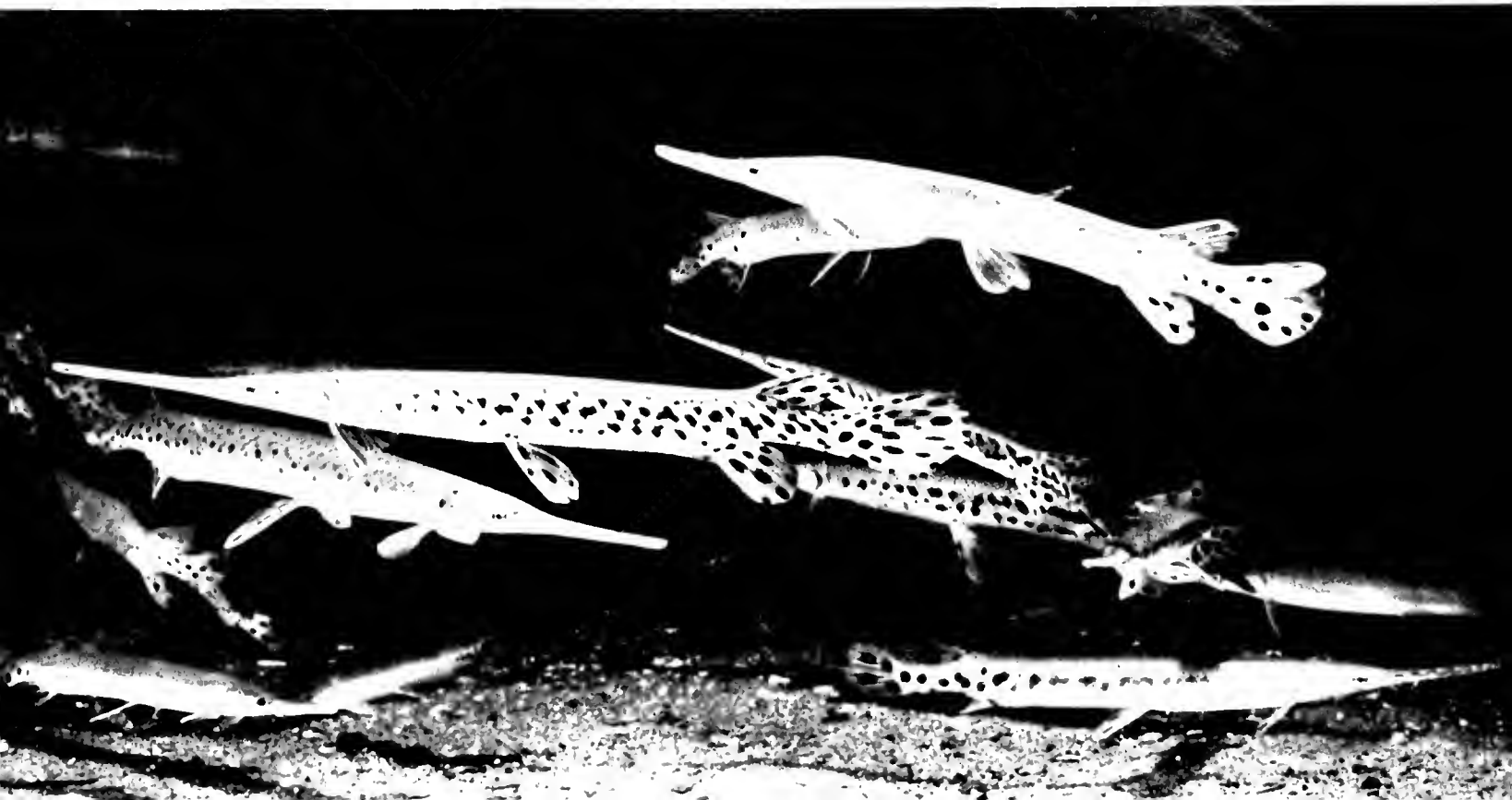
American sturgeons (*Scaphirhynchus platorhynchus*) proceeding along a river. The head is lengthened into a rostrum and underneath there is a small tubular mouth by means of which they can suck in food. Barbels are carried on the snout. Photograph New York Zoological Society.





The muskellunge (*Esox masquinongy*), the terrible pike of the American Lakes. It can reach a length of more than 8 feet and weigh more than 60 pounds. Photograph New York Zoological Society.

Young garpikes of the rivers of the Southern United States (*Lepisosteus osseus*). The adults can measure more than 6 feet in length. Photograph New York Zoological Society.



The abundant life of northern seas.

After the months of the long polar night, when all life seems to be held in abeyance, the sun creeps back over the horizon and for several hours its slanting rays bring out clear blue and green shades in the icebergs. Then more and more it becomes the master of the sky. Towards the time of the summer solstice, twilight has vanished, and the glaring sun prevails over the northern landscape, never for one hour leaving the sky. At midnight its orange gleams light up a greenish sky and cast long purple shadows from the ice onto the slaty sea. And the broken pack-ice gleams a dazzling white in the dark mass of open waters.

At the ice-edge the polar bears, swaying their triangular heads in an uncertain rhythm, are well aware that this is their mating season. Seals lie solemnly on isolated floes or suddenly dive to overtake some prey seen in the transparent sea. In the ocean there is a prodigious development of living beings, both in the sunlit surface waters and in the depths. The rays of the sun bring forth swarms of microscopic algae and the endless division of the diatoms gives rise to dark green patches in the sea. This abundance of plant life, the well-known floating pastures, is an endless source of food to countless small crustaceans and these, while they eat, become the fodder of more powerful animals. Small shrimps (*Meganyctiphanes* and *Thysanoessa*) mass together in such dense swarms that the sea surface grows crimson as they pass. Scandinavian fishermen call these swarms of restless shrimps "krill". Voracious fishes dart into these teeming masses. Great whales with mouths agape plunge through the krill, engulfing countless numbers, which are screened by their whale-bone filters when the jaws are closed. Suddenly depressing their great tongues the whales swallow the krill at one gulp.

The drifting pelagic life of the northern seas is also revealed in the form of numerous transparent and hyaline jelly-fishes, some of which can be very large. The bluish umbrella of the great brown-tentacled *Cyanea* can be as much as 6 feet in diameter. Chains of *Salpa* like crystalline garlands make their way through a slate-blue sea. Larval fishes, particularly the young of cod, form seething yellowish patches amid this tremendously rich planktonic life. Close-packed silvery ranks of shoaling herring move through the floating pastures, thrusting aside the salps and jelly-fish. And as the herring move, they batten on the krill.

The herring (*Clupea harengus*) ranges over northern Atlantic waters, venturing as far as 80° N. and occurring in the Barents Sea and off the coasts of Greenland. It abounds along the Scandinavian coasts, in the Baltic, in the North Sea and in the eastern English Channel. In the Bay of Biscay, where it is less common, it extends down to the latitude of La Rochelle. Off the American coast it lives over the Banks of Newfoundland, Nova Scotia and Maine, reaching the New York region. A closely related species (*Clupea pallasii*) replaces it in the Pacific. We have already suggested how oceanic relicts of this species came to live in the White Sea following an ancient warming up of the arctic.

It used to be thought that the herring undertook long migrations. Dodd and Anderson wrote of a vast shoal leaving the Arctic Ocean in the direction of Iceland and moving down the Norwegian coast. After entering the North Sea and passing into the English Channel the shoal returned polewards by way of the waters to the west of the British Isles. This line theory was demolished by the discovery of local races, which was due to the remarkable work of the German Heineke and the Norwegian Hjort. Study of the average numbers of vertebrae has enabled us to distinguish the following races: the *boreal* race (Greenland, Iceland, Norway), reaching a mean length of nearly 12 inches after 4 years and with 57 to 58 vertebrae; the *American* race (Labrador, Newfoundland and Maine) also reaching 12 inches after 4 years and with 56 to 57 vertebrae; the *North Sea and eastern English Channel* race, 10 inches after 4 years, 56 vertebrae; the *Baltic* race 7 $\frac{3}{4}$ to 10 inches after 4 years, 55 vertebrae and the *Irish* race (Scotland, Wales and western English Channel), 10 inches after 4 years, 56 vertebrae. Other local populations in the Zuyder-zee and Breton estuaries are comprised of small herring with 55 and 56 vertebrae.

Above all, herrings are fishes of the polar seas and continental waters. In winter they position themselves at the edge of the shelf at a depth of about 100 fathoms. But the arrival of

the transgression sets them moving, for they cannot tolerate warm and salty waters. This is a coastward movement and it coincides with the spawning period. Retreating before the Atlantic waters, they climb along the valley lines of rivers that used to run in the undulating planes of the North Sea and the Irish Sea, before these latter subsided. This ascent is partly anadromous in character. As a matter of fact these fishes never enter fresh water although some races are restricted to estuaries filled with brackish water. The main centres of concentration are: the ancient estuary of the Rhine, to the east of Scotland, now the Fladen Ground; that of the Clyde, to the north of Ireland, near Inishtrahull; and that of the Severn, at the entrance to the Irish Sea, now Small's Ground. Receding before the encroaching waters, the shoals arrive at a particular date in definite regions. In August they are off Aberdeen; in September near Cullercoats; in October, before Flamborough; and in November near Yarmouth and the Belgian coast. Later in winter they appear over the Banks of the Straits of Dover and in the eastern English Channel as far as Cap d'Antifer. Each race has an habitual spawning ground and the eggs are always shed in continental waters with a salinity less than 35 ‰.

Herrings are exceptional among pelagic fishes in that their eggs are demersal; they do not float like those of other species. They are fastened singly or in small clumps on hydroids and bryozoa or when spawning takes place close in-shore, on branched algae. Each female bears more than 30,000 eggs. After spawning a feeding migration takes place and "spent" herrings, emptied of their sexual products, go in search of food. They fill up with diatoms and raven on swarms of copepods. During years of extensive transgressions when, for instance, the North Sea is invaded by warm water, it sometimes happens that the herrings find food hard to come by. This occurred in 1922 after the great transgression of 1921. The starving, emaciated fishes, with their reserves of fat exhausted, perished in great numbers.

Growth varies according to race. On an average a length of 5 inches is attained at 1 year, 7 3/4 inches towards 3 years, 11 inches at 6 years and 12 1/2 inches at 9 years. Sexual maturity is reached towards the fourth year. The maximum life-span is perhaps 20 years.

The herring — the "king herring" of the British — is the most important fish from an economic standpoint. At all times it has meant wealth for the Scandinavians. In 809 Charlemagne founded Hamburg as a herring-fishing port, and in the same way the Normans established Ostend, Dunkirk, Étapes, Dieppe and Fécamp (the "Fisk havn" of the Vikings). The clergy levied tithes on these fishes, which stirred up revolts, notably in Flanders during the 12th century. The Hanseatic League strove against the Scandinavian countries for the possession of the herring fisheries. In France the sale was regulated by the royal decrees of Louis IX and Charles V, with the Parisian Corporation of the "Marchands de l'eau" having the monopoly. The war between Holland and England in the 17th century was concerned with the maritime ownership of the Dogger Bank. Conflicts have also raged about the Pacific herring. The fishes in the Sakhalin region are vital for Japan and the war in 1902 against Russia was largely undertaken to establish a supremacy over these fisheries.

Herring are eaten fresh, while some are salted in barrels. There are also various ways of smoking them, from the Dieppe craquelot to the kipper and the red herring. When marinated in white wine they make an excellent preserved food. The partly preserved roll-mops and the Scandinavian pickled herring are also much appreciated.

Shoals of sprats (*Glupea sprallus*) — "brisling" to the Norwegians — are not so conspicuous in the teeming life of northern seas. The sprat has a dark blue back and a silvery belly and does not grow beyond a length of 6 inches. Like the herring it lives in cold waters and retreats before the transgressions. It is abundant around Scandinavia, in the Baltic, the North Sea and the English Channel. While rare in the Bay of Biscay it is found again off the Galician coast. The eggs are pelagic and the life-span is no more than 6 years. After maturing in a sweetened pickling brine it becomes "Norwegian anchovy".

All the cod-like fishes figure among these swarms of animals: there are whiting, haddock, cod and ling. Demersal fishes are very numerous along the sea bottom. There are gurnards, rays and various kinds of flat-fishes; turbot, brill, dabs and especially plaice.

The plaice (*Pleuronectes platessa*) lives pressed close to the gravel, sand or mud, lying on its left side. The eyes and jaws are twisted towards the right side. These fishes are grey or



yellowish in colour, being perfectly camouflaged. Sometimes, however, there is an extensive production of the yellow colour-cells in the form of conspicuous spots. At spawning time plaice are slightly catadromous in habit and move down to depths around 15 to 25 fathoms. The eggs float and the larva is at first quite symmetrical. But very soon it sinks to the bottom; the migration of the left eye takes place and the young now look like flat-fishes. During their early years the small plaice live in sunny in-shore waters in sandy bays called "nursery grounds" by the English. When they reach about 3 inches in length they migrate down to depths of about 5 to 8 fathoms. After 2 years they measure $5\frac{1}{2}$ inches, and at 3 years nearly 8 inches. In the fourth year, having grown to about 9 inches, they become sexually mature for the first time. Growth now slows down, a 2 foot plaice being more than 20 years old. Plaice are euryhaline and eurythermal, changes in hydrological conditions having but little effect on these sedentary fishes. The amount of food ingested plays a great part in the growth of a plaice. Finding that growth was poor in the littoral zone, Danish scientists transplanted such plaice to the Dogger Bank, where an abundant planktonic life led to their rapid development. These fishes are much esteemed in the Scandinavian countries and in the British Isles, but off the French coasts they are at the southern limit of their distribution and the indifferent quality of their flesh precludes their being very much appreciated.

Fish is an important part of the diet in northern countries, whose fishing vessels are supplied from this immense reservoir of living matter. An extensive fleet of trawlers or drifters, without counting the small boats of the in-shore fisheries, ranges over the grey waves of the northern seas. Herring nets measuring several miles drift at the surface. Trawls have been more and more improved for sweeping the bottom. Human exploitation of the riches of the sea has little effect on the blue, pelagic fishes, which are only subject to natural fluctuations, but the demersal fishes have been seriously affected. Biologists are now permanently concerned with the impoverishment of fishing grounds. The North Sea is becoming depopulated, for it is constantly scoured for fishes. As an old English saying has it: "If you drop a shilling into the water near the Dogger Bank, it may not be fished up on the same day but someone is bound to haul it up the day after."

CHAPTER III

TEMPERATE REGIONS

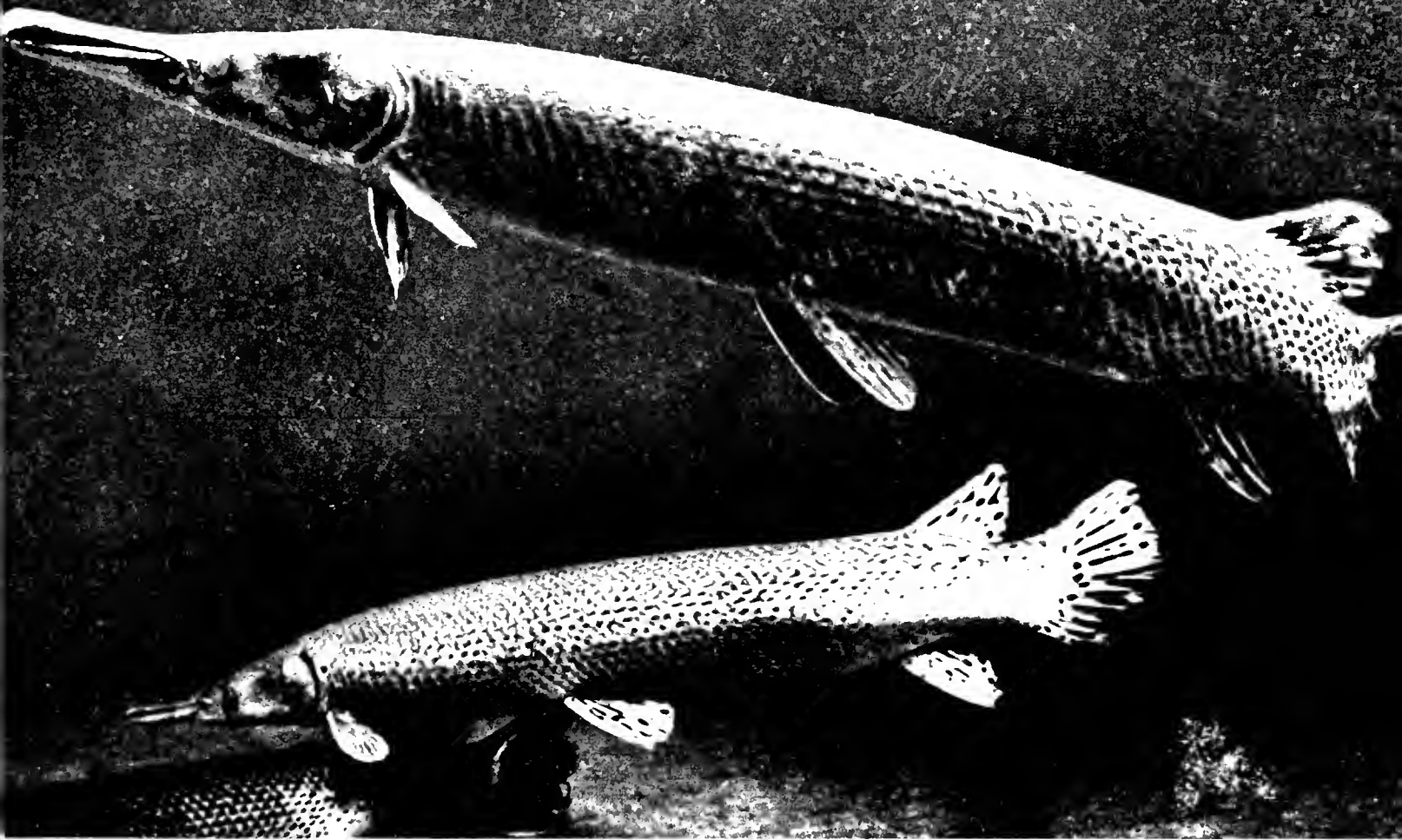
A trawl haul on the Great Sole Bank.

Having sailed out of La Rochelle in the evening, the trawler has headed for the north-west throughout the night and during the following day and night, voyaging for forty hours. At dawn, very far from land on the long rolling swell of the open sea the crew sees great cargo-ships that run from England to South America silhouetted against the horizon. The echo-sounder reads 80 fathoms, for the ship is at the edge of the continental shelf in latitude 49° 30' N., longitude 11°W. Below it, under the waves of the Celtic Sea, at a depth of 80 fathoms, is a sunken continent extending from the south-west of Ireland to the region of Brittany. The courses of ancient rivers are marked by deep-cut fjords which alternate with raised banks, the most westerly of which is the Great Sole, this bordering the valley which used to be the Severn estuary. The waters of this once great river used to flow along undulating country right to the South of Ireland, along country that has now disappeared under waters flown over by grey seagulls.

The boat has just shot its trawl. Buoyed on top by glass floats and weighted along the bottom by a large chain, the great mouth of the otter-trawl opens between two iron-shod doors. It swallows the fishes in its path, taking them into an immense "stomach", a deep, close-meshed pocket of the net which is further narrowed by the drag of the animals already caught. At the end of the tow, the trawl is winched up alongside the ship and hoisted on deck by intricate manœuvres. As soon as it is opened from below, a mass of still living fishes spills out, jumping about in their death-throes. Scarcely emptied, the trawl is put back into the sea, while the crew sort the catch and stow it in ice in the hold. The practised eye of the skipper has judged the value of his poundage and a smile appears on his weather-beaten face. He is quite happy, for there is plenty of hake — and they are large.

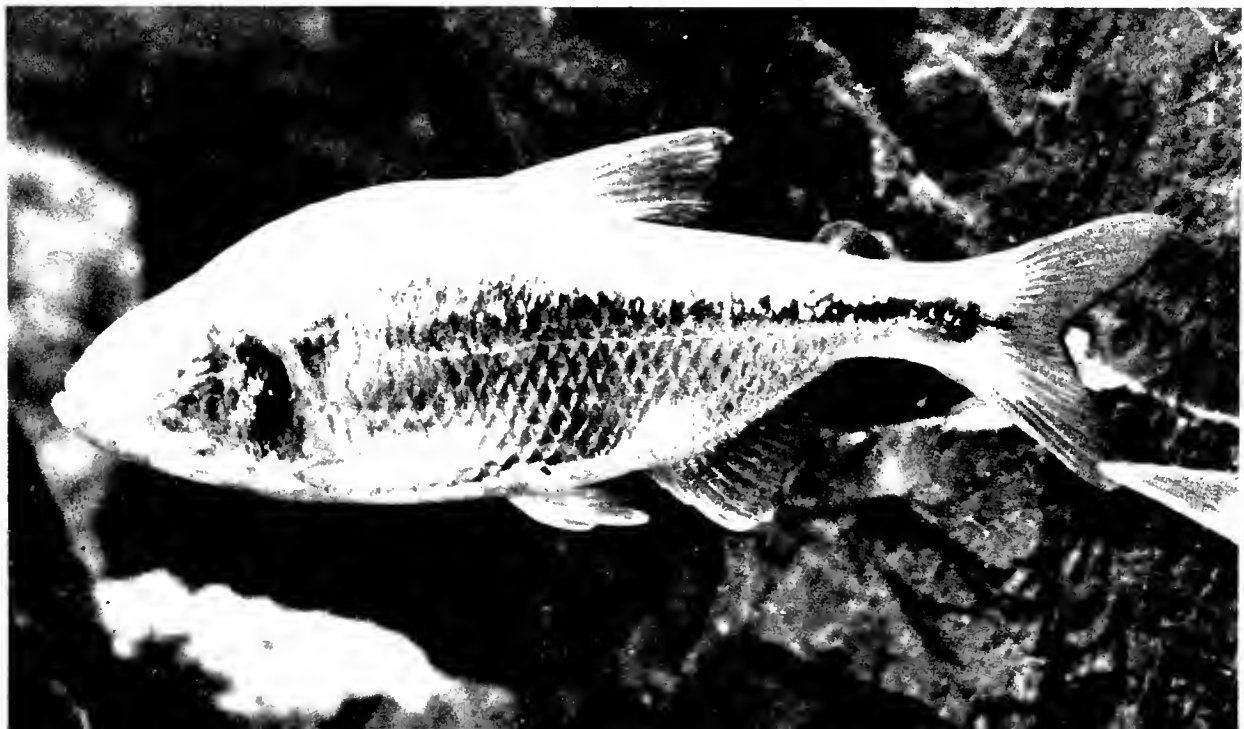
The hake (*Merluccius merluccius*) is, in fact, one of the most valued fishes on the French market. In the Central Market in Paris it is improperly called ("colin") "coalie", for this name should be kept for a gadid, the green pollack (*Gadus virens*), the coalfish of the British. This term "colin", which calls to mind charcoal, does not suit the hake with its light-grey colouration. In the South of France it is called "merlan", a confusion with yet another very different fish, the whiting.

Hake are near relatives of the cod-like fishes and for a long time were placed in this group. They have a long body bearing two fins on the back and a single anal fin along the underside. A dark lateral line extends down each side of the flanks. The jaws of the bony head are strongly



Alligator garpikes (*Leptosteus tristochus*) from North America. Photograph New York Zoological Society.

Anoptichthys, a blind cave-fish from Mexico. Photograph New York Aquarium.





Two flying-fishes. The upper one is gliding over the water; the lower one is mirrored in the calm water from which it is taking off, leaving behind a wake showing its progress. Photograph by Harold E. Edgerton.

A marlin (*Tetrapturus*) which is related to the swordfishes, leaping vertically out of the waters of the open ocean.
Photograph by J. van Coevering Rapho.





A marlin (*Tetrapturus*) swimming at the surface with the dorsal fin folded down.
Photograph by J. van Coevering Rapho.

armed with formidable teeth reminiscent of those of the pike. Thus it used to be called "sea pike" (*Maris lucius*). Unlike the cod-like fishes living in polar waters, the hake is a fish of Atlantic waters and keeps to the layers of the transgressions. In our regions it is stenothermal, living at water temperatures between 8° and 12° C., and as it is stenohaline it remains in waters with a salinity of 35 ‰. The studies of G. Belloc and J. Cadenat have enabled us to distinguish local races according to the vertebral complement and the number of fin-rays in the first dorsal fin (D.1). These are: (a) *Irish* race, var. *septentrionalis*; D.1 = 10, 51/52 vertebrae; (b) *Franco-Iberian* race, var. *atlanticus*; D.1 = 10, 50/51 vertebrae; (c) *Moroccan* race, var. *atlanticus*; D.1 = 10, pelvic fins short; (d) *Mediterranean* race, var. *mediterraneus*, D.1 = 10, 52 vertebrae, pelvic fins long; (e) *Senegalese* race, var. *senegalensis*, D.1 = 11, 54 vertebrae; (f) *Congo* race, var. *polli*, D.1 = 10, 53 vertebrae; (g) *Cape* race, var. *capensis*, D.1 = 11, 51 vertebrae.

The Senegalese hake is distinguished from the European form by its darker, almost black, colour, by its softer flesh, and by its larger eyes. Off the Mauretanian coast these two varieties, which are called white-hake and black-hake, live in the same area.

Other kinds of hake are found elsewhere. Along the American coast (Newfoundland and Maine) there is *Merluccius linearis*; in the Pacific, along the Californian coast, *M. productus*; off Chile and New Zealand (*M. gayi*).

In the Atlantic hake, growth is more rapid in the southern races, the females growing faster than the males. The yearly increase in size, which is about 4 inches at the beginning, slows down after a time. On an average, a three-year old hake measures 14 inches; towards 6 years, 28 inches and towards 10 or 11 years, 39 inches. The Mediterranean race consists of small hake barely exceeding a length of 15 inches, a size reached towards 10 or 12 years. In the Atlantic hake sexual maturity is attained after 3 or 4 years, when the males measure 15 and the females 20 inches. These data show the great danger of a too intensive fishery of this species, and this is what is actually occurring. It is really criminal from an economic standpoint to allow the fishery and the sale of young hake of 6 and 8 inches. They are profitlessly destroyed, whereas they would later become fishes with a high market value. Year by year the fishing grounds of the continental shelf are becoming impoverished, and neither the improvident ship-owners nor the indifferent public authorities think of applying any remedy.

During the winter, hake live on the Atlantic slope at a depth of 100 fathoms, often close to the corals. Spawning occurs when deep-seated transgressions reach the continental shelf: in April and May off the Spanish coast; in June in the Bay of Biscay and in the Celtic Sea towards July. Along the African coast and in the Mediterranean, where the effect of the transgression is feeble or lacking, spawning occurs in winter. Hake enter the North Sea from July to October but do not reproduce there. They only move into this sea for a few months simply to feed. The eggs float and the young hake move coastwards towards depths of 25 to 40 fathoms in summer, where they grow up in the warm water masses exposed to the sun. The large reproductive individuals rarely leave the edge of the continental shelf. When the transgressions are strong the hake move with them to the north and are met with as far as the coasts of Scandinavia.

It is only quite recently that hake has become a favoured food-fish. Sixty years ago French housewives set little store by "colin" and no one would have dared to serve it at a middle-class table. Now it is the favourite fish and fetches unforeseen prices. In the Middle Ages it was fished in the Bay of Biscay and salted, Penmarc'h then being the great port of registry. The discovery of the Newfoundland Banks by the Basques ("Terre Bacalaos") and the success then enjoyed by salt cod ousted the hake. Furthermore, a terrible storm in 1404 destroyed the whole fleet, which was not rebuilt. The looting and burning of Penmarc'h during the wars of the League brought about the ruin of the hake fishery.

Sea-breans rank next in importance among the mass of fishes brought back by our trawler. A great many of them with shining pinkish backs stand out beside the grey hake. They have a black spot on each shoulder and the sun gleams on their white bellies. The common sea-bream (*Pagellus centrodontus*) belongs to the large family Sparidae, which contains a number of edible species. It is a fine fish with a rounded head, large eyes and a laterally compressed body: it can reach 15 to 20 inches in length. It is also a warm-water dweller, and keeps to waters with a salinity close to 35.4 ‰. In winter the sea-breans stay on the slope at a depth

of about 150 fathoms and in spring follow the transgressions at the surface. When these Atlantic waters have spread over the entire shelf, the bream descend to some distance from the bottom, a little above the hake. These sea-bream "besugos" are very abundant off the Spanish coast but become rarer in the North Sea.

Alongside the sea-bream there are red mullet with scarlet shades blending with the red or golden gleams from their flanks. The red mullet or surmullet of the Mediterranean (*Mullus barbatus*) has a convex snout and long barbels hanging from the lower jaw. It is a magnificent fish and from a gastronomic point of view is in the first rank of all the fishes in the sea. To appreciate the full flavour of its flesh and its distinctive aroma, it must be eaten when freshly caught and grilled without being gutted. The Romans of the Imperial Period, who were unrivalled gourmets, paid fabulous sums to taste surmullet.

Like the sea-bream, red mullets are among the red fishes of the neritic type and they tend to go to the bottom to root in the mud with their barbels. P. Debrosses has found that spawning takes place in May and June at a depth of about 50 fathoms and in waters with an average salinity of 35 ‰, for these fishes live in the encroaching water masses (transgressions). Young fishes about 2½ inches long move coastwards in August, but in November, when about 6½ inches, they retire seawards and during the winter grow but little. Red mullet first spawn when two years old and as they grow older gradually move into deeper waters. The males do not grow so rapidly as the females but as these fishes form groups according to size rather than age, the males are surrounded by females younger than themselves. Many die at an age of two years, having only spawned once. However, some females and a few males survive, reaching a length of about 16 inches when about 10 years old, but this is an exceptional life-span. While their normal habitat extends from Ireland to the African coast and the Mediterranean, during warm years they venture into the North Sea.

The trawlermen carry on sorting their first haul, which has been profitable. Hake, sea-bream and red mullet have already been well stowed and iced, and now they turn to the far more numerous gurnards, fishes belonging to the family Triglidae. These have a large, completely armoured head bearing spines and the eyes are set in projecting orbital arches. The body is covered with fine scales that are smooth or spiny, the feel of the skin being soft or rough according to the species. The head is concave in outline, while the upper edge of the snout is rounded or sloping. In some species the large outspread pectoral fins look like butterflies' wings and are set with iridescent blue spots. Furthermore, the lower rays are curiously modified, three of them resembling fingers: the gurnard can use them as legs as it forages along the bottom with its shovel-like snout.

The numerous species of gurnards are coastal fishes with bottom-dwelling habits. There are pink gurnards with rough, grooved heads; for instance, the imbriago (*Trigla imberbis*) and the red gurnard (*T. cuculus*). The grey gurnard (*T. gurnardus*) has greenish or bluish shades on its grey body, while another "rough" species, the piper (*T. lyra*) is a fine red, with a very long spine behind the gills. Smooth gurnards, such as the tub-fish ("the tomb of the Biellois", *T. lucerna*) is brownish or reddish in colour and is the largest species, reaching a length of nearly 2 feet. Another smooth species, the long-finned gurnard (*T. obscura*), has a long filamentous ray in the dorsal fin. In the Mediterranean there is another rough gurnard called the cavillone (*T. aspera*) with a very small greyish body. The armed gurnard (*Perisledion calaphractum*), also found in this sea, has the body entirely invested with bony plates forming an armour. The snout is deeply notched. This armoured and brilliantly red fish is very agile, running quickly on its finger-like rays and swimming swiftly. On the Great Sole Bank, the grey gurnards form the greater part of the triglids caught in the trawl.

While the white-bellied fishes are now lifeless, the long, grey-bodied conger-eels (*Conger conger*) are still active, writhing like reptiles. On sandy bottoms they are pale-coloured: on rocky grounds they are dark. These fishes can reach or exceed a length of 6½ feet. The fishermen are well aware of their powerful teeth, some having had fingers cut off by the fearful jaws of an apparently dying conger, which they have unwarily approached. This "limbless" fish, without pelvic fins, has a single fin encircling the body. It extends deeply down the continental slope. Like its relative the freshwater eel, it undergoes a metamorphosis, but it does not migrate over



such vast distances. The eggs hatch into transparent leaf-like leptocephalus larvae with chevron-shaped muscles along the body and a small round head with two shining black eyes.

At first described as a separate species, this larva was identified in 1886 by Y. Delage, who kept it in the aquarium at Roscoff and followed its change into a small $3\frac{1}{2}$ inch conger. The bluish-coloured young fishes live in-shore among brown seaweeds or under stones. When about two feet long, the fishes move down the continental shelf to lead a bottom-dwelling existence. The conger-eel spawns but once in its life. Just before this, it stops feeding and takes on the appearance of an abyssal fish. It becomes darker in colour and the eyes, especially in the males, are enormously enlarged. Being a markedly catadromous fish, it then moves down into the depths, from where it never returns, and where it dies.

In sweeping over the bottom, the large and heavy "foot-part" of the trawl stirs up rays and flat-fishes in front of it, fishes that were lying close to the ground. On being disturbed they leave the gravel, sand or mud with which their colours harmonise, their movements now being confused. Not knowing where to turn, they are engulfed by the gaping mouth of the otter-trawl. When they are brought to the surface their upturned underparts or immaculate sides flash white among the catch.

The many species of rays have a lozenge-shaped body and a slender tail. The snout may be extremely pointed (skates) or short and blunt (rays). First, there are the large "*pocheteaux*", which can exceed 6 feet in length, the flapper skate, (*Raia batis*), with pale spots on its yellowish back, and the bordered ray, (*R. marginata*) with greyish, tending to dark-brown, colours. The short-nosed rays have colours varying from "chamois" to grey: the smooth ray (*R. asterias*) is dotted with small dark spots right to the edge of the disc; in the spotted ray (*R. maculata*) these spots are larger and fewer and there is a pale patch on each wing; the small-eyed painted-ray (*R. microcellata*) is greyish with white, wavy bands more or less following the outlines of the body; the undulate-ray (*R. undulata*) is more brilliantly coloured, for its mahogany-tinted body has strikingly dark bands edged with white dots and curving into graceful arabesques; in the flowered-ray (*R. miraletus*) each of the light-beige coloured wings bears a beautiful eye-spot and yellow or white designs edged with black or purple stand out on a brown background; the thornback-ray (*R. clavata*) has white and grey marblings and the skin is set with sharp spines that rest on knob-like bases. All these rays are taken by trawlers in the Celtic Sea, but many other kinds live in other seas.

Paired rays may often be found in the trawl and on the hooks of line fishermen. Even when taken from the water they do not separate and remain clasped together until they die. The males have long cartilaginous appendages, called pterygopodia or claspers, on each side of the pelvic fins, and these are inserted into the cloaca of the females. Furthermore, in a number of species, these claspers bear spines which help to keep the pair together. The eggs are enclosed in a quadrangular, opaque shell which is tough and horny and bordered laterally by long crests forming horns at the front and back. These horns anchor the eggs in light-soiled grounds. The shape and size of the shells varies according to the species, those of the skate being rather more than 6 inches in length. Rays live from coastal regions down to depths of some 800 fathoms. Now and then, while sorting out the rays, a fisherman swears loudly on getting a sudden electric shock that slightly numbs his arm. He has just put his hand on a torpedo-ray. This round-bodied fish has a muscular tail and may reach a length of more than 3 feet. The power of the electric organs, which are placed on either side of the body, has been much exaggerated. The torpedoes (*Torpedo marmorata*, *T. oculata* and *T. nobiliana*) are viviparous. But it is more dangerous for the fishermen to be wounded by the saw-edged spine that is set in the whip-like tail of a sting-ray (*Trygon pastinaca*). This large, black ray can crush all kinds of shell-fishes in its powerful jaws and the "pavement-mouth" as it is called, is a terror to oyster-culturers. The tail spine is poisonous and may cause serious inflammation.

Lying among these animals are the brown bodies of monk-fishes (*Squalina squalina*), which look like flattened sharks. The expanded wings are not fused to the head and the gill slits are concealed in their axils. These bulky and sluggish animals are viviparous and may measure from 5 to $6\frac{1}{2}$ feet in length. The large females move quietly along the bottom, surrounded by twenty or so young fishes which lash their muscular tails in their efforts to follow the adults.

The fishermen have cut off the wings of the large skates and taken out the bulky livers of the largest rays. The deck is rapidly becoming empty. The valuable flat-fishes (pleuronectids) have still to be sorted. Grunts of satisfaction from the crew show that there are some turbot (*Rhombus marinus*) and several brill (*R. laevis*). These are fine creatures with a thick rounded body bearing the eyes on the left side. They can camouflage themselves so well that on a gravel bottom or on a black-dotted sand, these large fishes can escape notice. The turbot of our regions can reach a length of 3 feet and beyond, while the brill grows little more than 28½ inches long. The young fishes enter the warmer waters of the seaweeds along sandy beaches, those escaping systematic destruction from shrimp trawling descending to 15 fathoms and deeper. Growth is slow and after about 5 years a turbot measures 8 to 9½ inches. The females contain more than 10 million eggs but this prodigious fecundity hardly compensates for the great destruction of the immature fishes. At night-time, turbot and brill take off in the vertical plane to swim rapidly after all the fishes within their reach, for they are very voracious. They fetch high prices on the markets.

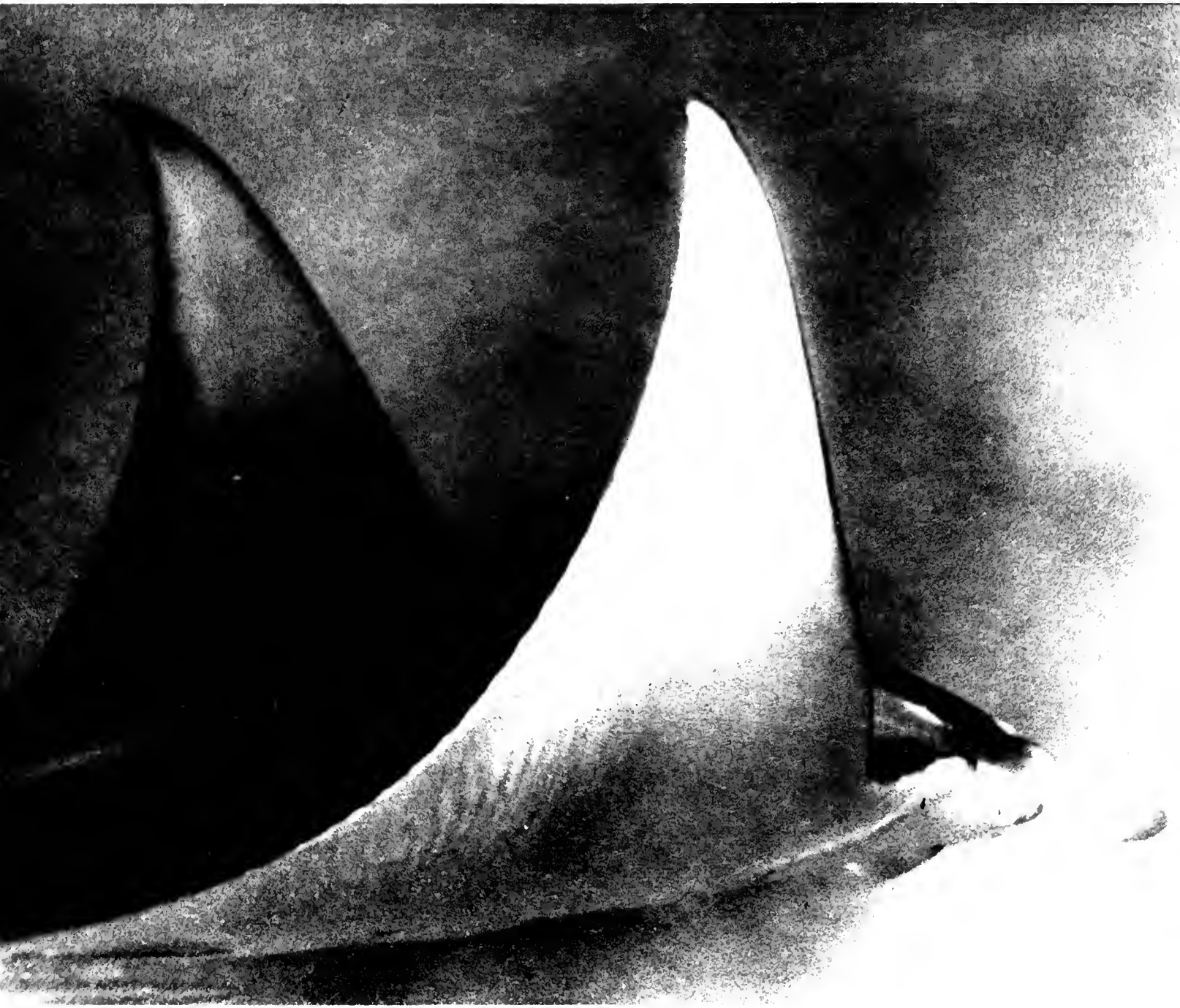
Close by them at the edge of the continental shelf lives a "poor" relative, the megrim, (*Zeugopterus megastoma*). The deck of the trawler is littered with their oblong bodies, the coloured sides always looking partly skinned, for the scales fall out very easily. The males, as J. Furnestin has pointed out, differ from the females in their deeper bodies, shorter heads and longer pectoral fins. They range from 15½ to 23½ inches in length. There are local races distinguished by the number of vertebrae, and the megrim of the Atlantic differ from those of the North Sea. They are fishes with a mediocre kind of flesh, but have finally found a place on the French market.

The true soles (*Solea solea*) are rather scarce on the Great Sole Bank and the fishermen of our trawler will not often count more than a dozen in one haul. On the other hand, the variegated soles (*Solea (Microchirus) variegata*) are abundant, being mixed with the megrims, with which they live on muddy grounds. They are small fishes which do not exceed a length of 8 inches and have a bluish colouration with brown marblings. "Cats' tongues", as they are called in the west of France, have a delicate and justly appreciated flesh, but they do not reach the Paris market.

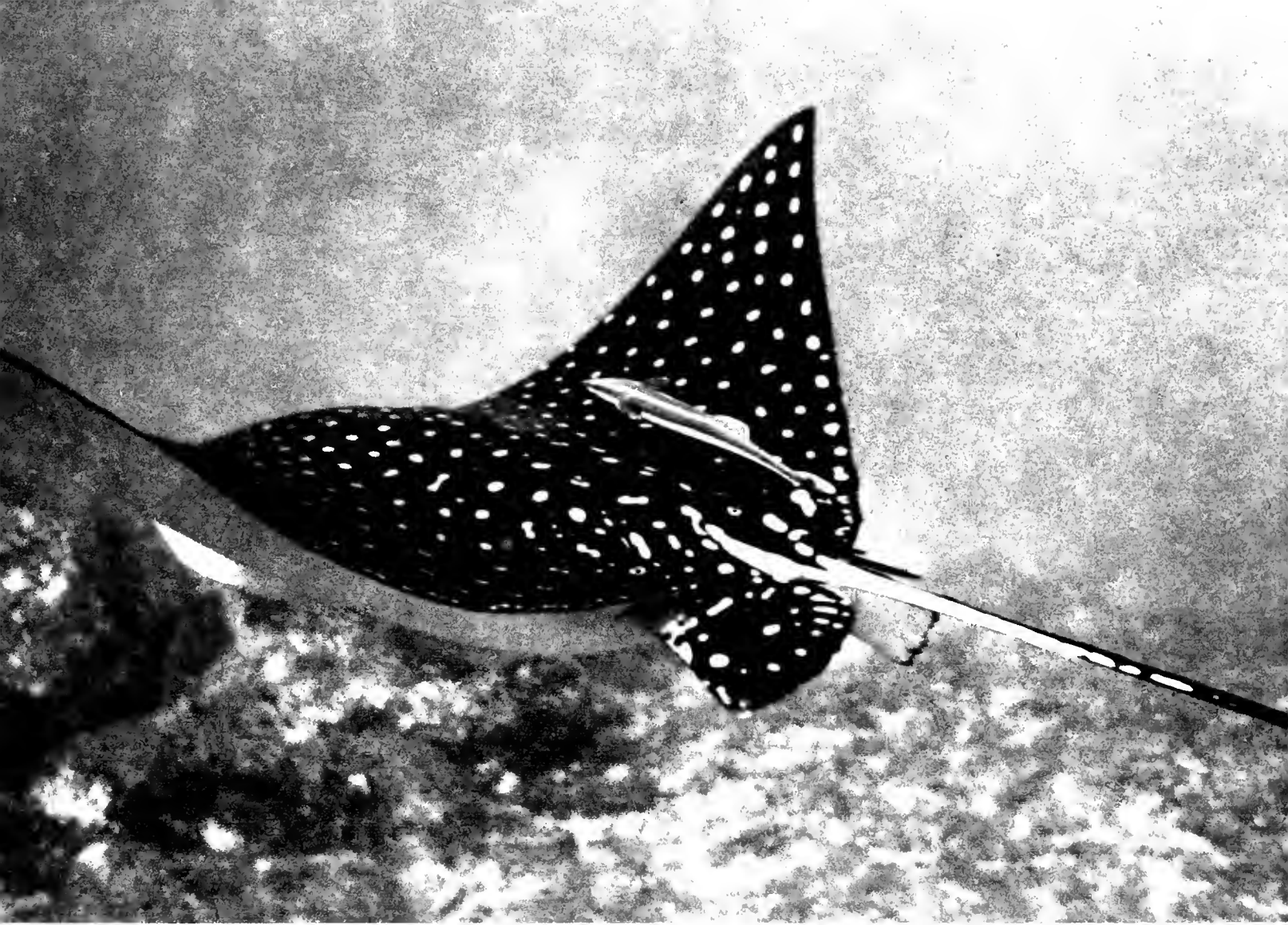
The fish sorting is finished and all the catch is stowed in the hold. The fishermen carelessly gather up spiny-dogfish, dog-fish, whiting-pout and other unimportant fishes. Only purple sea-urchins (*Spalangus purpureus*), which swarm on the bottom of the Great Sole Bank, now remain on the muddy deck. All this debris is hosed and swabbed into the sea. Another trawl tow is ended and in a few minutes a new flood of fishes will pour onto the fore-deck. For six to eight hours without a break the catches will be mounting up in the hold. Then the ship will head back for La Rochelle, where the owner, having been informed by radio, impatiently awaits her arrival.

Aboard the little craft.

Long ago, when I was a child and until the 1914 war, the coming and going of the sardine fleet during the summer gave the ports of southern Brittany a most picturesque appearance. The great long-boats left at dawn when the rays of the rising sun shone pink or bronze on their brown or blue triple sails. Throughout the day they were silhouetted like tiny cut-outs against the horizon; then towards evening they raced back to port to make sure of the first sale. The old seamen in their blue berets and catechu-tanned clothes, some still wearing a Newgate frill beard and small gold earrings, followed these manoeuvres and were not backward with their criticisms. The women from Douarnenez or Concarneau with their round caps and those from Pont l'Abbé in lace mitres impatiently awaited the stroke of the bell calling the factory hands to work. From the factories there wafted a rancid smell of frying oil. The fishing boats were anchored in the port with sails furled and masts festooned with blue nets.



The manta ray or devil-fish, in full "flight". This giant ray measures about 20 feet in width.
Photograph by Haas-Rapho.



An eagle-ray (*Actobatis narinari*) accompanied by a remora, swimming close to the bottom in the Caribbean Sea. Photograph by Isy Schwart.

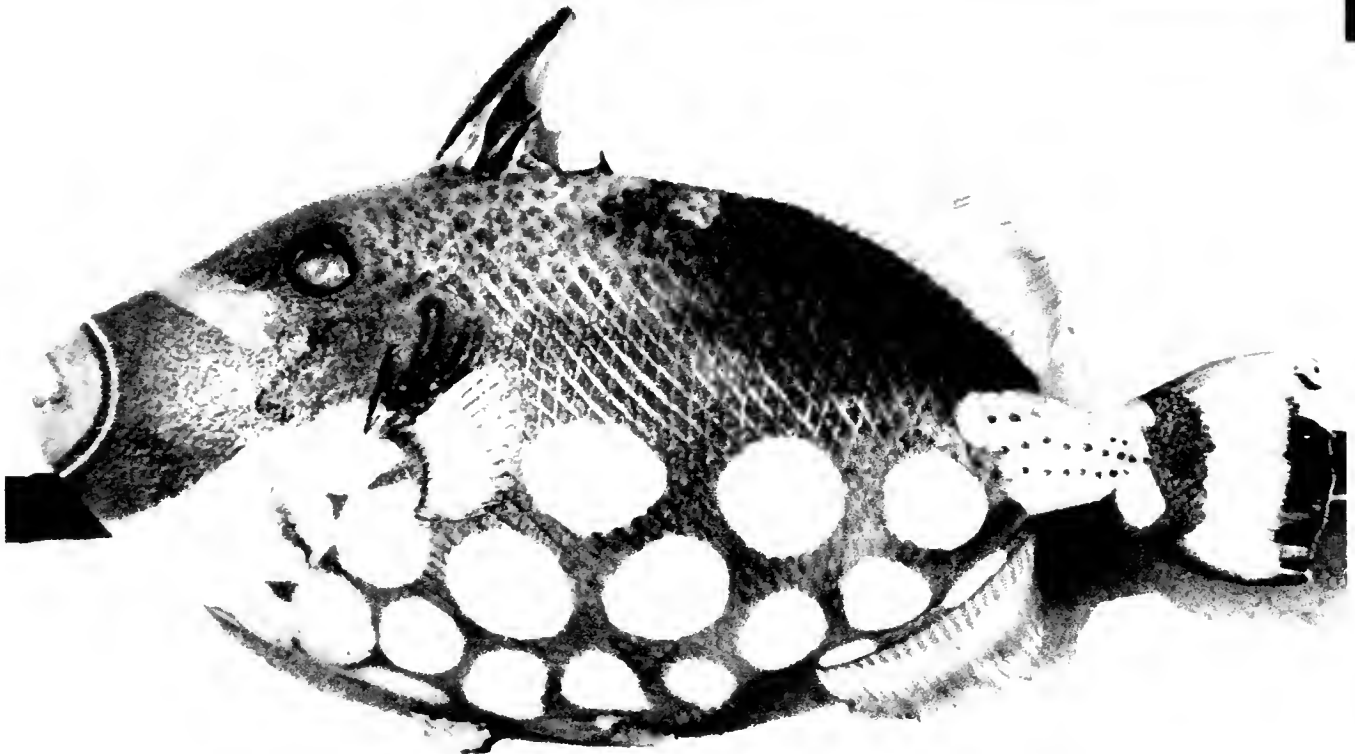


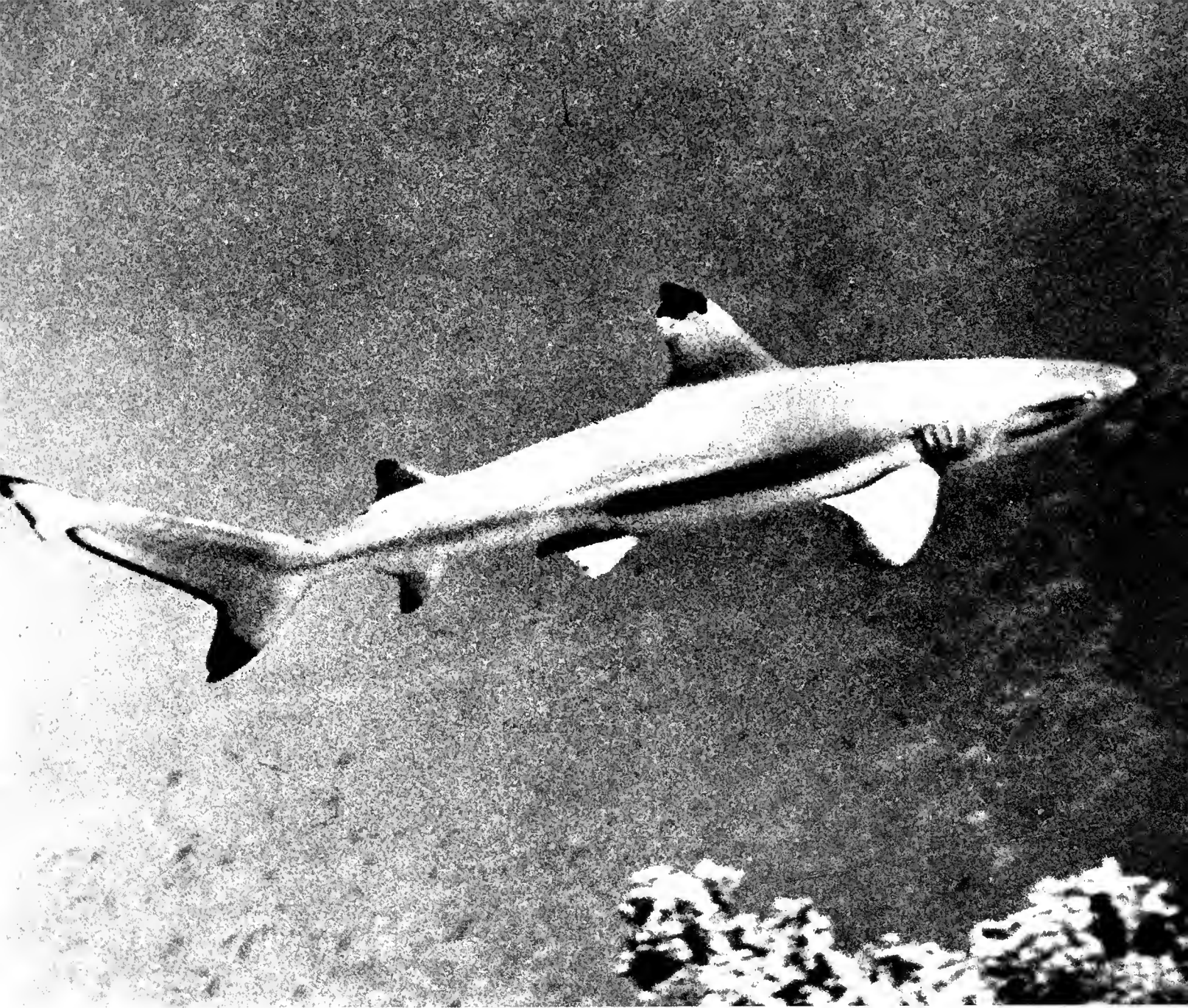
The head of a remora (*Echeneis*), showing the leaf-like appearance of its dorsal sucking disc. Photograph Popper-Atlas-Photo.

The ocean sunfish (*Mola mola*) a harmless fish from warm waters. Sunfishes can weigh as much as a ton.



A trigger-fish (*Balistes conspicillus*) from the West Indies. Photograph by Isy Schwart.





A young shark in the Tuamotu Archipelago. Photograph by Isy Schwartz.

This traditional kind of fishery had changed but little since the Middle Ages, when pilchards from Boulogne, the large "sardines de dérive" from Brittany and the "sardines sauvages" from the Vendée were salted and pressed in barrels. But the discoveries of Nicholas Appert and the setting-up of a canning industry gave new life to the sardine ports and now the young fishes were most in demand for packing into air-tight, sterilised tins. Each technical innovation stirred up agitations among the population of small fishermen. When automatic crimping replaced the old soldering by hand; when it was thought desirable to have dinghies like those of the Sables-d'Olonne to help with the manœuvring of the sardine boats; when "turning-nets" were shown to be better than "straight nets"; when engines were introduced into the boats — each time there were strikes and riots and "sardine crises", with which were mixed doubtful intrigues under the cover of "economic questions at the political level". Similarly in the Mediterranean the question of the lamparo net raises endless protests. Technical progress is held back by such dissensions with their electoral bias, while the demands of the fishermen, too high prices, traditional prejudice and the lack of industrial concentration, hinder canning plants from taking the place that is coming back to them in the trend of world affairs. To excuse this lack of planning, business men blame the sardine and "accuse" it of deserting our coasts. Now, nothing of the kind has happened, but it is still necessary to take the trouble of looking for it. The biology of this valuable fish is becoming better and better known but it would be more to the point if this had some influence on the customs of those that fish it and put it to account.

The sardine (*Sardina pilchardus*) is a fish belonging to Atlantic waters. It has a dark-blue back, sometimes marked by a row of black spots, and silvery underparts. The scales, which fall out very easily, are rather few in number, there being from 30 to 40 series of rows. Beginning in the North Sea, its geographical range extends down as far as the Mauretanian coast and even to Dakar. Sardines belong to various local races, this being shown by the work of J. Furnestin. He distinguishes four races by their average numbers of vertebrae, these being: (a) *Northern Atlantic* race, from the North Sea to the Cantabrian coast; 52 vertebrae; (b) *Southern Atlantic* race, from the Cantabrian coast to the Gulf of Cadiz; 51 vertebrae; (c) *Moroccan* race, Morocco and Rio de Oro; 50 vertebrae; (d) *Mauretanian* race; from Rio de Oro to Dakar; 51 vertebrae.

During their life, sardines undertake considerable migrations. The adults live in the northern part of the geographical range of their race but the immature fishes move far to the south to seek warmer and lighter conditions. The large sardines of the northern race, the pilchards of the English and the "célans" of Boulogne, live in the North Sea up to the coast of Northumberland. They measure from 10 to 11 inches and are up to 10 years old. Younger adults between 2 and 5 years old populate the coastal waters off Brittany but the immature fishes grow up at the bottom of the Bay of Biscay near Saint-Jean-de-Luz. Two to six year old adults of the northern race are met with again along the northern coast of Spain, whereas the young ones swim in Portuguese waters. Similarly, off Morocco, the large sardines are found around Safi and the small ones near Agadir. The Mauretanian race, which was first described by Monod and rediscovered by Furnestin, is a dwarf race. When about 4 years old these fishes do not measure more than 1½ inches. The shoals appear to be rather sparse but extend down as far as Dakar.

The arrival of the transgressions has a great influence on spawning, which takes place at temperatures between 10° and 17°C., varying according to the race. Sardines are catadromous fishes and go deeper in order to spawn. Their numerous spawning places have been found, these being; from Gibraltar to the Galician coast, November to June; from Santander to Arcachon, from November to April; off the Breton coast, from February to July; and in the English Channel and the North Sea, from April to November. Two populations can be distinguished within the northern race. There is an *Aquitanian* population, the young of which are born in the Bay of Biscay, where they spend their first two years. Then, having spawned, they move back to the north and do not return to their birth-place. The *Armorican* population is hatched in the Celtic Sea or along the south coast of Brittany. The fry move down to the region off

Saint-Jean-de-Luz, where they stay during the autumn and winter. Then they return to their native waters.

Sardines have floating pelagic eggs. They feed on plankton organisms, such as diatoms, peridians and small crustaceans. These fishes have a great importance in the canning industry. Young sardines in oil, tinned in France, Spain or Portugal are much in demand. Competing with them are numerous sardine imitations prepared from sprat or young herring. However, a ruling by a British Court of Justice recognised that the term "sardine" must be exclusively reserved for the young of *Sardina pilchardus*.

Large sardines or pilchards are generally prepared in tomato-sauce in oval tins. This product originated in California, on the Pacific Coast of the United States. A related species, *Sardinops sagax* or *coeruleus*, lives there and is the object of a very important industry. Following variations in the Pacific transgressions, the American pilchard left the coastal waters for a cycle of nine years but came back to its old sector last year. The same fish is found again along the Chilean coasts and also on the Atlantic coast of South Africa, where there has been a remarkable increase in the fishery and cannery during latter years. In the Gulf of Mexico, particularly in Venezuela, another fish, *Sardinella aurita*, related to the European sardine, is canned.

From the beginning of April to October, small boats from the Channel ports and the Breton coast take to the coastal fishery for mackerel. The boats and gear differ from place to place. There are large boats from the north; caiques from Fécamp and Yport; cutters from Cherbourg; flambarths from the Hague or Lannion; *bisquines* from Cancale or Granville; dinghies and sloops from Finistère. These are all strong and well-rigged boats, remaining at sea for the whole season. The tackle used is a weighted trailing-line carrying numerous hooks. In the Bay of Audierne motor pinnaces catch mackerel in sardine nets.

There is a fishery from large vessels by herring drifters from Boulogne and Fécamp and dundeeds from Douarnenez, but this is carried out in more open waters from February to June in the Celtic Sea. The fishery moves on the arrival of the transgressions over the continental shelf. It starts in April at the edge of the slope, to end in June at the mouth of the English Channel. The hauling on board of a large drift-net should really be seen at sunrise. In the rosy light of the dawn mother-of-pearl shades shine from the undersides of fishes just out of the greenish, mist-covered waters. The mackerel fall stiffly on the deck and in their death-throes gleam an intense purple, the epitome of their dying beauty. In harmony of shape, so well adapted for swift movement, and in their deep-green, black-marbled upper parts merging with their glittering flanks, these scombrids are the perfect type of open-ocean fish. This is an end point of a long evolution of form, and the species is so well stabilised that anatomical differences, such as in the number of vertebrae, cannot be used for separating the local races over its great range in the North Atlantic.

The mackerel (*Scomber scombrus*) is found from Norway to the Canary Islands; in the Mediterranean, the Black Sea; from Labrador to Cape Hatteras. Based on the differences in growth, in time of spawning and the temperatures of the waters in which they live, three races and several populations can be recognised.

(a) *Eastern Atlantic* race; length from 13 $\frac{3}{4}$ to 17 $\frac{3}{4}$ inches; spawns in May and June.

- Northern population (Baltic and North Sea), in waters from 8° to 10° C. in temperature;
- western population (Ireland, Celtic Sea, Iberian coasts), in waters from 10° to 14° C.;
- southern population (Cape Saint Vincent, Canaries) in waters more than 14° C.;

(b) *Western Atlantic* race: length from 17 $\frac{3}{4}$ to 21 $\frac{3}{4}$ inches; spawns in May and June.

- Nova Scotian population; in waters from 6° to 10° C.;
- New England population; in waters from 10° to 14° C.;
- Cape Hatteras population; in waters more than 14° C.



- c) *Mediterranean* race : length from 10 to 12 inches; spawns in February and March.
- western Mediterranean population;
 - eastern Mediterranean population;
 - Black Sea population.

Mackerel swim in dense, sometimes enormous shoals that may be several miles long. As they move around, they are pursued by numerous enemies, such as dolphins, tunny, swimming crabs and sea-birds. They are voracious fishes, swallowing any prey within reach, including their own young. But they also gorge themselves on planktonic organisms like diatoms, copepods etc., They keep within the waters of the oceanic transgressions. In winter they lie at a depth of about 100 fathoms at the edge of the continental shelf. In spring, together with warm water layers, they move, at about 5 to 10 fathoms below the surface, into the Celtic Sea, where they spawn. When nearly a year old, the immature fishes move coastwards, and in July large numbers are caught along the Breton coasts.

The American mackerel, which are particularly large fishes, spawn near Cape Hatteras in April; off the coasts of New England in May; and near Nova Scotia in June. In the Mediterranean where the spawning period is not related to the movements of the transgressions, this takes place in February and March.

After spawning, the remaining shoals of spent mackerel go in search of their food, moving up as far as the Norwegian coast and the Irish Sea. On an average, the life span of the mackerel is ten years, but may extend to 15 years. These fishes are of great economic importance and when freshly caught are much appreciated. They are used in the canning industry, the immature fishes being tinned like sardines and the adults prepared as filets. Mackerel are also salted and smoked.

In the coastal fishing fleet there are also a number of line fishermen; these laying trawl-lines along the bottom in the evening and hauling them up in the morning. Rays and conger-eels are particularly taken. During the day they catch sand-eels and silversides, with which they bait their many hooks. Small trawlers ceaselessly scrape the bottom for plaice, sole and other bottom-dwelling fishes. They do not move far from the coasts and take a fearful toll of immature and young fishes in their close-meshed nets which allow nothing to escape. This they do in spite of the regulations that have been laid down, regulations that are never observed because there is no supervision.

All along the coasts, in much smaller boats — in simple dinghies — fine seamen, often helped by a ship's boy, spend the day at sea with their fishing-lines. Their intimate knowledge of the rocks enables them to approach the breakers in search of excellent fishes. They know where they will get bass. In the Mediterranean, they excel in catching surmulletts. As soon as they have caught a few fine fishes, including some for their family, they make for port and offer their best fishes to the hotels. Then they go home to eat their fish stew.

The bass (*Morone labrax*), called "wolf" in the Mediterranean, is an animal with a dark-blue back, silvery flanks and belly. It may reach rather more than 3 feet in length. Although it is a very good swimmer, it doesn't move very far, living in the coastal zone near surf-swept rocks and in beds of the large seaweed, *Laminaria*. The flesh of the bass is remarkably good and it is rightly considered as a luxury fish.

The in-shore fishermen also bring back pollack and whiting-pout, which are small cod-like fishes. The whiting-pout (*Gadus luscus*) has a compressed body bearing three dorsal and two anal fins and the lower jaw carries a long barbel. Its back is brownish-yellow and the belly white. These fishes live on sandy, coastal grounds in waters with a temperature around 10° C. and a salinity of 34 ‰. Growth is rapid, a length of about 10 inches being reached after a year and 13 ¾ inches at 2 years. But their life is short and they die towards an age of 3 or 4 years, having spawned once or twice. The flesh of the whiting-pout is light and pleasant in taste but it does not keep. It is found from the North Sea to the Mediterranean, where it becomes sparse and is replaced by related species, the capelan. The pollack (*Gadus pollachius*), a gadid without a barbel, ranges along the coasts from Norway to Spain. It enters estuaries

and ports; it may reach a length of two feet or even a little beyond two and a half feet. It is eaten locally.

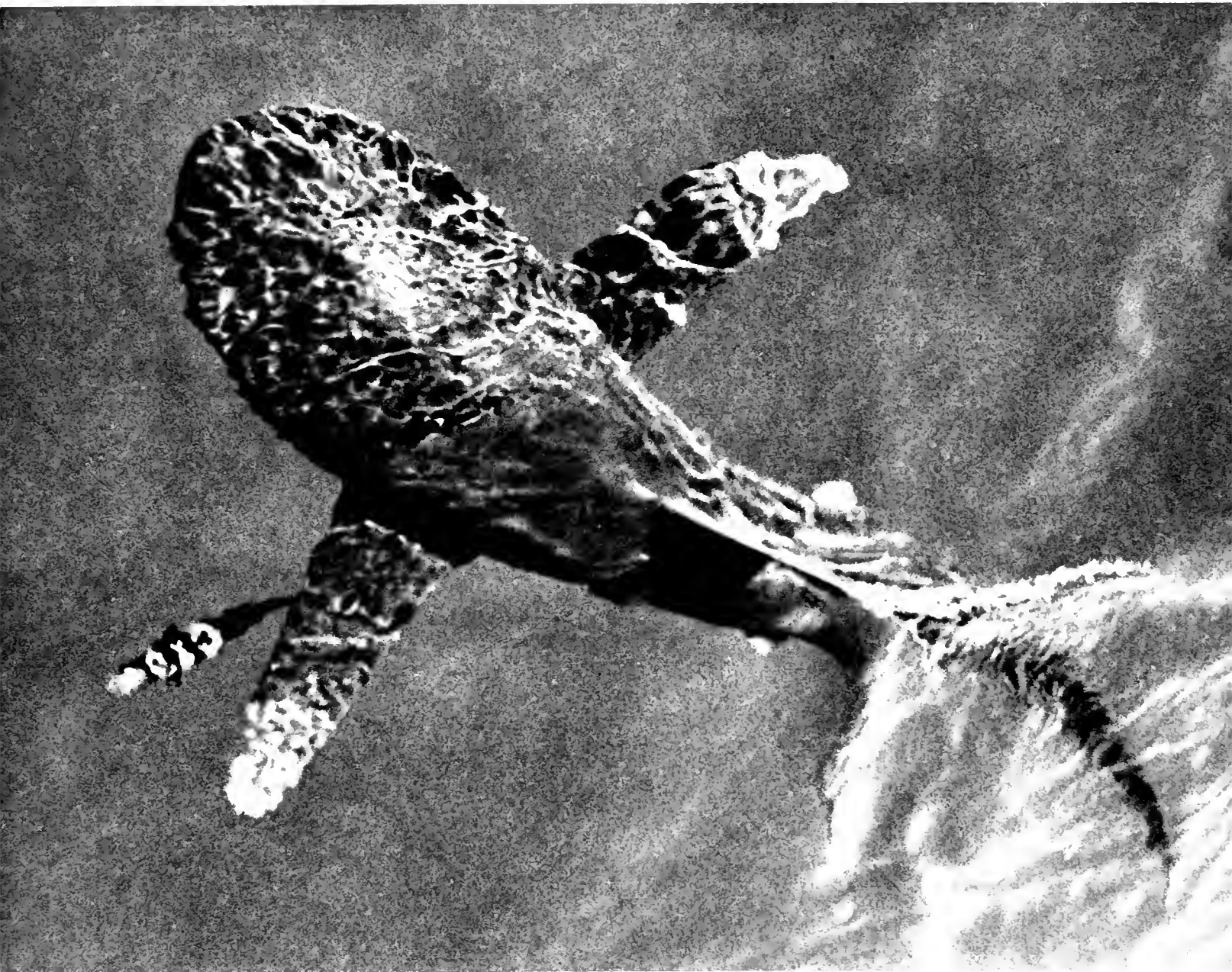
Fishermen in small dinghies also go after wrasses, fishes of the family Labridae with brilliant colours and numerous species, which live in coastal regions. In the Mediterranean they bring back girelles and scorpion-fishes. All these lighter craft delight the summer visitors, and it is most often on board them that they make their first sea-trip in a " nice fishing party ". The old boatman looks at them with a smile, for he reckons that the sea-sickness of his passengers will give him a good share in their hampers of tasty food. With this end in view he slyly holds his dinghy athwart the waves.

Rivers and lakes of the northern continents.

In the peaceful plains of western Europe, idly flowing streams twist and turn between curtains of poplars that shiver with the slightest breeze. A fairly perceptible current flows over the middle of the river bed to play against the arches of old village bridges with the musical sound of a small cascade. But along the banks, lined with rushes and reeds, under the cover of small willow-trees, the waters are almost still. The sun gleams on these waters and the movements of aquatic insects send out ever widening ripples that rebound from the river banks. The shadows of water-lilies stand out on the brown muddy bottom.

These streams are the home of cyprinid fishes, a group with extremely numerous species. We may mention : carp (*Cyprinus carpio*), barbel (*Barbus fluviatilis*), gudgeon (*Gobio vulgaris*), tench (*Tinca tinca*), minnows (*Phoxinus phoxinus*), rudd (*Scardinius erythrophthalmus*), roach (*Leuciscus rutilus*), dace (*L. leuciscus*), chub (*L. cephalus*), orfe (*Idus melanota*), bleak (*Alburnus alburnus*), and bream (*Abramis brama*). These fishes, which are usually slow-moving, are seized with a feverish activity at spawning time. They become agitated, leap out of the water, then gather in shoals and move to the quietest creeks to lay their eggs. The shoals of roach and rudd are so dense that the rubbing of one fish against another produces a kind of rasping noise that can be heard a long way off. When sexually stimulated, cyprinids lose all sense of danger, and their predators, taking advantage of this, exact a heavy toll. The males are more numerous than the females : three or four of them court one female and share in the fertilisation of the eggs. On the back and sides of the males, particularly in carp, are rough tubercles which must play some part in defence during the fights that go on at the breeding season. With these tubercles the males also butt the sides of the females when the eggs are being laid, for pairing has its brutal side. In tench the differences between the sexes are expressed in modifications of the pelvic fin rays. The breeding season is in summer and spawning occurs in waters of rather high temperature. The number of eggs varies according to the size or length of the female: a four and a half pound carp carries 400,000 eggs, one of seventeen and a half pounds contains more than a million. The gudgeon, with large eggs, lays a rather small number, while those of the tench, being much smaller in size, are expelled in hundreds of thousands. The species of cyprinids are still not very stable and cross-breeding between them is quite common.

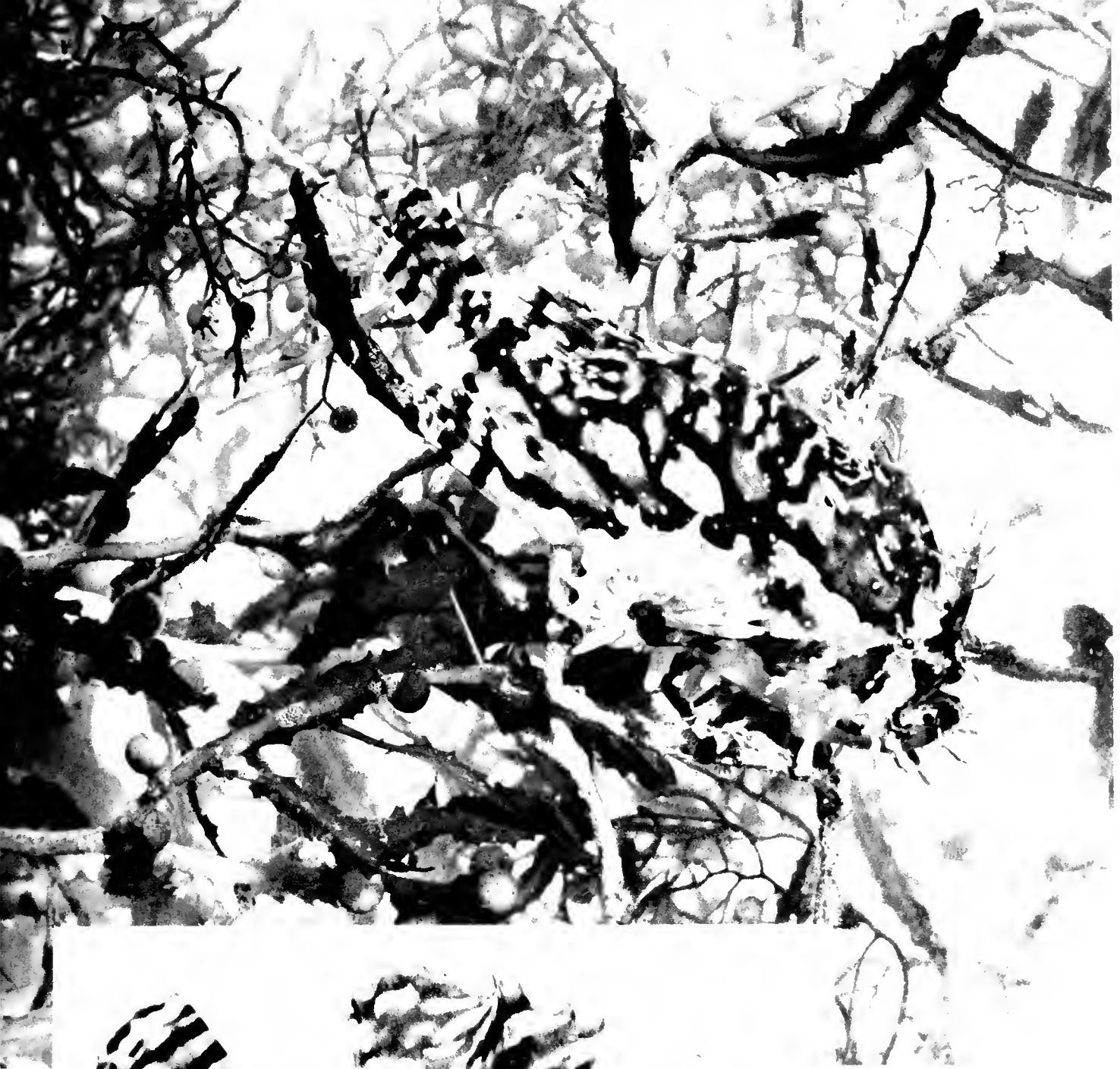
Among the cyprinids, particular mention must be made of the habits of the bitterling (*Rhodeus amarus*). These small (2 to 3 inch) fishes are usually a grey-green with brightly coloured underparts, but at the breeding period, purple and pink shades are added to form the breeding dress of the male. The male also has outgrowths of skin on the snout. The female has a long spawning tube or ovipositor and with this organ she can insert the eggs in a safe place. Bitterling have discovered such a secure shelter inside the shells of certain freshwater mussels called *Unio* and *Anodonta*. The fishes do not have to look after the aeration of the spawn, for this is done by the respiratory currents of the molluscs, which also help to ensure the fertilisation of the eggs. It has been stated that the males are not initially stimulated on seeing the females, but that this is generally brought about by their approach to shells containing the progeny of their own kind. There is certainly a real biological association between the bivalves and bitterling; and the spawning of these animals occurs at the same season. The molluscs ensure the fertilisation and aeration of the eggs and young fishes. On the other hand, the larvae of *Unio* and



A shark from the Seychelles, accompanied by its pilot-fish. Photograph by Popper-Atlas-Photo.

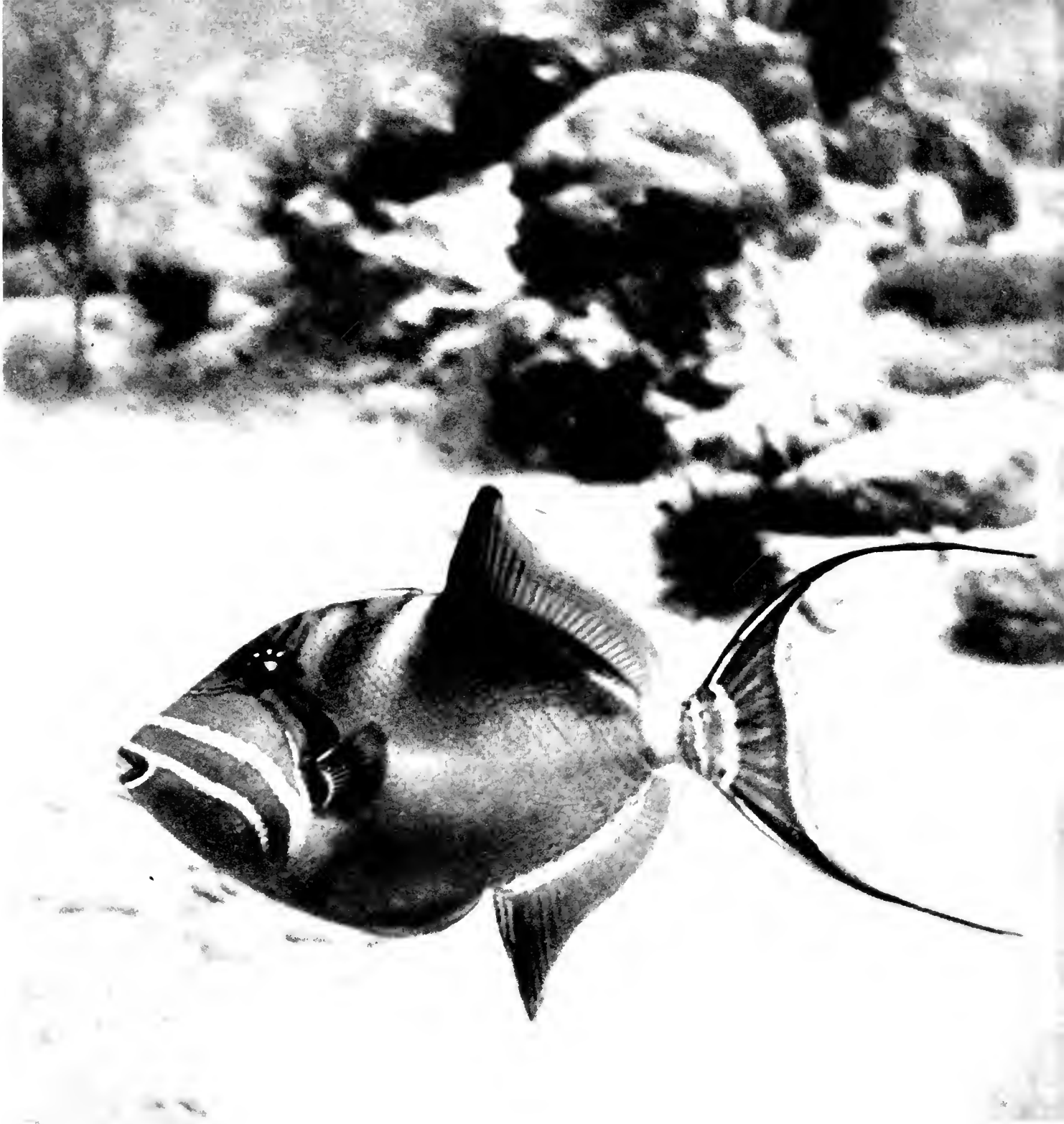


A swimming sawfish (*Pristis*) with remoras sticking to its body or following in its wake. Sawfishes can reach a length of about 20 feet and the snout is prolonged into a large bony plate, provided with teeth along the two edges. Photograph by Hugo H. Schroder-Rapho.



The frog-fish (*Pterophyrne histrio*) concealed among Sargassum weed.

The same fish, away from the floating algae. Photographs New York Zoological Society.



The red trigger-fish (*Balistes vetula*) which is decorated with blue and yellow stripes, among the corals. Photograph H. Haas, *Mes Chasses sous-marines*. Payot, Paris.

Anodonta, which are provided with hooks, hang on to the bodies of the bitterling, where they undergo their early development.

River loaches (*Cobitis barbatula*) live in clear running brooks and spawn in the spring. When there is a storm, they come to the surface and with their snouts above water take in air. This passes through the stomach into a chamber richly supplied with blood-vessels and here the oxygen is absorbed. The stale air is got rid of through the intestine.

Among the gentler kinds of fishes, is the blenny (*Blennius fluviatilis*), which is a freshwater form of the marine family Blenniidae and is particularly found in the rivers of the south of France. It is brownish in colour, being somewhat camouflaged. The flange-shaped crest in the middle of the head is more emphasised in the males. In the same rivers there are gobies, especially *Gobius lota*. Several other species live in the fresh waters of Italy.

Millers-thumbs (*Collis gobio*), which are found near mill-races and in trout-streams, have a biology recalling that of the marine species of the family. The rather dull-looking females have a whitish belly, whereas the colours of the males are intensified, the abdomen being grey and striped with dark spots. As in the marine millers-thumbs, the eggs are put under heaps of gravel or in crevices and the males stand guard. In spite of the formidable appearance given them by their spines, they are harmless enough. Now and then, when some enemy has designs on their spawn, they seem reluctant to give battle. Millers-thumbs normally live concealed under stones, feeding on insects and small crustaceans. Great quantities of trout eggs are also eaten by them.

Not far from the millers-thumbs live burbot, freshwater members of the cod family. They are fairly voracious and have an enormous fecundity, for their eggs are counted by millions. These do not float like those of other gadids, nor are they attached. Like shad's eggs, they are heavy and roll gently over the bottom at the mercy of the currents. Being a fish of northern rivers, the burbot is rather rare in France.

Beside these gentler kinds of fishes, the rivers contain predatory animals which are a great menace to the other species, for they seize anything within their reach. The pike (*Esox lucius*) is probably the most fearsome. With its long slim body and fins set well to the rear, it gives a great impression of power. The large head with the broad, flat snout is reminiscent of that of a crocodile. It is hardly a fish of rapidly-flowing streams, but is found in rather still waters, which contain more of its prey, particularly the cyprinids.

In one day a pike can eat a quantity of food equal to its own weight. He seizes other fishes sideways-on and swallows them head first. When he hunts, and this takes up the greater part of his time, he very often lurks among the weeds or else is quietly poised in the water looking very like a piece of moss-covered wood. He is thus able to draw near his prey and he eyes them without arousing suspicion. Suddenly he darts, devours his fish and disappears in a trail of foam. His ravages are not confined to the typical river dwellers. Frogs taking the air on water-lilies, rats prowling along the banks and waterfowl that may be washing and preening their feathers are seized and devoured. Sometimes pike eat prey as large as themselves; the stomach becomes much distended and digestion takes several hours, during which time they are quite sluggish.

During the breeding-season they have a poorer appetite. And from time to time they become less voracious and eat rather little, this being put down to their gums being sensitive while teeth are being replaced. Pike are polyandrous, one female accepting several males. She stays quite still while these contenders closely beset her; then sends them off with a flick of the tail. But she allows them to make another approach. The eggs are laid at random and are in no way cared for by the parents. Many of them are destroyed or eaten.

Pike can attain a considerable size and a long span of life. At least until the 1914 war the Russian government kept fishes of this species that had been marked by Peter the Great in the ponds of Tsarskoe-Selo. When these ponds were being cleaned, the pike were caught and transferred to another pool. This operation was not entirely without danger, for the fish did not hesitate to attack the men in charge of this tricky job. These pike were about 6 feet long.

Although the perch (*Perca fluviatilis*) is very voracious it is far from being as dangerous as the pike. It lives on little else but fish. On account of its form it was taken by Cuvier as the

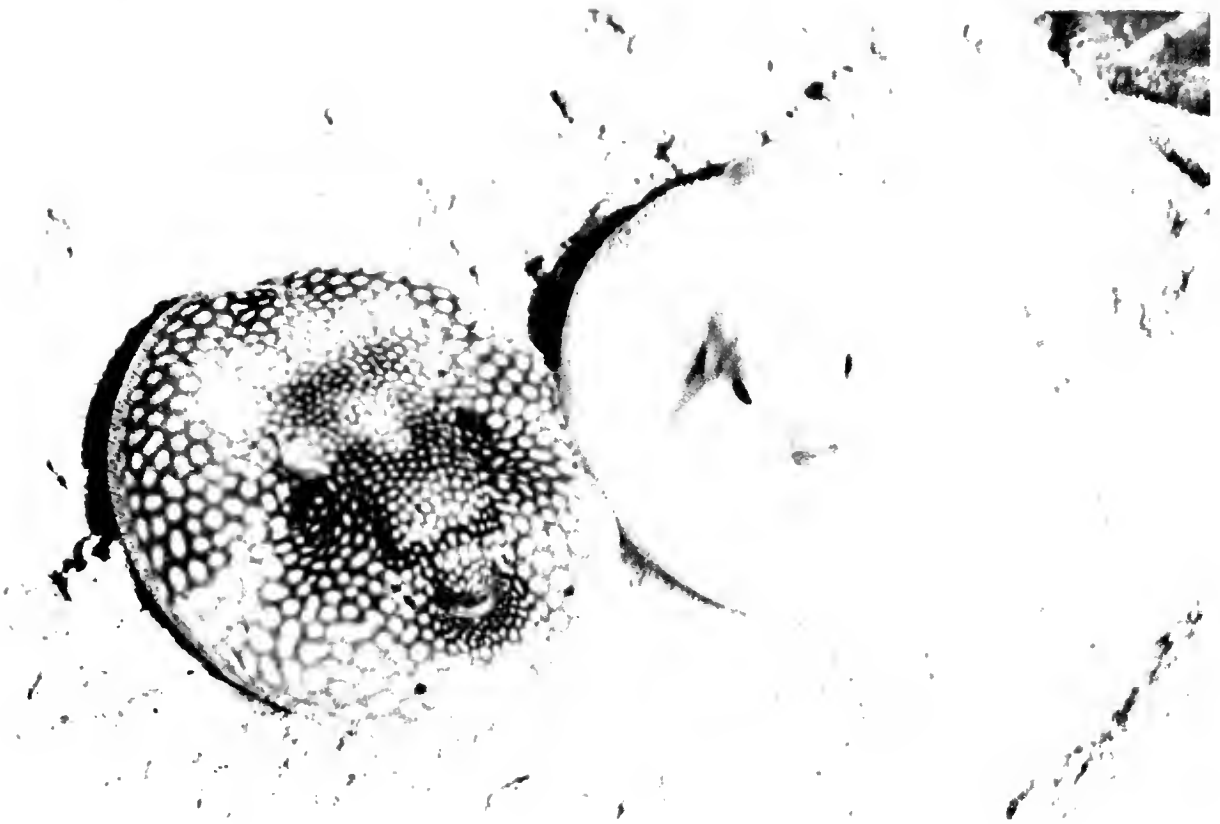
standard type of bony fish. It is rather variable in colour, usually being a grey-green with dark vertical bands. At spawning time perch give up their solitary life and form shoals containing more females than males. The eggs are not extruded separately but are grouped in slimy strands. Because of this, the females sometimes find it very difficult to get rid of them. In order to cut these sticky strands, they have to rub the belly against sharp edged pieces of wood or on broken stems and roots of aquatic plants.

The muds of the old land of China are drained out of the plains by immense rivers whose turbid waters flow from west to east, from the mountains towards the ocean. Great floods sweep over the rice-fields, bearing villages away and drowning thousands of people. Unconcerned at the sight of corpses carried by the current, Asiatic fishermen in their light but strongly built boats, continue their work. From this kindly element, the water, the sign of which gives a propitious meaning to their hieroglyphic characters, they continue to draw an ample supply of food, enabling them to ignore famines and the vicissitudes of ceaseless wars.

The Yellow River, Hwang-Ho; the Blue River, Yangtze Kiang; and the Red River, Si Kiang, contain innumerable fishes in their clear or coloured waters. The most abundant of these are cyprinids, particularly the famous gold-fishes (*Carassius auratus*). By ingenious methods the Chinese have managed to transform these fishes into strange creatures with "pop-eyes" and fins extended into silky sails. There are numerous species of barbel, one of which, the mahseer (*Barbus mosal*), bears huge scales, and many bitterling (*Rhodeus sinensis*, *R. oculatus*). The enigmatic kia-yu (*Hypophthalmichthys molitrix*) has low-set eyes enabling it to see the bottom of the river. According to the naturalist Eul-ly, its nostrils only acquire external openings at the end of its first year, but when this process is over it grows rapidly, to reach a weight of 45 pounds. There are also gudgeon, bleak and loaches (*Cobitis*), the latter being called "tipsy-fish" by the Chinese. Near by the cyprinids are stickleback, perch and pike similar to those of our rivers, fishes showing the faunal unity of the northern regions of the Old World. The crying cat-fishes, he-ya-ya and siao-yu-yu utter harsh sounds. In the Yellow River and Blue River swim enormous Chinese sturgeon (*Psephurus gladius*) which can reach a length of 20 to 23 feet. The body is rather like that of a sturgeon but the head, which is a third of the total length, ends in a large pointed beak. This has sensitive parts for finding the small mud-living creatures on which this giant fish feeds. More to the north in the Amur River and as far as Kamchatka, salmon (*Salmo mykiss*) leap the waterfalls when on their way to spawn. Then they return to feed in the low-salinity waters drifting from the polar regions (the Oyashio Current).

The depths of Lake Baikal contain peculiar species not found elsewhere. They belong to the family Comephoridae, which is related to the marine millers-thumbs, and they live down to depths of about 550 to 820 fathoms. These pallid fishes have no pelvic fins, while the skeleton is reduced in substance and is fibrous: the eyes are enormous. The comephorids slither over the bottom in the black and icy depths. The females, which are viviparous, die after giving birth to the young, which perpetuate these degenerate species in cold and darkness.

During the second millenium B. C. the Sogdian and Bactrian plains of Turkestan were still fertile, being watered by the great rivers Jaxartes and Oxus (Syr Darya and Amu Darya). These flowed towards the Aral Sea, which had a wide connection with the Caspian. Vast pasture-lands made possible the breeding of horses. But the rapid drying up and advance of desert conditions led to the dispersion of the tribes of horsemen and so to the spreading of Indo-European languages over the world. The Kehatriyas invaded India and Persia, while the Kymris or Cimmerians made for the west, and after centuries rode to the borders of the western world. After them Scythian peoples took back their ways of fishing, as for instance the Massagetae (matsya, Sanskrit for fish), who later fought against Cyrus in the disastrous military operation in which he was killed. The Cimmerians in Central Asia only knew of freshwater fishes and were astonished when they met with fishes in the ocean. In the lakes they had been impressed by the gigantic cat-fishes or silurids and had called them "the great" (in Sanskrit, valh) considering them to be the giants of the aquatic world. When the Goths arrived in Scandinavia and saw whales they compared them to silurids and also called them hval. They



had also been struck by the appearance of large female sturgeon full of caviar and heavy-laden like beasts of burden. These were given the Sanskrit names *staera* or *stürin*, words which are still in use (German, *stör*; Scandinavian, *styrga*).

The wels fishes (*Silurus glanis*) inhabit the great rivers of eastern Europe. They seek still waters where they forage in the mud with six small barbels set on the jaws. They reach a length of about 6½ to 10 feet and are very voracious. The most frightful crimes have been levelled against them, Gesner asserting that the stomach of one of these cat-fishes contained a human head and a hand bearing gold rings. Lambs and children, first one, then the other, were also alleged to be eaten. These cat-fishes spawn in summer, the females brushing out a hole with the tail in which to lay their eggs. Attempts to acclimatise an American cat-fish (*Ameiurus nebulosus*) in Europe have had unforeseen results, for these New World fishes straight-way cleared out the ponds in which they were placed.

Sturgeons belong to a very ancient group in fish evolution. Together with the spoon-bills of China and America they are relicts of the archaic group of chondrosteian fishes which reached the peak of their evolution in the Jurassic period. The long head with the extended rostrum is armoured with a solid shield of dermal bones and the naked body is set with five rows of shield-like, supporting plates. As in sharks, the tail is turned up. There are small barbels on the snout and the small tubular mouth opens on the lower side of the head, thus enabling the sturgeon to suck in its food.

The Atlantic sturgeon (*Acipenser sturio*) spends the marine feeding phase of its life close to the coasts of Europe and North America. In spring they ascend the rivers to spawn, seeking sandy banks in deep, rapidly-flowing, well-aerated waters. The females are distended with black or greyish, sticky eggs, which can number more than three million. These are the valuable caviar. At spawning time the eggs are laid in clusters on no particular support; on gravel, algae or roots. The incubation time varies according to temperature and lasts from 2 to 3 months at 20°C. The young fishes go down-stream in September and remain in coastal waters until they have grown to 3 to 4½ feet. Then they venture into deeper waters, as far as the edge of the continental shelf. Here they suck up worms and small molluscs from the mud and grow faster. In France this fine species is now disappearing, being found only in the drainage-basins of the Garonne and the Dordogne, where it is the basis of a caviar industry. But there is a danger of this being jeopardised owing to the lack of interest by public authorities. Indeed, sturgeons are destroyed as they ascend the rivers by the boom-nets of the naval conscripts. In fresh water their spawn is damaged by river-cleaning operations, and ripe sturgeon are hunted by poachers. On descending seawards the young fish are again killed by the same naval conscripts, these always being assured of impunity. The protests of biologists and people in the French caviar trade have been of no avail, for it is better to sacrifice a national resource than to displease the electorate.

In geological times the Aralo-Caspian Depression connected the Baltic with the Black Sea, and extended northwards from the Aral sea area to the Ob basin. This was part of the northern Eurasiatic land-system and it is still the "chosen" country of sturgeon. Six species are found there. As well as the western sturgeon (*Acipenser sturio*) there are the pastruga (*A. stellatus*), the nisetru (*A. guldenstaedti*) the morun or beluga (*A. huso*), the sterlet (*A. ruthenus*) and the viza (*A. glaber*). Of these the largest is the beluga, which may weigh close on a ton. In a large female there is more than 220 lbs of caviar, which surely suggests large beasts of burden that are bled much like cattle. The viza has become a freshwater fish, no longer making the descent to the sea. In their marine phase, the other species live on the muddy, in-shore grounds of the Black Sea, feeding there on shell-fishes, such as mussels and cockles; on worms, small crustaceans and fishes such as small anchovies. Young sturgeon that have made their first migration to the sea, live side by side on these feeding grounds with adults that have come to regain their strength. There are also animals that have become sterile with age, giants of 1,800 pounds, spending all their time in feeding.

Towards autumn sturgeon begin moving into the deltas to spend the winter in deep holes. In the Danube others await the spring break-up of the ice before making their ascent, the males in February and the females in March. The mouth of this great river is a great freshwater

lagoon. Raised alluvial banks overlook marshes bordered with reeds. Outgrowths of the rhizomes and stolons of these plants spread over the surface of the water to form great rafts with a vegetation of their own, small willows growing in abundance among ferns, convolvulus and forget-me-not. The Rumanians call these floating platforms "plaur". In the deeper channels the water keeps fresh but under these reed structures it becomes fetid and the lack of oxygen makes the sturgeon retreat. So the Rumanian government, at the instigation of Professor Antipa, had large canals cut in this encroaching vegetation. These were both a safeguard for navigation and for the ascent of the sturgeon. Destruction then came from the thoughtless fishing of trawlers in in-shore waters.

The Volga sturgeon fishery and the preparation of caviar is a source of wealth for Russia. In 1908 I stayed for two months on the *barges* of the Baschkir Cossacks. They are honest, lively and courageous people and with them I went down the great river from Samara to Astrakhan. While the left bank is flat between Samara and Tsaritzin (now Stalingrad), the right bank is steep, the bed of the river being deeper on the western side, the bank off which the spawn is laid. The fishery was carried out by means of traps or harpoons. To make the sturgeon come to the surface, the Baschkirs struck the water with their long oars or frightened them by cracking their whips and yelling like savages. South of Tsaritzin there are fewer spawners, for the Volga slows down, flowing sluggishly among the islets and swamps of the delta.

Scaphyrhynchid sturgeons move around in the rivers of Asia. They have an enlarged snout and the females are larger than the males. There are also sturgeon in the Blue River (*Acipenser dabryanus*) and in the Red River (*A. kiangsinensis*) and green sturgeon (*A. mediorostris*) swim in the rivers of the Pacific side of North America.

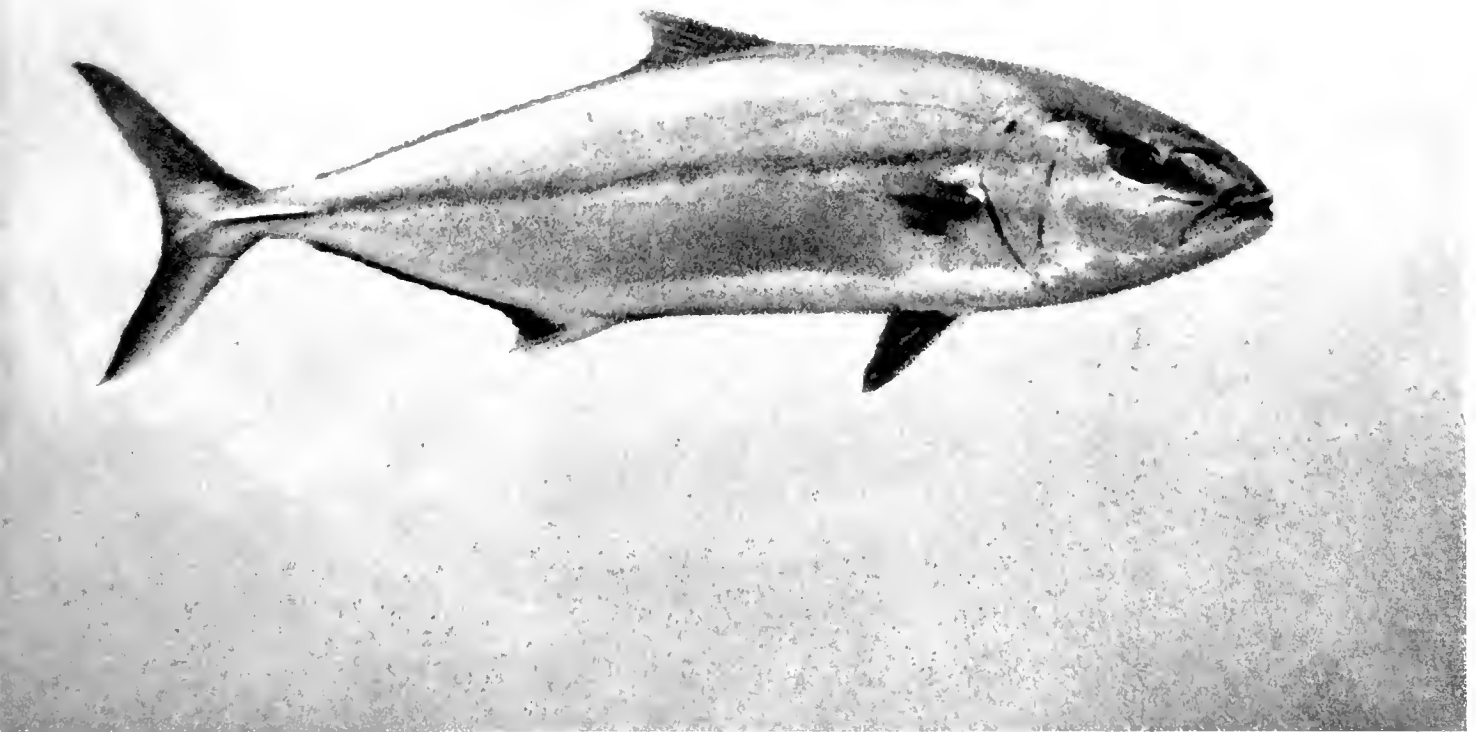
Beside the anadromous salmonid fishes and sturgeons, the freshwater fauna of North America contains the same families as those in the northern regions of the Old World. The cyprinids are less numerous, being only represented by a few minnows and chub (*Leuciscus*, *Hybopsis* and *Leucotilus*) with an Asian origin. But the closely related family Catostomidae (suckers) takes their place. These heavy-looking sluggish fishes live on the bottom, sucking in mud with their large red lips. From Alaska to the Gulf of Mexico there are more than 70 species of suckers. Their flesh has a muddy taste and they are of no commercial importance. Not far from them, in the Mississippi, cat-fishes abound and these follow the enormous flooding of the river. The blue cat-fish (*Ictalurus furcatus*) moves off to be captured far from the river in fields or forest. The bullhead (*Ameiurus nebulosus*), the acclimatisation of which in French rivers was so untimely, takes great care of its spawn. This is put under cover in hollow tree stumps or, failing this, in old pails or tin cans. The fish may even excavate a hollow in the mud. The male watches over the hatching of the eggs and guides the larvae into a compact shoal around him, so that he can look after them and defend them.

The perches are represented by an American species (*Perca flavescens*), and also by saugers (*Stizostedion*) similar to those that live in the rivers of eastern Europe and Siberia (*S. lucio-perca*). The black bass (*Micropterus dolomieu*) has been successfully introduced into France.

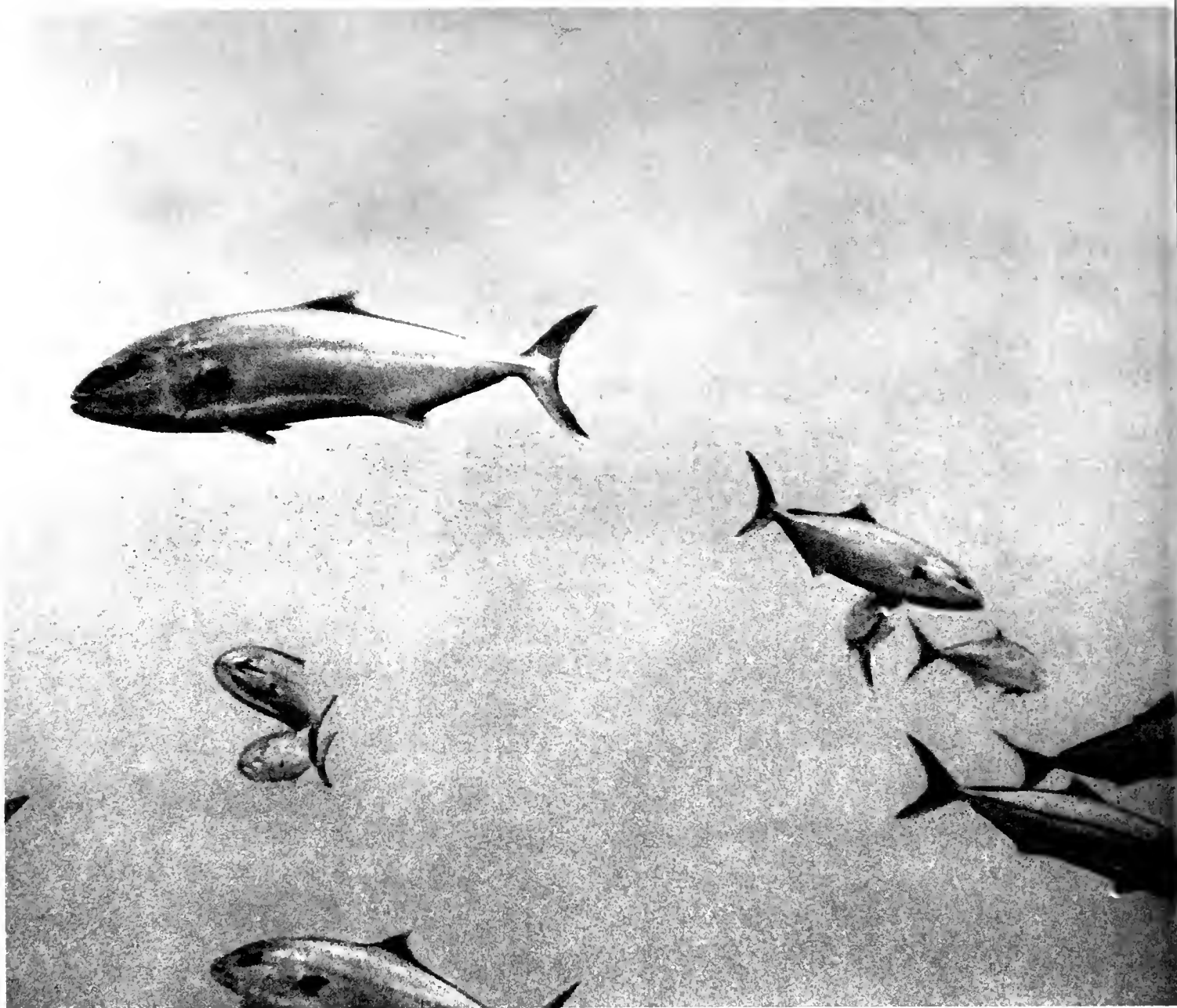
Pike are the large predators, these surpassing those of the old world rivers in size and power. The maskellunge (*Esox masquinongy*) reaches a length of 8 feet and a weight of 110 pounds. It lives in Lake Winnipeg and in the innumerable rivers of Manitoba, where it indulges in a fearful slaughter of cyprinids and coregonids (whitefishes). Fishermen fear it.

In the fresh waters of the New World there are archaic forms that have disappeared everywhere else, relics of the order of holostean fishes that were a dominant group in geological times. These are the bowfin (*Amia calva*) and garpikes (*Lepisosteus*). They are covered with strong, ganoin-enamelled scales, these giving them a particularly shining appearance. At the breeding season, bowfin come from the depths of the lakes towards the verges. Here they throw themselves round and round, breaking the stems of water weeds and smashing their roots until all this vegetable debris has been piled and crushed to form a basin very like a bird's nest. The male stands guard close by the eggs and later on looks after the young fishes.

The garpikes (*Lepisosteus osseus*, *L. platystomus*) live in the rivers and lakes of the United States and Mexico and are even found in Cuba. They are large fishes that may reach up to 10 feet in length. The diamond-shaped ganoid scales are united to form a strong and compact



A leer-fish (*Lichia*). Photograph by Y. de Rolland.



A group of leer-fishes (*Lichia*). Photograph by Y. de Rolland.



A grouper (*Epinephelus guttatus*) from American coastal waters. Photograph New York Zoological Society.



A huge spotted-jewfish (*Promicrops itaiara*) lying on the bottom. Photograph New York Zoological Society.

armouring and the flat head with its dermal plates and strongly armed jaws looks like that of a crocodile. In spite of their formidable appearance they are much less dangerous than the neighbouring muskellunge, only attacking small cyprinid fishes. To get near them, they keep quite still, looking like pieces of floating wood, gently moving forward. Then with a sudden snap of the jaws they devour a complete group of small fishes. Spawning takes place in May in rather shallow waters, each female being surrounded by 3 or 4 males. The eggs are sticky and cling firmly to rocks. After a short period of incubation, the larvae emerge and fix themselves to stones by means of the adhesive discs at the end of the snout, organs that disappear after the yolk sac has been completely absorbed. Then they swim freely, feeding on the larvae of mosquitoes. Garpike and bowlins can breathe atmospheric air, which passes into their swim-bladder.

Among the unusual fishes of the nearctic fauna, the blackfish of Alaska may be mentioned. It lives in swamps and peat-bogs and when the weather becomes very cold is frozen in the ice in a state of almost suspended animation. It is claimed that it may be completely frozen and that even its blood circulation is stopped. Turner says that a frozen blackfish was eaten by a dog and on coming to life jumped about, making the dog vomit it up. It immediately began to swim on being placed in a bucket of water.

In the caves of the Mississippi and Ohio valleys there are fishes of the family Amblyopsidae. *Amblyopsis spelaeus* and *Typhlichthys subterraneus* have become blind, their eyes being hidden under the skin. They are colourless, pallid fishes. Sometimes they swim at the surface and can easily be caught by hand, for they are quite unaware of danger. However, it does appear that their hearing organs may be quite sensitive, even to the slightest noise.

As in Lake Baikal, the deeper reaches of Lakes Ontario and Michigan contain degenerate forms related to the millers-thumbs (Cottidae). There is the genus *Triglopsis* and a cottid, *Cottus ricei*, this having lost the spiny appearance of the marine or freshwater millers-thumbs. These fishes lead lives as dismal as do those species in the great Asiatic lake.



CHAPTER IV

TROPICAL REGIONS

The open ocean.

In the spacious days of sailing ships, great four-masted barques would leave Nantes or Falmouth and double Cape Horn on their way to Melbourne. They returned to European ports loaded with phosphates from Chile. These splendid ships used to beat to windward across the Atlantic and then cross the surge-swept southern ocean. Casting off once more they cruised close by the groups of oceanic islands, sometimes making a call for several joyful hours or days in these blissful parts of the world. When the breeze freshened and the wind was fair the ship sailed at full speed with all sails set, leaving a glittering wake by day and a trail of greenish phosphorescent lights by night. In the doldrums, under the line, the sailing ship would be becalmed, to drift slowly in the sea. Leaning on the bulwarks or perched in the crow's nests, the idle seamen scanned the deep blue sea around them as far as the circle of the horizon.

Lines hung over the side brought in fine, strikingly coloured fishes, while aft a swivel-hook baited with meat was trailed to attract any ravenous shark. Gliding over the surface, there would be the blue umbrellas of "by-the-wind-sailors" (*Velella*), small jelly-fishes, carrying a small triangular sail. Or there might be the large blown-out floats of sky-blue physalids ("Portuguese-men-of-war"), trailing their extremely long filamentous tentacles. Dolphins would play around the prow and far away, at wide intervals, might be heard the rhythmic blowing of a school of sperm-whales as they broke the glassy surface to leave a foaming wake. And sometimes a large bird would perch, exhausted, at the end of a yard before taking wing once more to the south.

Given a slight breeze, flying-fishes would take off with a gentle splash, to be swept by their flight on to the deck, to the great joy of the seamen, for these fishes have a particularly delicate flesh. The exocoetids (*Exocoetus* and *Cypsilurus*) have a blue back and silvery underparts and the pectorals are fashioned as large transparent wings. When they are going to fly, they increase their swimming speed and take off at the crest of a wave to spread their wings in a glide over the sea. To get themselves off, they vibrate the tail, but they cannot steer well and must touch down on the water to change direction. With a good wind they can soar to about 20 feet and make sustained flights of 300 or 400 yards at a speed of about 40 miles an hour. This flight enables them to escape from numerous predators, but they may glide without being pursued.



The skippers (*Scomberesox saurus*) can leap out of the water to elude an enemy but only for very short distances. Above all, they are rapid swimmers. They are closely related to garfishes and have a long body, ending in a pointed beak. Behind the dorsal and anal fins there are finlets very like those of mackerel. Skippers live in close-packed shoals and are ceaselessly preyed on by dolphins, tunny and other scombroid fishes. When the sea is phosphorescent, the movements of a shoal of these fishes at the surface look like a great firework display. They live well away from the coasts, but sometimes move landwards and enter sardine nets, causing considerable damage to the catch and blinding the miserable clupeids with jabs from their beaks. They have floating eggs provided with thread-like attachments like those of garfishes and flying-fishes. On hatching, the larvae have no beak, but first the lower jaw becomes elongated and then the upper jaw, which extends beyond its partner in the adult. Together with skippers, there are half-beaks (*Hemiramphus*) in the warm seas, fishes having only the lower jaw in the form of a beak. Some of them, such as the 'aguyones of the West Indies, can reach a length of 5 to 6½ feet and are feared by the natives.

All sea-going vessels know the coryphaenids (*Coryphaena hippurus*), dorados or dolphins. The body is elongated and immediately behind the head with its rounded snout and curved profile is a long dorsal fin extending to the tail. They are magnificent animals. The emerald-green back is dotted with brilliant blue spots; the belly is golden; the large purple dorsal fin has light-coloured stripes and the tail is yellow. These glittering colours disappear when the fish dies. Dolphin fishes attain a length of 6½ feet.

The colour pattern of the opah (*Lampris guttatus*) is even more magnificent. This large rounded fish with its laterally compressed body has a purple and silvery dress with a rose-coloured "breastplate". The head and gill covers are blue, while the jaws are a deep red. Willughby, a seventeenth century English naturalist who had done much sailing, declared that the opah was surely "the Master of Ceremonies in the Court of Neptune". It has an excellent orange-coloured flesh and the Vikings called it "gudlax", meaning the salmon of the gods. Except around Madeira, it is a rather rare creature, but it is found in all the oceans. Its scarlet pectoral fins have a horizontally placed insertion, whereas in other fishes this is oblique. When it swims these fins beat up and down like the wings of a bird.

When the ship is becalmed, and the sea is quite flat, the sailors might see a small "flotilla" smoothly drifting by not far from the side. Black sails two feet high, stretched between numerous upright rods like those of some Chinese junks, keep the same course, exactly hugging the wind by the deliberate tilt of their rays. They are the large dorsal fins of sail-fishes (*Istiophorus nigricans*), elongated scombroids reaching a length of 6½ feet and having a snout ending in a long beak. Far away from land they sail in the open ocean, tacking in the light breeze that runs along the sea surface in the tropics. If the weather freshens, the flotilla leaves the surface and the sails fold into a groove placed along the back. The fishes dive and swim rapidly: the junks have become submarines.

But these fine sail-fishes cannot compete in swiftness with the rover of the seas, the swordfish (*Xiphias gladius*). The lines of its body are those of a torpedo: the powerful bill thrusts a way through the sea and the sleek flanks allow the displaced waters to flow backward without hindrance. Even the pelvic fins have disappeared. The sickle-shaped pectoral fins are reminiscent of the front flippers of dolphins and the strong tail acts as a powerful rudder. Swordfishes are the swiftest of fishes. They can exceed speeds of 30 miles an hour and are only surpassed by cetaceans. They are found in all seas, but most frequently in the tropical regions. However, they meet with cold polar waters, as when following the transgressions they enter the Barents Sea. Here they are hunted by the Lapps. They can be seen throughout the Indian and Pacific Oceans and off the Californian coast they are the sport of big-game fishermen. There is a colony of swordfishes in the Mediterranean. In May they enter Turkish waters to pass through the Bosphorus and sport in the Black Sea. They return in August.

In the oceans these fishes do not live in shoals or even in schools, but travel in pairs. The larvae are found in the tropics, where the adults undoubtedly reproduce. The great northward and southward excursions must correspond to feeding migrations. Studies have been made of swordfish eggs from the Mediterranean, where young fishes of about half a pound are brought

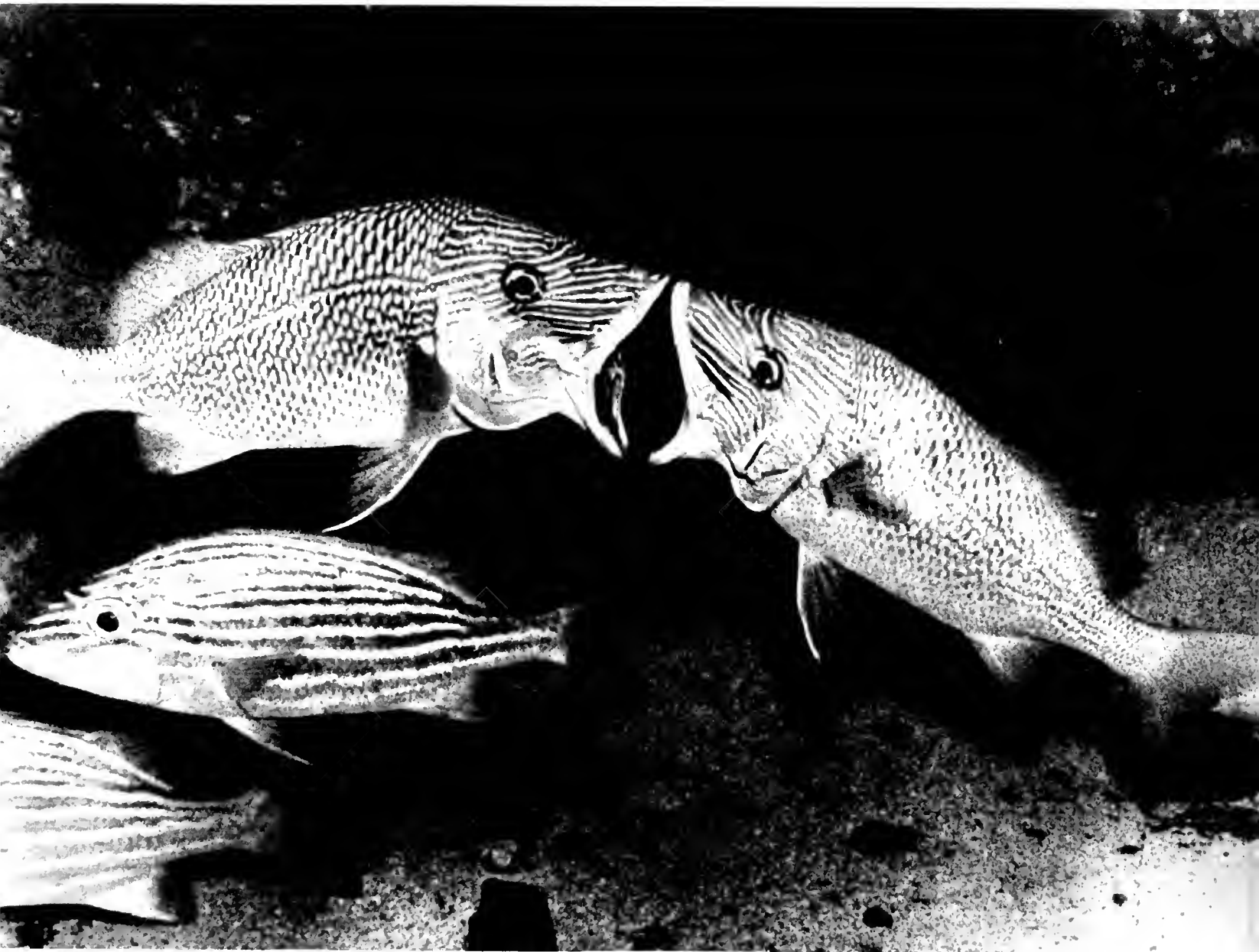
to the markets. Towards 6 months the fishes weigh some 13 pounds. On the coasts of the United States they are rarely less than 650 pounds, while some exceed a length of 16 feet and can attain a weight of 650 to 900 pounds. Although it is not a rare fish, very few facts are known concerning swordfish biology. The most extravagant tales have been told about it; that it attacked whalebone whales and transfixed boats. When it is wounded it may well turn furiously on its pursuers, but otherwise it appears to be quite harmless and even timid.

While these strong swimmers hurtle at top speed through the seas, there are slower and lazier creatures in the surface waters of the open ocean, such as the sunfishes (*Mola mola*). The body is rounded and very compressed, with a scalloped hinder margin formed by the caudal fin and carries very high dorsal and anal fins. The small mouth is formed into a firm beak and the thick skin is lined with a layer of tough gristly material. Sunfishes certainly look grotesque creatures and their intelligence is at least very limited: the brain of a 450 pound sunfish weighs about 1½ oz. These stupid fishes live in the encroaching water masses (transgressions) and in summer they can be seen floating, motionless and asleep, lying on one side. To gaff them it is possible to get quite close without waking them. But they have a vague sense of danger and move away, swaying heavily from side to side and making a loud noise. When they are caught they begin grunting and in every sense of the word, roll their large, blue, black-encircled eyes. Sunfishes can reach a weight of a ton.

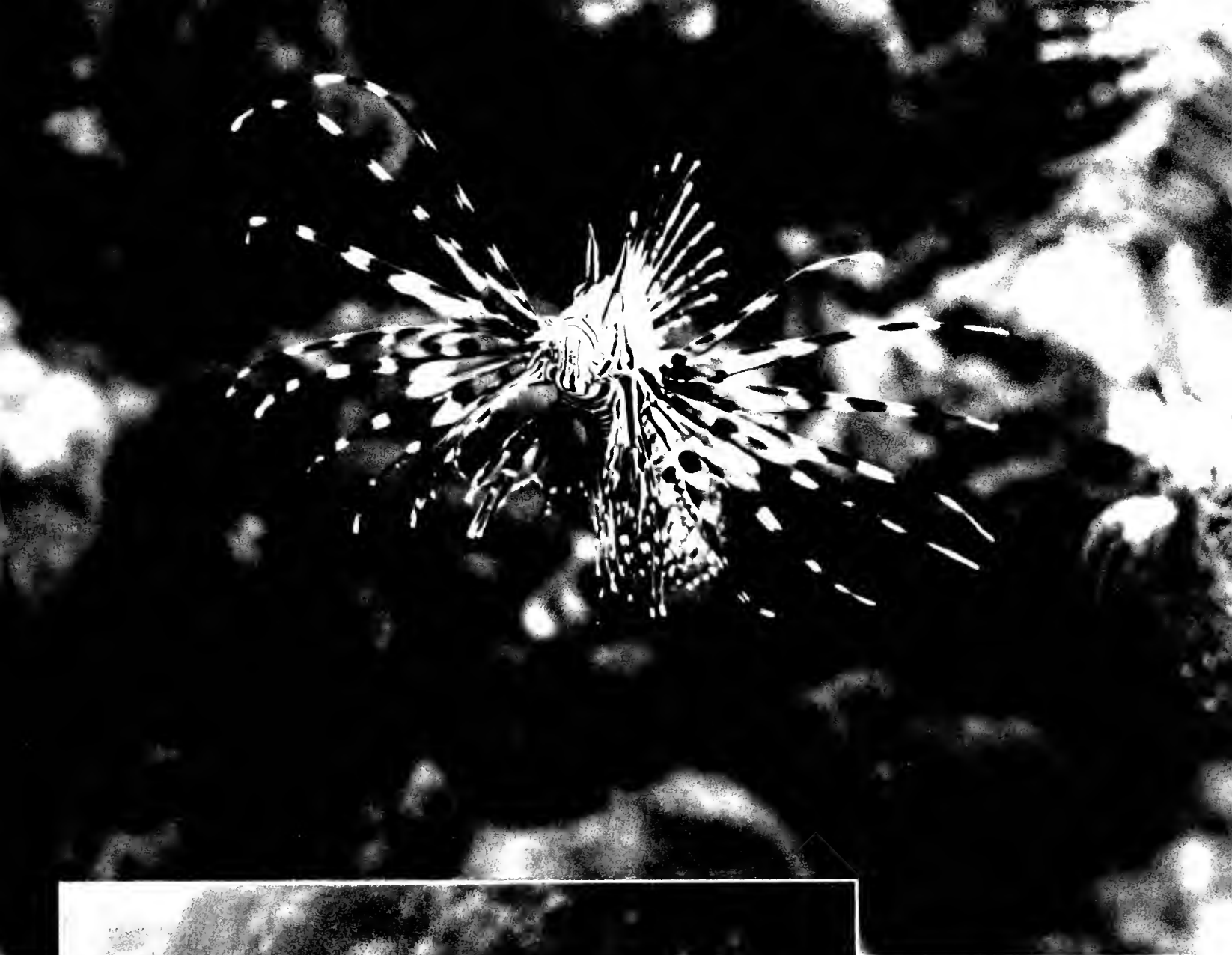
Once it was not uncommon for the look-out of a sea-going vessel to spot a piece of floating wreckage. If for lack of wind the ship was stopped, a boat was soon lowered to see what this object might be. They hoped it might be a cask full of good wine or rum. Very often these hopes were dashed, only a tree trunk or an empty barrel or one half-full of water being found. Hanging from this floating wood would be the brown stalks of goose-barnacles (*Lepas anatifera*) each ending in a bluish shell, shaped like a duck's bill. In the shade of the wreckage, protected from the sun's rays, a large grey fish might be seen, this being the wreckfish (*Polyprion americanus*). These fishes have a rough head, set with bony tubercles and the gill-cover bears a strong, transverse crest. Swimming around the wreckfish, which grows to a length of at least 6 feet, small fishes of the genus *Lirus* might be seen. These, like the wreckfish, feed on the barnacles and "escort" the wreckage. Failing good wine, the sailors would take back enough of them to improve their daily fare, for these animals have an excellent flesh. The boat would be hastily hauled in, because the wind was freshening. The four-masted barque would resume her majestic course in the boundless ocean.



A grouper (*Dermatolepis marmoratus*) from American coasts with a colour pattern blending with the colouration of the corals. Photograph New York Zoological Society.



In the coastal waters of the Caribbean Sea. Two grunts (*Hu milon plumieri*) "kissing". The other fishes are yellow grunts (*H. sciurus*). Photograph New York Zoological Society.



The scorching-hot (*Pterois volitans*), a formidable-looking inhabitant of coral reefs. Photographs: New York Zoological Society and Dr. Villaret.



A Pacific dragon-fish (*Pterois*) from coral at Tahiti. Photograph by Dr. Villaret.

Sharks by Paul BUDKER, *Sous-directeur au Museum National d'Histoire Naturelle, Conseil technique du Ministère de la France d'Outre-Mer.*

The dog-fishes that are found off the coasts of France are, strictly speaking, sharks in miniature. Actually, this word "shark" only applies to Pleurotremata of a certain size, there being a rather ill-defined length, over which the dog-fish has every right to be called "shark". Moreover, it is difficult to say why, for there is no test enabling one to choose the adequate word when faced with this hazy dividing line. According to Valery: "A subtler being (than man) would doubtless have neither hard and fast units nor things that tend to be confused or assimilated with one another when collections are made of them. Any concept (as the saying goes) is expedient...".

In short, it doesn't really matter. It is only a question of vocabulary, which does not preclude the shark group from having its own place among fishes and from having an unusual and many-sided appeal.

Because of their cartilaginous skeleton, which lacks true bone cells, and other characters besides, sharks (and the related rays) are sometimes regarded as primitive creatures. That may be countered by weighty arguments. The central and peripheral nervous systems, for instance, are highly developed. With regard to the urinogenital system, this is markedly superior to the precarious arrangements in teleost fishes. Within this very uniform group of sharks, although it is made up of rather few species, can be found the most elaborate reproductive processes ranging as far as the placental type of viviparity. It is no wonder that biologists have chosen certain shark-like fishes as laboratory animals and that dog-fishes, that is, those of a size allowing of ready handling, are a source for numerous and important scientific works from year to year.

But sharks have yet another claim they might boast of: the giant among fishes is one of them.

We know that the largest animals live in the sea. No other living creature has ever attained the colossal dimensions of the blue whale, with a length that may exceed 100 feet and a weight of about 100 tons. Certainly no fish can stand comparison with such a living mountain, but the Goliath of gill-bearing vertebrates is "not to be sneezed at". This is the shark, *Rhincodon typus*, which easily holds the record for size. It is said to reach a length of nearly 60 feet. No one has been able to weigh such an animal, but we do know that one of 40 feet scaled about thirteen tons. This fine fish is known as a whale-shark, not that it comes from both whale and shark, as one ill-informed author once wrote. Our *Rhincodon* only comes from the shark side. It is certainly one hundred per cent a fish and the word "whale" is only there to give an idea of the unusual bulk of this very authentic shark.

Its habits are rather odd, so far as the little we know of them goes. It is quite harmless, feeding on plankton and seemingly leading a nonchalant sort of life. For the most part, it lazes at the surface and this exposes it to a peculiar — and not infrequent — accident. When it is slowly sculling with the dorsal fin out of the water, moving gently along as though it were sunbathing, disdainful of all around it, a ship may collide with it full on the beam. This has happened several times in the Red Sea and the Indian and Atlantic Oceans. In this encounter, the whale-shark is not generally cut in two. Because of the speed of the ship and the resistance of the water, its body is brutally bent back and is held on either side of the bows. This adventure always ends disastrously for the rammed fish. The ship comes to a stop and the great body breaks, no longer being pressed against the hull. It slowly sinks in sight of the witnesses of what may be considered a kind of traffic accident, in which the victim is entirely to blame.

The whale-shark is mainly to be found in tropical and subtropical seas. Nearer French coasts a lesser "lord" the basking-shark (*Cetorhinus maximus*) often appears. Its size, while not reaching that of its enormous relative *Rhincodon*, is nevertheless very imposing. Individuals of nearly 40 feet in length are not rare and it is a fact that a specimen of nearly 30 feet can weigh rather more than 4 tons. The basking-shark is livelier than the slow

whale-shark, but it is also very inclined to idle at the surface, thus deserving its name "basking-shark" — the "shark that sunbathes". It occurs mainly in arctic waters and also in the north and south temperate zones. It is particularly abundant around Iceland, off the west coast of Ireland (who does not recall the famous film "Man of Aran"?) and it is equally well known off Breton coasts. There is a fairly active fishery for it. Finally, to complete its analogous features with those of the whale-shark, it also feeds on plankton and is quite harmless.

Harmless... this word has been used twice concerning two sharks, when there are probably no other creatures in the world with such a bad reputation as sharks. Concerning these two, however, there is no possible doubt. The whale-shark or the basking-shark have never deliberately attacked a man. Their mild dispositions are well known. But there are others...

Human flesh is certainly not the usual diet of sharks. Yet the moment we leave the great plankton-eating sharks we come up against carnivorous species with formidable, often sharp-edged, teeth arming their jaws — fishes that are not always particular in choosing their prey. Some of them are inclined to swallow anything, whether edible or not, within their reach, the stomach contents being a real collection of odds and ends : kegs of nails, a tom-tom; a casket "containing pearls and jewels worth a thousand pounds"; a buffalo skin; waste material; ropes-ends etc. A swimmer passing within reach of such a voracious creature would plainly run a great risk.

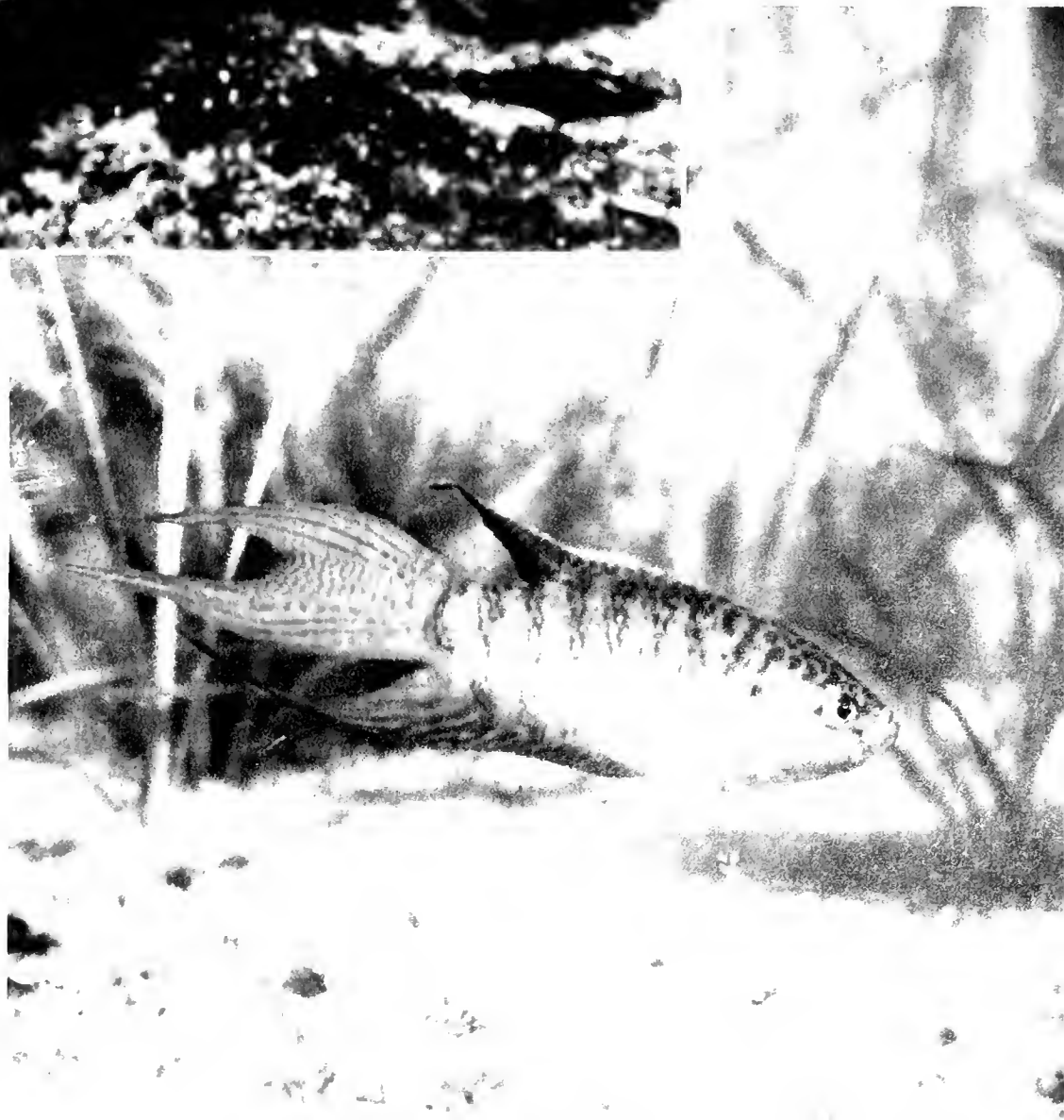
Some species are thought to be more aggressive than others. The great white shark (*Carcharodon carcharias*) is also called "man-eater", a name indicating well enough its sinister reputation. It has been charged with numerous misdeeds. As for the very abundant representatives of the circumtropical family Carcharinidae, some of these must have a "heavily burdened conscience" on this score. It is true that one lends only to the rich and that public reports have definitely tended to accuse rather than to exonerate the sharks. In this field, our knowledge will certainly benefit in the future from the observations that underwater swimmers are beginning to make.

However it must be admitted that man-eating by sharks is only one of the facets of the question. It is rather like a townsman in the fields, who, while crossing a meadow, becomes anxious when faced with a bull and asks himself if the bull will go for him. This anxiety is certainly legitimate, from the view-point of the townsman in question. But it recedes into the background of the concerns of veterinary surgeons and stock-breeders. Similarly that which interests the biologist and fisherman is not so much to know what will be the reaction of a shark in front of a swimmer (so long as they are not themselves in full view, of course...). Their problems lie elsewhere.

During recent years, sharks have been of vital importance, mainly because their liver-oil is rich in vitamin A. Furthermore, the skin, the fins, the edible flesh and skeleton could be put to profitable uses. And the essential question that faced the fishermen, was to know as precisely as possible what were the species of sharks with the highest quantities of vitamin A in their liver-oils. The psychological reactions of their quarry in no way bothered them.

For various reasons these industries have recently slackened and then stopped. One day they may be resumed. However this may be, the problems facing biologists and oceanographers rest untouched. "These dirty dogs that eat men" are among those oceanic animals whose study offers the most absorbing of interests.

P. B.



The Sargasso Sea.

In the western Atlantic, between the West Indies and the Azores and to the south of Bermuda, from longitude 45° to 50°W. and latitude 20° to 35°N., extends the Sargasso Sea with its "submerged and bottomless" meadows. It is surrounded by currents; to the north by the blue waters of the Gulf Stream that flow towards Newfoundland; to the south by the Equatorial Current, moving towards the Caribbean Sea. An immense deep-sea landscape extends below the brown algae at depths from 2,200 to 3,300 fathoms. Here is the bottom of that basin-like formation of the abyssal waters that is filled with equatorial waters. At a depth of about 1,350 fathoms the temperature is about 10°C. and about 15°C. at 270 fathoms. This region is rarely disturbed. Currents surround without penetrating it and storms are broken by the dense masses of marine vegetation.

We should have to go far into the past to seek those navigators who, venturing towards the west, were the first to be amazed by this immense expanse of brown seaweeds. If the inhabitants of Atlantis were hardy seafarers, as told in the priestly legend of Sais and in Plato's Dialogue, they must have left their archipelago (now drowned by the waters and represented only by Madeira and the Canaries) to discover the unknown western lands. Perhaps their ships would have stopped in the face of these floating meadows.

The Phoenicians, who were steeped in these traditions, would undoubtedly have tacked towards the west, but with their usual mysterious and discreet ways, would not have reported these episodes. The Arab sailors, who told their geographers of the existence of the great island of Antilia and went in search of Saint-Brandan's Land, doubtless knew this part of the Ocean Sea where marine plants blocked the path of galleys and where fabulous monsters reared out of the water. Columbus, who took advantage of the experiences of Basque pilots in the rediscovery of America, was nearly stopped on his voyage by a mutiny among the crew, who, seeing the sea covered with coastal seaweeds on which crabs were moving about, refused to go further so as not to run risks from unseen reefs. Finally, it is to the bold Portuguese sailors of the 16th century that we owe some real information concerning this marine region which they called the Sargasso Sea. The monsters of the ocean have vanished into the past and marine plants no longer impede the oars of galleys. As it is off their route, modern ships rarely spoil the calm of this plant landscape by the churning of their screws.

In appearance sargassum weeds are so like coastal brown seaweeds that they were for long believed to be algae torn from the American coasts and carried out to sea by the Florida Current. But the studies of algologists have definitely shown that these are purely pelagic plants. They grow and reproduce in the open sea, thus excluding the former idea of a collection of plant remains. At first, they were grouped together by botanists under the name *Sargassum bacciferum*, but the supposed berries of sargassum weeds are really groups of stalked floats. Receptacles that are the reproductive organs have been found in other parts of the plants in a mature state. Botanists now distinguish eight species, which are, moreover, very close to one another. Their origin is unknown. Certain characters, such as the presence of a kind of central stalk, would lead one to suppose that they were once attached algae. But where did they come from? We do not know, for they are neither found off continental sea-shores nor around archipelagos. They must surely have evolved a long time ago.

The Sargasso Sea gives very much the appearance of a coastal habitat in the open Atlantic, and the error of Columbus' sailors is quite excusable. In regions where the algae are very thick and massed level with the surface, crabs, that do not belong to swimming species, may be seen scuttling about. Tube-dwelling worms, such as *Spirorbis* and colonies of hydroids are as numerous on *Sargassum* "leaves" as on those of wracks (*Fucus*) from European coasts. Some insects have even become adapted to this marine life and jump from clump to clump. And the fish fauna entirely confirms the coastal nature of this environment. As in a bed of *Zostera* grass, tube-mouth fishes, such as pipe-fishes (*Syngnathus pelagicus*) and sea-horses (*Hippocampus ramulus*) are found. A small monacanthid of the trigger-fish family, rounded and flattened and with a large spine behind the eyes, gently moves and grazes among the clumps of seaweeds just like its relatives do in coastal regions of the tropics. Another equatorial

species, the frog-fish or sea-clown (*Antennarius marmoratus* = *A. histrio*) is a regular dweller among sargassum weed. Although related to the angler-fishes, it is not very like them. Its small squat body, measuring from 1½ to 2 inches in length, can be slightly inflated, and on the snout stand spiny rays erected like horns. The mouth is larger in the vertical plane and the pelvic fins have come to be placed almost beneath the chin. The rough skin is covered with many cutaneous tags and also with parasites. The colours of these small fishes are extremely handsome, there being dark marblings on an orange background and light-blue bands on the fins. The males are distinguished from the females by their more vivid colours. For a long time frog-fishes were thought to build a nest in the sargassum weed, but we now know that the eggs that were attributed to them are those of the flying-fishes that play in these quiet confines.

Under this "coastal carpet", that shines golden in the sun, come in succession all the different levels of marine life down to the cold, dark abysses. Here, at a depth of more than 3,000 fathoms, blind and degenerate brotulid fishes slide over the ooze. Higher in the water come black, bathypelagic fishes with their luminous organs flashing. Then above these, perhaps at the limit of the isotherms for 9° or 10° C., that is towards 500 or 600 fathoms, occurs the mysterious reproduction of the freshwater eels. Having forgotten their life in the fresh waters of far-off continents they have changed into deep-sea fishes and, after their great journey across the ocean, they finally come together for the long-awaited breeding act. Their transparent eggs are laid to drift in water masses, from which the adults will never return.

This Sargasso Sea seems to be an immense breeding ground, for below some 270 fathoms, at the lowermost point of the 14°C. isotherm, albacores also come to spawn. The natural history of these fishes will now be told.

The epic story of tunny-fishes.

Whereas the great rovers of the open ocean, the sharks and swordfishes, wander unexpected and alone, the tunny-fishes are masters of the seas of all three oceans; the Atlantic, the Indian and the Pacific. They range over all the tropical and temperate regions of these immense marine expanses. Their schools regularly appear in definite localities, where maritime populations await their arrival as a source of wealth.

Among fishes they are in a "class" by themselves. In form they are the most highly evolved of the rapid swimmers, being shaped as perfectly as a torpedo. The "midships section" is set forward so as to contend with the resistance of the water and to allow the easy sliding of the backwardly tapering body. Over the rear section, the flow of water is facilitated by series of finlets, and lateral keels strengthen the base of the caudal fin, this being a powerful rudder. Tunny can keep up a speed of 20 knots and cross an ocean in the same time as a large steamer.

This expenditure of power is made possible by certain anatomical features. The segments of the large lateral muscles fit together in the form of strong, supple cones. A subcutaneous blood system with main branches placed along the muscle surface furnishes a blood reserve to avoid a loss of energy. Unlike other fishes, their temperature does not follow that of the surrounding medium, but exceeds it by about 8°C. As tunny are essentially stenothermal and live in waters with temperatures never less than 14°, and which may reach 24°C., this means that the muscles are continually kept at temperatures from 22° to 32° C. The character and taste of the flesh recall that of warm-blooded animals, so it is more logical to speak of "tunny-meat".

Four species of tunny can be distinguished :

- bluefin tunny (*Thunnus thynnus* (L.);
- blackfin tunny (*Thunnus atlanticus* (Lesson);
- albacore (germon) (*Thunnus alalunga* (Gmelin);
- yellowfin tunny (*Thunnus argentinus* (C. V.).



A group of damsel-fishes (*Amphiprion percula*) resting among the tentacles of sea-anemones. Photograph by Günter Seufft.



A school of damsel-fishes (*Dascyllus trimaculatus*) swimming above rocks covered with sea-anemones. Near Moorea, Tahiti.
Photograph by Dr. Villaret.



Among the corals. Above : a few damselfishes (*Dascyllus*)
below, another of these fishes in the middle of dangerous tropical sea-anemones (*Heliathoipides*).
Photograph by Dr. Villaret.



A butterfly-fish (*Chaetodon lineolatus*) from the Great Barrier Reef of Australia. Photograph by Dr. Villaret.

The bluefin tunny has been known since very ancient times, the name "tunin" being among the few fishes that are mentioned in the Bible. The Phoenicians had already developed a fishery which they took to Carthage, where tin anchors used for fixing the madragues (tunny-nets) in position, have been found. They are still in place and also at Gades (Cadiz) beyond the Pillars of Hercules. Aristotle describes migrations of "thunnos" that are still watched by seamen in the Bosphorus. He points out the regularity of these migrations and remarks that the fishes always travel along the left shores, this enabling the nets to be nicely directed. From this he infers that the fishes are blind in the right eye. Arriving tunny that spawn in April in the Black Sea are distinguished from the returning tunny that go back to the Aegean Sea in September.

In the Mediterranean, ancient traditions have been preserved. Indeed, the recognised spawning centres of tunny ("atun" of the Spanish and "tenn" of the Arabs) are situated off the coasts of Libia and Tunisia, around Sicily and in the Gulf of Cadiz from Cadiz to Morocco. Large reproductive tunny with a weight of 330 to 660 pounds arrive at the Syrtes (Gulfs of Sidra and Gabes) in April, May and June, when the water temperature rises to 18°C. and the salinity is 38 ‰. Later in the season, smaller fishes that are also sexually mature appear when the sea is still warmer and more salty. It is to a head of the tunny-nets, who is called *rais* after the old Berber name, that we owe a description of the spawning. According to him, the male and female rise to the surface close together so that their bellies are touching. At the same time the female releases the eggs and the male the milt and this occurs several times during the day. Just as the spawn is produced, mendoles (maena fishes) swoop down in a body to devour the eggs, which cloud the water by their abundance. Their development has been followed. Hatching occurs at the end of two days and a larva with a length of about $\frac{1}{8}$ inch is born. Growth is rapid; a length of about 3 feet is reached at 3 years; about 5 feet towards 5 years and 6½ feet towards 10 years. Old tunny weigh more than 880 pounds and there is a record of a fish of some 1,580 pounds from the Gulf of Maine.

The great feeding migrations begin after spawning. The young adults do not move very far, but the old fishes venture far afield at top speed. In July they round Cape Ortegal, appearing off Saint-Jean-de-Luz; then they enter the Bay of Douarnenez; the English Channel; the North Sea, and even swim as far as the Norwegian coasts, having travelled 2,500 miles in one month. During this period they are no longer strictly stenothermal, but do not leave the high salinity waters of 35.5 ‰. Even when they are hungry they keep to the waters of the Atlantic transgressions, where they find, moreover, sufficient food, anchovies, sardines, mackerel, crustaceans, cuttle-fishes etc. When ravenous they attack large fishes, like bonitos and albacores. When they are famished they fear no enemy, neither sharks nor cetaceans, whereas in their reproductive phase they are easily frightened.

In the western Atlantic, to the south of Bermuda, probably in the Sargasso Sea, there is another spawning centre. Like their European relatives, these American tunny spawn in spring, then proceed in June and July to feed off the coasts of Maine and Nova Scotia and over the Newfoundland Banks. The younger fishes often spend the winter close to the coasts, thereafter disappearing in spring to spawn in tropical regions.

Pacific tunny ("bluefin tuna") have a similar biology. In February and March they may be seen passing Guadalupe Island and they gather together further to the south, probably in the regions of Central America or the Galapagos Islands. From June onwards they reappear off the coasts of California. In the Japanese area, the bluefin tunny (*var. orientalis*) reproduces around the Ryu-Kyu Islands and then makes off northwards from July to November towards Hondo and Hokkaido. In the southern hemisphere it is reported off the coasts of South Africa, around Australia and in the Pacific near the Juan Fernandez Islands, where there seems to be a spawning place.

Throughout the Mediterranean, tunny have been salted in barrels for thousands of years to form part of the local diet. There are very important preserving trades for it in Italy and Spain. The salted and pressed eggs or "pontargues" are in great demand throughout Mohammedan countries. There are canneries for bluefin tuna (red-meat tuna) in California.

Little can be said of the biology of the blackfin tunny, which is also called the obese tunny because of its thick-set body. It is very like the bluefin, from which it is particularly distinguished by its large eyes. It is more or less confined to the equatorial zone and lives in waters of high temperature (more than 20°C.) and salinity (to 36 ‰). When these tunny disperse on their migrations they proceed to the Moroccan coast as far as Cape Juby and to Madeira and the Azores. In the South Atlantic the "big eye tuna" swims off the American Continent from Mexico to Chile. To the west the "mebashi" is caught from the Hawaiian Islands to Japan and it is also found around Australia. Its red meat is canned but is of limited economic importance.

While the ancient writers have much to say about the bluefin tunny, they remain silent on the albacore or germon, which they do not appear to have known. Even in the 16th century the great ichthyologist Rondelet does not mention it. At last, in 1788, an Encyclopaedist, the Abbé Bonnaterre gives a description of it and the Fishery Inspector Duhamel of Monceau reports that Basque seamen who used to go to the New World to catch cod, took albacore on trailing lines in the open Atlantic on the outward and homeward voyages. However, albacore fishing, although unknown in Mediterranean civilisations, goes far back into the past and the word "germon" as used in the Vendée may be of Ligurian origin. When the Moors occupied Portugal and Spain, they also knew of these fine fishes that swam in schools and reminded them of a herd of cattle. They called them "al beqr", whence comes the name "albacora" used in the Iberian Peninsula.

For several centuries the west-coast ports have been equipped with sailing craft that leave in June to catch tunny in the Bay of Biscay until October. These fine, well-made boats have brown sails extending into long fishing yards or tangons to which the trailing fishing lines are fastened. The fishermen knew from experience that in June they must look for the albacore near the Spanish coasts; in July and August in the Bay; and later towards the west as far as the Great Sole Bank, or even to the south of Ireland at the end of the season. Improvements have come about during recent years. The fishermen of Luz have adopted first steam and then motor vessels. A French engineer, Krebs, has provided the sailing craft with ice-cooled holds. More and more under the influence of American techniques in the Pacific, the boats are acquiring the gear of the Californian "tuna clippers", with refrigerators and wells containing live sardine bait for the fishery.

When they are under way, albacore travel near the surface, often leaping out of the water. Their silvery flanks gleam in the sun and their enormous pectoral fins enable them to move at high speed. While investigating the movements of a shoal of these superb fishes in 1921 I was able to learn something of their hitherto unknown biology. They have guided me in setting up the theory of oceanic transgressions. Because of their completely stenothermal habits I have, in fact, been able to determine that off the French coasts they only live in waters with temperatures greater than 14°C. at 25 fathoms depth and a salinity of at least 35.5 ‰. Since they always follow these temperature conditions they are valuable biological indicators of the encroaching water layers (transgressions) which they never leave. But the albacore of our waters are immature fishes and the life of the reproductive individuals and their spawning-grounds remained unknown. Thirty years later I was finally able to find some precise data which have enabled me to build up a general picture of the biology of the Atlantic albacore.

It is towards the west, in the prolific Sargasso Sea, that their spawning-place must be sought. As early as 1925, two French scientists, Gruvel and Conseil, reported that they had found sexually mature albacore near Martinique. Later, in these same regions, the Danish oceanographer, Johannes Schmidt collected larvae that the German Professor Ehrenbaum regarded as *Thunnus alalunga*. Little notice was taken of these discoveries and ingenuity was strained in seeking a spawning centre for albacore in the Madeira area, although in the eastern Atlantic larvae or young have never been found.

In November 1950 I caught small albacore of about 12 to 14 inches long on lines trolled in the Caribbean Sea off the Venezuelan coast, among the Windward Islands near Blanquilla. These immature fishes must have been not more than 1½ to 2 years old and could not have been





very far from their birth-place. This then is where Johannes Schmidt found the larvae; that is, in the Sargasso Sea.

Adult albacore do not enter European waters. They range across the Atlantic in a vast belt between latitudes 10° and 40°N. from the Gulf of Mexico to the entrance of the Mediterranean, living in waters with a salinity from 36 to 36.5 ‰ and a high temperature varying from 18° to 24°C. The westward concentrations gather in winter or at the beginning of spring in the "basin" of equatorial waters, where, south of Bermuda, the isotherm for 15°C. descends more deeply to about 270 fathoms. Then the large hungry albacores disperse over an area from the West Indies to Morocco. Fishes with spent ovaries are sometimes caught around the Azores, Madeira and the Canaries.

Development of the fry is accomplished within a perimeter extending round the Sargasso Sea at a distance of about 800 miles. At the end of the first year they measure little more than 9 inches in length and are the selected victims of numerous predators such as sharks, swordfishes and other tunnies. When towards 3½ years of age they have reached a length of about 18 inches, the immature albacores begin their travels and move towards the north-east with the Atlantic transgressions, always keeping in waters with a temperature of 14°C. and a salinity of 35.5 ‰. These are the fishes that move by the Iberian coasts in April to enter the Bay of Biscay from May to July and reach the Celtic Sea from August to October. In autumn they withdraw to the south, swimming at the surface if the waters are still warm or diving towards the depths along the isotherm to reach the groups of islands where they spend the winter.

When they are about 4 or 5 years old and measure about 27 inches they become sexually mature for the first time. These fishes also move northwards but to a much lesser extent, for they never leave those waters of 36 ‰ salinity and a temperature of 16°C. It is probable that fishes with lengths of 31, 35 and 39 inches are 8, 10 and 12 years old respectively. We do not know whether they return to the Sargasso Sea each year or if there are wider intervals in spawning so as to recuperate their powers, for crossing the Atlantic is an easy matter for these strong swimmers.

Albacore are not found just at the equator, but in the South Atlantic there is a population that follows the southern transgressions towards Angola and the Cape of Good Hope and around isolated islands like Ascension, St Helena and Tristan da Cunha. The spawning-grounds should probably be in the west above the great depths of the Brazilian basin, where the salinity reaches 36 and 37 ‰. Ehrenbaum has reported on larvae from the region of Pernambuco, which could be those of the albacore.

When on board a Canadian ship travelling between Vancouver and Hawaii, I was able to ascertain the course of the Pacific transgression off California and Oregon, and to follow the passage of albacore very like those of the Atlantic. Between January and May in 1937 the Japanese ship "Fuji Masu" discovered a gathering of albacore to the west of the Midway Islands, from 28° to 34° N. and 170° to 173° E. All sizes of fish from 9 to 31 inches were represented. This grouping of fry, immature fish and adults suggests a spawning-ground; this corresponding in position with the Sargasso Sea and having the highest salinity in the Pacific. As early as 1923, Kishinouye found small tunny in the stomachs of other fishes taken around the Ogasawara Islands, 1,200 miles west of Midway. In 1937 and 1938, American ships confirmed the passage of albacore shoals that I reported in 1923. Evidently this concerns a journey of immature fishes in the waters of the transgressions covering some 2,500 miles. The winter quarters should be around the islands off the Mexican coast. Based on these data, the American scientist, Vernon E. Brock, made precise studies on the biology of the North Pacific albacore in 1943.

From Colombia to the East Indies on the equator there extends across the Pacific a belt of low salinity water which seems to be a real barrier for tunny and separates the northern populations from those of the south. Albacore are known from the Juan Fernandez and Easter Island areas and they are found again round Australia and New Zealand. In the Indian Ocean they occur near Réunion and Madagascar. Nothing is known of their biology, but within this immense marine area there are probably at least two distinct populations with their own spawning-grounds.

Lastly, there is a local race of albacore in the Mediterranean, the eggs and larvae of which have been taken by Sanzo and Ehrenbaum in the Strait of Messina and near Cape Matapan. Reproduction takes place in the southern Adriatic. After spawning, which lasts from July to September, the albacore dash off to feed in the eastern Mediterranean — in the Archipelago and the Black Sea. The albacore is of great economic importance. Prepared either in oil or in the natural state, its firm, white flesh (white tuna meat) is one of the most valued products in the world market.

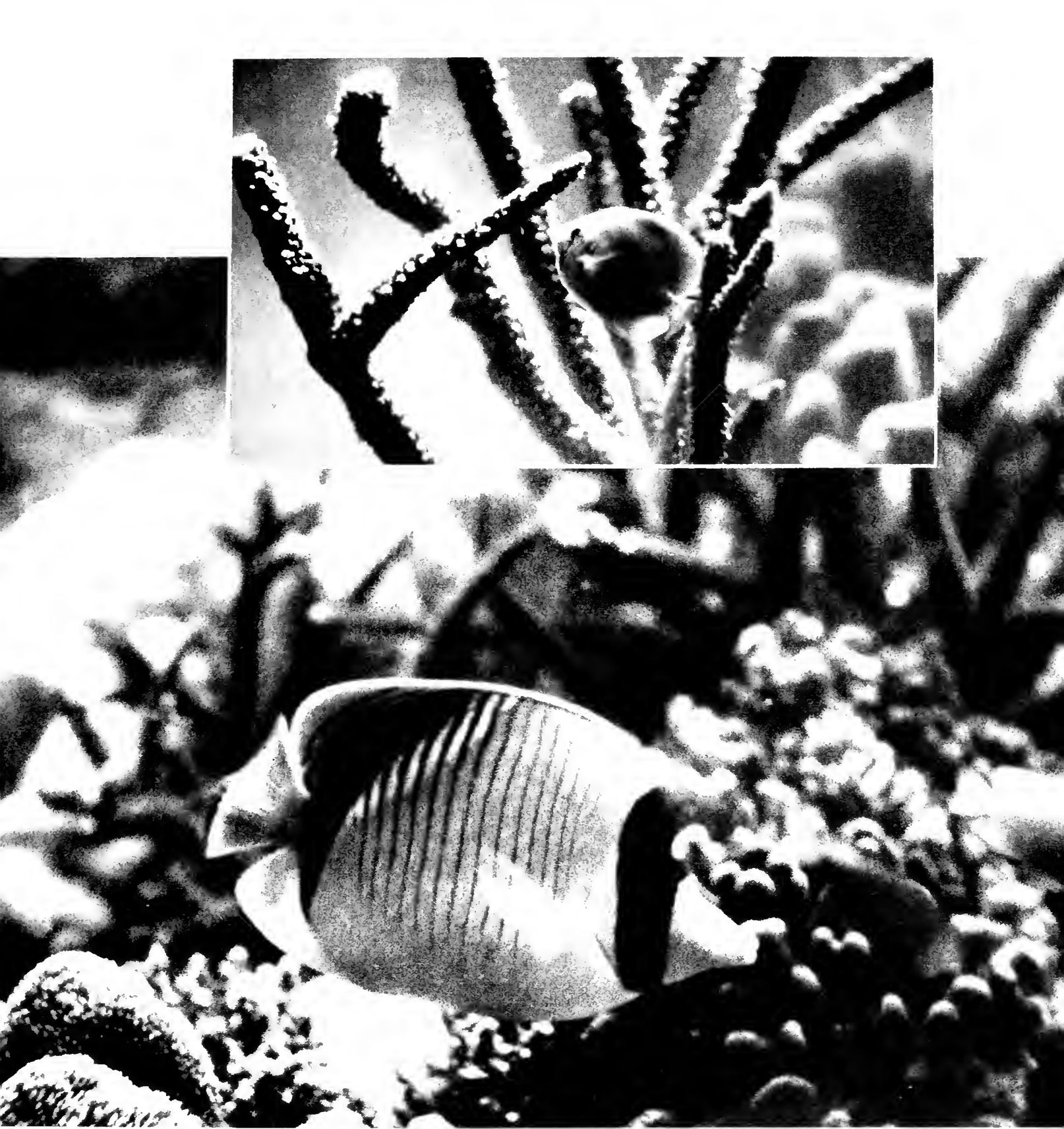
The yellowfin tuna of the Americans (really the true albacore) is often confused with the albacore or germon through an ambiguous name given to it by Sloane in 1707. The two fishes can be readily distinguished as the pectoral fins of the yellowfin are shorter than those of the albacore, the tips not extending past the end of the first dorsal fin. Then again, the first rays of the second dorsal fin are extremely high, being longer than the lobes of the tail. Hence the Canary Island fishermen call them "ravail".

The biology of *Thunnus argenteivittatus* recalls that of the albacore, but it does not move so far afield. Moreover, instead of being a tropical fish that moves towards temperate seas, it is typically equatorial and in those waters it replaces the albacore. Its movements are more restricted, since throughout its life it never leaves those waters having a salinity of 36 ‰ and temperatures above 20°C. In 1954 I tried to adduce precise evidence concerning the life of the yellowfin tunny, but it is still poorly known. According to J. Cadenat, the fishes from 55 to 66 pounds reproduce in July and the spawning-ground is probably south of the Cape Verde Islands. But large tunny of 180 to 220 pounds most likely spawn later, in winter, perhaps in the Brazilian basin. Like the immature albacore, young yellowfins migrate northwards, this journey beginning in June. They pass by Port Etienne and arrive at Cape Juby towards September. Striped-bellied bonitos or skipjacks (*Katsuwonus pelamis*) mix with the shoals of yellowfin, the formation of the shoals seemingly being much more according to size than species. During their journeys with the skipjack the immature fishes must sometimes depart from stenohaline rules. But this departure must be rather slight, for they remain in waters of 35.5 ‰ salinity. Adult fishes of 55 to 66 pounds also move around, but to a lesser degree, as far as the Canaries. Fishes of 110 to 130 pounds do not appear to go beyond latitude 20° N. (towards Port Etienne) while the large reproductive individuals are confined to water-layers of 36.5 to 37 ‰ salinity around the equator. These migrations come to an end in January, when all the yellow-finned tunny move down again towards the south to regain their spawning-grounds.

The Pacific yellowfin tunny has a similar biology, but lives in waters of 34.5 to 35.5 ‰ for this ocean has a lower salinity. The Japanese scientist Kishinouye (1923) and the American ichthyologists, M. B. Schaeffer and J. E. Marr (1947) have recognised that the spawning periods vary according to the age and size of the fishes. Adults of 27 to 31 inches spawn from April to July, those from 31 to 39 inches from May to August and large reproductive individuals in winter. Spawning centres have been discovered around the Marshall Islands, in the Celebes Sea, around Hawaii, off Costa Rica and in the Galapagos area. Immature fishes, together with bonitos, live in coastal waters for months on end. They grow rapidly, being about 2 inches long after 1 year, nearly 2 feet after 2 years and 27 to 31 inches after 3 years, when they first become sexually mature. Towards 4 or 5 years they are nearly 5 feet long. Yellowfin tunny are found in the South Atlantic, off Angola and in the South Pacific and Indian Oceans.

Yellowfin tunny flesh is pink (light-meat tuna) and is just as good as that of the albacore. An enormous fishery for this tunny is carried out by American clippers which travel as far as the Galapagos Islands, these being the fishes most used in the United States canneries. The exploitation of the Atlantic yellowfin tunny has only just begun, but excellent products have already been manufactured in Port Etienne.

In the beautiful lines of their strong bodies, in the immense journeys they undertake and by their rigid adherence to oceanic laws, tunny, in the splendour of their wandering life, surpass all the dwellers of the open ocean.



The butterflyfish (*Chaetodon lineolatus*) in the Antrim area '88.
Above: an even smaller butterflyfish. Photographs by Dr. Villavicencio.



A butterfly-fish (*Chelmo longirostris*) with a pointed snout, among coral masses in New Caledonia.
Photograph by Isy Schwart.



The Moorish-idol (*Zanclus cornutus*) in the corals of Tahiti in the Pacific Ocean. Photograph by Dr. Villot.



An angel-fish (*Pomacanthus acutus*) swimming over rocks bearing sea-urchins, Off Brazil. Photograph by Isy Schwart.

The coral fairyland.

At the bottom of the Pacific Ocean extends an immense deep-sea landscape at depths of 1,600 to 3,200 fathoms or more, a sea floor stretching without interruption from north to south of this ocean. But in the tropical zone, between latitudes 30° N. and 25° S., insular shelves bear archipelagos and island chains. Sometimes a volcanic peak towers above high-topped palm-trees; sometimes the island is quite flat, only the low barriers of the mangroves showing on the horizon; sometimes there is no island, but a great circle of foam denotes a belt of reefs enclosing a sheet of calm water reflecting the deep-blue, equatorial sky. This oceanic region with emergent islets and atolls is the Coral Sea. Continental subsidence marks its far distant past, while volcanic archipelagos have risen elsewhere; some still persist, others have disappeared, for the period of changes in the earth's crust is by no means past.

Volcanic activity and coral building are the essential bases of island formations in the Pacific and they are closely linked. Due to volcanic changes an excess of carbon dioxide leads to a supersaturation of calcium carbonate in the sea water. It is this massive, chalky deposit that is transformed by all the organisms living in the Coral Sea. The appearance and shape of the polyp structures varies according to the lay-out of the subsided lands. On the sites of submerged islets atoll-rings arise. The borders of ancient continental shelves bear fringing reefs and barrier reefs, the Great Barrier Reef of Australia being among the latter. This mighty rampart of more than 1,200 miles in length rises off the Queensland coast from a depth of about 80 fathoms. It is intersected with channels and there are islets and sandy banks. The madreporic coral masses are ceaselessly subject to marine erosion and the sand formed as they crumble cements together the trunks, stems and branches of the coral colonies or falls slowly to the bottom of the lagoons. The wind carries plant seeds to these fortified reefs, and currents deposit seeds and coconuts. Breadfruit trees and mangroves fasten their roots into cracks and the mangrove swamp gradually yields a soil allowing the growth of other plants, such as palms and banyans. Eventually these push the swamp back from the fertile soil that it has created.

There are innumerable varieties of madreporic corals. Some *Astroides* species have slender branches like stags' horns; others have cups with crenelated edges and look like gear-wheels, while strong, wavy crests separate the lodgements of brain-corals. Fungias spread out like the upturned umbrellas of mushrooms with their radiating plates. Countless coloured or immaculate polyps open out, graceful flowers of a garden that could not even be described by the most poetic of the Arab story-tellers. Remarkable creatures with brilliant, blending colours are fastened on the corals. There are alcyonarians with purple or orange branches, pink or yellow gorgonians, tube-dwelling worms with extending, many-coloured plumes, and sponges of all shades. Among these tangled thickets open the massive wavy-edged valves of giant clams (*Tridacna*) with their scarlet mantle lining. Sea-urchins erect their sharp-pointed spines, which radiate like the quills of a porcupine. Conch-shelled or helmet-shelled molluscs drag their massive shells with their orange enamellings or mother of pearl lustre. Star-fishes stretch their red or green arms and fleshy nudibranch molluscs crawl around, looking like enormous marbled or spotted slugs.

A strenuous life prevails throughout the coral reefs. Each crevice is a shelter giving concealment and some security to crowds of timid creatures, when it is not the haunt of some formidable animal. Lying motionless and watchful in holes are great moray eels (*Echidna* and *Lycodontis*) reaching a length of more than 6 feet. Their long snake-like bodies with their patterns of spots and mottlings, together with dark-brown or light-yellow shades, blend most strikingly with the colours of the corals. Unseen, they await the passing of an unwary fish. This suddenly stops, held by the gaze of two small cruel eyes that are fixed on it. Although the triangular head is slowly getting nearer, it is unable to get away and so becomes the easy prey of the fierce moray eel.

While they are very voracious fishes, groupers are less dangerous predators. Owing to their perfect camouflage they lie hidden among the craggy outlines of rocks. In spite of their heavy bodies they can dart out with incredible agility to savagely snap up some appetising prey.

There are numerous species, such as groupers of the genera *Epinephelus* and *Garrupa* and jew-fishes (*Mycleropectera*), some of which can weigh more than 220 pounds. Swimming round the coral masses are coastal fishes, the brilliance of their glowing colours adding to the rich shades of the background. In shape they are like our sea-breams but their flesh is more delicate, as, for instance, the snappers or pargos (*Lutianus*), porgies (*Archosargus*, *Calamus*) with their sheep-like heads, grunts (*Haemulon*) with light spots blending into a darker background colour, and scarlet catalufas (*Priacanthus*) with large, clear-blue eyes.

About the madreporal coral masses the strange dragon-fish (*Pterois volitans*) springs jerkily forwards. It is related to the scorpion-fishes, being an exaggerated form of such fishes. The head-spines and skin-tags are very numerous and the fins are highly developed. The very high first dorsal fin looks as though it is formed of a line of sabre blades, while the enormous pectoral fins have large, flattened, blue rays that are curved like yataghans. The tail is a splendid fan. The colours of the dragon-fish, which surpass anything that could be imagined by a Chinese artist, are most vivid, with purple, red and white bands, recalling the war tattooing on some chief from Oceania. This animal has a terrifying appearance and is poisonous like the fishes of the related family Synanceiidae. These are extremely venomous and the dorsal spines with their poison glands may cause wounds that are sometimes fatal.

Among the coral polyps, large, brilliantly coloured helianthopsid sea-anemones send out their tentacles, these being crammed with stinging cells and capable of paralysing sizeable fishes. Now these dangerous actinians, which may be 20 to 24 inches in diameter, have a commensal damsel-fish (*Amphiprion*). The general colour of this fish is garnet-red, the snout and pectoral fins are red and there are startling white bands behind the eyes, at the end of the tail and along the back. The damsel-fishes have no fear of the formidable batteries of stinging cells possessed by the helianthopsids, and they pass to and fro among the tentacles, not even hesitating to enter the gastric cavity of these anemones. It is said that the *Amphiprion* acts as a bait to lure other fishes towards the anemones, where they are killed on contact and where the accomplices have a share of the remains. At all events it seems probable that the damsel-fishes are immune from the toxins of their hosts.

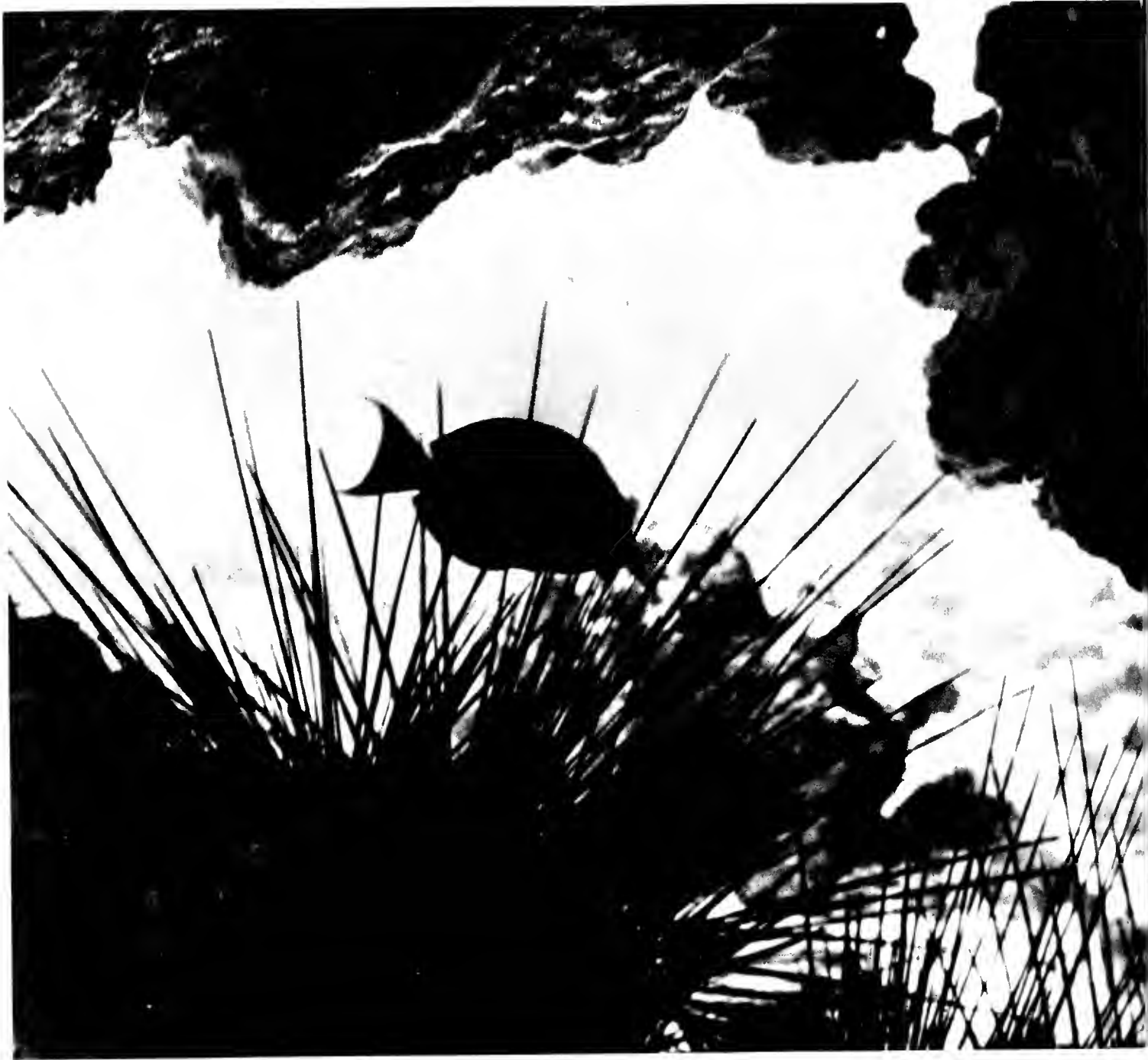
Among the fauna of the coral reefs there are specialised fishes which feed on the madreporal pores, whether they browse on the polyps or crush the branches to extract the living substance. Such adaptations are shown in the structure of the mouth, which has become beak-shaped. On the other hand, the dentition is sometimes modified, the teeth being fused into crushing plates.

The butterfly-fishes (*Chaetodon*) deserve this name because of their beautiful colours. The body is compressed from side to side and the small beak ends in a pointed snout. One of the commonest species in the Pacific, *Chaetodon acuminatus*, has a fine ground-colour of orange or chamois with two oblique jet-black stripes, one behind the head extending down to the pelvic fins, the other set in the middle of the body. The very long first rays of the dorsal fin undulate above the fish and extend well beyond the rear part. In the coral masses of the West Indies the butterfly-fishes give way to angel-fishes. The black angel (*Pomacanthus arcuatus*) and the blue angel (*Holocanthus ciliaris*) swim around the reefs of the Bahamas, both being covered with dark scales edged with clear-white or yellow lines. The Moorish idols of the Pacific (*Zanclus cornutus*) are round and flattened, with enormous fins, three large black bands standing out against the light-coloured body. All these graceful fishes nestle among the coral heads like humming birds in the flowers of an equatorial forest.

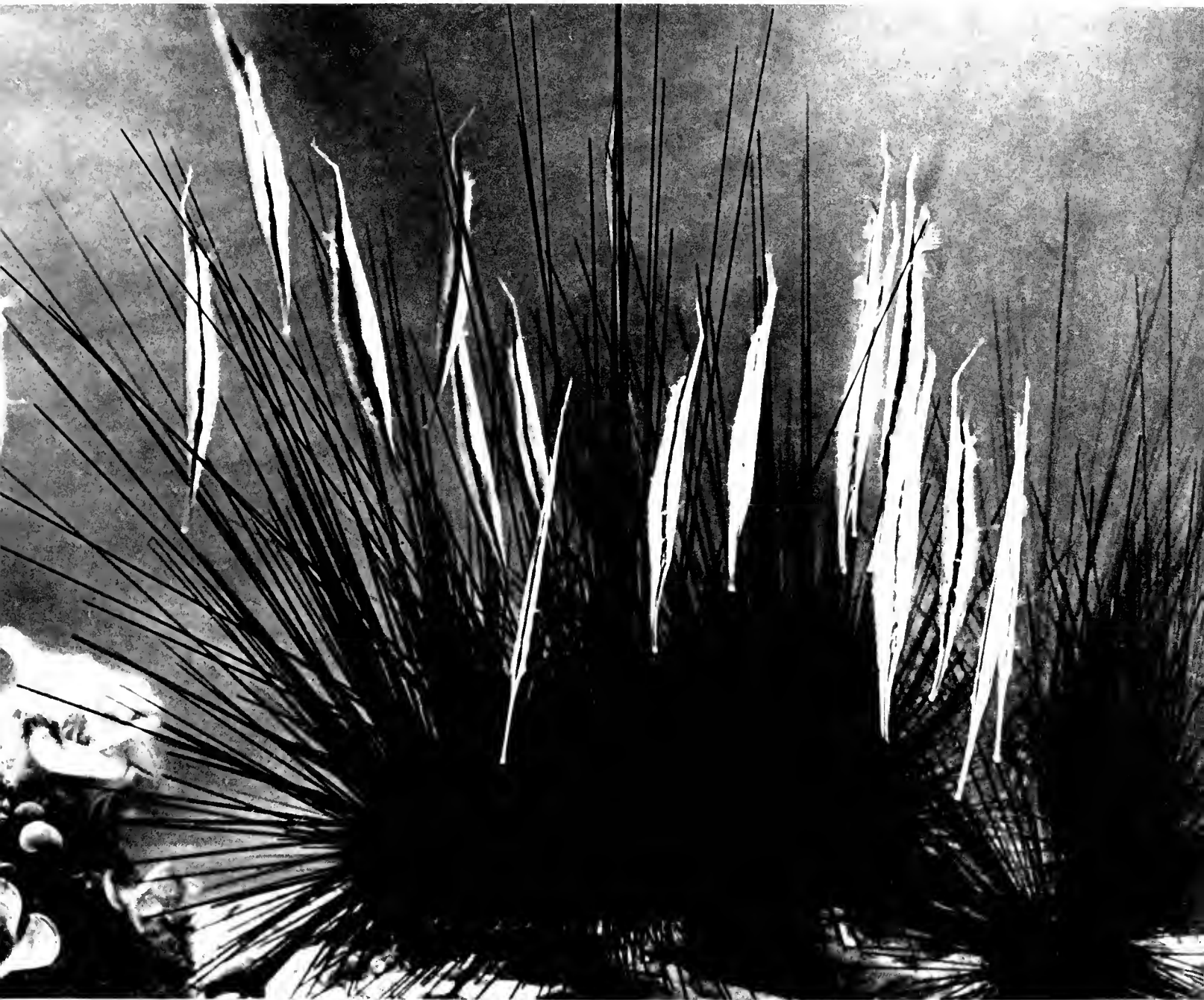
The oval-shaped trigger-fishes are more massive and rigid because of their sheathing of scales. They swim around the reefs and may even take to the open sea at times. On the back behind the eyes rises a strong pointed spine, which can be fixed in position by a bony locking device. Their colour patterns are very diverse: black with large orange spots; grey and yellow with blue stripes; red with dark lines edged with lemon colours; slate-coloured with a large scarlet tail that is rounded and fan-shaped; and there are many other shades. During years when the oceanic transgressions are strong, a wandering species, *Balistes capriscaus*, leaves the tropical zone to roam as far as the western coasts of Europe.



A large-finned bat-fish (*Platy pinnatus*). Photograph New York Zoological Society

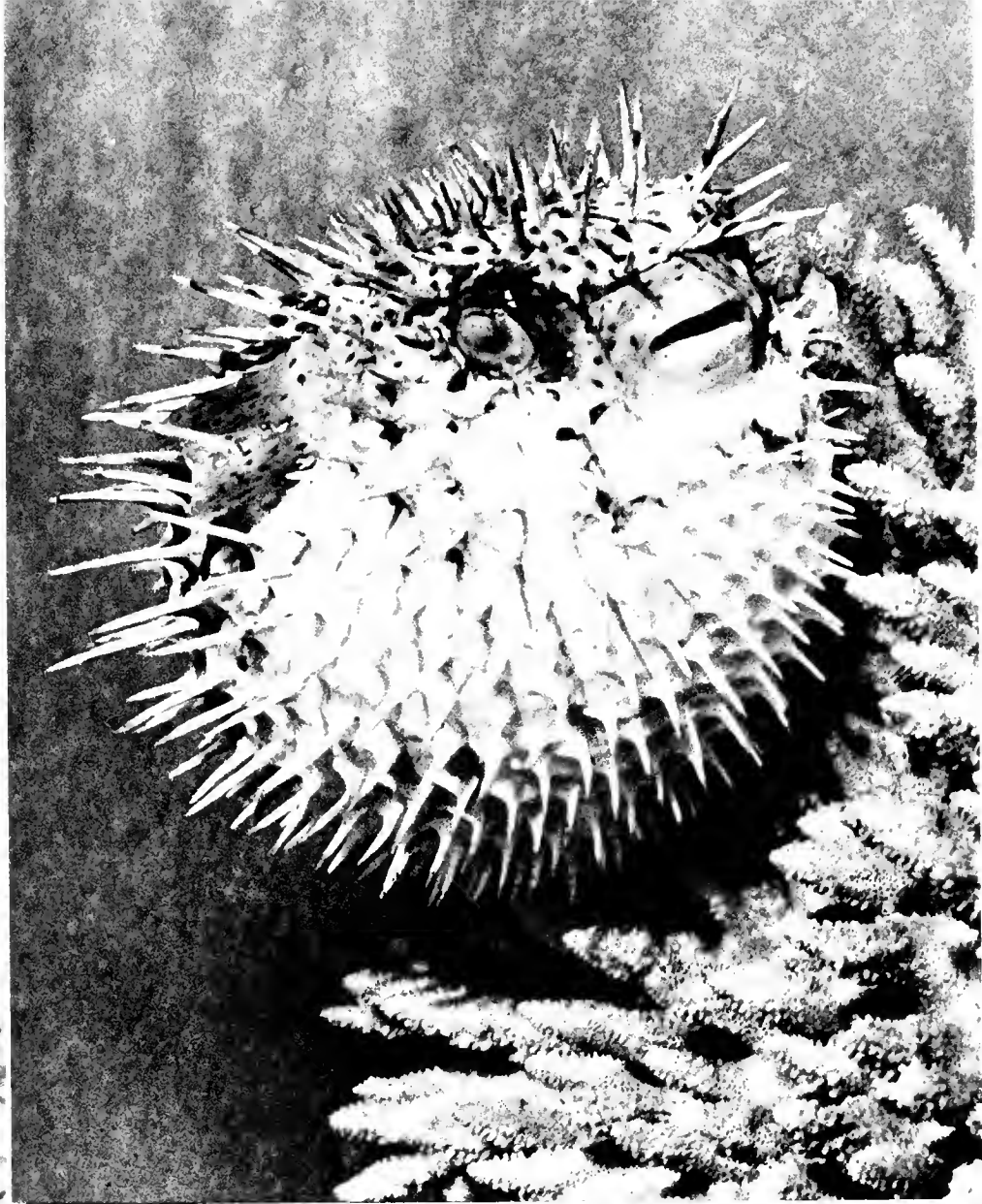


A surgeon-fish (*Acanthurus*) at the entry of a coral cave in Tahiti. Photograph by Isy Schwartz.

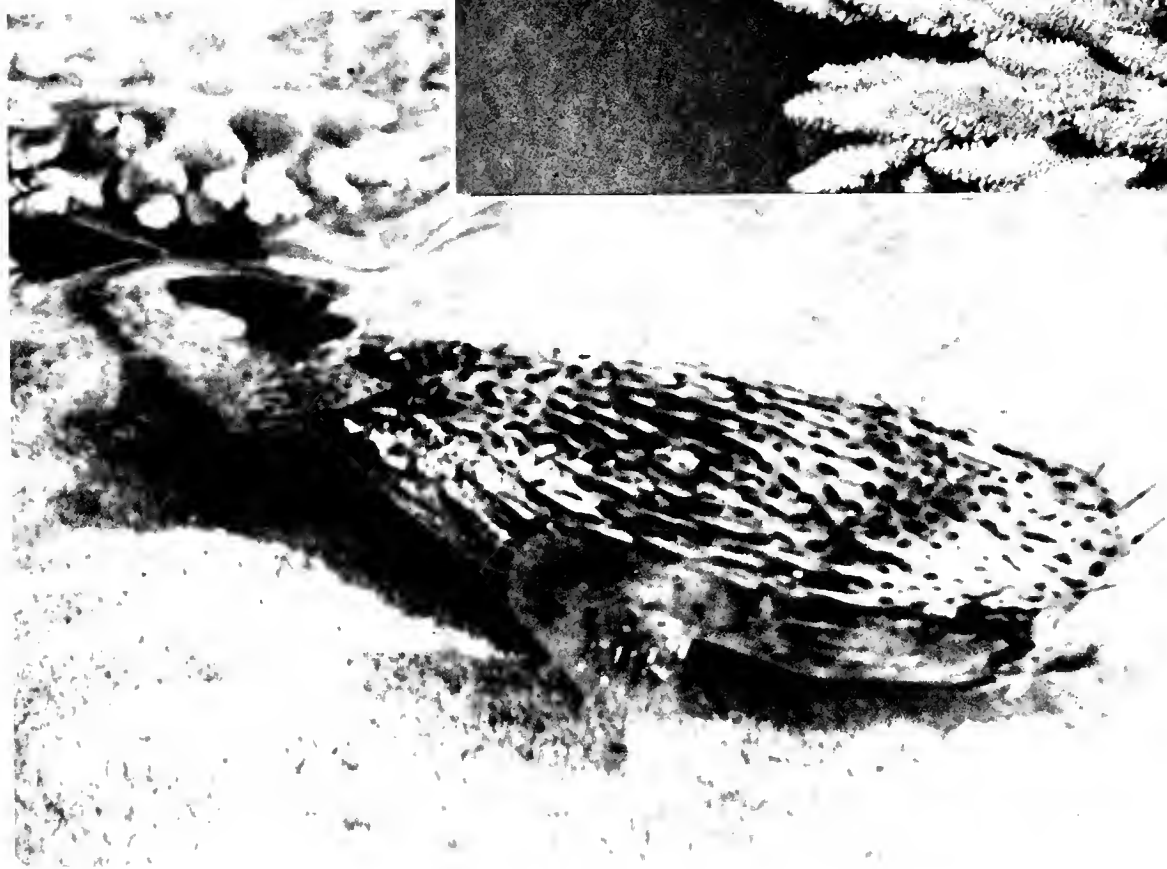


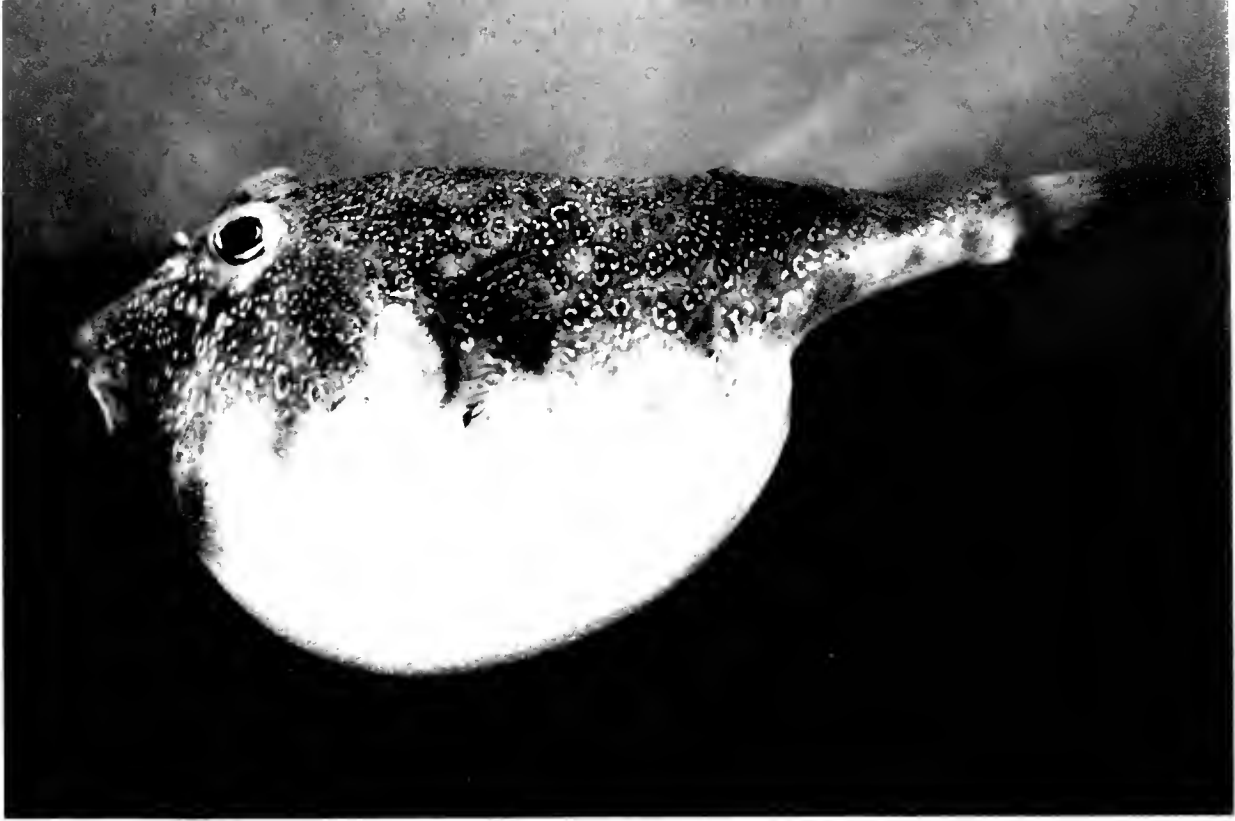
A school of shrimp-fishes (*Aeoliscus strigatus*) swimming with their heads down among the spines of a sea-urchin (*Diadema*).
Photograph Cathala.

A completely distended porcupine-fish (*Diodon*) from the coral-reefs of Polynesia. Photograph by Dr. Villaret.



A deflated porcupine-fish swimming along the bottom. Photograph by Dr. Villaret.

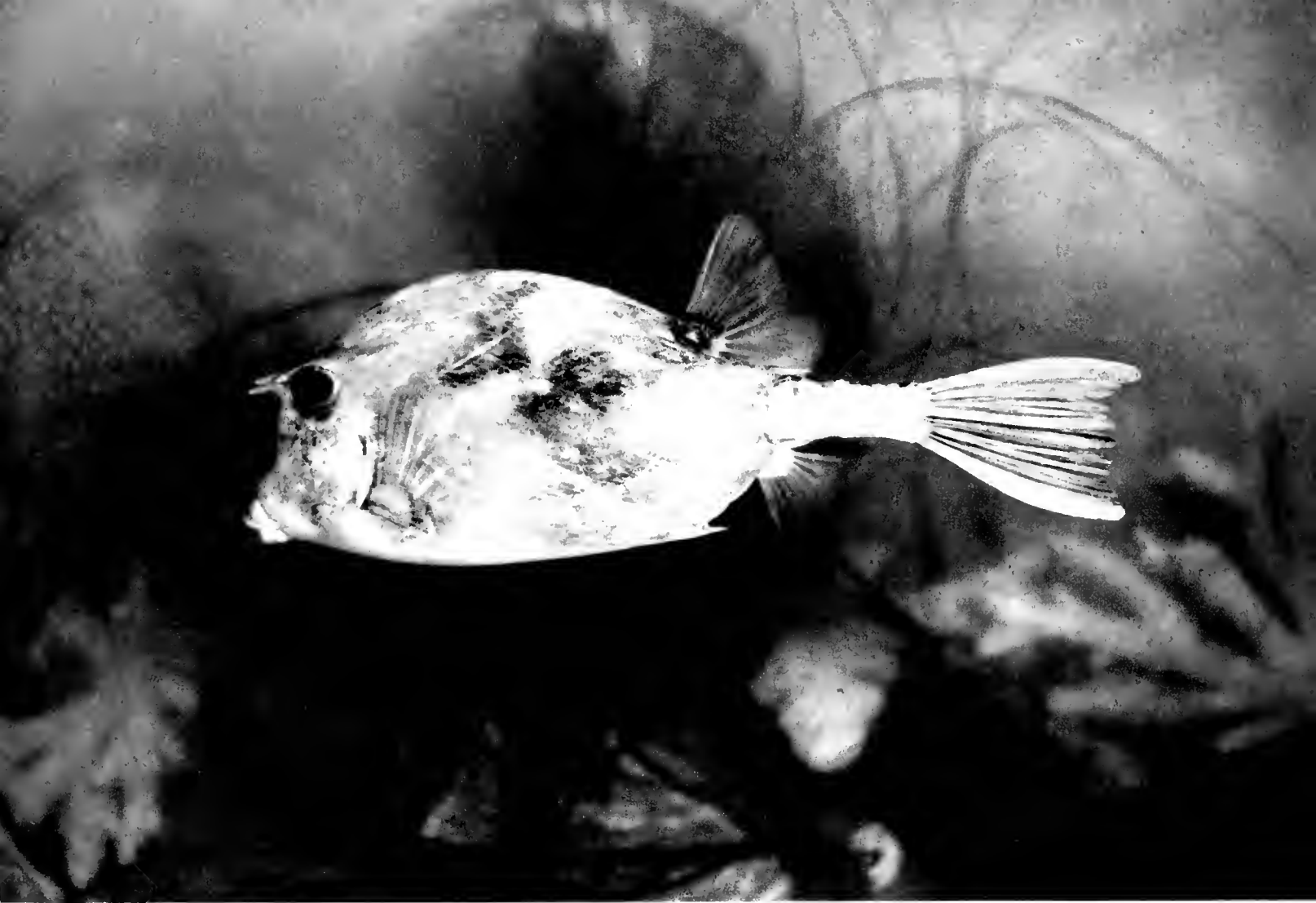




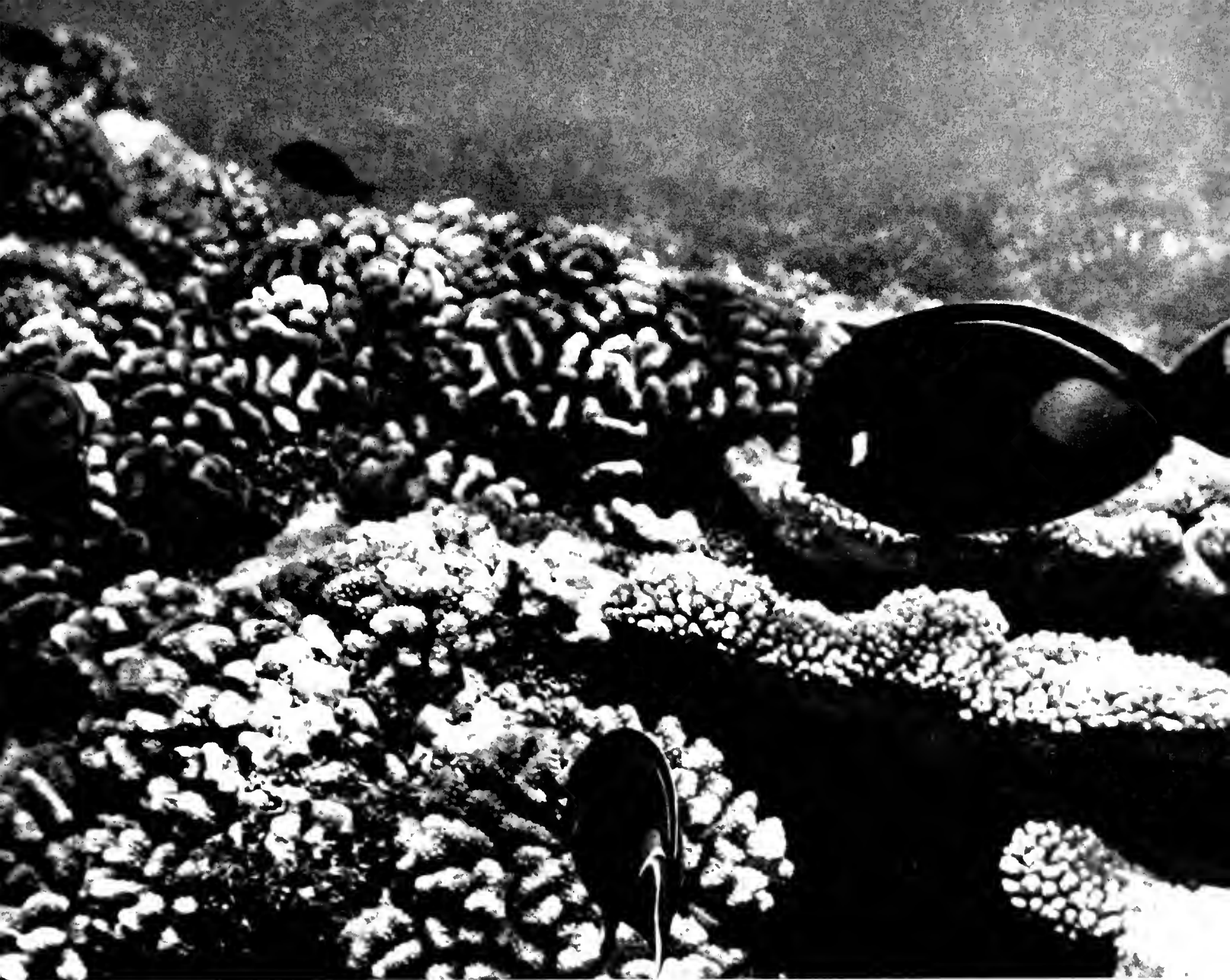
A puffer-fish (*Spheroides greceyi*) from Guiana. Photograph New York Zoological Society.

A triangular box-fish (*Ostracion triqueter*) from the West Indies. Photograph New York Zoological Society.





A cow-fish or horned box-fish (*Lactophrys cornutus*) from the Bahamas.
Photograph New York Zoological Society.



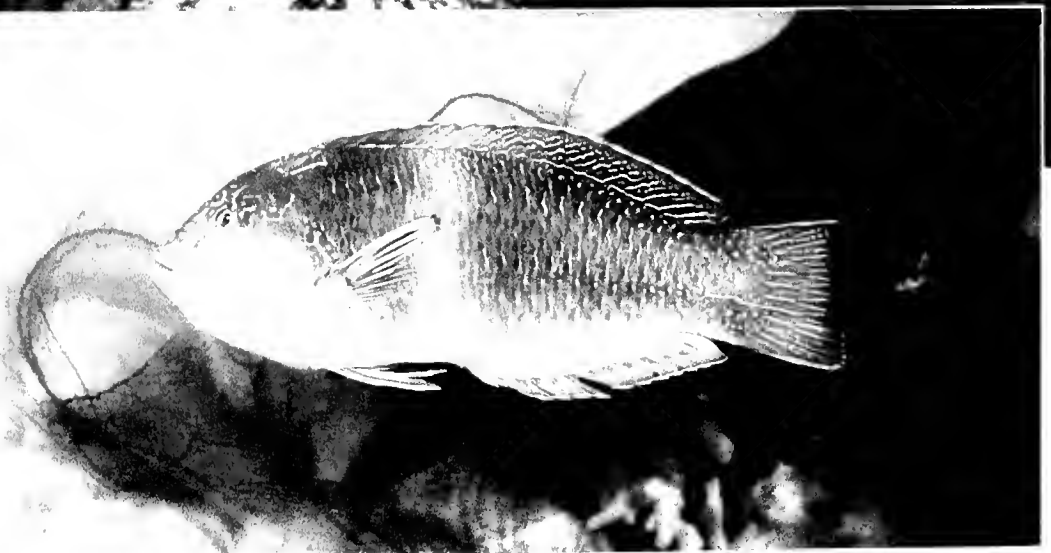
Surgeon-fishes among coral in New Caledonia. Photograph by Isy Schwart.

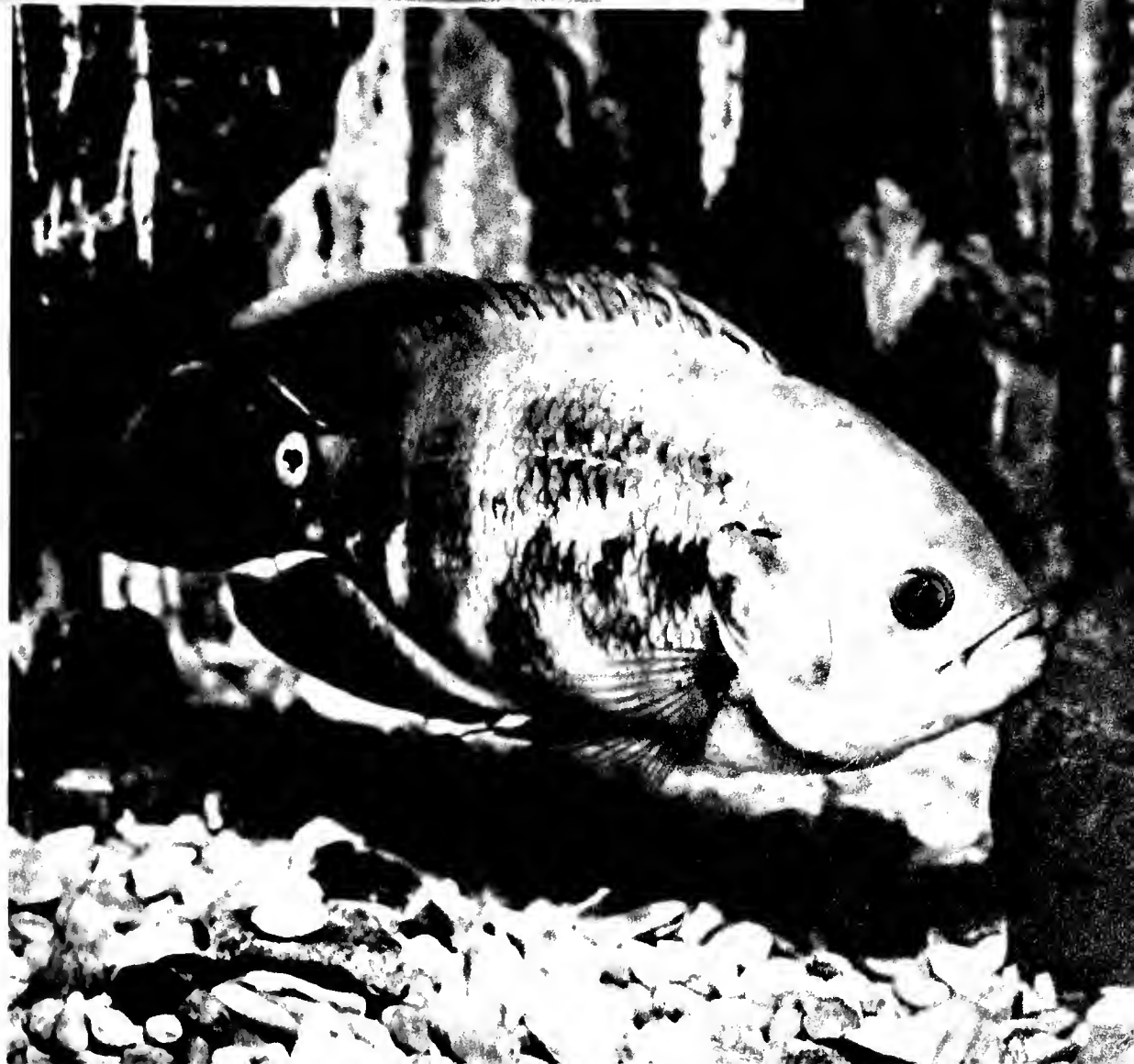
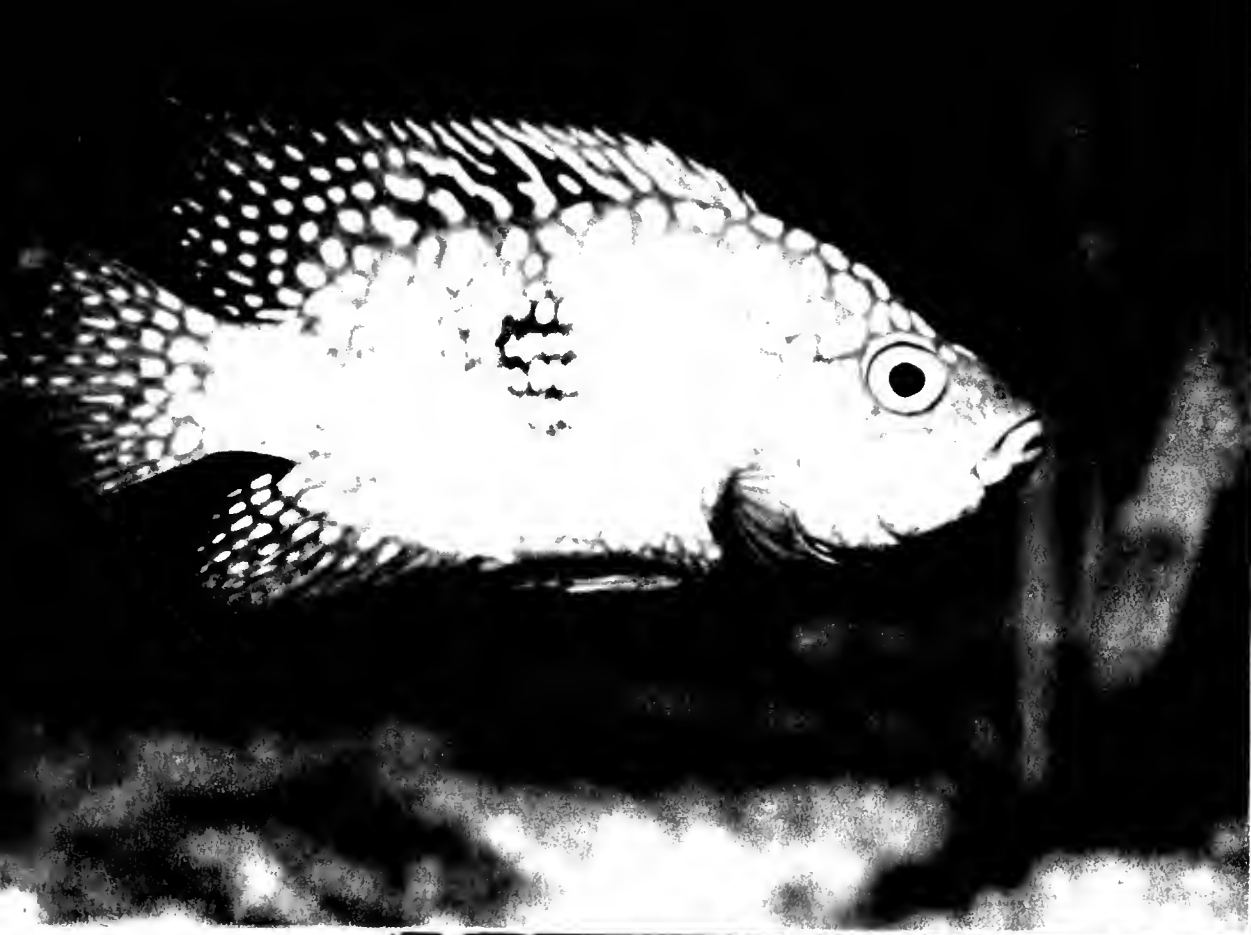
Opposite: *Herichthys cyanoguttata*, a cichlid from Mexico;
Astronotus ocellatus, a cichlid from Guiana, the Amazon and Para-
guay. Photographs by J. M. Bauffe.

A trumpetfish (*Aulostomus*) among coral in Haiti.
Photograph by Isy Schwart.



The piddingside (*Labo radiatus*), a coral-dwelling wrasse from the West Indies. Photograph: New York Zoological Society.







Parrot-fishes or scarids are labroid fishes that have become adapted to a reef-dwelling life. Their teeth are joined together to form a powerful beak and at the back of the throat are tooth-plates acting as rasps. They are thus able to crush shells, carapaces and the stems of madre-pore corals. The name comes from their luxuriant colouring which is quite like that of the forest macaws and parrots. These contrasts of colours are unexpected, but blend through their very brightness. Green, blue, pink and yellow parrot-fishes with spots, bands, stripes and many-coloured marblings add further enrichment to the magnificent range of coral-reef colours.

But the most typical fishes of this fabulous living-space are surely the puffer-fishes, porcupine-fishes and box-fishes. The puffers and porcupine-fishes have a globular body and by swallowing air can blow themselves out to a spherical shape, so that they float at the surface like bladders. When they are going to resume their normal mid-water existence, they get rid of the air they have swallowed and this takes some time. This distension raises the many-rooted spines set in the skin and thus puts them on the defensive. The puffer-fishes, (*Tetraodon*) have four tooth-plates, two in each jaw, while the porcupine-fishes (*Diodon*) have only two. These strong plates enable them to browse on the coral and to break off the branches so as to extract all the nutritive material. More than one pound of pulverised coral has been found in the stomach of large porcupine-fishes. The appearance of all these fishes is somewhat grotesque, for as well as being "puffy" their round, wide-set eyes give them a startled, surprised look. Marblings and eye-spots of their colour pattern have the right sort of shades to make them blend with those of the reefs. Some rather exceptional species, like the lagocephalids, which venture into the open ocean and may even swim far away (they have been found as far as Ireland), assume the colouring of pelagic fishes, having dark backs and silvery flanks. The box-fishes (*Ostracion*) have the body enclosed in a very strong shell, formed of hexagonal plates fused solidly together. This bony box is rounded, trapezoid or triangular in cross section; there are often spines set above the eyes and emerging from this armour is a well-muscled caudal peduncle which supports the backward-placed dorsal and anal fins and acts as a propelling device. So long as they are not pursued box-fishes hardly try to move at record speeds, but tend to lead a lazy and peaceful existence among the corals. Shining on their brown or greenish shells are bright-blue, iridescent spots or purple or emerald ocelli. A number of serrated teeth in the narrow mouth enables them to chew up polyps, worms or small crustaceans.

The narratives of the old seafarers who went "to the islands", also tell of a nostalgia for the care-free and easy life they once knew in these blissful parts of Oceania, and in the East or West Indies. To their descriptions of terrestrial beauty may be added all that is conjured up in the magnificence of this fairyland of coral.

From the Nile to the Congo.

On the walls of the Cities of the Dead, Egyptian artists drew calm and peaceful scenes to recall the sweetness of earthly life to the troubled souls of the Pharaohs. To provide for the needs of dead and departed kings they conjured up the wealth of food in the waters of the great river, the source of all fertility. There are fishermen with their nets, lines and traps catching many fishes, which are well drawn and easily recognisable. In this way the first list of Nile fishes was drawn up four thousand years ago and there are few items that can be added to it. This deep knowledge of aquatic life is reflected in their many hieroglyphic signs, some of which are remarkable stylisations of certain fish species. Fishes were ardently worshipped in Egyptian towns and they became the tutelary deities of cities. Mummies of these sacred animals were ceremoniously embalmed and have been discovered centuries afterward.

The mormyrid fishes were especially worshipped at Oxyrhynchus and the killing of one of these stirred up a bloody war with the people of Cynopolis in the first century A. D., requiring

the intervention of the firm but impartial justice of the Romans. These mormyrids, which are entirely African fishes, are strange creatures with a proboscis-like snout ending in a tiny mouth; with this they root in the mud and crannies to suck in small prey. They spawn among the vegetation along the river banks. One of them (*Heteropisus bebe*) lays bare the roots of reeds as a place for its eggs. After four days' incubation the larvae that hatch attach themselves to the roots by means of mucous threads secreted by special glands on the head. At the end of five or six days, having digested the yolk sac, they leave their supports and begin to swim in the muddy waters. *Gymnarchus niloticus* is a small eel-like mormyrid without pelvic fins; it builds a four-cornered nest among the reeds. Three sides of the nest float at the surface while the fourth is immersed to a depth of 4 to 8 inches. The larvae, which have large yolk sacs and external gills, develop within this shelter and only leave it when these temporary organs have disappeared.

The special posture of a cat-fish (*Synodontis balensoda*) was not unnoticed by the Egyptian painters of the Pharaonic periods: this cat-fish has the habit of swimming belly-upwards at the surface and this unusual position has led to changes in its colour pattern. The underparts are brown or black, while the back, which is always shaded, is whitish. The electric cat-fish (*Malapterurus electricus*), the raad or thunder-fish, lives in African rivers. Moving very slowly and living in partly obscure conditions, it waits for some prey to pass within reach and strikes it down with an electric discharge. The electric organs are formed of transversely directed plates set in a layer of gelatinous tissue between the skin and muscles of the trunk. When its victims are paralysed and dead, the electric cat-fish leaves them to decay a little before eating them.

In the Nile a serranid fish, *Lates niloticus* takes the place of our European perch. It is a voracious animal and a fierce enemy of any of the small fishes belonging to the Cichlidae, a family studied by the French scientist Pellegrin. In the main, these fishes look like wrasses or perches and they are able to live in fresh or brackish water and even to cross an arm of the sea. In the past they came from America and followed the shore-lines of the vanished continent of Archibelenis joining Brazil to Senegal. Then they swarmed in the rivers and lakes of Africa and even reached the Near East for they abound in Lake Tiberias. The legend of the miraculous draught of fishes has been attributed to a massing together of the fishes in this lake. The cichlids are able to tolerate temperature changes as well as those of salinity. The *Tilapia* of Lake Magadi in Kenya live in waters with a temperature from 40° to 45°C. More characteristic eurythermal and euryhaline types of fishes could hardly be found. They are very voracious and this increases their great vitality. The males are distinguished by humps of fat placed on the back, these being found in both young and very old animals. Some species build nests; others take the fertilised eggs into the mouth, between the gill filaments or in a pocket formed by bones at the back of the throat. The larvae develop in this secure shelter until they are able to look after themselves. Even when they have emerged, the male and female watch carefully over them.

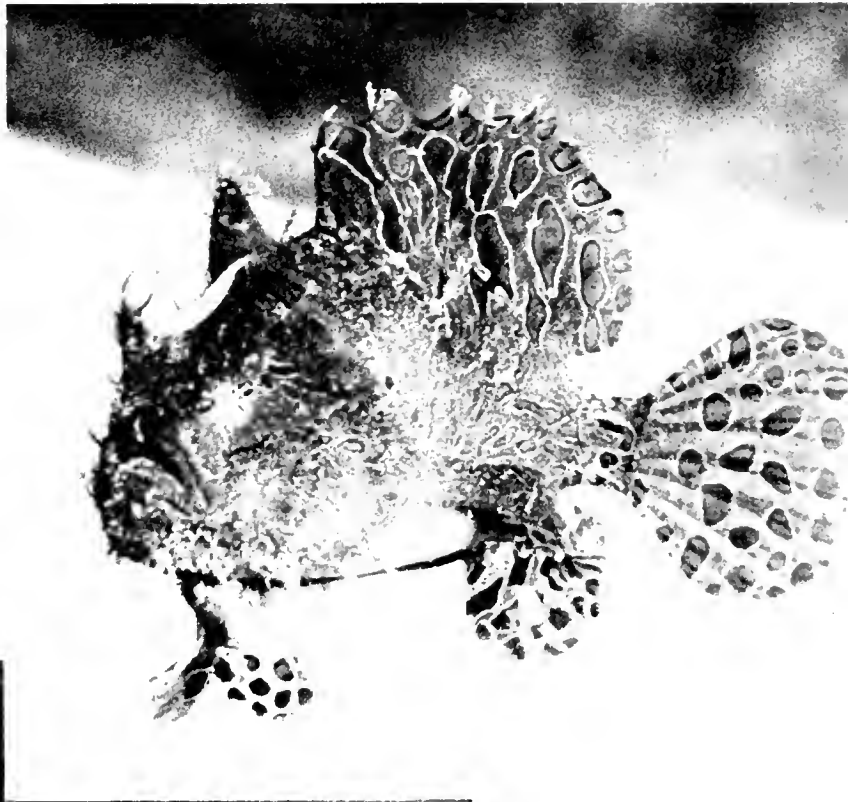
In the Nile there is a puffer-fish (*Tetraodon fahaka*) which is related to those that swim among the corals. Its small spines bristle when it takes in air and blows out its abdomen. The ancient Egyptians who called it "chept", thought this was a form of dissatisfaction. The Arabs thought its round and startled-looking eyes showed terror, and called it fahaka, which name has been adopted in Britain.

The waters of the cone-shaped Nile delta leading to the sea are full of fishes. Grey mullets, which enter arms of the Nile and the lagoons, are abundant in the brackish waters.

Most of the Egyptian fish species are met with again in Lake Chad. In the Congo basin, the fauna of which has been described by the ichthyologist Boulenger, characin fishes abound. They are fairly near relatives of the cyprinids, but like the salmonids have a small adipose fin in front of the tail. The many species have very different habits. Some are harmless herbivores, while others are fierce predators. Among these latter are the tiger-fishes (*Hydrocyon goliath*), the kelb-el-bahr of the Arabs (and of our terminology), which may reach a length of more than 6 feet. It does not even fear the crocodiles. With its strong teeth it is able to cut through the copper traces of the hooks of fishing-lines. It can only be killed by spear thrusts,



A spotted frog-fish.
Above : fishes are attracted by the
twitching of the filamentous bait.



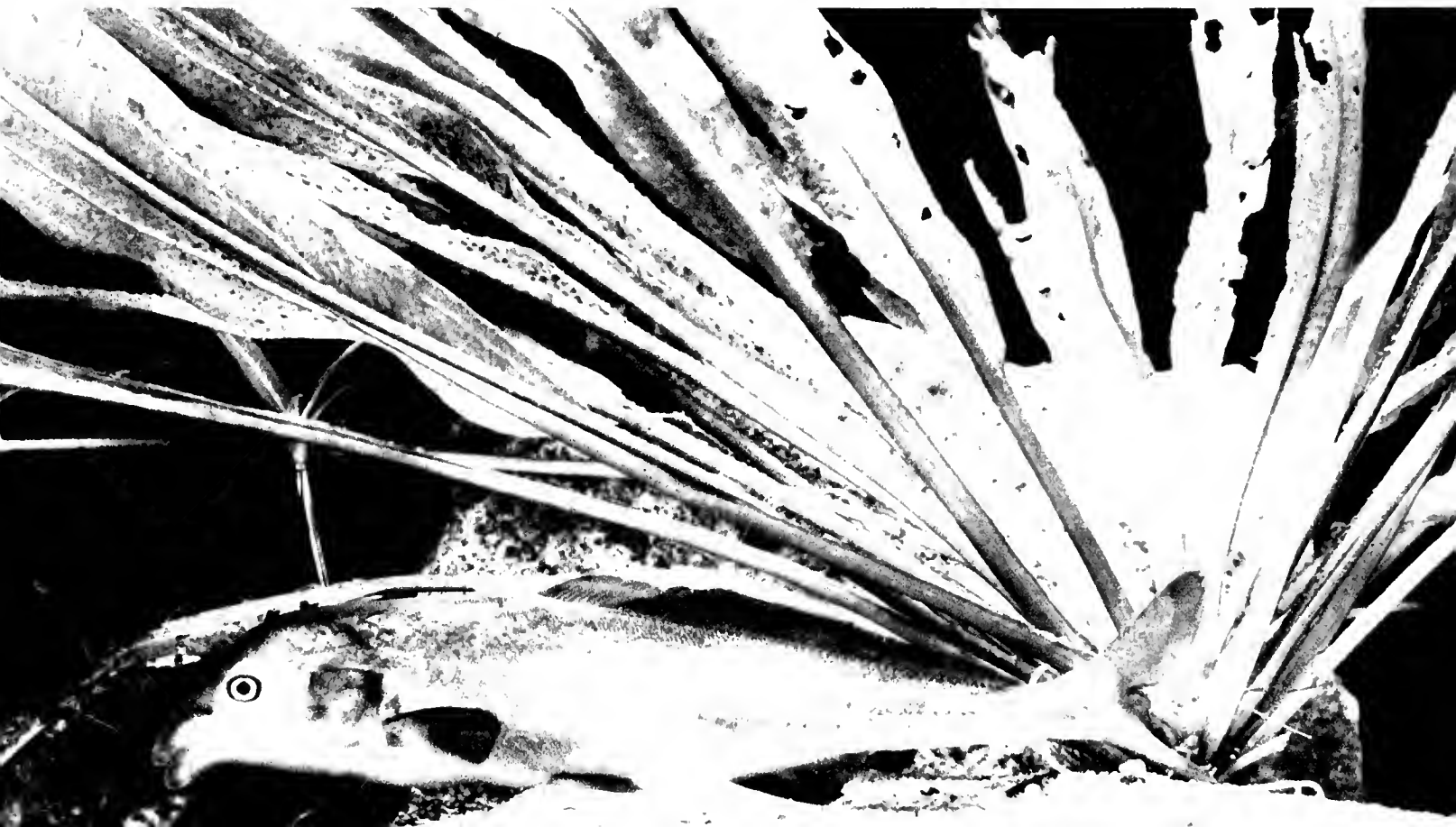
Below : the victim draws near and the
frog-fish is about to seize it. Photo-
graphs New York Zoological Society.





A mormyrid fish (*Mormyrus lanius*) from the Congo.

Another tube-snouted mormyrid (*Gnathonemus*).
Photographs New York Zoological Society.





The electric cat-fish (*Malapterurus electricus*) from African fresh waters, Congo. Photograph by J. M. Baufle.



Cat-fishes (*Synodontis nigricentris*) which swim upside-down. Congo. Photograph New York Zoological Society.



A feather-back (*Notopterus afer*) from the Congo Basin. Photograph Société Royale de Zoologie d'Anvers.

A puffer-fish from fresh waters, the mbu (*Tetraodon mbu*); deflated and swimming along the bottom of the Congo. Photograph Société Royale de Zoologie d'Anvers.



after heading it off into small creeks along the banks. Contrarily, other characins like *Distichodus* are small, graceful creatures with an elongated body striped with long black bands. They browse among the reeds.

In the clear waters of the Congo swims a fine cyprinid, the biriki (*Barbus tropidolepis*). Like a salmon, it leaps in the waterfalls and torrents. This species, which may exceed three feet in length, has a first-rate flesh and is intensively fished.

Mormyrids and cichlids are still found at the equator, the latter fishes being particularly abundant in Lake Tanganyika. The mbu (*Tetraodon mbu*), a puffer-fish closely related to the Nile species, often floats at the surface in a quite distended state. Unfortunately, it may be spotted by young Congo natives, who use the poor animal for a football match and then throw it back into the river where it deflates with all possible speed so that it may sink and recover from its emotion. Along the banks, a small greenish, silvery fish sometimes rises into the wind to glide with its outspread pink-coloured fins. It is the chisel-jaw (*Pantodon*), and was first observed by M. de Brazza.

Because of its constant climatic conditions, the nature of its soil and also because of the difficulty of penetrating its interior, which hinders the ravages of so-called civilised people, the African continent is peculiar in retaining animal species that may have disappeared elsewhere. It is the "chosen land" of "living fossils"; elephants, giraffes, aard-varks, okapis and other mammals, without counting the last descendants of old human races. These still manage to survive in the dense forest or in the savannahs, shielded from the hunting or colonising incursions of the so-called pioneers of European progress.

In the aquatic province it is much the same. In sight of hippopotamuses and crocodiles there remain a few fishes that have disappeared elsewhere. The bichirs (*Polypterus*) were the last known crosspterygians before the recent discovery of the coelacanth. The species of *Protopterus* are among the last of the lung-fishes and the osteoglossids are archaic teleosts. The bichirs, (*Polypterus bichir*), which survive in the basins of the Nile, Niger and Congo, have a very long body armed with oblique rows of shining lozenge-shaped scales. Along the back the fin is broken into a series of discrete spines, followed by some soft rays. These fishes remain motionless on the mud, the head raised and propped up by the lobed pectoral fins. When the water is very stagnant they swim to the surface to gulp pure air. The spawn is laid on the underwater banks and out of the eggs come attractive looking fry with black and golden stripes. They bear long, feathery external pink gills which disappear at the end of development.

Devonian fishes used to live in marshes at the boundaries of red-sand deserts. But the heat of the very warm summers completely dried up the mud in which they were buried in their search for cool surroundings. Deprived of water, they became adapted to these hostile natural conditions. Their swim-bladder became a lung and so they were able to breathe in oxygen directly with the air. These fishes with two ways of respiration are lung-fishes and one representative of this group in Africa is *Protopterus annectens*. During the rainy season it is active, hunting for frogs, crustaceans and worms, and fighting with members of its own kind. But at the dry season, when the waters are beginning to disappear, it hollows out a burrow in the mud. It rolls itself up in this hole, and glands in the skin secrete a mucus, which is made into a cocoon, with a single opening to which the lips of the fish are applied. In this way it remains motionless for several months in a state of suspended animation, slowly digesting its accumulation of fat reserves. When the waters once again invade the swamps, the lung-fish leaves its protective cocoon and begins to experience the irresistible urges of the breeding season. The eggs, which are laid in a hole in the mud, are guarded by the males, who have made a small hidden exit at the bottom of the nest, through which they can escape amid the reed beds without attracting the attentions of predators, avid to gobble up the brood. The young fishes look like salamander tadpoles with feathery, pink, external gills. During the daytime their colouration blends with that of the mud but at night they become transparent and invisible through the contraction of their colour cells. After a month in the nest the fry lose their external gills and acquire a lung through the transformation of the swim-bladder. The habits of all these African fishes have been studied by the English scientist J. S. Budgett.

Large osteoglossids (*Heterotis niloticus*) swim ponderously in the neighbourhood of the

African lung-fishes. The massive body is invested with heavy bony scales, but these primitive bony fishes are not adapted to an aerial existence and must keep to the rivers and marshes, while avoiding dried-up conditions. Like the North American bowfins, they build large nests of about a yard in diameter in the reeds by crushing the plants with the tail and the weight of the body. The females lay numerous eggs which soon hatch. The larvae, which have large gill filaments of a fine red colour, reach the surface and swim around in the enclosure of the nest. The next day they form into a round-shaped school in the middle of this little pool. Then they shed the external gills and on the fourth day they venture outside, being watched over by the parents. A little later they are able to lead an individual life.

At the mouths of the great rivers and along all the African coast from Gambia to Angola extends the littoral belt of mangroves, which Aubert de la Rüe has described in his book "The Tropics". Crabs scuttle around the roots on which oysters are growing, and in this tangle of plants, numerous fishes swim around. This is the home of cat-fishes, which root in the mud with their many barbels (*Arius*, *Clarias*, *Chrysichthys*, *Galeichthys*). Not far away swim thread-fins (*Polynemus quadrifilis*). On the sides of the head they have a gelatinous mask and their pectoral fins carry long thread-like rays which are used for exploring in the mud. They are excellent food fishes of great economic importance to the riparian populations. Grey mullets are also very numerous. All these fishes fear the passing of the mangrove swamp predators, the barracudas, the becuna of the West Indies. These large voracious beasts with their very elongated bodies, which may be more than 6 feet in length, stir up much the same kind of fright in brackish waters that pikes do in fresh waters. Native fishermen fear barracudas at least as much as they do sharks and merciless struggles are waged in the shade of the mangroves.

Descending the Amazon.

In the torrents that come from the eternal snows, under the cold, unflinching stare of condors and black eagles, are fragile fishes that are adapted to the unusual surroundings of mountain streams. They live among the towering peaks of the Andes and cling to the rocks, where they withstand the violent shocks of the waters. They are a line of evolution of the mailed cat-fishes (loricariids), which live in tropical rivers. But in their ascent to the deep basins hollowed out by whirlpools, where they find shelter from voracious enemies, they have lost their defensive armouring. By an enlargement of the lips the mouth of *Cyclopium* has been turned into a powerful sucker and the lower surface of the pelvic fins has been similarly modified. With this double means of support the fish are able to struggle against the currents and to progress while clinging to the vertical walls of rocks. The prenadillas (*Arges*, *Stygogenes*) penetrate into the subterranean streams of the cordillera, which run in volcanic fissures. An eruption, which made them leave their inaccessible retreats and move with the torrents of mud and cinders coming out of the craters, first brought them to light.

Numerous streams run down the slopes of the great mountain chain and unite in the Brazilian plain to form the great river. In the shade of the forest at the rainy season all these streams overflow and when the floods retreat, marshes and watercourses are left under the cover of the trees and lianas. Here are found loricariids that have kept their armouring. Some, such as *Acestra*, have a tapering body ending in a tubular snout and look rather like the marine pipe-fishes. Others, like the chaetostomids, are more heavily built and resemble the armed bullheads or agonid fishes. Under the chin of the males there are outgrowths of the skin and numerous barbels. They root in the river mud by the side of cascadas (*Callichthys paleatus*), cat-fishes invested with a carapace formed from a double row of overlapping plates that are joined at the level of the lateral line and arranged according to the body segments.

Another cat-fish, *Doras*, leads a more active life. It is unarmoured and moves along the river banks at great speed, running on its pectoral fins, which are assisted by vigorous beats



of the tail. These movements, which may extend over several days, enable it to pass from one river to another. The related aspredinids have a curious way of ensuring the incubation of their offspring, the care of which reverts to the females. The skin of their bellies becomes soft and spongy before spawning and as soon as the eggs are expelled and fertilised, they lie on them in such a way that they become incrustated in their soft abdomens. Small pits are formed in the skin, and in these the eggs are enclosed until they hatch.

All who have read Jules Verne will be aware that descending the Amazon is not without its risks. Furthermore, he has not described all of the dangers. A native recklessly venturing into the waters of the great river may be cut into pieces by the piranhas (*Serrasalmo*). Like the terrible tiger-fish of African rivers they are characins and are even fiercer than this species. Crowds of them live together in shoals and they travel with amazing speed when they have scented blood, even if this has come from far away. With their sharp-edged teeth they can cut a man into shreds.

If the foolhardy man has escaped the bites of piranhas, he may get electric shocks from the electric eels (*Gymnolus electricus*) or trembladores. According to travellers, these discharges may be strong enough to stun a horse. They are eel-shaped fishes without a dorsal fin, but there is a very long anal fin. The electric organs are carried in the very long tail and consist of two masses of tissue running longitudinally under the lateral line.

Our unfortunate Brazilian may be more insidiously attacked by candirus (*Slegophilus insidiosus* and *Vandellia cirrhosa*), small cat-fish of the family Trichomycteridae. They are rather less than 2 inches in length and have become parasites of the larger cat-fishes, gliding about within their gill chambers, inflicting wounds and sucking the blood. But they can also enter the urinary organs of bathers, doubtless during micturition. If surgical attention is not speedily given, the candirus enter the bladder and set up fatal inflammation.

But less harmful creatures live in the Amazon, such as the toothed-carps (cyprinodonts), which are attractive fishes well enough known to amateur aquarium keepers. They are viviparous and coupling fishes, the sexes being readily distinguishable. As well as having more brilliant colours, the males carry a conical papilla in front of the anus. This priapium is directed to the right or left and there are bony appendages for holding on to the female. In some species (*Anableps tetraodon*), the female has a special scale (foriculus) concealing the genital pore and an opening is left at one of the sides. Coupling is then carried out laterally and a male with a priapium pointing to the right must pair with a female having a left-handed opening to the foriculus. In addition to these sexual peculiarities *Anableps*, the "four-eyed" fish, has a special visual device. Connective tissue divides each eye into two parts, the upper being adapted for aerial vision and the lower for seeing under water. When poised at the surface the fish can then watch for flies as well as for aquatic creatures.

The Amazon basin is the land where the cichlid fishes originated and where they abound. Moreover, when a group of fishes becomes isolated in a watercourse they quickly become modified, like the trout of European rivers. The most beautiful of the Brazilian cichlids is the well-known angel-fish (*Pterophyllum scalare*), which has a shape very like that of some coral fishes. Its flattened body extends upwards and downwards into high fins. The general colouration is light in shade with large black vertical stripes, these colours matching this superb fish with the upright stems of the aquatic plants, among which it moves in a slow and stately fashion. In these surroundings we once more meet with a lung-fish and osteoglossids. The lung-fish, *Lepidosiren paradoxus*, swims in swamp waters beneath the plants, carefully avoiding the caymans, which are greedy for its flesh. Occasionally it rises to the surface to breathe in a little pure air. At the dry season it hollows out a tunnel and blocks up the end of its shelter with a clay plug, perforated by small round holes. When the dried-up pools are once more covered with water it resumes an active life. The nests are horizontal passages about a yard long, excavated in the mud. The male guards the eggs and his care never fails, for he is even able to breathe in stagnant waters by means of red filaments on the pelvic fins, which form accessory gills. The osteoglossid companions of *Lepidosiren* are among the largest fishes. The arapaima can exceed a length of 15 feet and weigh more than 400 pounds.

Across the Brazilian landscape with its luxuriant equatorial forest vegetation the immense

volume of waters making this giant river flow until they reach the Atlantic. The sea-water barrier cannot halt their course and in the open sea more than 10 miles from the great delta the fresh waters of the Amazon are still to be found at the surface.

The swamps of Asia.

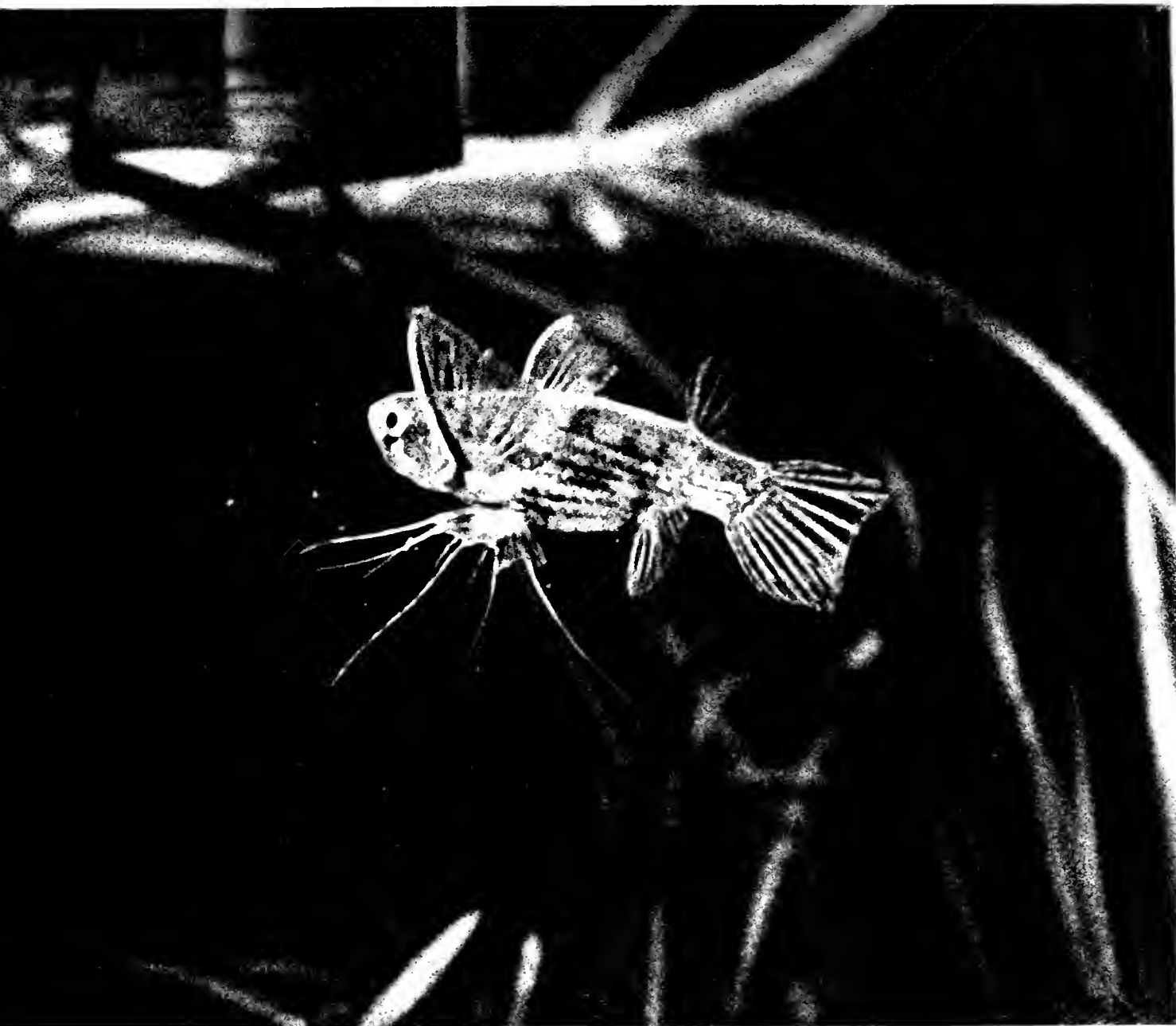
The moisture-laden air lies oppressively over the lower plains with their gently rustling bamboos. It overlies rice-fields, the deltas of great rivers and the stagnant waters of marshes that are hidden under a treacherous carpet of water-plants. The potent scent of vegetation rises in the heat and the odours of a swarming life are mixed with the unpleasant smell of decay. In the dense shade of the great trees there is no breath of wind. The fierce, dazzling rays of the sun stream into the dried-up clearings where the mud cracks into hexagonal patterns. Both brackish and fresh waters are rank, and for a long time any trace of life-giving oxygen has been wanting. The boundaries of banks become indefinite, for among the plants the muddy water-sides merge into the mire of the swamps.

Tired with swimming in these overpowering surroundings, the fishes slither over the bottom, where they find some food. Then fleeing from the stench of the polluted waters, they rise towards the sun and the pure air. Some species have become eel-like. Wriggling along, they emerge from the disturbed depths of pools to shelter under the moisture-laden leaves of reeds. The *cuchia* (*Amphipnous cuchia*) has assumed the form of a snake, the pectoral and pelvic fins having disappeared, while the unpaired dorsal and anal fins are reduced to mere feeble folds of skin. This symbranchid fish leads an amphibious life. When it is in the water it often rises to the surface to gulp in air but it does not stay there long and is often found lying on the banks.

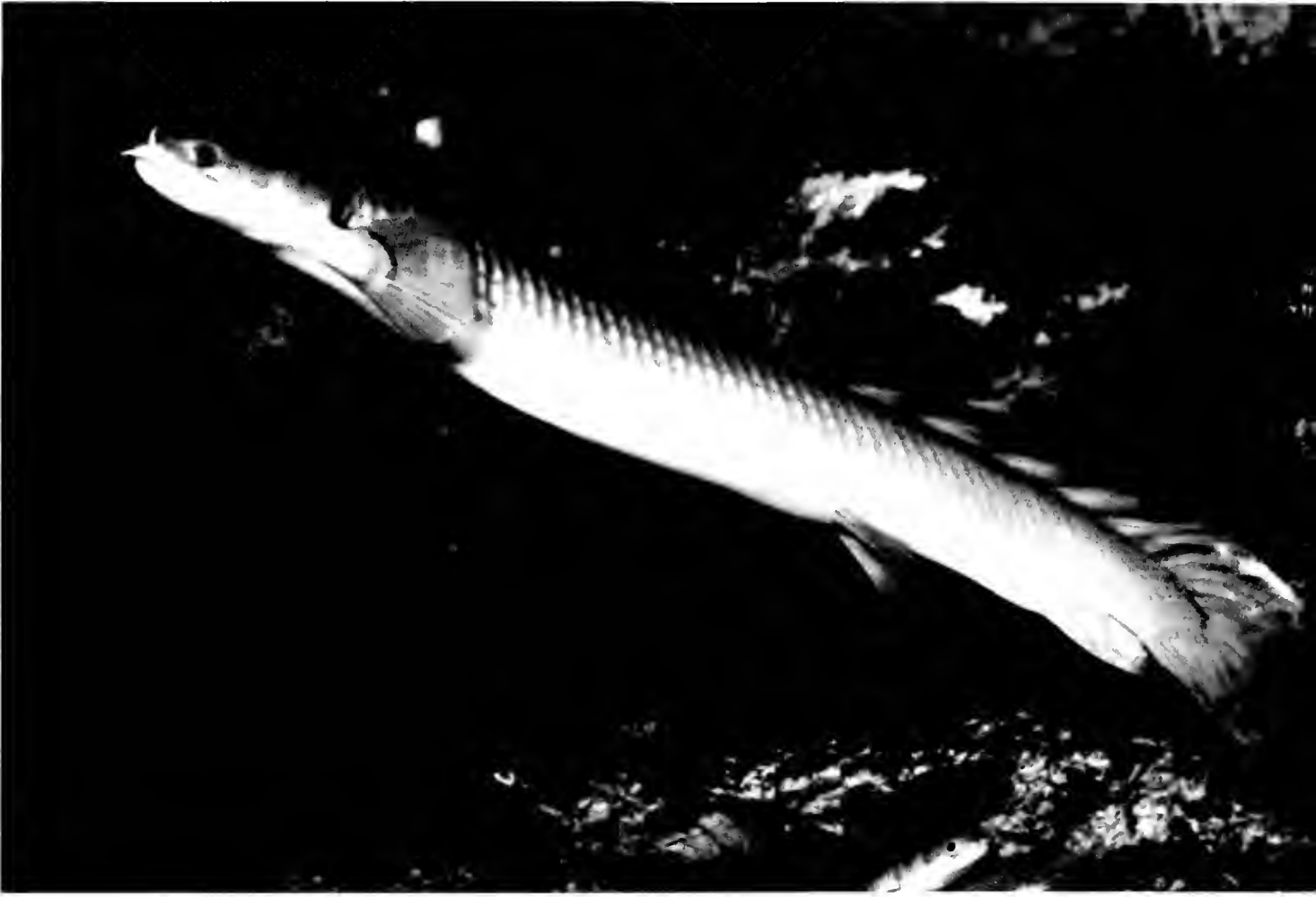
Another eel-like fish *Rhynchobdella*, of the family Mastacembalidae, has appendages at the end of the snout that enable it to burrow in the mud. It is claimed that this animal is so well adapted to an aerial life that it "drowns" if unable to breath atmospheric air. The anabantid fishes (*Anabas scandens*, *A. leshudineus*) have the standard fish shape and they belong to a family related to grey mullets. However, they can travel out of water with a surprising speed, which has led to the popular name "mouse". Their gill complex consists of a cavity filled with elaborate lamellae, which enable them to store a small amount of water. Guarded against the rigours of a long stay out of water, they travel over land by heeling over and using their gill-cover spines as crampons. The scales along the tail-stalk are very spiny, thus affording them extra purchase. By this method of creeping they can cover long distances. The snake-heads (*Ophiocephalus striatus*), which are related to the anabantids, have a more elongated body, edged above and below by long fins. They have labyrinthine respiratory organs. They seek out the moisture-saturated plants along the banks but also remain for a long time in the foul and overheated waters of the swamps in conditions that other animals could not tolerate. A snake-head from Ceylon, *Channa*, has become eel-like and leads much the same kind of life as the *cuchias*.

In the brackish waters of the great deltas of the Mekong and the Irrawaddy, and going up into marshy waters, there is a goby called *Periophthalmus*. It hops along the clinging-roots of mangroves or perches itself, while supported on the fork between the pectoral fins, on a stone in the full glare of the sun. With its head raised, it ceaselessly scans its immediate surroundings with its bulging mobile eyes. When the gills become dry from the intense heat it trails its tail in the water and is able to respire through the very thin skin.

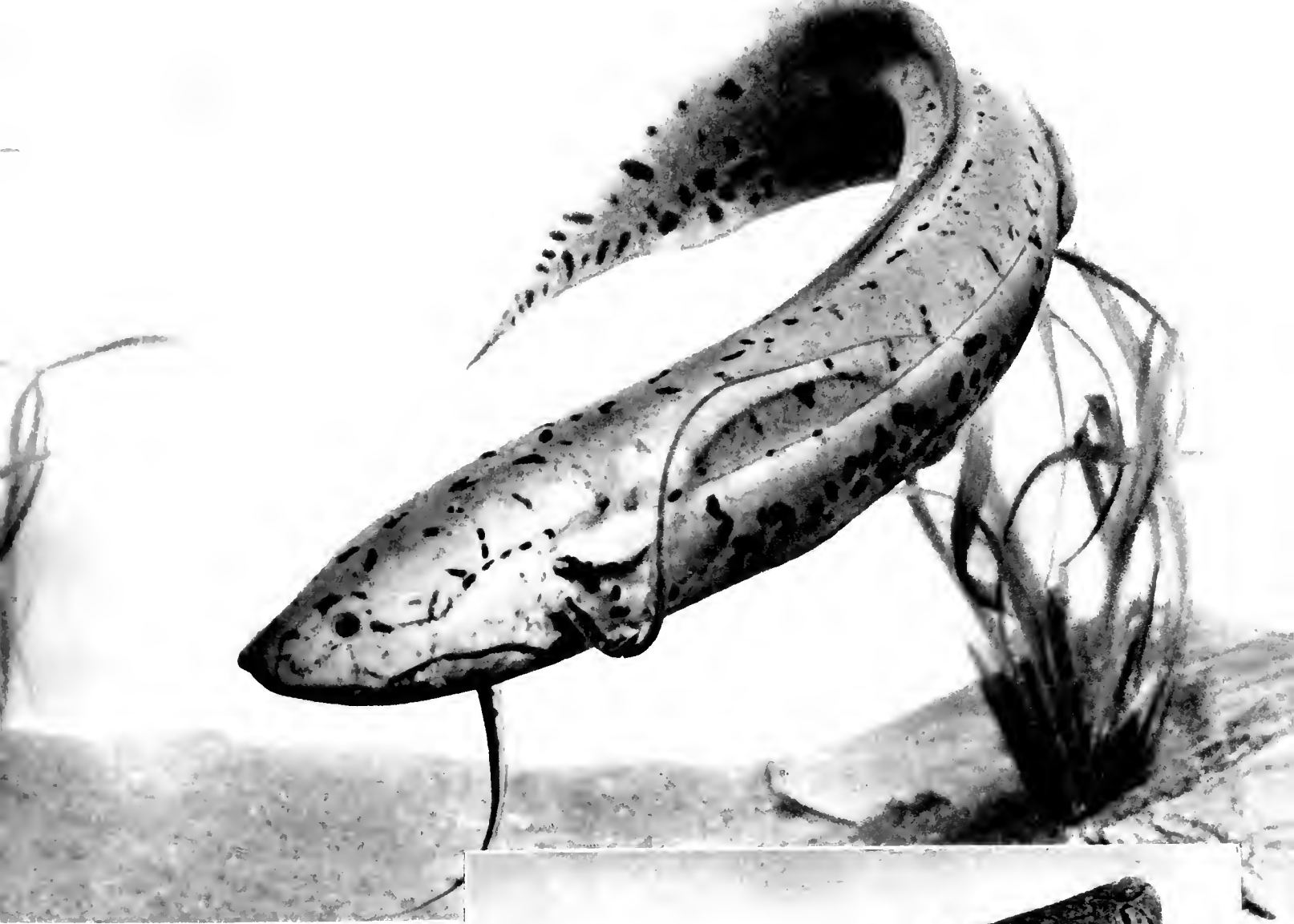
Near the river banks in the East Indies, the archer-fish, *Toxotes jaculator*, lives among the reeds. It is well known for the way in which it catches flies. When one of these insects hovers near the surface, the fish shoots out of its mouth a large drop of water, even when its prey is a fair distance (sometimes more than three feet) away. The drop rarely misses its mark and the shot-down fly is immediately swallowed.



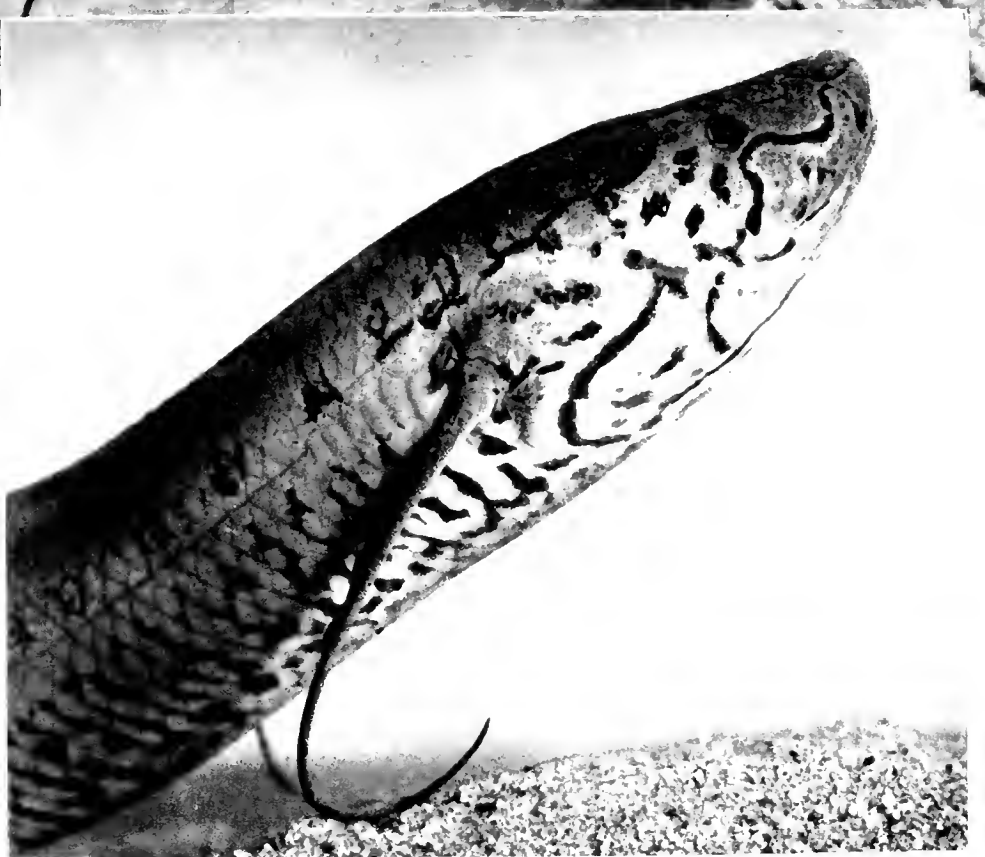
The small flying-fish (*Pantodon*) from the river Congo.
Photograph Société Royale de Zoologie d'Anvers.



The bichir (*Polypterus bichir*), an archaic fish from African fresh waters. Photograph by J. M. Baufle.

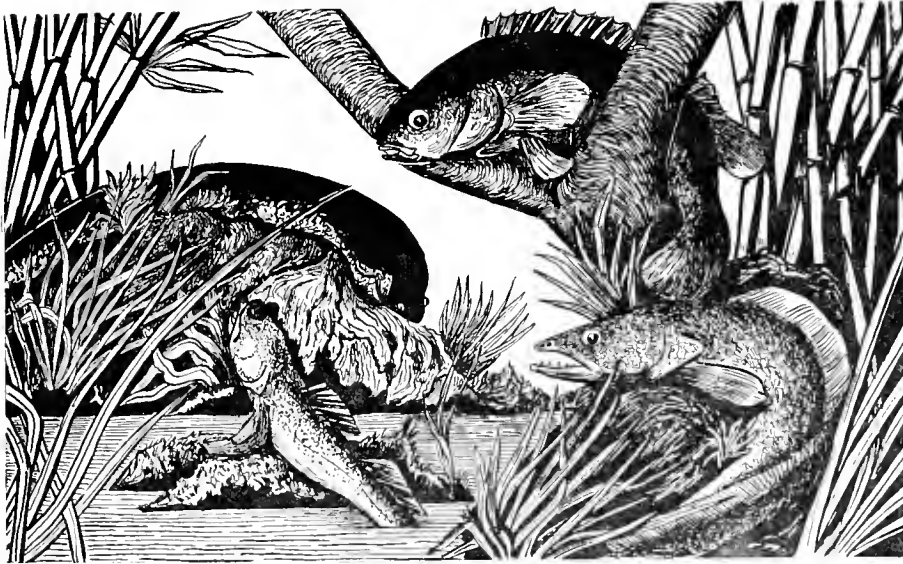


An African lung-fish (*Protopterus annectens*). Photograph by J. M. Baufte.



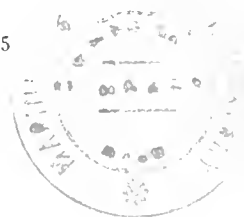


Blind, pallid fishes (*Coccocharbus*) from dark caves in the Congo. Photograph New York Zoological Society.



In the tropics in a brackish water pool. *Periophthalmus* with its tail in the water. Above it, the euchia. On the right of the picture, perched in a tree, *Anabas testudineus*; below this, *Ophiocephalus striatus*.

The osphronemid fishes live in the clearer waters, such being the gourami (*Osphronemus olfax*), the paradise-fish (*Macropodus opercularis*) and the fighting-fish (*Betta pugnax*). The nests of these three species are made of air-bubbles blown by the males, who secrete a sticky mucus around the bubbles which come together at the surface to form a kind of dome, providing shelter for the eggs. The gourami and the paradise-fish have floating eggs but those of the fighting-fish are heavier than water. This bellicose animal swims right up to the female, turns her over and grips her tightly. During this embrace the eggs are extruded and fertilised. The male then takes them in his mouth and rises to the surface, sticking them under the raft of foam. Then he watches over them and for several days after hatching stops the fry from going far away, keeping them in their artificial shelter. The prowess of fighting-fishes, which has excited the Siamese since time immemorial, is well known. Considerable sums of money are staked on these fights and the state budget draws a substantial levy.



CHAPTER V

SOUTHERN REGIONS

In the land of the coelacanth by J. MILLOT, *Professeur au Muséum National d'histoire naturelle, Directeur de l'Institut de recherche scientifique de Madagascar.*

The Western Indian Ocean, with its many islands of all sizes — Madagascar (really a small continent), the Mascarenes, the Glorieuses, the Comoros, the Aldabra group, the Seychelles and small barely emergent reefs in the north of the Mozambique Channel — is one of the most enthralling for the traveller and scientist. The peculiarity of the animals and plants populating its archipelagos must be due to isolation, which has lasted for hundreds of millions of years on the great Madagascan land. Owing to this, life has taken forms found nowhere else and archaic species which died out in other regions have survived. In this fortunate region the waters yield little to the lands in interest. The recent discovery off the Comoro Islands of the renowned *Lalimeria chalumnae* has strikingly shown this and put this part of the world — “the land of the coelacanth” — to the forefront in current scientific affairs. After long neglect, there has been a happy revival of oceanographic investigations. Research stations are in full swing at Zanzibar, Lourenço Marques and Durban, while France heads this productive rivalry through the setting up of a fine research centre at Nossi-Bé.

All these groups of zoologists are carrying out careful researches. They are working on whales, the schools of which regularly migrate from north to south; on turtles, from which come tortoise-shell; on oysters, which when cultivated would equal our Whitstables; on molluscs, (burgaux) in great demand for their mother of pearl; on *Murex*, the opercula of which when burned give off a sweet-smelling, cleansing smoke dear to the Arabs, Chinese and Hindus; on brilliantly coloured spiny lobsters; on soft holothurians, “cucumbers” or “sea Priapus”, that crawl over the rocks and are reputed to have aphrodisiac qualities, this ensuring them an unlimited market in China, and drawing junks from the Far East to Madagascan coasts to collect them for several thousand years; on sea-urchins with enormous spines; and on coastal and migratory fishes.

Round-snouted sparids, dorados and sea-breems cruise around the reefs, together with lethrinids, the “captains” of the Indian Ocean, which have a delicious flesh. There are serranids, typified by *Variola louti* (the “yellow crescent”) with a yellow-edged tail contrasting strongly with the red body. In Mauritius this fish is believed to be poisonous and its sale is forbidden, but in the Seychelles and South Africa it is much esteemed. This difference in



appreciation is undoubtedly due to a local variation in diet, for the poisonous power of fish flesh often comes from the stinging corals that are eaten and whose toxins accumulate in the tissues of the fishes. These are also particularly dangerous from March to December during the "flowering" of the madreporic corals.

Agile butterfly-fishes swim in running water oxygenated by the breakers and there are labrids or wrasses, inexpressibly beautiful when alive but losing their colours when taken from the water. The breeding-dress of male *Cheilinus* fishes is most somptuous, but they have no gastronomic value. On the other hand, the lutianids are excellent fishes. They are called "snappers" because of the sudden forcible opening and shutting of the jaws during their death-throes. This can cause nasty wounds on the hands of imprudent Mauritian creoles, who call them "blasted dogs".

On each side of the tail of the acanthurids or surgeon-fishes are erectile spines capable of dealing cruel jabs. The balistids or "cross-bow" fishes with their dorsal fins locked in position, crush the branches of madrepores. A tetraodont or puffer-fish (*Arothron stellatus*) is extremely poisonous because its skin, liver and viscera contain a virulent toxin causing severe pain and death to its predators and, on occasions, to human beings who have tried to eat it. Now and then large carnivorous fishes have been found with a tetraodont in the throat. Fishes that may also be mentioned are: carangids (*Caranx* and *Chorinemus*), tachysurids or cat-fishes, sciaenids or false-whiting, epinephelids or groupers and a great many others.

For the most part these fishes have kept the picturesque creole names that were given them by the first settlers in the Ile Dauphine (Madagascar) or in the Ile de France (Mauritius) or in the Ile Bourbon (Réunion) — names such as "captain long-in-the-mouth" (*Lethrinus migratus*) "drunken woman of the breakers" (*Teuthis nebotus*); "great-tailed surgeon-fish" (*Acanthurus nigricans*); "fallen lady" (*Cheilinus*); "little priest" (*Engraulis baelama*) "blasted red dog" (*Etelis carbunculus*) "cow unicorn" (*Naso unicornis*) and "paving-stone mouth" (*Chrysophrys sarba*).

The powerful, fast-swimming migratory fishes consist of scombroids; yellow tunny, white tunny, sealy-tunny and bonitos. The false-tunnies or scomberomorphs yield nothing to them in the delicacy of their flesh, and the "lamatra" (*Scomberomorus commersoni*) is much appreciated in Madagascar. One of the swiftest sea-dwellers is the peto (*Acanthocybium solandri*). When hunting, it can often be seen making acrobatic leaps, and it is a fine sporting fish. The barracudas, with their accustomed ferocity, roam over the Indian Ocean.

The remoras (shark-suckers) deserve particular mention. These 16 to 20 inch long fishes have a very large sucking-disc — a modified dorsal fin — on top of the head, and this enables them to cling with great tenacity to all floating bodies. They were known to the ancients, having the reputation of being able to hold back galleys. Mark Antony's defeat at Actium was attributed to their immobilising his ship at a critical point in the battle. With naive symbolism remoras are used in Madagascan magic to keep or bring back an unfaithful wife to the conjugal dwelling-place. So as to make her stay at home the sorcerer fastens a small piece of the sucking-disc to her neck. To make her return, he burns the disc in front of the husband's house and guides the smoke in the direction taken by the unfaithful departed-one. Captive remoras, with a long line attached to the tail, are used to catch tortoise-shell turtles. Released into the open sea, they fasten themselves so securely to the breast-plate of one of these chelonians that it is enough to haul in the line to bring fish and turtle alongside.

The rays of the Mozambique Channel include very dangerous species (Dasyatidae), with a long tail armed with a serrated spur connected to a poisonous mechanism. They can inflict mortal wounds. The devil-fish (*Manta birostris*) is a giant ray spanning 20 to 26 feet. There are two large horns on the head and its very narrow digestive canal only allows it to eat small prey. Sometimes it floats at the surface with one of the fins raised above the water or it may make great leaps out of the sea and fall back with a resounding splash. These giant animals are gentle and harmless, but if they are harpooned their struggles may sink the boat of their foolhardy attackers. The sawfishes (*Pristis*) which reach a length of 25 feet, have the snout prolonged into a great flat, bony blade armed with teeth along each edge.

For the most part, the sharks frequenting this region are small sized, being less than 7 feet

in length and belonging to the *Eulamia* group. But in the open sea and at the mouths of great rivers there are tiger-sharks, rightly feared by the natives, for their voracity is quite unrivalled.

We now come to a sea-dweller renowned beyond all others — the famous coelacanth (*Latimeria chalumnae*). We know that *Latimeria* is a large fish — it weighs more than 160 pounds — with most interesting anatomical features and an unusual antiquity. It is a typical representative of the large archaic group of crossopterygians (“tassel-fins”), the ancestors of most present-day vertebrates. Until recent years these fishes were known only as fossils arising in the Devonian period (as geologists call it) more than 300 million years ago. And they were believed to have disappeared from the earth some tens of millions of years from the present time — well before the appearance of the forms of life we see today. The discovery of a living representative is considered to be the most important event of the century in the realm of natural history.

Four years ago, in December 1952, an unexpected gift arrived. One of these animals was caught in the waters of the delightful island of Anjouan in the Comoro Archipelago. Professor Smith, the well-known South African specialist and the author of *Latimeria* was immediately informed; he came after it in a special government aircraft, a trip that aroused keen interest throughout the world. But there were no means on the Comoros for properly preserving the fish and, despite his diligence, eventual scientific examination showed it to be badly spoiled and practically unusable.

But this Anjouan coelacanth could not be the only one. The fact of a chance capture suggested that an organised search would result in others being found. Accordingly, a simple but effective fishing and preservation scheme was at once set up in the archipelago by the Institute for Scientific Research in Madagascar. This was magnificently supported by the French Administration, while a gathering of local doctors and administrators freely gave their services. The project was actively publicised among the local fishermen, each of whom received full, useful instructions and the promise of large rewards. Drawings of the fish were displayed in the villages; stocks of essential preservatives were provided, and means of rapid transport by special air-mail secured.

In less than two years, these measures, to which everyone gave devoted service, have resulted in the sensational capture of nine well-preserved coelacanths, which have come from both Anjouan and Grande Comore. And these incomparable zoological assets have enriched international science.

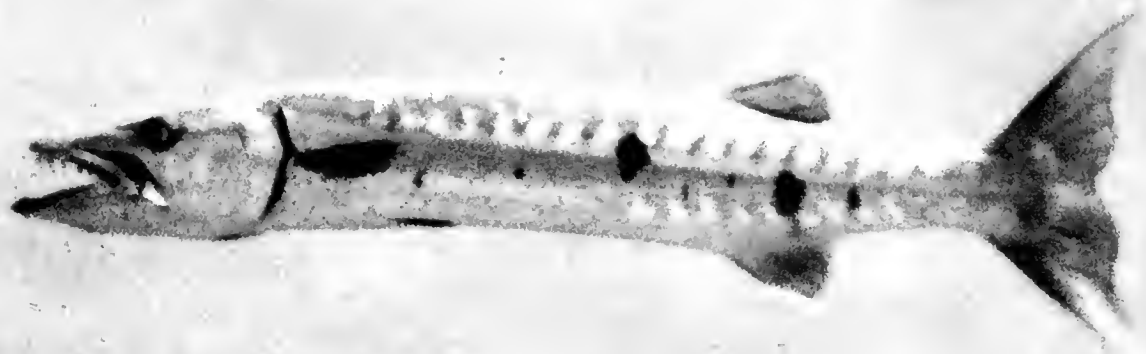
The interest in coelacanths does not reside in their beauty. They are heavy, bulky fishes with a dark-blue colour shading into brown, and invested with large mucus-oozing scales. As soon as decomposition sets in they exude unbelievable quantities of oil.

First and foremost, their peculiar features are shown externally in their fins, which are seven in number. The pectoral and pelvic fins make two pairs and there are three unpaired fins; first dorsal, second dorsal and anal. Except for the first dorsal, all these fins are of a very special type, being carried on stalks which are a real complex of parts and have no equivalent in other fishes. Supported by their own skeleton they have an elaborate system of muscles enabling them to take up a most varied series of positions and giving them an exceptional range of movement. Hence the popular name “paw-fishes” sometimes given to coelacanths.

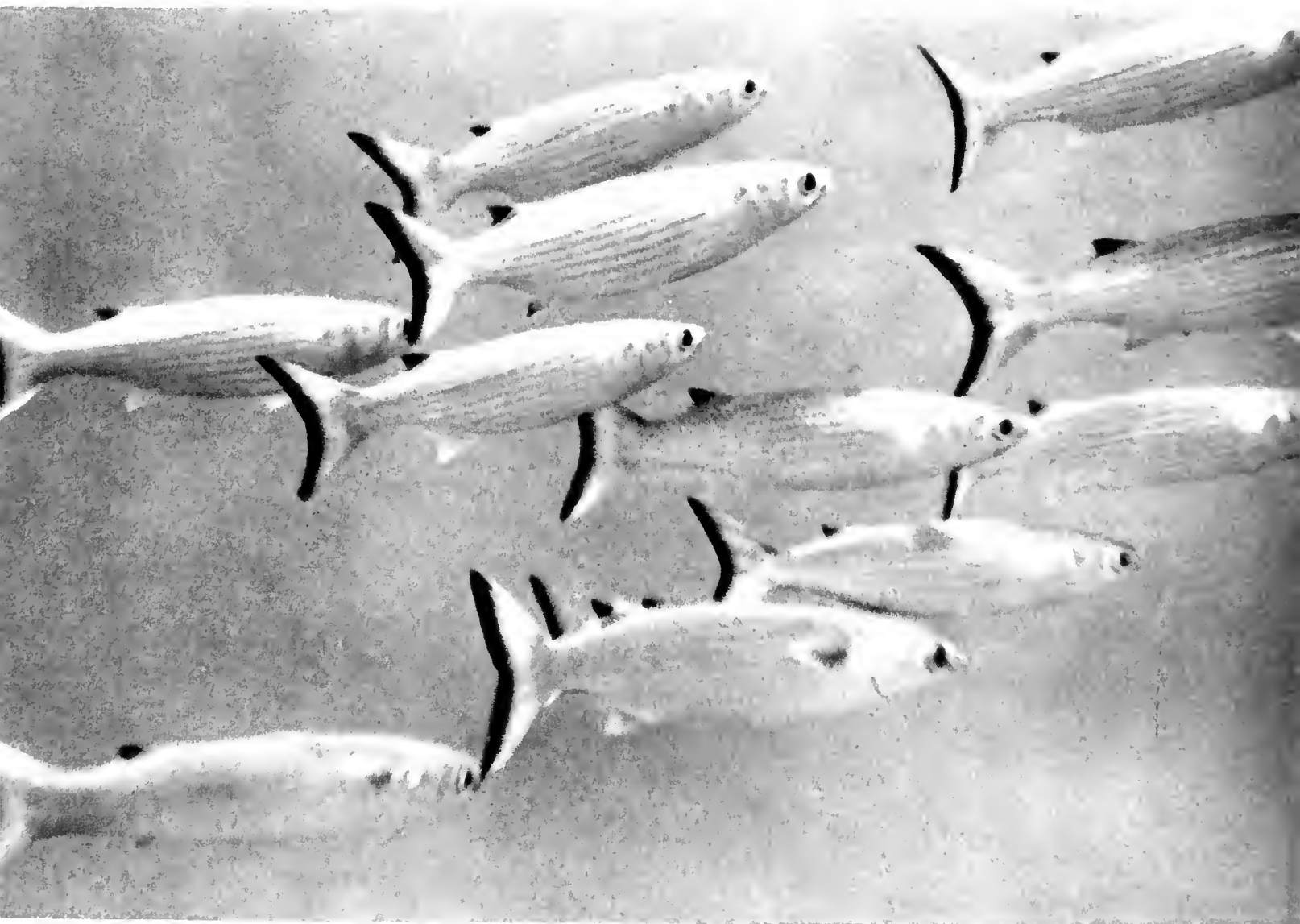
Internally, coelacanths show a complex of remarkable structural arrangements, some being more remarkable than others in that they are only found in the embryos of other vertebrates. Such are the persistence of an almost linear heart, the remains of a lung of large size, a hypophysis still connected to the roof of the mouth and an axial skeleton without vertebrae, being entirely chordal and fibrous in nature.

From a very general point of view, the unusual value of coelacanths is essentially based on three grounds :

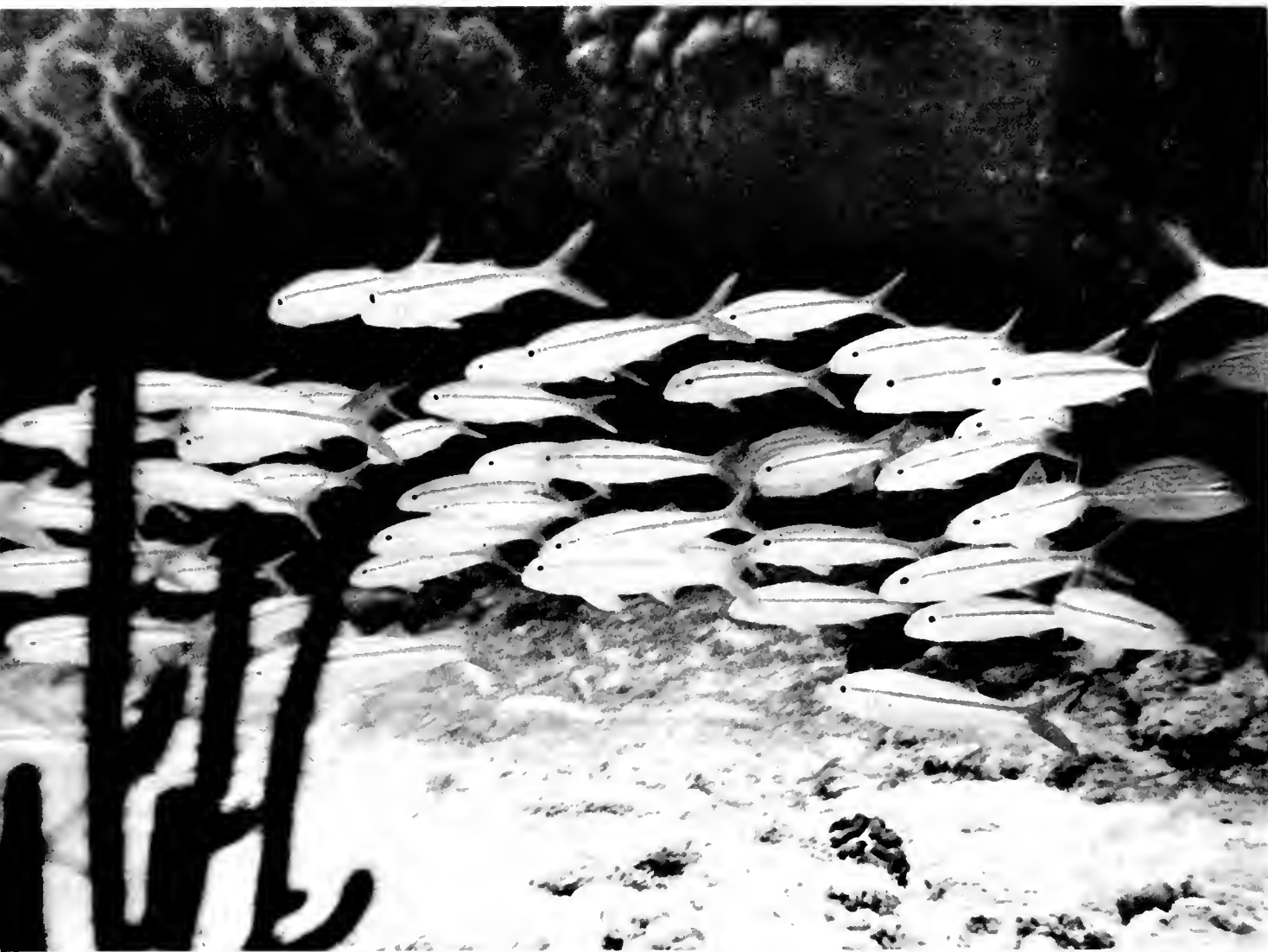
(I) Their very great antiquity. They are by far the oldest of the vertebrates alive today, and from this aspect alone are worth consideration as zoological curiosities.



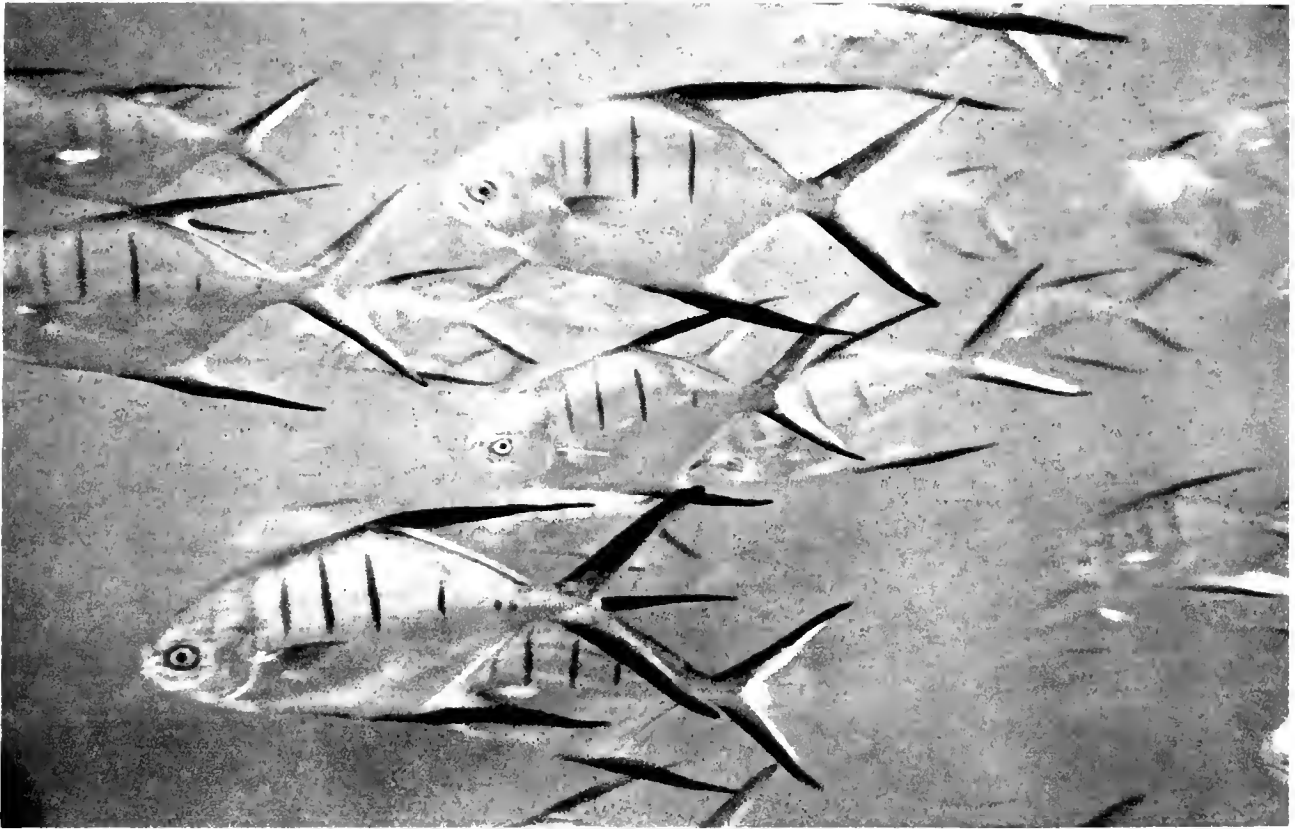
The barracuda (*Sphyraena barracuda*), feared by native fishermen in the West Indies. Photograph by Isy Schwartz.



A shoal of grey mullets (*Mugil curema*) from Brazilian coasts. Photograph by Isy Schwartz.

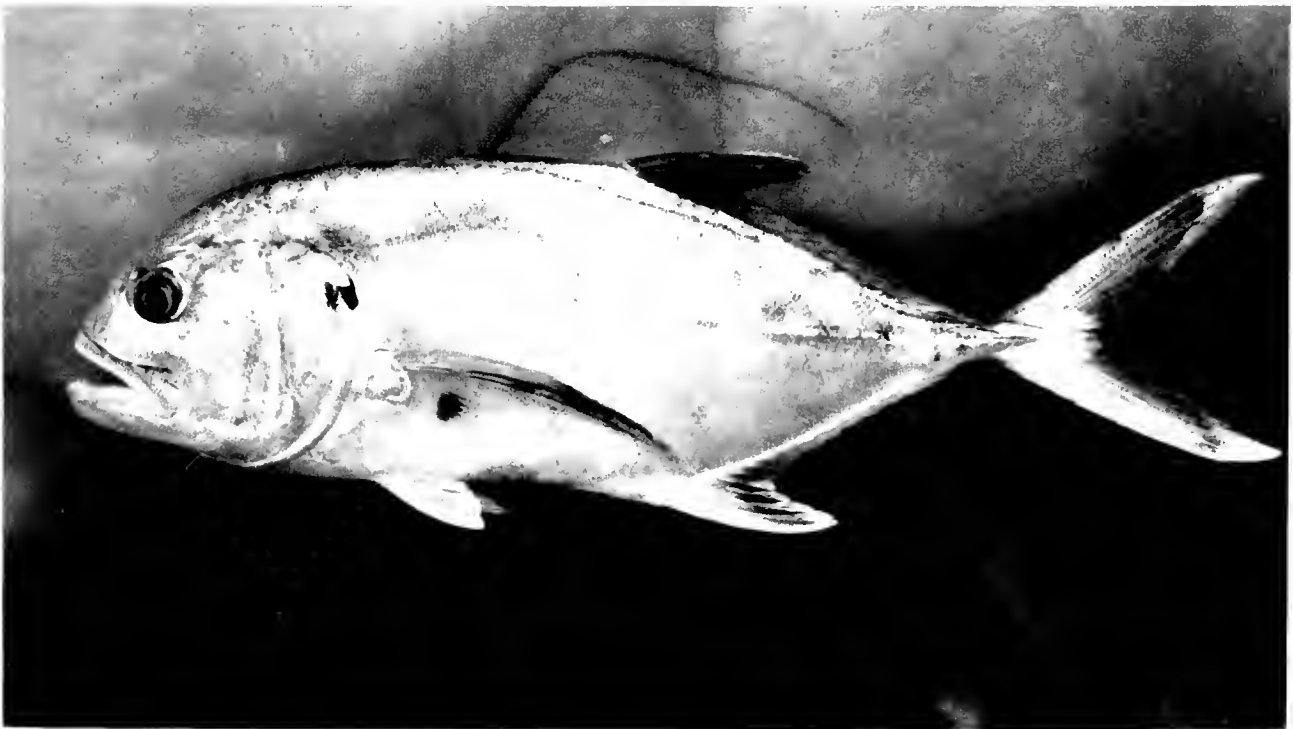


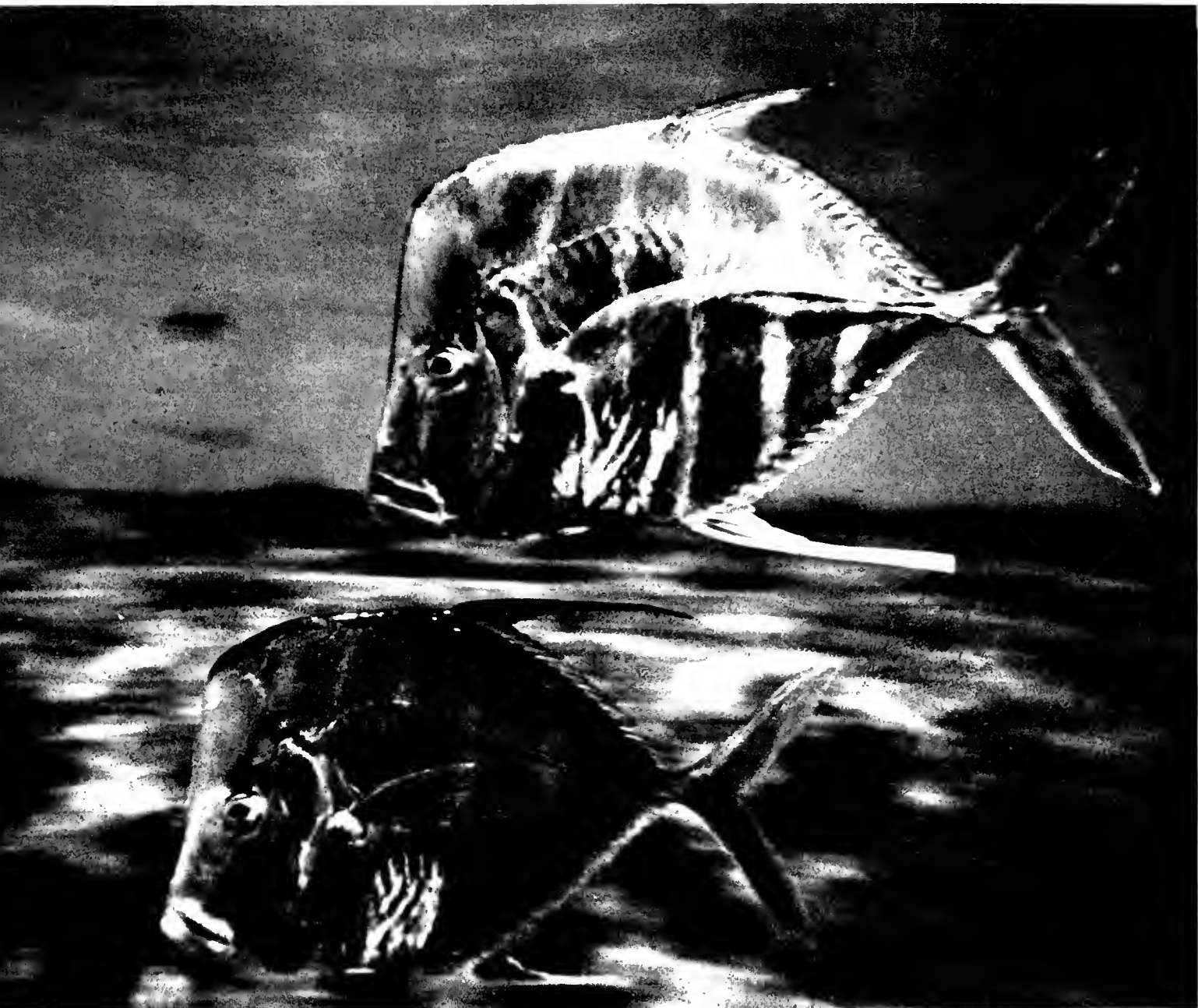
A shoal of silversides (pejerreyes) from the Atlantic coast of South America. Photograph by Isy Schwart.



Pampanos (*Trachynotus glaucus*) from the coasts of Florida and Virginia. Photograph by Isy Schwart.

An amber-jack (*Caranx hippos*) along the Brazilian coast. Photograph New York Zoological Society.

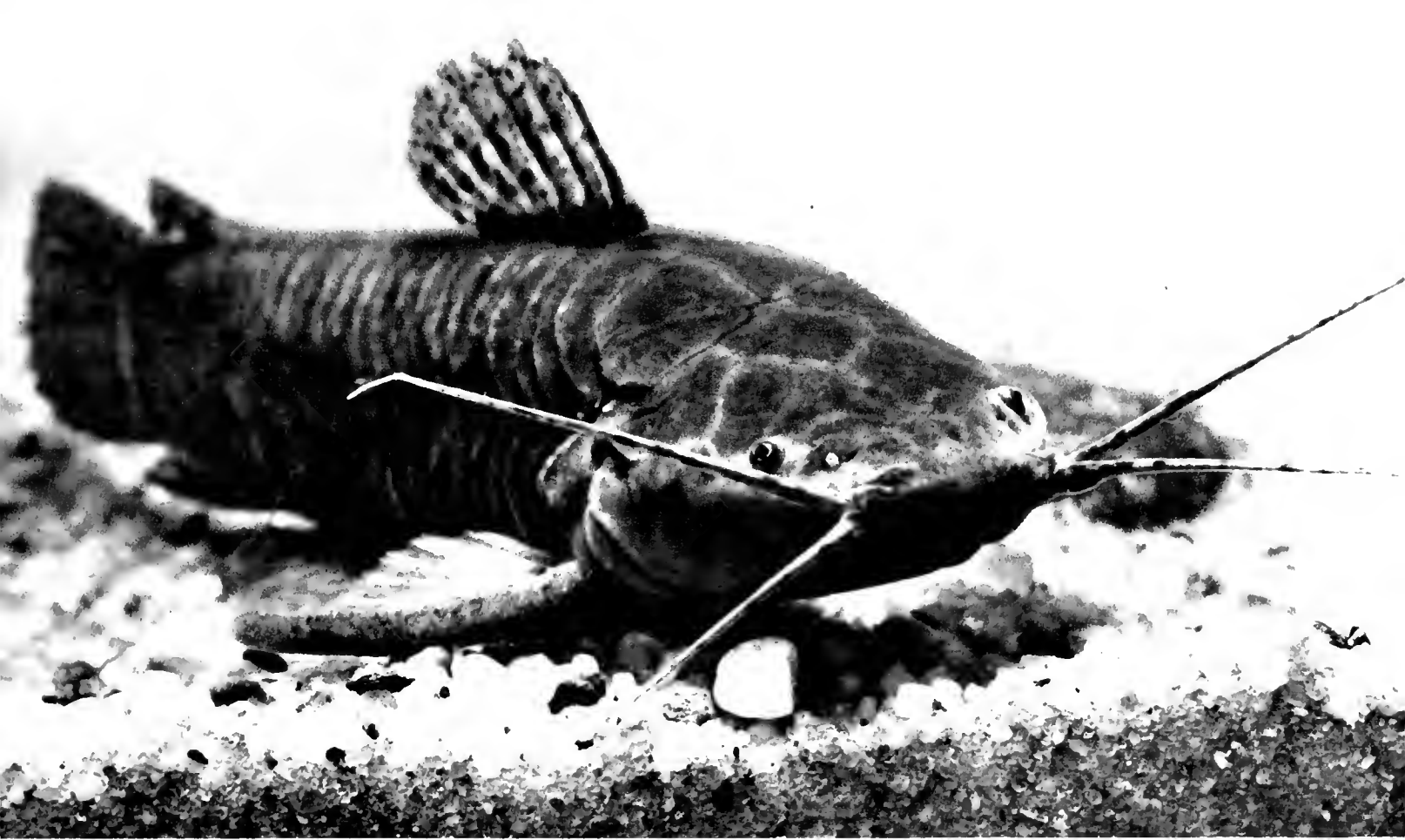




The "lookdown" fish (*Sclenc vomer*), from the tropical coasts of Africa and America. Photograph by Isy Schwart.



A school of sea-bream (*Archosargus*) passing along the coast of Brazil. Photograph by Isy Schwartz.



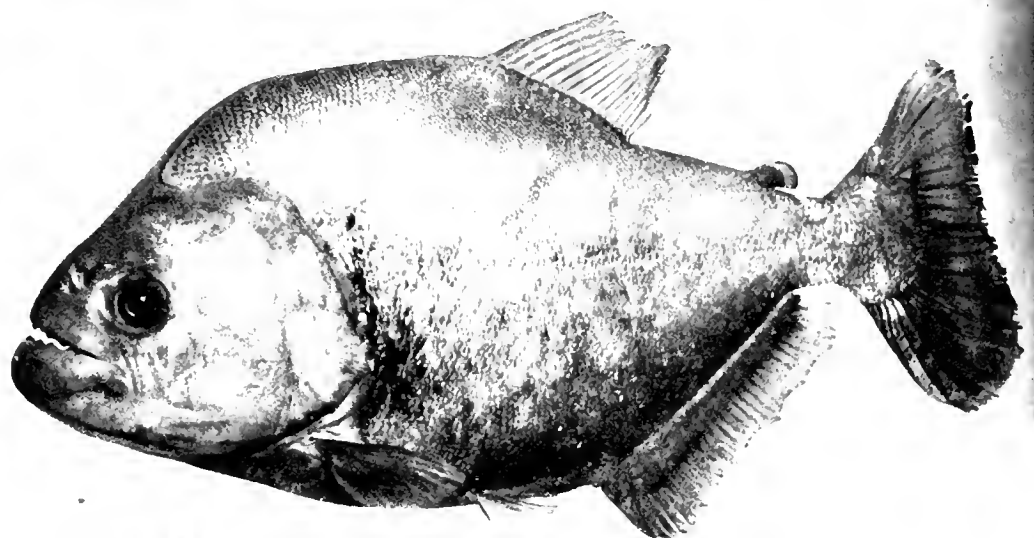
A large armoured cat-fish (*Callichthys callichthys*) from the Amazon. Photograph New York Zoological Society.

A fox-snouted cat-fish (*Pseudoplatystoma*) from the Amazon. Photograph New York Zoological Society.





The ferocious piranha (*Serrasalminus*) in the Amazon. Photographs by Paris-Match and New York Zoological Society.



(2) Their remarkable stability. When the living world around was profoundly changing; when diverse groups were coming into being and then disappearing; when the giant dinosaurs vanished from the face of the earth, having once dominated the animal kingdom, the contemporary coelacanths, by a kind of defiance of evolution, remained the same in all essential characters. Reconstruction by palaeontologists of fossils imprinted in the geological strata from the Old Red Sandstone right to the Cretaceous have shown this.

(3) The fact of their being the only survivors of the great group of crossopterygians, the key group from which came the whole of the immense line of air-breathing vertebrates up to man. Furthermore, they became stabilised at a level that is particularly instructive for the history of higher animals; at that when fishes acquired lungs and limbs and set out to conquer the continents.

If there were no questioning that coelacanths are our direct ancestors, as some have a little hastily declared, at all events they are directly related to those ancestors. They are a source of most valuable information enabling us to perceive an essential stage of animal evolution from life itself. And they deliver to us intact a kind of primitively organised vertebrate of an interest that cannot be overrated.

Their habits are still a mystery, as are the causes for their prodigious survival through the ages and their present restriction to the north of the Mozambique Channel. We only know that they are exclusively carnivorous, feeding on other fishes and living in deep waters. They have been caught between depths of 75 and 200 fathoms on rocky grounds at the foot of steep gradients around the Comoro Islands. They undoubtedly live at greater depths, but as they keep close to the bottom amid masses of jagged basaltic rocks, nets cannot be used to catch them. One day their secrets will be revealed to us but only by the bathyscaph.

J. M.

Under the Southern Cross.

During the long polar night the Southern Cross shines over the ancient continent of Antarctica. It gleams on the crests of the great swell that surges eastwards in the Southern Ocean while moving round the earth. In the cold season, that is, during our summer, cold water masses move northwards to freshen the coasts of America, Africa and Australia, bringing whales, seals and penguins in their train. In volume the Falkland Current has an importance similar to that of the Labrador Current in the northern hemisphere. Like this current it is influenced by the force of the earth's rotation and so comes to hug the coasts of Patagonia, Argentina and southern Brazil. It overlies an immense continental shelf as large as the Newfoundland Banks, an area still unexploited, for the seas are rough and there are no fishing boats.

Cod-fishes are not found here, for the gadids, except for some deep-water species, belong to the northern fauna. But an abundance of large fishes could be taken, belonging to the family Batrachidae and the species *Porichthys porosissimus*, the southern "bacalao". The heavy body is edged with long fins along the dorsal and ventral surfaces and is perforated by very numerous mucous pores set in several rows, like so many lateral lines. Over the head, these pores form more of a network. The pelvic fins are placed under the throat. These animals, which may reach over a yard in length, are bottom-dwellers, but little is known of their biology.

The fauna of the Patagonian Shelf is subject to great physical variations. When the shelf is covered by cold waters, the Antarctic type of fish moves northward, but when these waters recede, the encroaching water layers of the southern transgression bring with them a partly tropical fauna. Now the cold-water fishes retreat to the south or move deeper down on the slope. Throughout the year sedentary forms such as the groupers (*Acanthistius brasiliensis*, *A. patagonicus*) and flat-fishes of the genus *Paralichthys* can be found. Undoubtedly the shelf fauna is also rich in hake (*Merluccius gajji*, *M. hubbsi*), seemingly a family that originated in southern seas, where it replaces the cod-like fishes. On the coasts of South America as well as

in the Solis Sea of the Chilean Archipelago, atherinids or "priests" abound, which are poorly represented in European waters. Such fishes (pejerreys of the genus *Menidia*) form an important part of the local fishery and can reach the size of grey mullets, which are themselves very numerous ("lisas" of Argentina and "tainhas" of Brazil) and undertake considerable northerly migrations in front of the Falkland Current.

It will not even be possible to give here a summarised account of South African fishes, which have recently been the subject of a remarkable work by J. L. B. Smith. However, among the pelagic forms, some mention may be made of the gempylids, a family related to the scombroids. In fact, these "snake-mackerel" look like very elongated mackerel. One of them, the "snoek" (*Thyrssites alun*) which reminded the Dutch settlers of a pike, is of real commercial importance and is suitable for canning. The snake-mackerel, *Gempylus serpens*, swims in all the southern seas. The Kon-tiki men were interested in this curious fish and Thor Heyerdahl relates how one tried to cut the log-line of the famous raft.

It would be surprising if the Australian continent with its strange terrestrial animals, duck-billed platypus, spiny ant-eaters, kangaroos, etc., belonging to vanished faunas, did not contain some "living fossils" in its fresh waters. As a matter of fact, the most archaic lung-fish (*Neoceratodus forsteri*) lives in the Queensland marshes and it has hardly changed in appearance since the beginning of the Secondary Age. Being less far-seeing than the African *Protopterus* or the New World *Lepidosiren*, it does not make a burrow but merely buries itself in the mud. As soon as the waters have dried up it makes use of its air-breathing capacity, but its skin must be kept moist for if it becomes completely dry the fish will die. *Neoceratodus* does not build a nest. Its sticky eggs cling to aquatic plants and during the rainy season the "tadpoles" hatch out. They have no external gills and assume the adult form without a metamorphosis. A fish regularly associated with the lung-fishes, a large-scaled osteoglossid, *Scleropages*, lives in the same localities.

All the lands bordering the Southern Ocean; South African, Australian, New Zealand and Magellanic contain fishes of the family Galaxiidae in their rivers. This family is sub-antarctic and is more or less related to the Esocidae or pikes. The galaxiids have long bodies with equal-sized dorsal and anal fins set well to the rear. Many live in fresh waters and are adapted to very varied biological conditions. In winter *Galaxias findlayi* becomes frozen up in New Zealand pools; *Galaxias coxi* clings to rocks to withstand the violence of torrents; *Neochanna* buries itself in the mud like a lung-fish. But another species, *Galaxias attenuatus*, is entirely catadromous. Spawning takes place in the sea during January or February in the warm season. The return to the rivers occurs in April and May, while the dense shoals of young fishes make their ascent of the watercourses soon afterwards. Like *Anguilla*, the freshwater eel, this *Galaxias* is one of the rare instances of a completely catadromous fish.

In the southern seas along the shores of the Antarctic Continent, there are species belonging to families that are found in northern regions. In the temperate and tropical zones these live only at great depths because of their strictly stenothermal habits. Such are lycodids, small eel-like creatures which keep distinctly to waters from 2 to -1°C., whatever the latitude. Following the curves of the isotherms they are littoral or coastal near the two poles and take refuge in the depths under the warm seas.

Over the continental shelf and slope, callorhynchid fishes (*Callorhynchus antarcticus*), related to the chimaeras, root in the mud with their soft snout, which bears a large fleshy flap at the tip. The tail ends in a long thread and a strong spine rises upwards in front of the first dorsal fin. These southern chimaeras lay very large eggs measuring nearly 10 inches in length. They are oval in shape and are covered with yellowish hairs. They are set securely in the light soil, where they hatch.

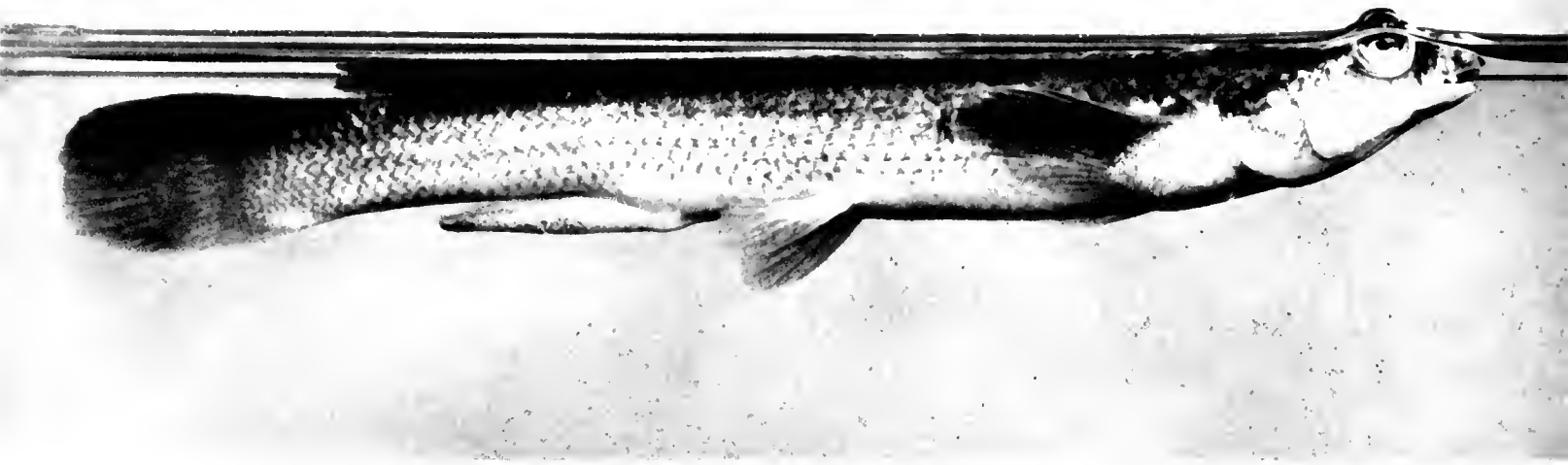
We saw that arctic seas abound in marine millers-thumbs of the family Cottidae. They are replaced by nototheniids in the Antarctic Ocean; fishes that are more or less related to the weevers. The head often bristles with spines and the elongated body, which is edged with long fins, ends in a sharp snout. The pelvic fins are placed under the throat and often extend into long filaments. *Pleurogramma antarcticum* has been taken farthest south, at latitude 78°S. in the Weddell Sea.



A gymnotid eel (*Gymnotus*) on the bottom of a great South American river.
Photograph New York Zoological Society.

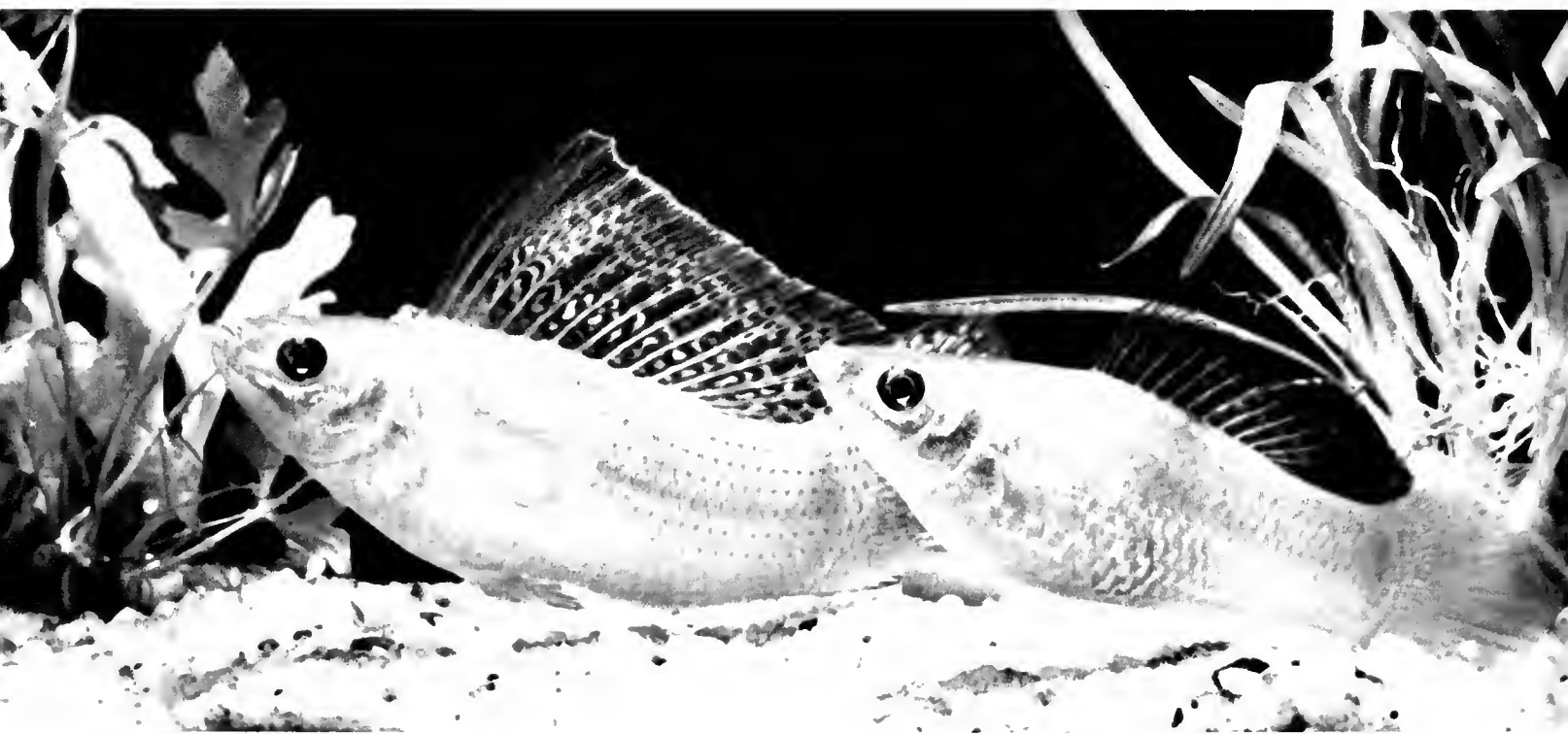
Another gymnotid (*Eigenmannia virescens*) among aquatic plants. It is a greenish, transparent fish.
Photograph New York Zoological Society.

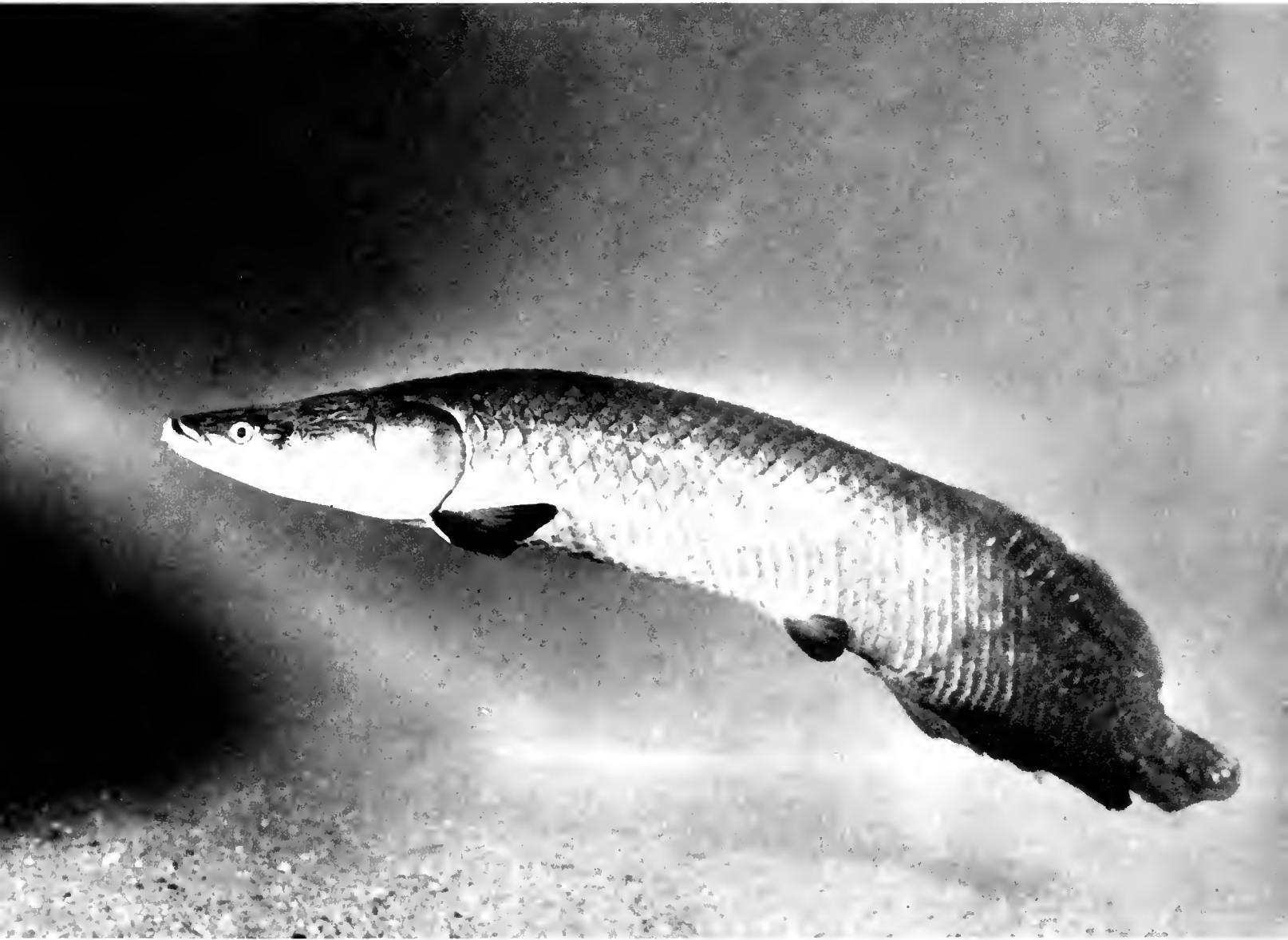




The four-eyed fish (*Anableps tetraophthalmus*) swimming at the surface on the look-out for insects and fishes. Connective tissue divides each eye into two parts, the upper part being adapted for aerial vision and the lower for seeing under water. Photograph New York Zoological Society.

South American cyprinodont fishes (*Mollienesia petenensis*). Photograph New York Zoological Society.





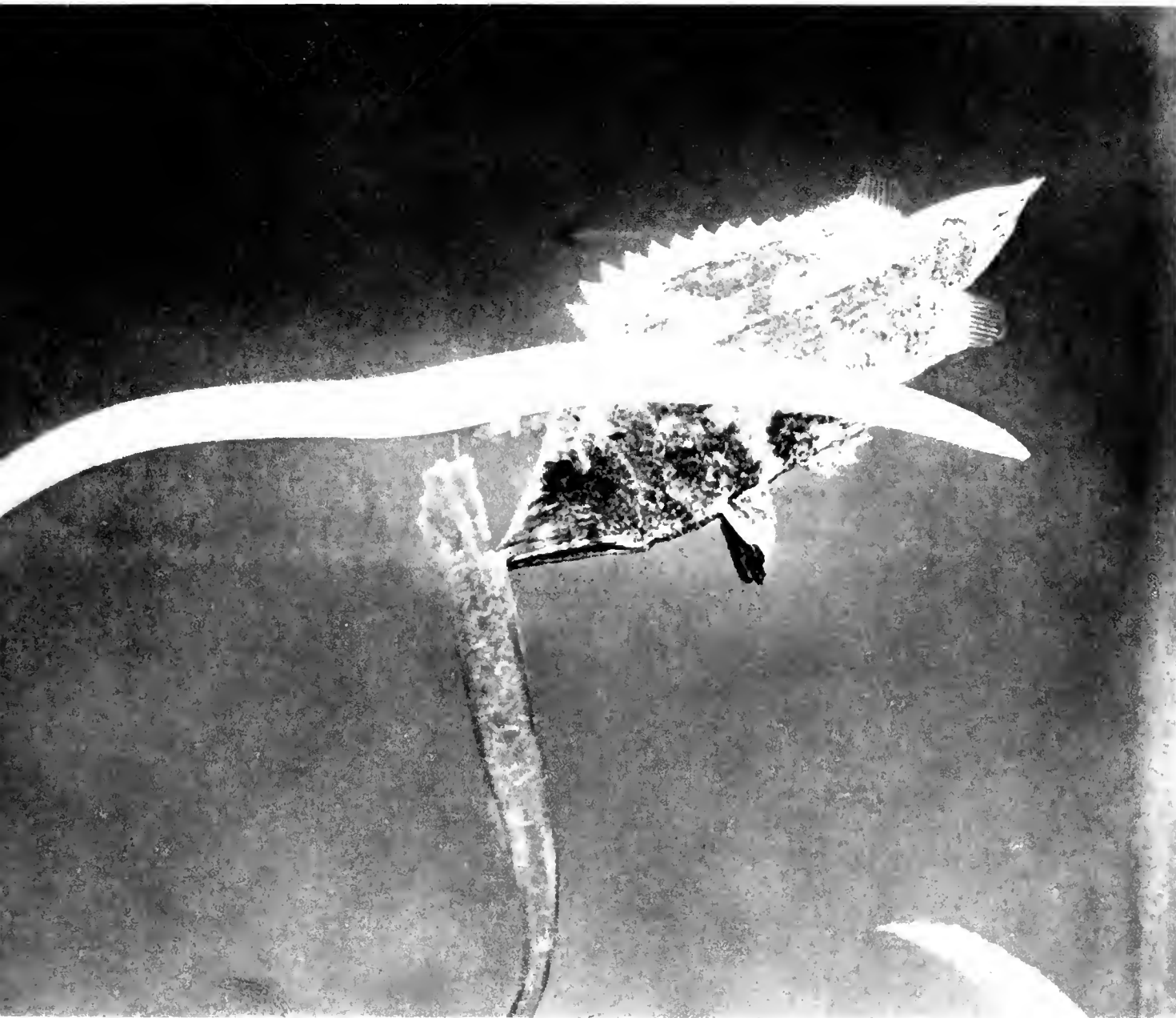
The giant fish of the Amazon (*Arapaima gigas*), which may reach a length of at least 16 feet. Photograph New York Zoological Society.



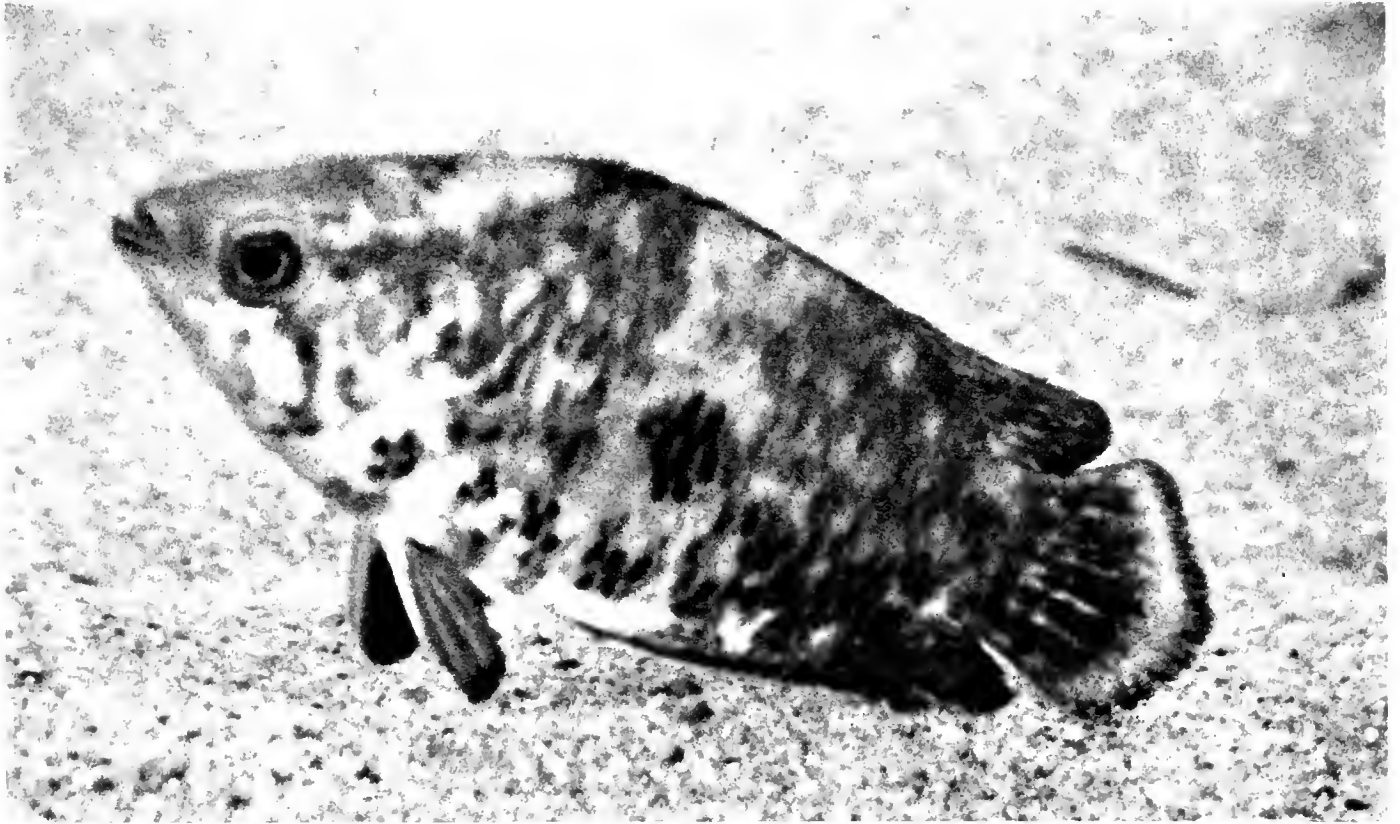
Small characius (*Thoracocharax*) swimming among water plants. South America.
Photograph New York Zoological Society.

A long-snouted cat-fish from South American fresh waters. Photograph New York Zoological Society.





The leaf-fish (*Monocirrhus polyacanthus*), a small South American perch, with its spawn.



The climbing-perch (*Anabas*), walking on dry land. Photograph Société Royale de Zoologie d'Anvers.

The euchia (*Amphipnous euchia*) from Asian swamps. Photograph New York Zoological Society.





Channa asiatica, a fish without pelvic fins, which lives in the swamps of Ceylon.
Photograph New York Zoological Society.

The mud-skipper (*Periophthalmus*), on the look-out on a stone.



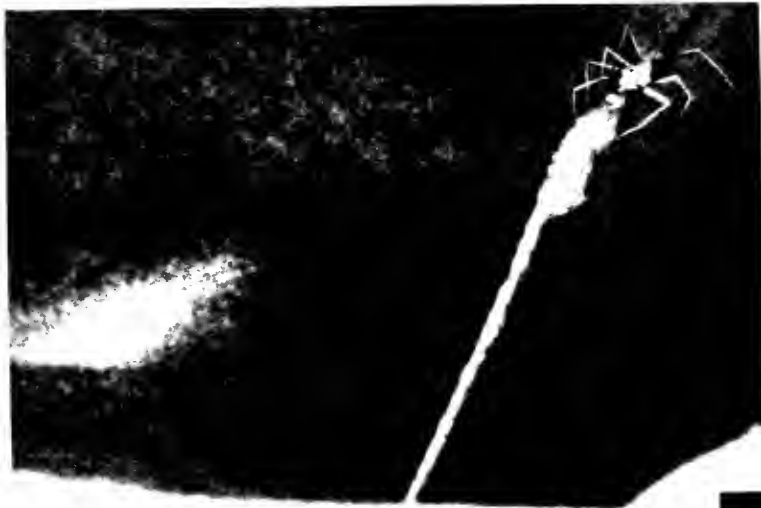
The archer-fish (*Toxotes jaculator*) from the swamps of Asia.



It sees a spider

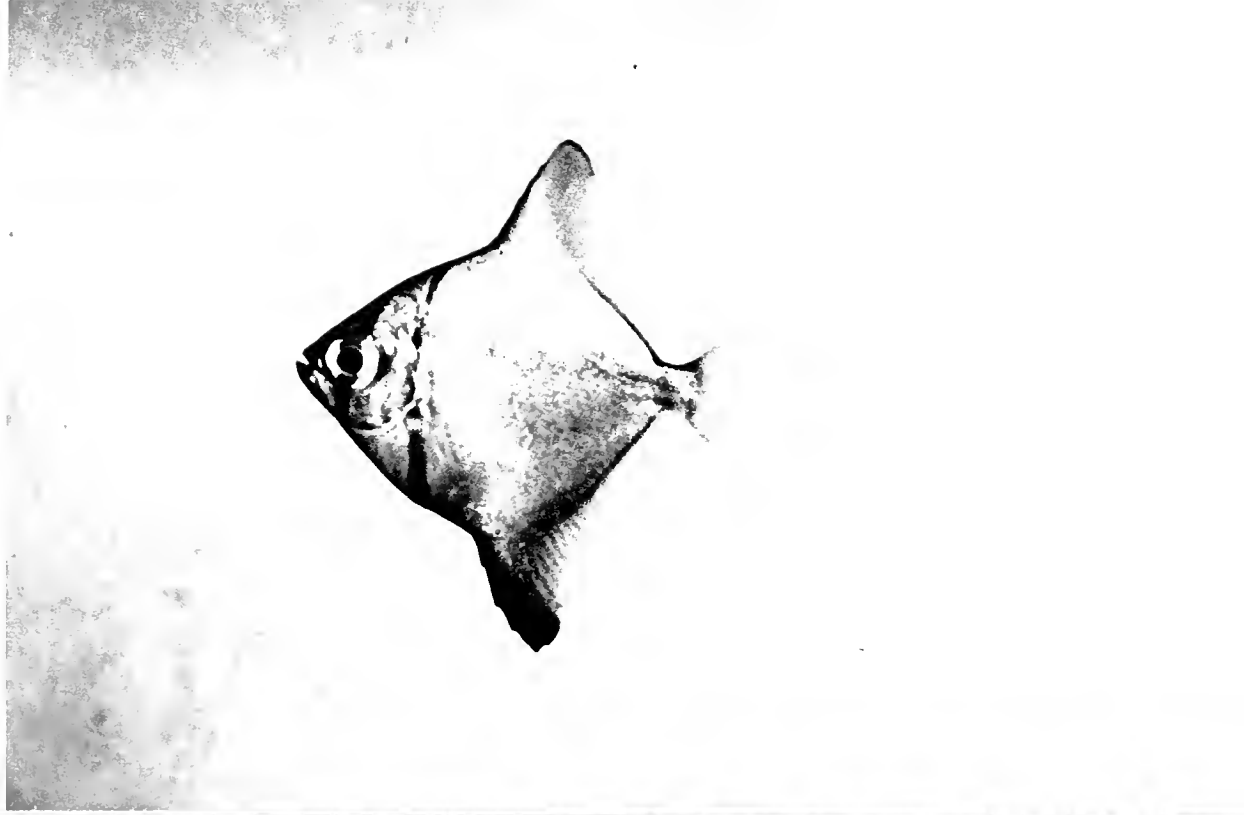


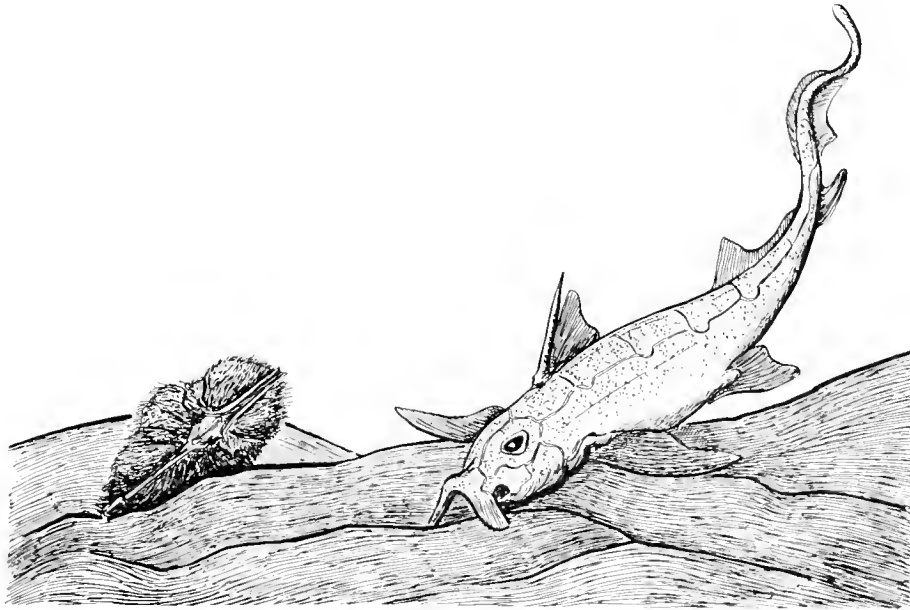
It shoots out a jet of water



It brings down its prey and eats it.
Photographs New York Zoological Society.







A female chimaera (*Callorhynchus antarcticus*) from the southern ocean. On the left is an egg stuck in the ooze.

The Norwegian scientist Johan T. Ruud has pointed out that Scandinavian whalers had for a long time noticed that three of these nototheniids (*Champscephalus*, *Pseudochaenichthys* and *Chaenocephalus*) have a perfectly colourless blood. Although completely without haemoglobin, this blood does not appear to restrict their activity. The physiologists drew most varied conclusions from this discovery, basing themselves on the Nieloux (1923) observations that life in aquatic creatures is not slowed down when their haemoglobin is overloaded with carbon dioxide and is no longer able to absorb oxygen. But antarctic fishes ought not to be found in such special conditions, for the heavy swell of the southern seas is sufficiently aerated to saturate with oxygen the haemoglobin of all animals living in it. The Scandinavian seamen's "bloodless fishes" add a new problem to the little known biology of the world living under the Southern Cross.

CHAPTER VI

THE DEPTHS OF THE OCEAN

In a bathyscaph, by Théodore MONOD. *Professeur au Muséum National d'histoire naturelle, Directeur de l'Institut français d'Afrique Noire.*

With bathyscaphs at his disposal, the modern zoologist has a device for an "on the spot" descent to the bottom of the sea. There he can watch abyssal fishes with his own eyes. Undoubtedly, these machines will be improved and so should the research methods of the biologist who is called to work under such unusual conditions. But right now a new era is opening up — the exploration of the submarine land surface.

In 1954, I was privileged to take part in the first scientific dives of the bathyscaph F. N. R. S. 3, which was piloted by Commander Houot.

Although the mid-water fireworks are quite spectacular, these will not be our present concern. But we are slowly approaching the bottom and soon resting on it. What will it look like in the beams of our powerful head-light?

First surprise: instead of a soft ooze — a kind of "soup" or "tapioca" that one had imagined — the bottom is obviously relatively compact and unyielding. The kind of track made by the guide-rope, the behaviour of small piles of ballast released from the bathyscaph and the very appearance of the ground with its "mole-hills" all bear witness to this fact. When all is said and done, it looks much the same as freshly tilled land.

Second surprise, which will undoubtedly explain the first. Down here, at depths of 750 fathoms, is a current — a current strong enough to bear a stream of passively drifting animals past the port-hole (of our bathyscaph). But here is something especially interesting; bottom-dwelling fishes, more or less "tied" to the ground. For instance, a great ray (genus *Raja*); some dark purple-grey sharks about 3 to 5 feet in length (*Centroscymnus*, perhaps); dark brown gadids (*Physiculus* or *Brosmiculus*?); a heavy thick-set greyish fish (undoubtedly a brotulid); a small, slender, silvery species, with a thread-like tail (perhaps a *Stylophorus*). Lastly, there are *Benthosaurus* resting on the bottom and facing the current, which throws their long, whiplike tails into a series of waves.

At an appointed time these animals gently work loose from the ooze, and allow themselves to be wafted backwards by the current. Backing out of the spot lit by our head-lights, they disappear into the night.

General comments: none of the fishes we saw seemed attracted — or in any way repelled — by the strange glare of our lights. They appeared to be quite indifferent. I admit to feeling a little "annoyed" for a time; that man takes all the trouble to go to them only to find that this utterly novel event means very little in their lives. These abyssal fishes are hardly polite...

T. M.



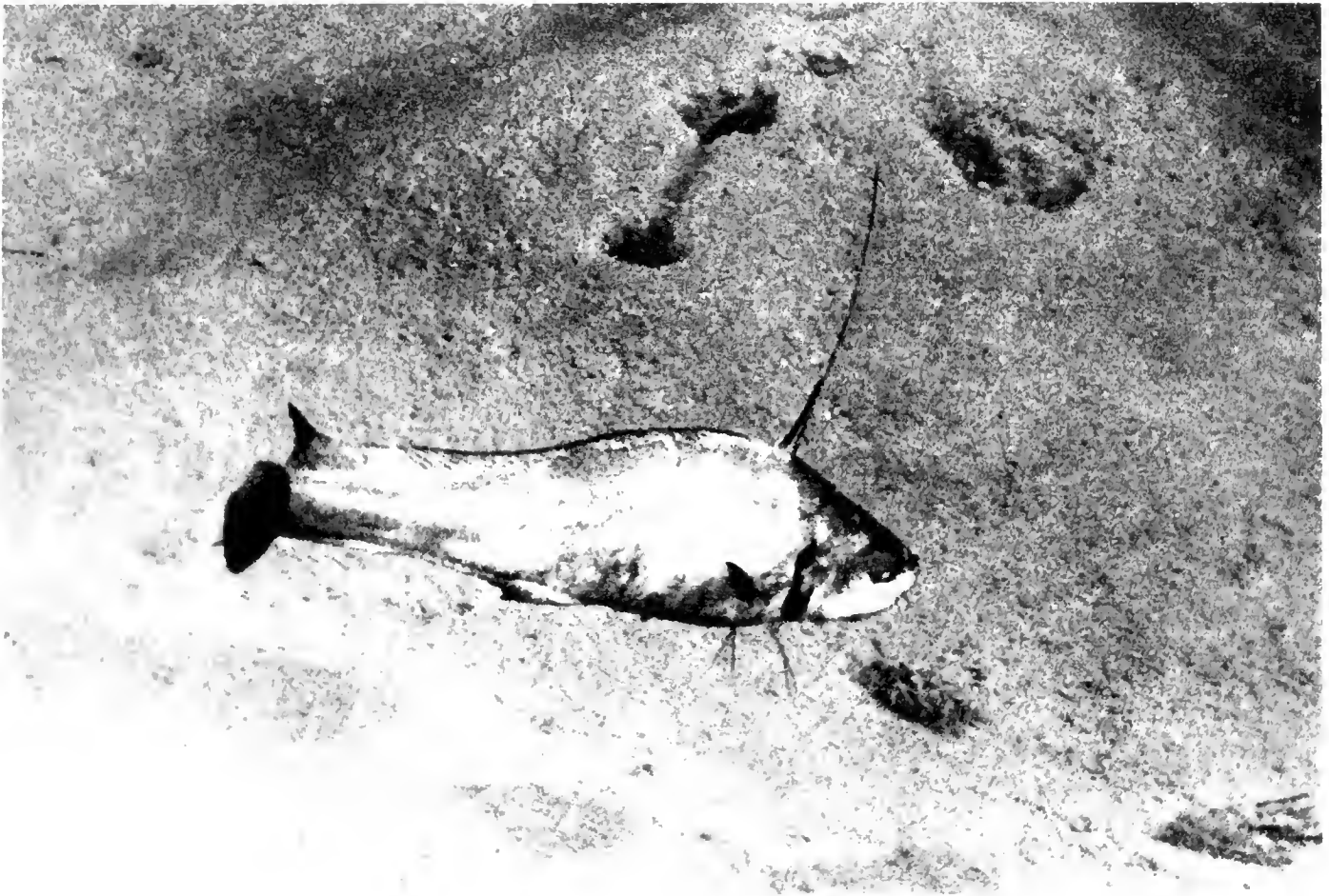
The Siamese fighting-fish (*Betta pugnax*) guarding its spawn in its bubble-nest.
Photograph New York Zoological Society.

A panther-fish (*Chromileptes altirdis*). Photograph New York Zoological Society.



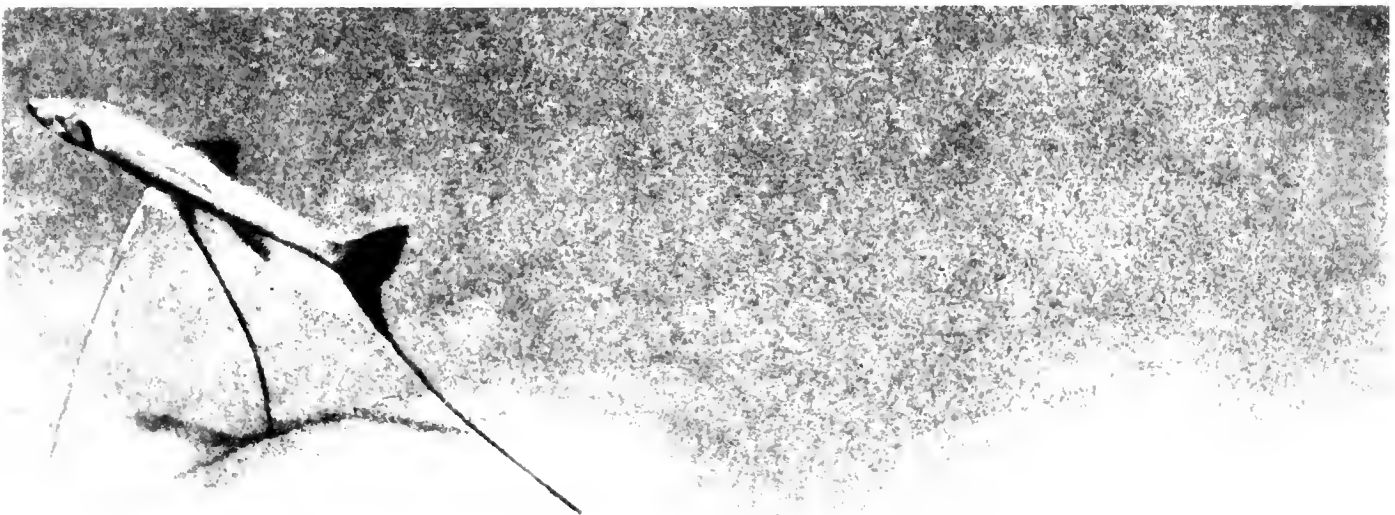


The archaic Australian lung-fish (*Neoceratodus forsteri*): at the bottom of a pool during the rainy season.
Australian Official Photograph



A deep-sea gadoid fish (*Halargyreus*) swimming over a pitted bottom at great depths. Seen from a bathyscaph.

A deep-sea fish (*Benthosaurus*) propped up on its fins. Seen from a bathyscaph.
Photographs by Commandant Houot and Pierre Dubard.



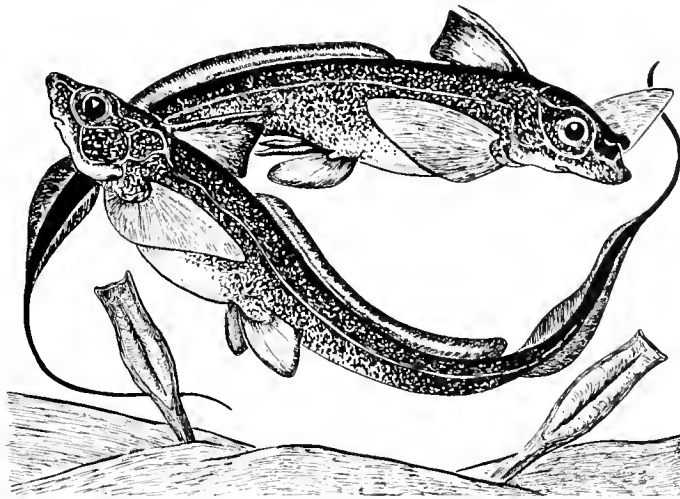


In the dark abyssal parts of the ocean, Gulper-eels (*Saccopharynx*) hunting by the light of their own luminescence.
Photograph: Ullstein-Berlin.

The cold night of the abyss.

In this "biological extract of the log-book of F. N. R. S. 3", Professor Monod gives a brief summary of phenomena that have eluded a hundred years of oceanographic research: the firm nature of the bottom and the existence of deep-seated currents. Above all, he has seen fishes alive that we only knew from the blind sampling of dredges and vertical nets. How can we write about abyssal creatures when, before long, new observations will undoubtedly destroy conceptions built up from results that have been patiently got by great scientific expeditions.

For a long time the submarine world was believed to be profoundly silent. Modern microphones have revealed that it is nothing of the sort. On the contrary, all those animals that were thought to be dumb produce an absolute hubbub of noises. For a long time one understood that the luminous organs of animals flashed with only a dim bluish or purplish light in the darkness of the depths. But Th. Monod tells us of deep-sea, mid-water fireworks casting a strong light into the abyssal blackness. However, this luminescence must be restricted. Certain parts of the deep-sea floor must be quite dark, otherwise we would be unable to understand the extreme development of tactile appendages in blind forms to compensate for a deficiency or lack of vision. Nevertheless, species with enormous eyes and those without eyes have both been recorded from the same level and even from the same place. The rapid improvements in modern equipment will undoubtedly enable us to resolve these many problems in abyssal biology.



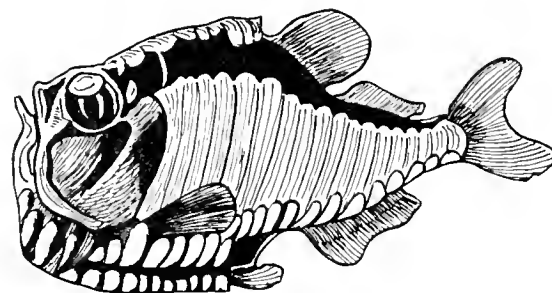
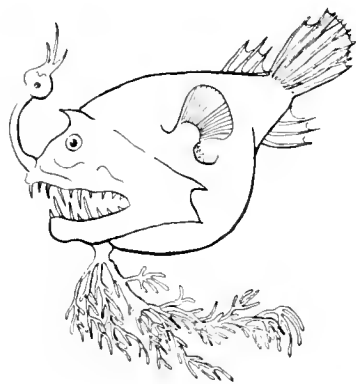
Chimaeras (*Chimaera monstrosa*), the male (above) and the female. Two eggs are stuck in the ooze.

The purple-blue coloured type of deep-sea fish living above the oozes of the continental shelf is made up of species with very large eyes and a snout projecting into a fleshy or bony rostrum. The first dorsal fin is protected by a strong spine or spiny rays and the rear part of the body tapers into a long filament. Such are the chimaeras, or Holocephali, the surviving evidence of the first stocking of deep waters with cartilaginous fishes — and the macrourids which have a bony skeleton and are related to the cod-like fishes. Close by these specialised forms, swimming along the bottom, are argentines (*Argentina silus*), ancestral salmonids, and telescope-fishes (*Epigonus telescopium*), sea-perches that have taken to the depths and become almost unrecognisable as such, because of the enormous development of their eyes.

The black fishes, which swim in the cool mid-water layers of the ocean, are full of life and activity. Numerous shoals, like those of herrings or sardines, move around in compact groups, lit by countless phosphorescent organs, such as myctophids or scopelids (lantern-fishes). Their agility is no protection against fierce predators — such as *Alepisaurus ferox*, a fish that may reach more than a yard in length. Running along the back is a high, many-rayed, dorsal fin like those of tropical sail-fishes. Being without light organs it swims and lurks under the cover of darkness, and taking advantage of the light emitted by these schools of harmless fishes, it wages a fearful slaughter.

The eel-like *Saccopharynx* fishes are no less dangerous. Two small close-set eyes, like those of moray eels, overlook a formidable mouth with its slanting gape. When their stomachs are empty the undulations of their slim, pliant bodies light up a row of luminous points, but when they have swallowed some large-sized prey the stomach becomes enormously distended and only returns to its original shape after a laborious digestion. These fearsome animals can exceed a length of 6 feet. Like other eels they metamorphose from a leptocephalous type of larva which is characterised, as soon as it is hatched, by a marked development of the lower jaw. The smaller stomiatoids with formidable teeth prey on other mid-water, deep-sea fishes. The hatchet-fishes (*Argyrolepeceus hemigymnus*) which are only an inch or so long, are their chosen victims. These are strange-looking fishes with a large head measuring nearly half the length of a body provided with two large tubular eyes. Their metallic-looking flanks are set with light-organs which reveal their grotesque shape. Another form, *Opisthoproctus grimaldii*, has two tubular eyes looking vertically upwards from a luminous head.

The mid-water, deep-sea fauna has now been well studied, naturalists on great scientific cruises having collected many kinds of black fishes. The general public was keenly interested



A ceratioid angler-fish (*Linophryne arborifera*) ($\times 2$).

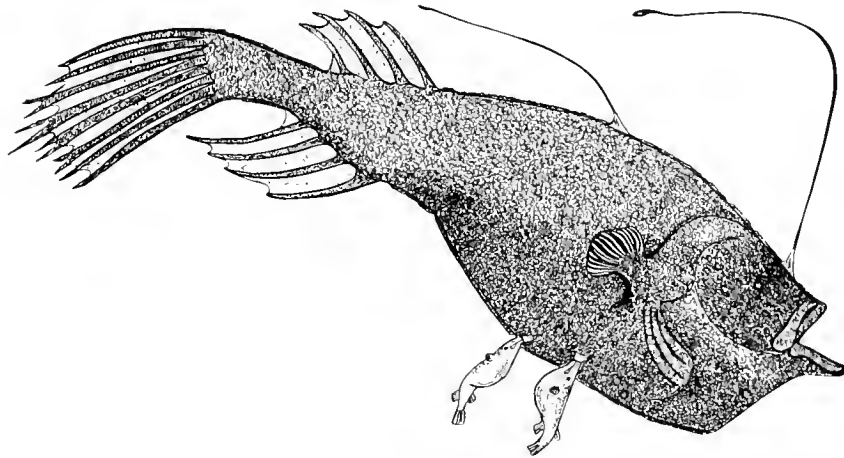
A hatchet-fish (*Argyrolepeceus hemigymnus*) ($\times 2$).

when these fishes were on view in the International Exhibitions of 1867 and 1878 in London and Paris held after the "Challenger", "Travailleur" and "Talisman" Expeditions, and every visitor to the Oceanographic Museum at Monaco knows of the collections made by Prince Albert I.

The deep-sea angler-fishes (ceratioids) attract a good deal of attention, which is not surprising in view of their extraordinary appearance. Descending from bottom-living angler-fishes, they have kept the fishing-line but this has become highly modified. It is frequently very long and ends in a spherical bulb bearing a luminous gland. Sometimes it branches into a bunch of phosphorescent tentacles. In species like *Linophryne* this intriguing arrangement is coupled with a many-branched barbel like a seaweed glowing in the darkness. The body is more or less globular in form, the pelvic fins have disappeared and the skin is raised into papillae



or bulges or is studded with bony plates. While usually blackish or brownish, the skin is transparent in *Halophryne*, revealing the intestines and muscles, which are enclosed in a gelatinous mass. The teeth are variable in form, being very large in *Melanocetus johnsoni*, one of the



A large female ceratioid angler-fish (*Ceratias holboelli*), with two dwarf males attached to the abdomen.

earliest known ceratioids. The length ranges from an inch or so to about two feet in *Himantolophus groenlandicus* and even to more than a yard in *Ceratias holboelli*.

For biologists, the most remarkable feature of this family is an extreme difference between the forms of the sexes, the difference in size being exaggerated to a degree unknown in other vertebrates. The males are veritable dwarfs. The visceral organs have disappeared and the body cavity merely contains a large testis. These small creatures fasten themselves by their jaws to the skin of the large females which grows around this contact to make a lasting fusion. Nevertheless, respiration and blood circulation are kept as distinct activities. This fixing process takes place during the larval development of the dwarf males and it is only afterwards that the genitalia develop. Polyandry is the rule, each female carrying several parasitic males attached to her underparts. Among the groups of animals it is not until we come to certain Crustacea that a comparable "dwarfism" is encountered. A cogent explanation of this paradoxical degeneration has yet to be found.

At far greater depths along the red clay of the deep-sea floor; between depths of 2,000 and 3,000 fathoms, live the highest of the invertebrates, the elaspod holothurians — flattened like a



At depths beyond 2,500 fathoms on the deep-sea floor. Brotulid fishes between two elaspod sea-cucumbers. In the middle *Barathronus parpariti*. On the left two *Leucochlamys cryptophthalmus*.

sole and set with stiff appendages. Slithering among them are degenerate looking creatures. They are pallid, blind and eel-like and they are brotulids, the last representatives of the versatile class of fishes in the deepest reaches of the abyss.

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