CHAPTER FIVE

Changes in the Sea

For though I scorn Oceanus's lore,
Much pain have I for more than loss of realms:
The days of peace and slumberous calm are fled;

That was before we knew the winged thing,
Victory, might be lost, or might be won.
Keats, *Hyperion*

In contrast to land and fresh waters the sea seems still almost inviolate. Yet big changes in the distribution of species have already begun as a result of human actions during the last hundred years. These actions are of three kinds. First the digging of new canals. Secondly, accidental transport on ships. And thirdly, deliberate introductions. The Panama Canal, though it has in a formal sense split the Nearctic from the Neotropical Region once more, is hardly a serious gap, nor much of a transport line for marine life from one ocean to the other. In 1935 and 1937 Hildebrand made a survey of the animal life in the locks and inner channels of the Canal and found that a good many fishes and some other animals have moved part of the way into the system from each end.[179] Indeed there is no physical obstacle to prevent them from doing so, and he prints a photograph of men picking up a number of very large fish after the emptying of one of the locks. The real barrier is the forty miles of fresh water, especially the great Gatun Lake. The fish that have penetrated at all are, as one would expect, those that can live in brackish and even in fresh water—various gobies and also other kinds of tropical fish. The only species known to have made a complete crossing is the tarpon, *Tarpon atlanticus*, of which four were found in the lowest lock on the Pacific side when it was emptied in 1937. They have also been reported at the Pacific sea-level terminus, but had not (in 1939) been

caught at sea in Panama Bay. They seem to be quite frequent in Gatun Lake.

The Suez Canal is quite a different matter, though it also presents some serious obstacles to the transit of marine species. Here the reason is the opposite from that in the Panama Canal. The Suez Canal is about 100 miles long, and in the middle there is a stretch of nearly 14 miles of the Great Bitter Lake. The Lake has very high salinity from the dissolving of rock salt deposits laid down in a much earlier period. But, according to Munro Fox who took the Cambridge Expedition to the Suez Canal in 1924, the salinity has grown less than it was, by the mixing with ocean water, and was then still falling.[176] As explained in Chapter 2, the great branch of the Tethys Sea connecting the Mediterranean region with the Indian ocean was severed by Miocene times, and great differences began to appear in the fossil faunas to east and west. The Indian Ocean kept its luxuriant fauna. The Mediterranean became much impoverished, no doubt chiefly because it was already part of the great brackish Sarmatian, and later the Pontian, seas that enveloped much of Central Europe, the Black Sea, and Caspian–Aral region. The detailed history of the Gulf of Suez is complicated, and not yet quite fully elucidated.[186] It is known however that it was for a certain time joined to the Red Sea, because sea-urchins and other fossils from there have been found in its Mid-Pliocene deposits. It also seems certain that it was cut off from the east during all or a great part of the Quaternary Period following this. In modern times the fauna of the Mediterranean and of the Red Sea were quite distinct, indeed they had and still have relatively few species in common. The other canal (from the Red Sea) that the Egyptian Pharaohs built several thousand years ago, could not have provided a highway for marine species, because it had such a long fresh-water stretch, and carried no traffic directly to the Mediterranean.[176]

Since the Suez Canal was opened in 1869 a fairly strong contingent of animals has managed to pass from the Red Sea into the Gulf of Suez and spread into the Mediterranean, some of them rather widely.[197] The exchange has gone mainly in this direction because of the set of currents, the tides for most of the year running westwards from the Red Sea end. Thus only two of the sixteen crabs taken by the Expedition in the Canal

were Mediterranean ones.[164] Though the shipping itself must have enabled a good many of them to run the gauntlet, by speeding up the passage through the Bitter Lake, there also seems to have been direct migration. The arrival of the Red Sea crab *Neptunus pelagicus*, a swimming species, was traced through observations made by the Suez Canal Company staff, whose interest was in fishing it for food.[164] It first began to be numerous in the Canal in 1889–93, reached Port Said by 1898 and four years later was common there. By 1930 it was common also in Palestine. Today it is a staple article of Egyptian food, fished for from Port Said, Alexandria, and Haifa, and it has reached at least as far as Cyprus.[174] *Myrax fugax* is another crab that has had a rather similar history of successful invasion. A crab, *Neptunus sanguinolentus*, and a bat-lobster, *Thenus orientalis*, both from the Red Sea, were detected in Fiume Harbour in Italy in 1896. The Red Sea pearl oyster, *Pinctada vulgaris*, has spread as far afield as Tunis.[176] So in the last ninety years we begin to see the redeployment of the fauna of the Tethys Sea. However, I suppose it is likely that the Bitter Lake, whose salinity is more than twice as high as that usually found in the sea, will prevent a good many plants and animals from getting through, or delay them for a long time.

Accidental carriage in or on shipping, that is in water ballast tanks or on the hull, has been a powerful and steady agency dispersing marine plants and animals about the world, just as it apparently carried the Chinese mitten crab to Europe. In 1946 the larvae of a prawn *Processa aequimana* were detected for the first time in plankton hauls from the southern part of the North Sea, and in 1946–8 the numbers of these increased each year. The adults had not yet been found there. This prawn is known to live in the Red Sea; its larvae have been found in the Suez Canal, and adults at Naples.[192]

The bottoms of ships will quickly get growths of sessile marine algae and animals amongst which more mobile forms can hide and feed: whole communities in this peculiar habitat have been surveyed.[178] Captain Joshua Slocum recounted that while he was sailing across the Atlantic alone in the *Spray*, the fishes and dolphins that had been accompanying him turned aside to go with a large sailing ship that had its bottom much fouled in this way, adding 'Fishes will always follow a foul ship'.[195] These

growths must provide a habitat for animals over great distances, and must still do so on many modern boats, in spite of the increased use of chemical anti-fouling treatments. It is known for certain that the slipper-limpet *Crepidula* (referred to later on) grows on the bottoms of ships that have been laid up for some time, and may get spread when these are moved to other stations.[161] The arrival of the diatom *Biddulphia sinensis* from the Indo-Pacific to the North Sea about 1903 is also explained in this sort of way. Its subsequent spread and astronomical multiplication there are summarized by Hardy, who gives excellent pictures of this floating microscopic alga.[177] Its spread is not merely of interest because of dispersal, but because it has become one of the dominant phytoplankton species of part of the North Sea, and has spread also to the Irish Sea and Scandinavian waters.

Shore seaweeds are also being moved from one ocean to another. There is a small and inconspicuous red alga, *Asparagopsis armata*, known also as *Falkenbergia rufolanosa* (Fig. 36), that grows at low tidal levels and is abundant along the south coast of Australia, and lives also in

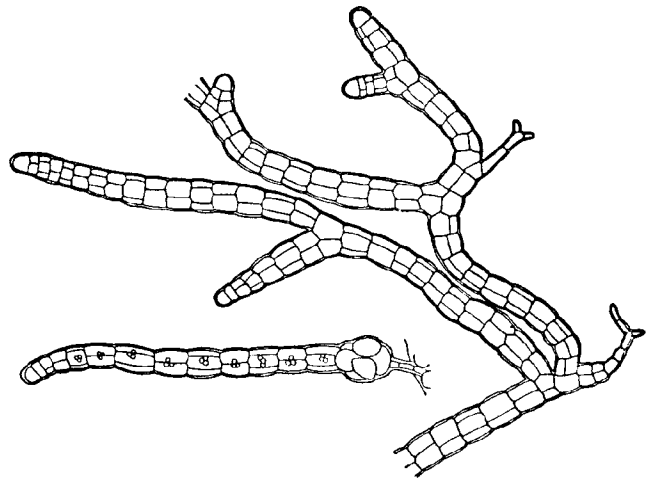


FIG. 36. *Falkenbergia rufolanosa*, an Australasian seaweed recently spread to Europe and North Africa. (From J. and G. Feldman, 1942.)

Tasmania and New Zealand. The exhaustive research of the Feldmans indicates that these two 'species' are alternative life history phases of the same seaweed, *Falkenbergia* being the tetrasporic phase of the other.[175] This conclusion is strongly supported by the recent simultaneous spread of both forms into the Mediterranean and Western Europe, no doubt dispersed on shipping (Fig. 37). *Asparagopsis* was first noticed in the extreme south of the French Atlantic coast in 1923, and in the same year *Falkenbergia* was found at Cherbourg, and *Asparagopsis* in Algeria. The map in Fig. 37 gives the later discoveries up to 1934. In 1941 it was in the West of Ireland, in 1950 well-established in Cornwall, in 1951 in the Scilly Isles,[180] and by 1954 there was a colony in the Isle of Man.[199] There is one other species of *Asparagopsis* that has a world-wide distribution in tropical oceans, but this may be natural.

Elminius modestus is a barnacle that lives on the intertidal rocky shores of New Zealand and Australia. In 1945 it was noticed on the south-east coast of England.[171] It must have arrived at least a few years before this, as a survey in 1947 showed that it was widespread from Norfolk to Dorset, and it was also living in one spot in South Wales. This barnacle is certainly able to get about on the hulls of ships, for it fouls them quite intensely, and was taken early on from a vessel going between Holland and England. It now occupies most of the north coast of France, and lives also in Belgium and Holland.[162] A single individual that had settled on the rocks in 1954 was found on the Isle of Cumbrae in the Clyde, in the course of considerable field research there upon other kinds of barnacles.[170] It has recently been detected also in Cape Town—1949, the first record for South Africa.[193] This is a tough and dominant species, able to occupy the shore in face of competition from other kinds of barnacles, though it does not replace them except in certain zones. It lives chiefly at the lower intertidal levels and below them, flourishing in rather sheltered and muddy waters, thus entering into competition with oysters as well.[167] '*Elminius* ranks as a dominant littoral organism in the estuaries of the Colne, Blackwater, Crouch and Thames.'[171] Other barnacles proved to have crossed the world on the hulls of ships are *Balanus eburneus* from eastern North America to the Mediterranean and thence to Britain; and *Balanus improvisus* from the Northern Hemisphere to Australia.[161]

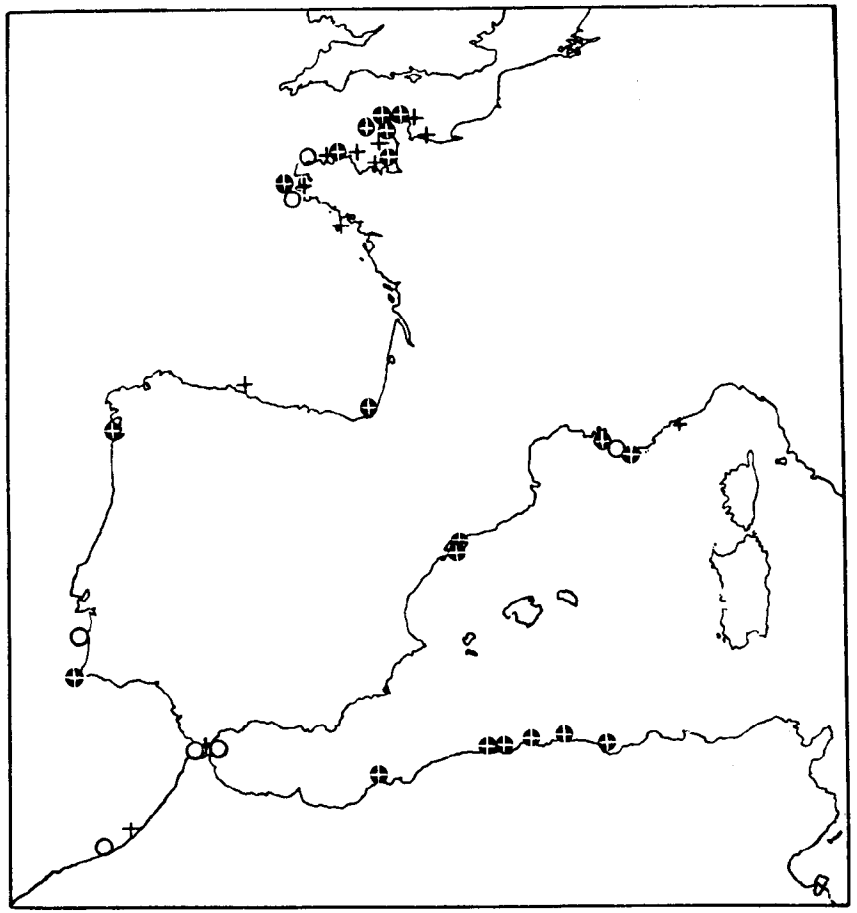


FIG. 37. Simultaneous spread of the two phases of an Australasian seaweed, *Asparagopsis armata* (circles) and *Falkenbergia rufolanosa* (crosses), or both (black with white cross), in south-west Europe and North Africa. (From J. and G. Feldman, 1942.)

But the greatest agency of all that spreads marine animals to new quarters of the world must be the business of oyster culture, a very ancient and world-wide craft now turning gradually into an applied science. It involves much greater managed interference with the natural habitat than any other kind of fishery, and in this way resembles more the crop or flock cultivation of agricultural land, while most other purely sea fisheries still remain at the hunting stage—depending on knowledge and on restraint but not on modification of the habitat in an elaborate way. Two features of oyster culture have deeply affected the spread of species. One is letting the free-swimming oyster spat settle on artificial surfaces like shells, tiles, bamboos, mangrove sticks and the like.[191] These are eventually planted on grounds where the food supply of plankton is rich, to fatten them up for use. The second practice is to bring in foreign oysters and similarly fatten them before they are sold. In England only the native oyster, *Ostrea edulis*, is able to breed and maintain itself. But in the past many shipments have been made of Portuguese oysters, *Ostrea angulata*, and eastern American oysters, *Ostrea virginica*, though these do not establish breeding populations in our waters. An interesting example of the unintentional transport of oysters to a new place by ship was the sinking of a ship at Arcachon in the Bay of Biscay about 1870 with Portuguese oysters on board.[191] This new French colony became one of the regular sources of supply. Oysters are therefore a kind of sessile sheep, that are moved from pasture to pasture in the sea.

The moving about, without particularly stringent precautions, of masses of oysters was bound to spread to other species as well. The first important one was the slipper limpet *Crepidula fornicata*, a native of the east coast of North America, whence it has been transported both to Western Europe and to the Pacific Coast.[200] Its early history in England is not exactly dated, but it first attracted notice at Brightlingsea in Essex about 1890.[167] Since then it has spread along the English coast to Scotland in the east and Cornwall in the west.[166] In 1953 a few were found for the first time in Milford Haven, in the south of Wales.[169] This multiple mollusc, whose individuals sit on top of each other in tiers, has somewhat similar needs to the oyster, since it lives by filtering plankton. It is therefore a serious competitor for space to sit on, especially as it favours the

same muddy kinds of shore (Pl. 33). I shall mention this species again in Chapter 6.

A serious enemy of oysters has also come in, though much more recently. Oyster beds all over the world are preyed upon by the small whelk tingles or oyster-drills, of which there are two English species: the dog whelk, *Purpura* (or *Nucella*) *lapillus*, also commonly seen around mussel beds, and known as an important predator of barnacles; and the smooth whelk tingle or oyster-drill, *Ocenebra erinacea*. In 1928 the American oyster-drill or rough whelk tingle *Urosalpinx cinerea* (Pl. 32) was found and has since spread to various oyster beds in Essex and Kent, but not beyond (Fig. 38). It does not have a free-swimming stage and is chiefly moved about by man. We know now that it had probably reached this country in the late nineteenth century.[165] It must be ranked as a really successful invader, living on young oysters as well as other animals, and reaching population densities of five to a square yard. Oyster populations in England have suffered severe disasters in recent decades and can ill afford an additional enemy that is able to destroy half the annual increment of an oyster bed. Oysters are susceptible to very cold winters, and suffered great losses in 1928–9, 1930–40 and 1946–7. *Ocenebra* also declined in numbers and in the latest catastrophe became almost extinct in Essex and Kent, though not on the South coast. But *Urosalpinx*, being less vulnerable to cold, did not decline and so has achieved a dominant place in this community.[167] In 1955 *Ocenebra* was just beginning to reappear in those parts.[188] *Urosalpinx* has also reached the Pacific coast of the United States.[184]

This traffic in oysters and their associates has effects that can only be touched upon in such a short essay as this. In 1949 consignments of *Ostrea edulis* were planted on the American coast in Maine, and began to breed with some promise of permanent populations.[184] The Japanese oyster, *Ostrea gigas*, was first brought over to the coast of the State of Washington in 1905, and in much later years other plantings were made in British Columbia, Oregon, and California, and a great new market for 'Pacific oysters' grew up.[183] But still the spat is grown in Japan, brought over and planted in America, as they only breed sporadically in their new habitat. As usual, other species have come in with the stock:

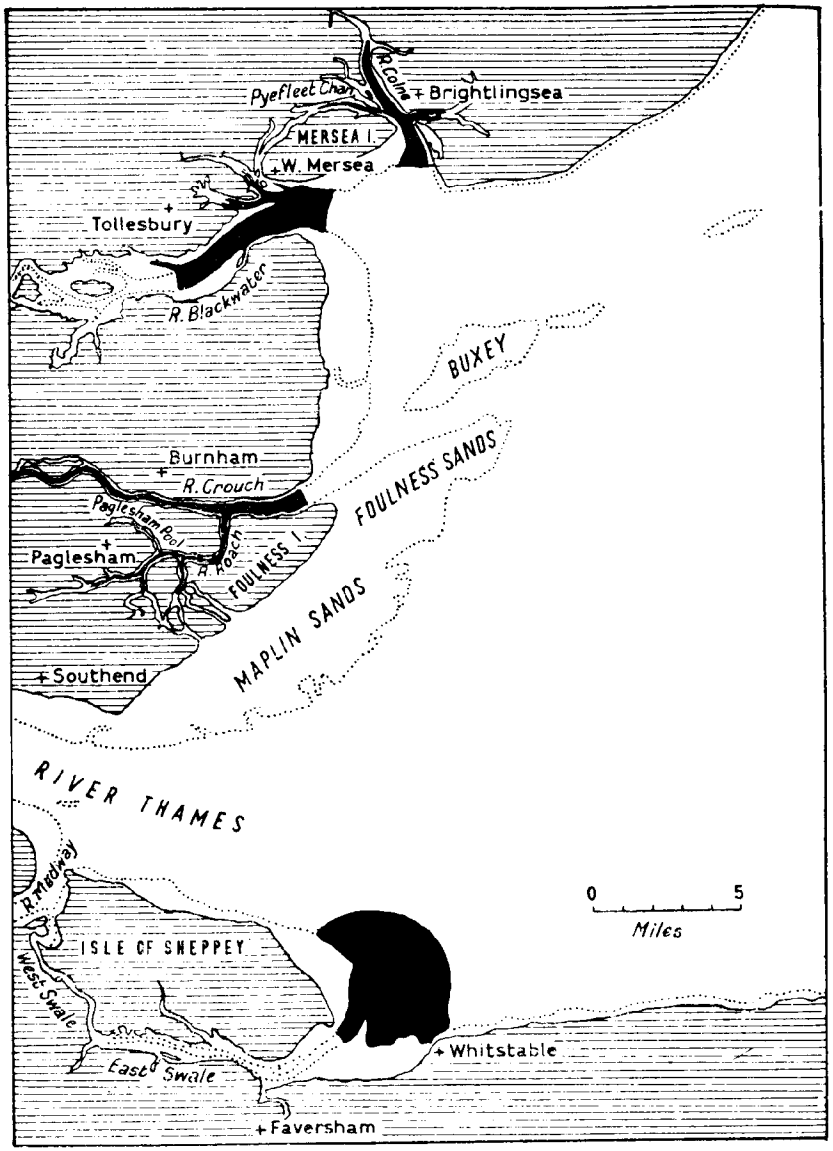


FIG. 38. Known distribution of the American whelk tingle or oyster drill, *Urosalpinx cinerea*, in English oyster beds. (After H. A. Cole, 1942, by permission of the Council of the Marine Biological Association.)

among others a Japanese clam, *Paphia philippinarum*, which is at any rate edible and a Japanese oyster-drill, *Tritonalia japonica*, which attacks oysters both the foreign and native. The Japanese oyster was taken to Australia in 1947–8: those put down in Tasmania established safely and have bred, though it is not yet known how permanently they will be able to live there.[198] This tale could be repeated endlessly—for instance, as if the tropical seas were not already rich enough, Hawaii has had *Ostrea virginica*, *Ostrea gigas* (which both made a good start), and *Ostrea cucullata* from Australia (which died).[173] If a large corporation had been set up just to distribute about the world a selection of organisms living around or just below low-water mark on the shores of the world, it could not have been more efficient at the job, considering that the process has only been going full blast for a hundred years or less!

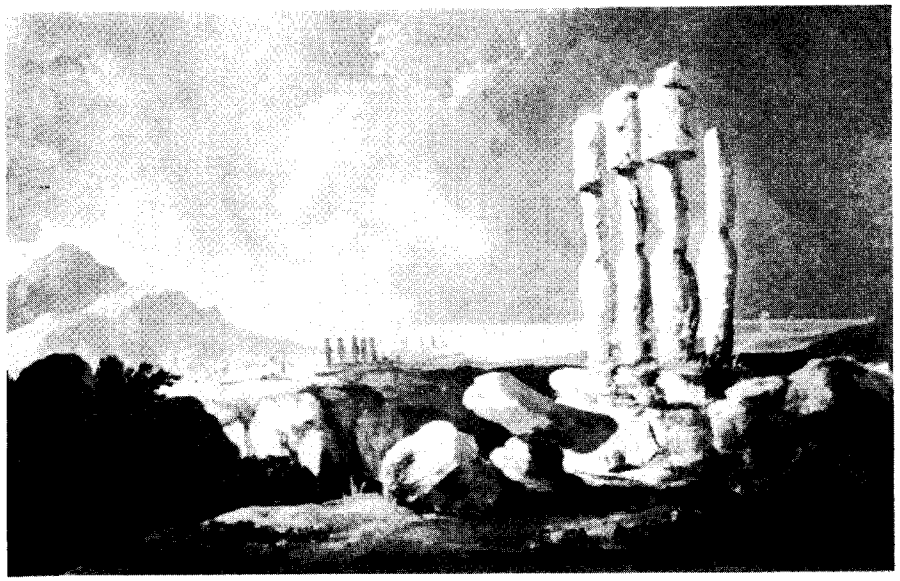
A good deal of chess play has also been done with clams, the often large sand-or-mud-living bivalves used for food. The Pacific Coast has now got the Eastern American soft clam *Mya arenaria* (that also lives in Europe naturally), brought by 1874, probably accidentally with oysters.[196] Hawaii has acquired two Oriental clams, *Paphia philippinarum* and *Cytherea meretrix*.[173] But these experiments are small in comparison with the great transfers of oysters everywhere. One final example of the transport of a species, but one that is not of any commercial interest, is a small Xanthid crab not more than an inch across, *Rhithropanopeus harrisi*, of Eastern North America which reached California probably with oyster materials about 1938. Here it lives in rather muddy estuarine water but only in places where occasional freshening of the water kills a native species of crab, *Hemigrapsus oregonensis*, with very similar habits. It likes to live among the calcareous tubes of the worm *Mercierella enigmatica*.[182] *R. harrisi* turned up in the harbour of Copenhagen in 1953, living with the same Serpulid worm, *Mercierella enigmatica*, also introduced there! It has reached other parts of Europe, including the Black Sea.[201–2]

In the midst of this rather complex tangle of species and dates and places we can discern the setting in of a very strong historical move, the interchange of the shore fauna of continents, and also sometimes the plankton of different seas. It is only an advance guard, yet some of the

species have already taken up prominent posts in the new communities they have joined: *Biddulphia* in phytoplankton, *Elminius* in the intertidal zone, oysters at various low levels of muddy shores, their dominant enemies like *Urosalpinx*, competitors like *Crepidula*, and we should remember (from Chapter 1) the grass *Spartina townsendii*.

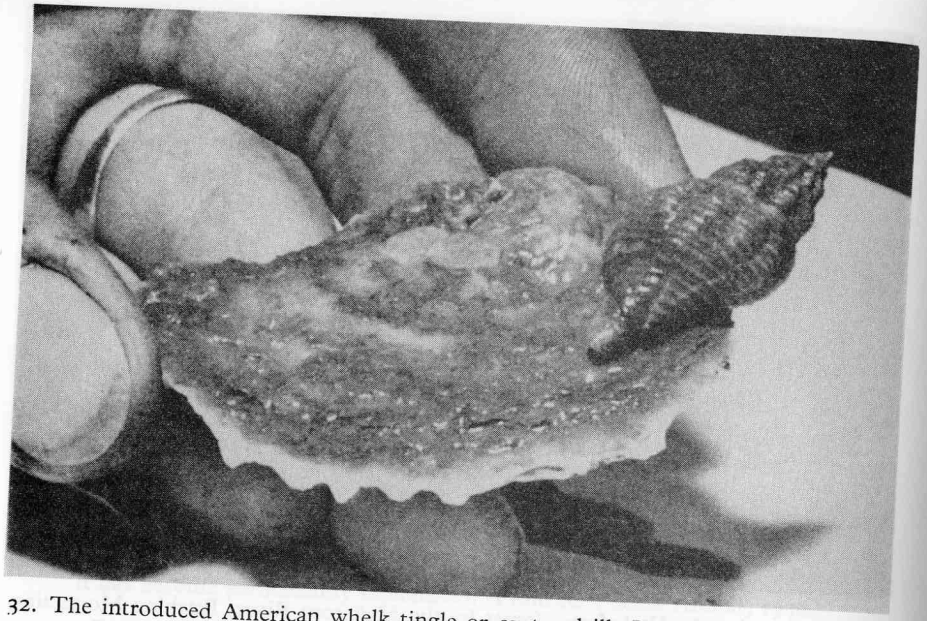
Some very startling explosions in marine populations have happened in the Caspian Sea. This highly modified relic of the Tethys Sea has undergone many vicissitudes before arriving at its present ecological state, yet still contains an enormous wealth of life. It is the biggest brackish lake in the world, 800 miles long, having about half the salinity of the sea and a rather different chemical composition, the lower depths sterile like the Black Sea of all except microscopic life, the northern part ice-covered in winter and inhabited by a race of Arctic seals. There is a very rich inshore bottom community and fisheries. Lake Aral, which is rather fresher, is also a marine relic. There are still in the deserts of these parts wells that have in them marine Foraminifera. Although the Black Sea is salt, its lagoons contain many of the brackish species that used to live in the Caspian Sea, and before that in the great Pontian Sea that united them all in Pliocene times. In 1934 Soviet marine biologists first suggested the deliberate introduction of animals from the Sea of Azov and Black Sea into the Caspian and Lake Aral, to help the fisheries.[203] The idea was backed by two extraordinary events of which we do not unfortunately have the complete history. At some previous time, but not very long ago, a bivalve mollusc, *Mytilaster lineatus*, from the Black Sea and a prawn, *Leander adspersus*, from the Sea of Azov got accidentally into the Caspian and multiplied colossally. These species both live also in the Mediterranean. Various fish have also been brought in, of which the grey mullet, *Mugil*, is said to have established itself successfully. But when a species of sturgeon was imported into Lake Aral it carried with it a parasite worm, *Nitzschia sturionis*, that did serious damage to another sturgeon there.

In 1937 research was being done on the physiological tolerance of a brackish water polychaete worm from the Black Sea and Sea of Azov, *Nereis succinea*,[190] and about 1940 it was introduced into the Caspian, with startling success.[160] By 1952 a whole programme of ecological work had been done on this species, because it was by then one of the dominant



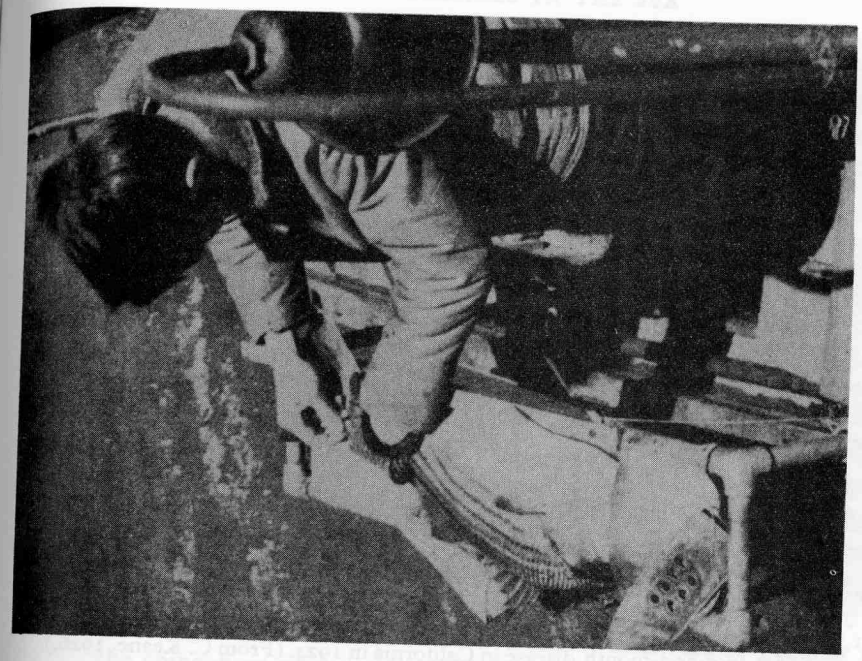
23. 'The Monuments on Easter Island'. The great statues made by the earlier Polynesian inhabitants. In the left foreground is apparently the island tree, *Sophora toromiro*, now almost extinct; in the middle distance natives by their house and some cultivated plantains. (Reproduced by permission, from a painting by W. Hodges, who accompanied Captain Cook's Second Expedition, lent by the Admiralty to the National Maritime Museum, Greenwich.)

24. The grassy slopes on the outer wall of the old crater Rano Raraku on the east side of Easter Island, with some of the great statues made by the early inhabitants. (From C. Skottsberg, 1920.)

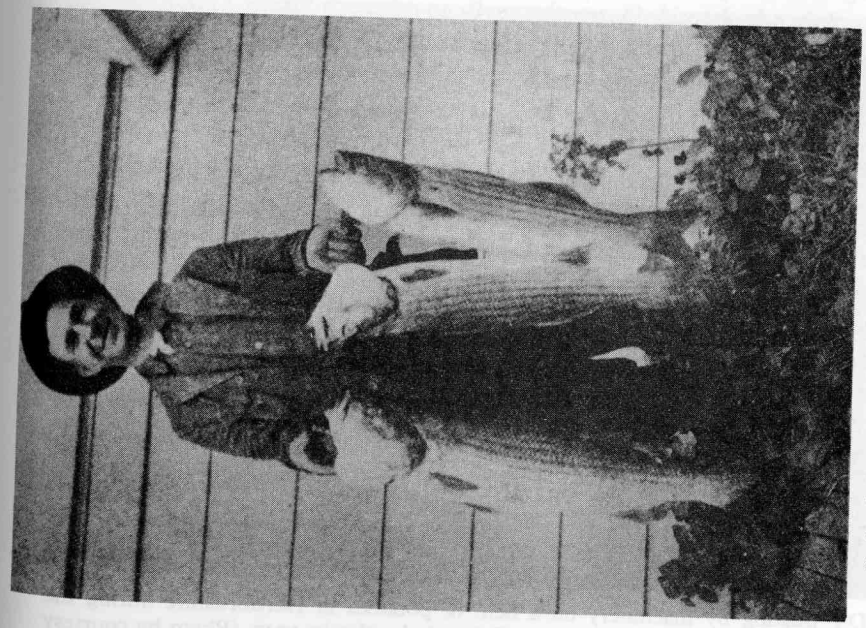


32. The introduced American whelk tingle or oyster drill, *Urosalpinx cinerea*, on an English oyster, *Ostrea edulis*. (From H. A. Cole, 1956B.)

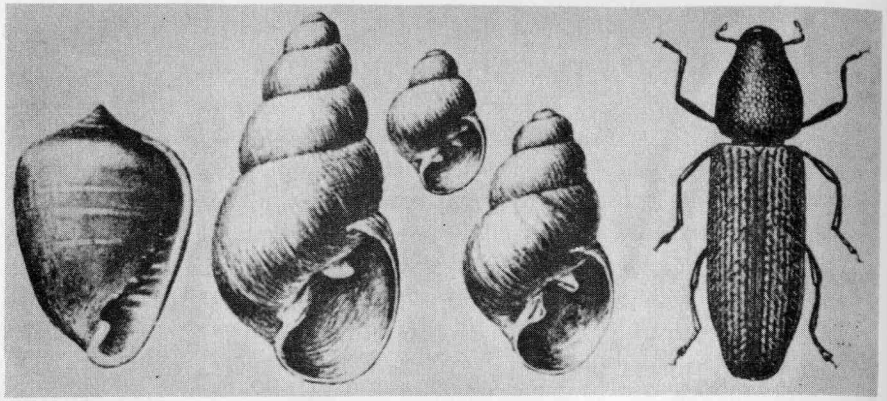
33. American slipper limpets, *Crepidula*, being cleared from derelict oyster beds in England. (From H. A. Cole, 1952.)



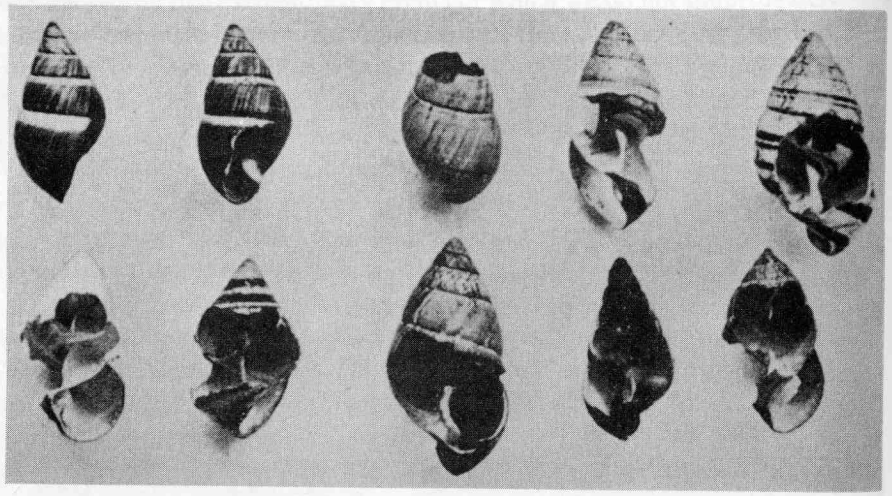
35. A striped bass, *Roccus saxatilis*, being tagged in California, for the study of its migrations. (From A. J. Calhoun, 1952.)



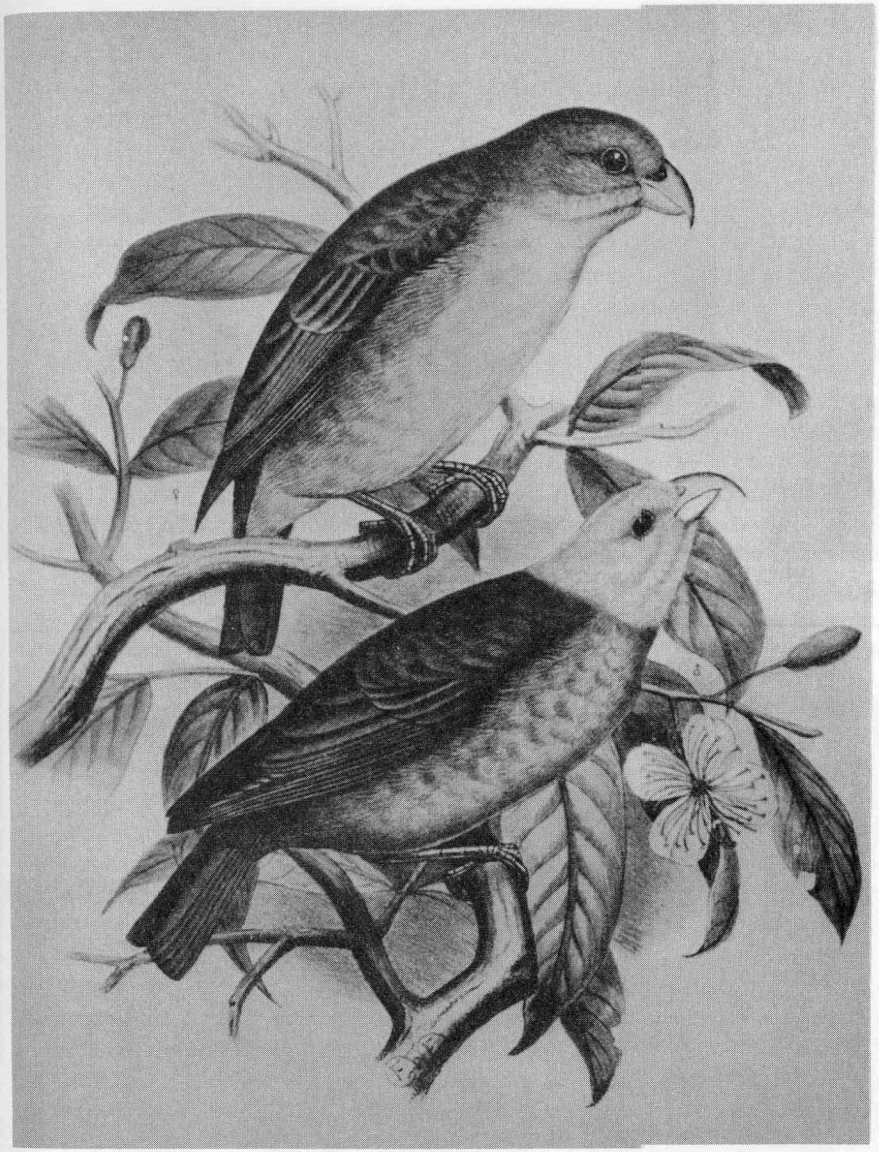
34. Striped bass, *Roccus saxatilus*, weighing 12–17 pounds, caught by an angler in California. (From N. B. Scofield and H. C. Bryant, 1926.)



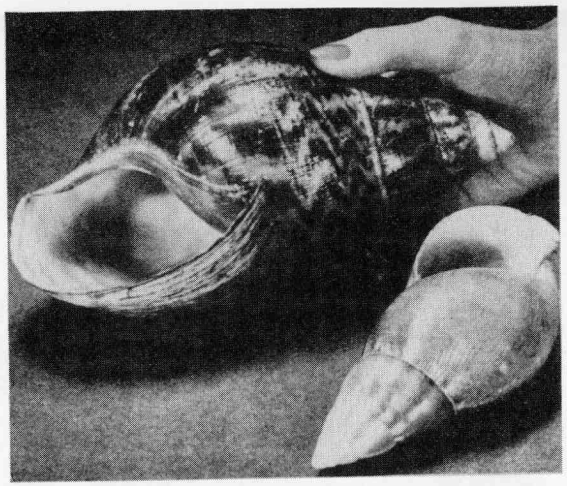
25. Easter Island has only five species of land and freshwater animals so far found to be endemic. The land snail, *Melampus pascus*, (left) and the weevil, *Pentarthron paschale*, (right) are two of these. The three land snails in the centre are forms of *Pacificella variabilis*, described as endemic, but since recognized as a Fiji species, *Tornatellinops impressa*. None of these three species measures more than 5 mm. (Snails from N. H. Odhner, 1926; weevil from C. Aurivillius, 1926; later note on *Pacificella*, see C. Skottsberg, 1956.)



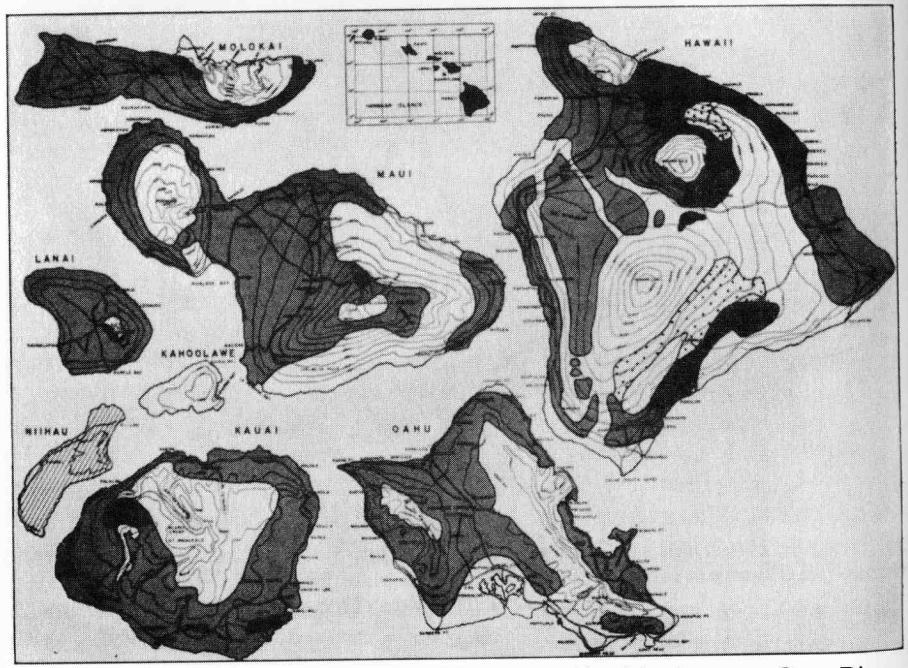
26. Shells of Hawaiian land snails attacked by introduced rats. 3–7 *Achatinella*, 9–10 *Amastra*. (From J. F. G. Stokes, 1917.)



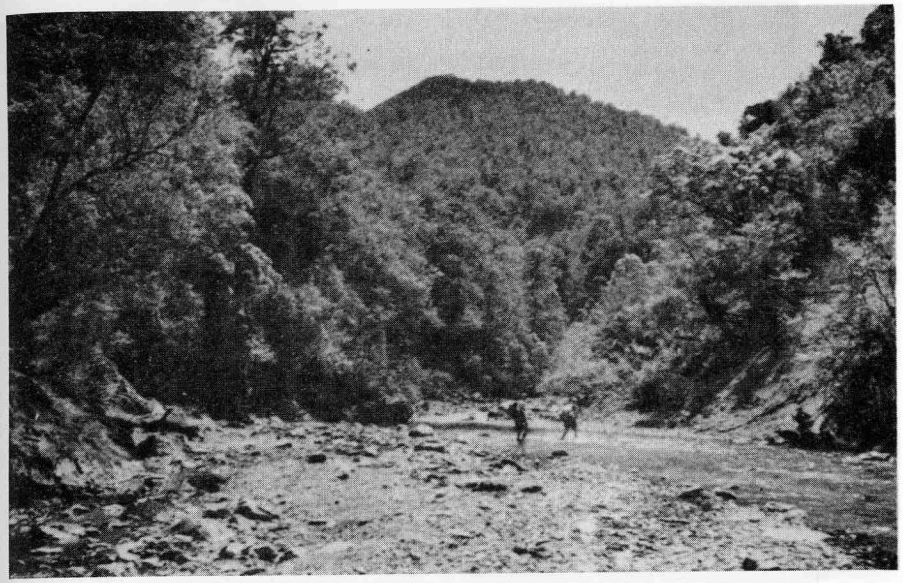
27. The Ou, *Psittacirostra psittacea*, one of the Drepaniidae, a family evolved entirely within the Hawaiian Islands. (From a coloured plate by F. W. Frohawk, in S. B. Wilson and A. H. Evans, 1890–9.)



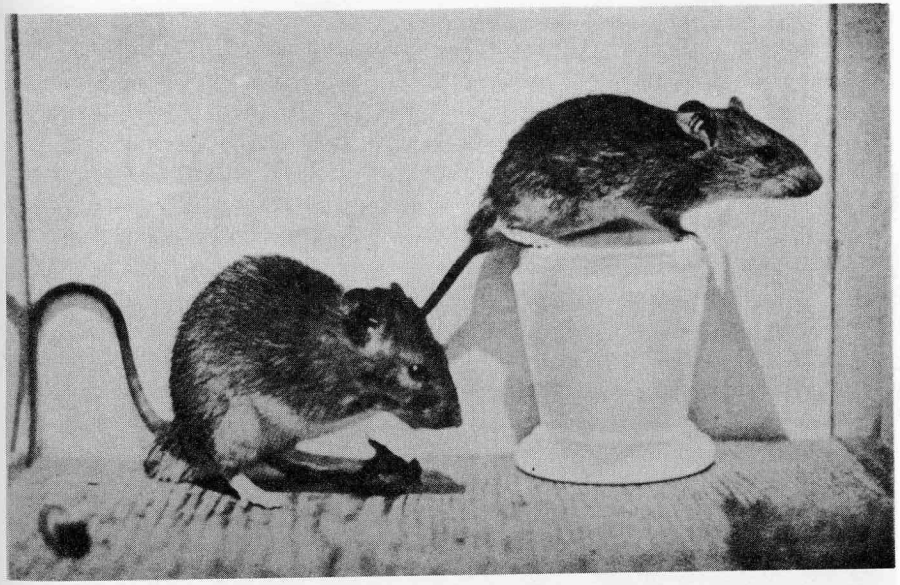
28. Giant African snails. The large one in the hand is *Achatina achatina*, still confined to West Africa. The other is *A. fulica*, spread from its native home in East Africa by man across the Indian and Pacific Oceans. Hawaii is the furthest eastern point at which it has become permanently established. (From R. Tucker Abbott, 1949.)



29. Distribution of introduced pheasants in the Hawaiian Islands, 1947. *Grey*: Ring-necked pheasant, *Phasianus colchicus*; *Stippled*: Japanese pheasant, *P. versicolor*; *Black*: mostly hybrids. (Niihau I. was not surveyed.) (Photographed from coloured map, with stipple added, in C. W. and E. R. Schwartz, 1949.)

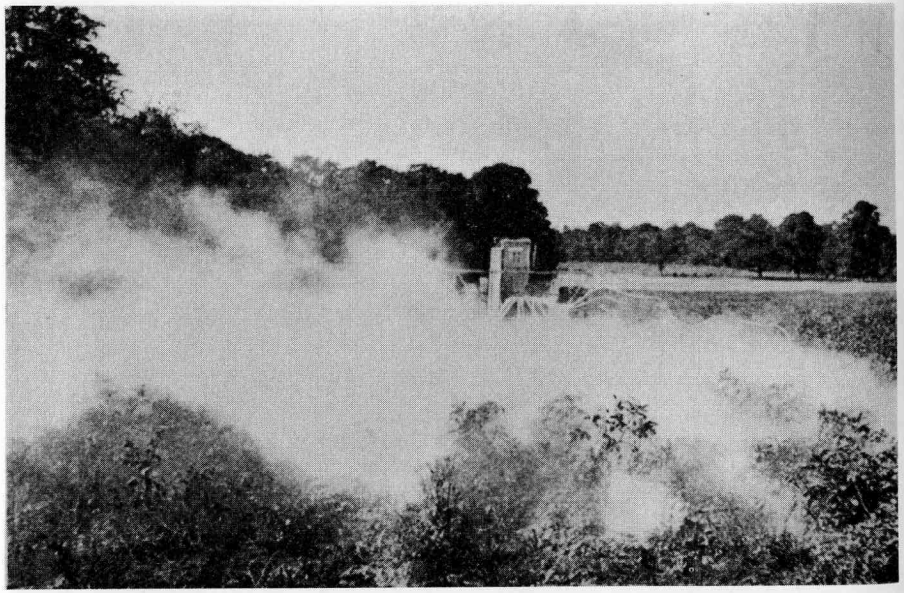


30. Southern beech, *Nothofagus*, forest by the Makaroro River, Ruahine Mountains, Hawkes Bay, North Island of New Zealand. It is now inhabited by introduced European red deer, *Cervus elaphus*, and Australian opossum, *Trichosurus*. (Photo J. S. Watson.)



31. Hawaiian rats (*Rattus hawaiiensis*). The small rats of this species group have been carried, originally from Malaya, across the Pacific by Polynesian voyagers. They still survive on some islands, including Hawaii and New Zealand, but in many places have died out partly through the presence of rats brought by Europeans. (From J. F. G. Stokes, 1917.)

36. 801 slaughtered cattle being buried in a 600-foot trench, during the successful campaign against foot-and-mouth disease in California in 1924. (From C. Keane, 1926.)



37. DDT dusting by machinery on a field of potatoes in Hertfordshire during the successful eradication campaign against Colorado beetles in 1947. (Photo by courtesy of the Plant Pathology Laboratory, Ministry of Agriculture, Fisheries and Food.)

inhabitants of the benthos layer. Like *Spartina* in England, it found a zone of muddy bottom that other species had not dominated. By 1946 its populations had spread to their habitat limits in the weaker brackish waters of the Sea; and it was possible to announce that '*Nereis* accounts for a quarter to a fifth of the total calorie value of the bottom fauna of the Northern Caspian in June'. It had become an important extra fattening food for two kinds of sturgeon; it is claimed that this had come about without disturbing the balance of other benthos animals. The worms live in the superficial layer of organic material on the mud and sand bottom, where they shelter, and on which they feed. The possibilities of spread into any environment that allows play for such expansion are suggested by the fertility of a female *Nereis succinea*—eighty to a hundred thousand eggs.[190]

It remains to round off this account by giving a few instances of river-running and also of true marine fish being successfully introduced. In the North Pacific from Japan to Western America there is a group of Pacific Salmon, *Onchorhynchus*, that provide one of the biggest salmon fisheries in the world. They live in the sea but ascend rivers to breed, like our own species. There are five kinds, with various peculiar names: the chinook or quinnat, *Onchorhynchus tschawytscha*; the sockeye or red salmon, *O. nerka*; the coho or silver salmon, *O. kisutch*; the pink or hump-back, *O. gorbuscha*; and the chum or dog, *O. keta*. We are concerned with the first four species. From 1872 onwards until 1930 the United States Bureau of Fisheries, with benevolent intent, supplied over 100 million eggs of Pacific salmon to people in other countries, with the idea of establishing new salmon runs there—a considerable attempt to bring in the New World to right the Rest. The job was done very efficiently, and unlike many such campaigns, a careful record was kept of the results.[172] Many countries tried it out, though Norway refused. Because of the limited range of tolerance to water temperatures that these northern salmon have, the introductions were only successful in the northern and southern temperate zones, and failed in places like Hawaii; while in some others like the Argentine the rivers were probably too full of silt. Some sea to river runs were achieved in Chile (coho or sockeye), New Zealand (chinook), Maine (pink), New Brunswick and Ontario (chinook); while

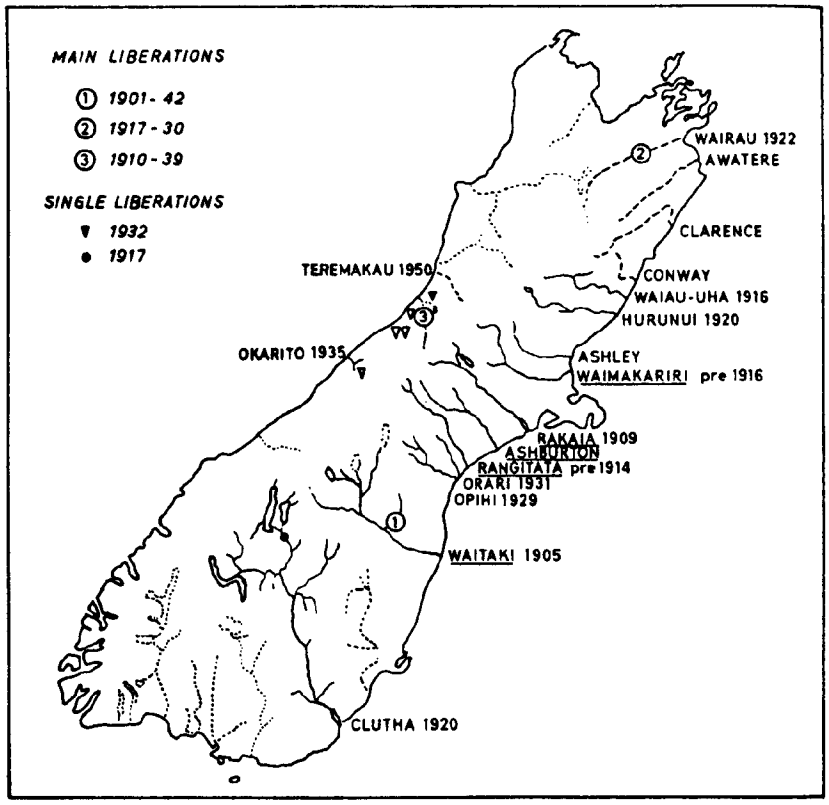


FIG. 39. Distribution of populations of the introduced Pacific quinnat salmon, *Onchorhynchus tschawytscha*, in New Zealand. *Solid lines:* well established stocks; *broken lines:* a few salmon; *dotted lines:* none. (After K. R. Allen, 1956.)

some of the populations took to an entirely inland life in lake or rivers, as in New Zealand (sockeye) and Tasmania (chinook) and certain populations in eastern North America. The quinnat (chinook) has established regular breeding stocks in New Zealand since 1905 (from eggs laid in 1901), and these occupy many rivers of the east coast (Fig. 39), ranging the seas as well, where the salmon spend a great deal of their mature life.[159] This enormous experiment has put a genus of fish formerly confined to the North Pacific into the other oceans of the world, in the belts where summer isotherms of the sea water are not above 15–20°C. After many attempts that failed in the last ninety years the Atlantic salmon, *Salmo salar*, has also achieved a breeding population in New Zealand, but only in a single river system.[159]

Between 1871 and 1880 over half a million fry of the shad, *Alosa sapidissima*, from Eastern America were planted in the Sacramento River, California, and nearly a million more in the Columbia River in 1885–6. By 1879 these fish had already begun to be abundant enough to sell and in latter years there has been an average catch every year of several million pounds.[185,196] Though the commercial fishery covers a narrower range, the shad itself now occurs from the Northern edge of Mexico right up to Alaska and Wrangell Island. Neave has remarked drily: 'Perhaps the best testimony to the fact that the shad is reacting like a native fish is to be found in recent complaints of depletion in the Columbia River, accompanied by requests for appropriate investigation of its status.'[189]

The final example of this sort of explosion of fish is the striped bass, *Roccus saxatilis*. This is a hefty fish, the official champion being one of 125 lb. from Carolina—perhaps six feet long and an angler's dream. The ordinary limit is about ten pounds, but it is apparently not rare to find them two or three times as heavy.[187] It is a sea fish but it goes into the less saline waters of estuaries to breed. Its natural home is on the Atlantic coast of North America from Florida to the Gulf of St Lawrence. In 1879 the first striped bass were brought to California, and in 1882 the only other lot, in all about 435 fish. The populations grow very fast and spread up to other places on the Pacific coast.[194] Although it is especially prized as a game-fish for anglers (Pl. 34), something like a million pounds weight of the fish were being caught in 1926, and this did not include the anglers'

contribution. But since 1935 only anglers have been allowed to fish for it in California. 'The annual catch in this state since 1942 has been stable at about 1,500,000 fish. It has been estimated that $10,000,000 is spent annually on bass fishing trips and that the species provides 2,000,000 man-hours of recreation per annum.' [189] A world that begins to assess its recreation in man-hours probably cares fairly little about the breakdown of Wallace's Realms; but it will be interesting to follow the research that California is doing on this fish, to see whether its rather hesitant seasonal migrations (Pl. 35) will reach a pattern like the Atlantic one, whether the fact that it feeds a great deal on anchovies and shrimps[181] will produce effects on other fishing enterprises, how many more dominant predatory fish could be moved around in this way with success and without ill results. As Neave remarks: 'In some respects our ignorance of population dynamics is demonstrated as effectively by these successes as by the failures which have frequently attended our efforts to introduce species into new environments.' [189] It is natural to turn from the almanack of invasions in continents, islands, and seas, to a consideration of the balance between populations.

CHAPTER SIX

The Balance between Populations

In the first part of this book I have described some of the successful invaders establishing themselves in a new land or sea, as a war correspondent might write a series of dispatches recounting the quiet infiltration of commando forces, the surprise attacks, the successive waves of later reinforcements after the first spearhead fails to get a foothold, attack and counter attack, and the eventual expansion and occupation of territory from which they are unlikely to be ousted again. And it was seen that the former isolation of continents and to some extent of oceans had evolved as it were more species of plants and animals than the world is likely to be able to hold if they are all to be remingled again—almost illimitable reservoirs of species moving out to bombard other parts of the world for thousands of years to come. The impression gained might be somewhat that felt by the reader of H. G. Wells's fantasy, *The Food of the Gods*, of which he wrote: 'It spread beyond England very speedily. Soon in America, all over the continent of Europe, in Japan, in Australia, at last all over the world, the thing was working towards its appointed end. It was bigness insurgent. In spite of prejudice, in spite of law and regulation, in spite of all that obstinate conservatism that lies at the base of the formal order of mankind, the Food of the Gods, once it had been set going, pursued its subtle and invincible progress.' How one wishes that the breakdown of Wallace's Realms could have been described by Wells at the age of forty-two!

With the invasions of animals and plants that I have described, it is the successful species that are concerned. But there are enormously more invasions that never happen, or fail quite soon or even after a good many years (like the skylark in America). They meet with resistance. It is this resistance, whether by man or by nature or by man mobilizing nature in