of birds left after autumn shooting) could be increased without over-exploiting the stock and without accelerating the decline, which is due to other causes (Jenkins *et al.* 1961:4). Research is gradually extending to cover soil sampling, botany, detailed behaviour studies and large-scale experimental alteration of population balance. Results at present indicate the need for resting and replenishing the land, possibly by allowing it to revert to scrub or woodland and introducing alternative game animals to maintain productivity. Thus the ecological research, although expensive and time consuming, has already helped to reduce expenditure on useless remedies, has shown the need for new methods of exploitation consistent with good farming, and has provided instruction on an economically important but neglected form of land management.

Similar research is required, and should be demanded, in every case where exploitation of birds is permitted under legislation or control. Only through such studies are we likely to gain the knowledge required to safeguard stocks, and at the same time allow a fair and efficient form of management in which interests both of licence holders and of protecting authorities are safeguarded.

REFERENCES

ARCHEY, G., 1941. The Moa, a study of the Dinornithiformes. *Bull. Auckland Inst. and Mus.* 1: 5–101.
BENT, A. C., 1921. Life histories of the North American gulls and terns. *U.S. Nat. Mus. Bull.* 113.
COTT, H. B., 1953, 1954. The exploitation of wild birds for their eggs. *Ibis* 95: 409–449, 643–675; 96: 129–149.
FISHER, J., and LOCKLEY, R. M., 1954. *Sea Birds. An introduction to the natural history of the sea-birds of the North Atlantic*. Collins, London.
GREENWAY, J. C., 1958. Extinct and vanishing birds of the world. *Spec. Pub. Amer. Comm. Int. Wild Life Prot.* 13.
JENKINS, D., 1959. *Enquiry into the decline of Red Grouse. Fifth progress report*. Scottish Landowners' Federation, Edinburgh.
JENKINS, D., WATSON, A., and MILLER, G. R., 1961. *Nature Conservancy Unit of Grouse and Moorland Ecology. Seventh Progress Report*. Scottish Landowners' Federation, Edinburgh.
LACK, D., 1954. *The natural regulation of animal numbers*. Oxford.
LOVAT, LORD, *et al.*, 1911. *The grouse in health and in disease*. 2 vols. Smith and Elder, London.
OLIVER, W. R. B., 1949. The moas of New Zealand and Australia. *Dominion Mus. Bull.* 15.
QUENNELL, P., 1951. *Mayhew's London*. Spring Books, London.
RIDLEY, M. W., and PERCY, LORD R., 1958. The exploitation of sea birds in Seychelles. *H.M.S.O. Colonial Research Studies* 25.
RICHDALE, L. E., 1944. The Sooty Shearwater in New Zealand. *Condor* 46: 93–107.
VESEY-FITZGERALD, L. D. E. F., 1941. Further contributions to the ornithology of the Seychelle Islands. *Ibis* (14) 5: 518–531.

UTILISATION OF MARINE INVERTEBRATES

L. R. RICHARDSON

Victoria University of Wellington

The utilisation of marine invertebrates extends from prehistoric nomad times through all levels of communal development to our present civilisation. The invertebrates have provided hard parts such as shells for tools, ornaments, symbols, a source of lime, jewellery, dress, weapons, fibres for cloth, dyes, and soft-parts for food. We retain today more of these usages than we have abandoned, and in some cases increased our utilisation in proportions greater than the increase in population. The requirement for commercial sponge has not extended and only a few hundred tons are now landed each year but the demand for ornamental corals is in the order of 4,000,000 pounds and more each year, while the demand for pearls is unsatisfied even with the tremendous production from Japan's pearl culture development.

Shell mounds were an old source of lime for mortar in earlier periods but now massive quantities of shells largely from recent oyster beds are utilised in the production of magnesium from seawater and as a source of calcium carbonate of high purity in other chemical industries. Coral is still important as a source of lime in Australia. Shell and coral are used in quantity in road-making. The combination of hard and soft parts of molluscs, crustacea and other invertebrates is finding increasing utilisation as fertilisers and as poultry and other meal. In 1956, 32,700 metric tons of poultry meal and other commodities were produced as a by-product from the crustacean fishery in North America.

The great bulk of marine invertebrates is landed for the table. These are surveyed in the F.A.O. Yearbook of Fishery Statistics. Russia and China do not fully report to this service. With their catch included, many of the figures used here would be considerably increased. The figures presented here are not based on landings in any one particular year, but are selected to give a general picture of the extent and importance of the landed catches of invertebrates.

The two major groups are the Crustacea and the Mollusca which together represent about 10% of the landings of world fisheries. Total annual landings are in the order of 2,750,000 metric tons, relatively close to the quantities landed for the more important groups of fishes, somewhat in the order of the total landings of the flounder-halibut group, and a little less than half that of the herring-sardine group. The molluscs make up some 2,000,000 tons of the catch. A recent Australian report shows landing of fish at 77,805,909 lbs, and of total crustacea at 36,816,027 lbs, which with oysters would come close to half the landed weight of fish. There is ample evidence in these figures to show that the invertebrates have no insignificant place in present economy.

With the exception of oyster culture, the production is still essentially from natural stocks. The invertebrates commonly show prolific reproduction, microphagous or scavenging habits, and reasonably rapid growth. These offer opportunities for relatively continuous high level yields. Utilisation is influenced by tradition and palate. Squid was totally neglected by the New Zealand fishery except as bait until very recently when inkfish was introduced to the retail market. Squid, cuttlefish and octopus are a favoured food of Mediterranean and Asiatic peoples. Total landings of molluscs in Japan are in the order of 740,000 metric tons. The size of this catch can be best appreciated by pointing out that it exceeds the total meat production of New Zealand which has stood in the order of 690,000 metric tons. Squid and octopus landings in Japan have averaged some 380,000 metric tons, a quantity far greater than either beef, mutton, or lamb production in New Zealand.

Squid constituted about three-quarters of the Japanese catch. These are oceanic animals, fishable in nearly all parts of the world as is indicated by small landings in many countries. We can barely conjecture at the addition to the world's protein supply when these animals are brought to full utilisation.

It is difficult to give perspective to the other molluscs at this time. Some, such as winkles, whelks and trochus, although numerous on rocky shores and bottoms, and traditional foods for many people, have nowhere developed to a significant fishery, not even in Asiatic or other countries where labour is low-priced. Cultivation has been attempted but to no great production. Bivalves have another history. The mussel is a remarkable exception. This highly palatable, hardy, fast-growing, readily cropped animal is eaten by most peoples but has never become a major commercial item of the table. Although cultivated for nearly 700 years in Europe for bait as much as for the table, landings for Denmark, Germany, the Netherlands and Italy were only 106,000 metric tons in 1958, a total probably exceeding the total for the rest of the world. Chile is the only other major lander of this shellfish. Generally as in New Zealand, utilisation is far below availability even though the conversion of mussels into poultry feed and fertiliser are proven practice. Such usage could well be investigated in New Zealand.

The oyster is of course the recognised major commercial bivalve. Under cultivation since the days of the Romans, natural beds in western Europe were adequate suppliers until the latter half of the last century. Rapid transport from the coast to major inland cities increased the demand to new high levels. Year-old oysters were fished from the natural beds to stock oyster farms. These and other factors led to the destruction of the natural beds. Simple overfishing cannot be the explanation. For example, one small area of under 40 square miles produced 80,000,000 oysters a year. Incidentally, the yield from this area over 100 years ago exceeded the catch landed into Bluff until the last few years.

Recent total world landings of oysters stand at some 570,000 metric tons; but data in this figure are not uniform. In fact, this was the magnitude of the U.S. landing in 1945 when the most careful estimation gave a world landing of between 760,000 and 800,000 metric tons. On a conservative estimation, this would yield in the order of 50,000 metric tons of oyster meat.

The oyster proves too large a topic to handle further here. It is sufficient to point out that 516,000 metric tons are landed in the United States and Japan alone. The bulk comes from cultivated beds and private leases.

The greater diversity of edible bivalves such as cockles, clams and scallops form another 408,600 metric tons in the landed catch of which over three-quarters is landed into the United States and Japan. These fisheries are still based almost entirely on natural beds. Such cultivation as is practised employs natural seed.

The other invertebrate group of major importance as food is the Crustacea with world landings totalling in the order of 750,000 metric tons. Half of this, about 390,000 tons is landed into the United States, Japan, and India, with landings in other countries mostly below 5,000 metric tons. The greater quantities of Crustacea landed are shrimps and prawns. In returns from 24 countries, where these are specified, they amount to some 256,700 metric tons in contrast to landings into 26 countries of lobster, crayfish and the Norway lobster totalling 50,300 metric tons. The New Zealand fishery is almost unique in not landing any prawns or shrimps. Landings of crabs in 20 countries amounts to 155,700 metric tons, the bulk being made up of some 58,000 metric tons of king-crab landed in Russia and Japan and the remarkable blue-crab fishery of the United States which lands some 51,600 metric tons.

In preparing this review, my curiosity has been taken by such records as the landing of 1,277,000 metric tons of molluscs in the Philippines for duck food; of some 2500 metric tons of barnacles into Portugal, Chile, Spain; of 16,300 tons of sea-urchins into Chile and Japan; of 3,200 tons of starfish landed into Germany; and other items which are sufficiently intriguing in the quantities given to warrant future attention. These quantities exceed landings of such traditional invertebrates as the *beche de mer* which is landed for the world in the order only of 1,000 metric tons.

The future in the utilisation of marine invertebrates will see only extension and diversification of the fishery with a still further venture into deeper waters. The latter has brought the Norway lobster into production. Prawns in several areas are fished in 400 fathoms and deeper. There will be an early extension of cultivation to the more highly valued smaller Crustacea such as prawns. Further we can anticipate that the chemical industries will turn an increasing attention to the invertebrate fisheries for by-products which are as yet little explored. There is almost certain to be utilisation of further invertebrates as sources of basic industrial chemicals not only because of their high density populations such as is seen in clam and mussel beds and in plankton, but also because of the range of inorganic and organic substances found variously in the invertebrates.

The New Zealand utilisation of marine invertebrates is barely commenced and hampered by ignorance of the high productivity of these animals. Continued resistance to the export of oysters and other restrictive limitations have held back the proper development of this fishery as was the case with the crayfish. Equally there is resistance to the export of paua shell and meat. The paua fishery is re-established but the shell has greater value than the meat, although the latter has a ready market in Hong Kong. The full utilisation of our extensive paua fishery, of our oyster fishery, of our mussels, of the several clams, of squid and other cephalopods, prawns and shrimps, such crabs as we have, and the other of our usable invertebrates is essentially still ahead of us. They will come into such utilisation only when this nation grows beyond its present rural status. We verge now on the situation where we may no longer be able to neglect the full harvest of the sea and this includes the full utilisation of the marine invertebrates.

THE EXPLOITATION OF THE INDIGENOUS FORESTS

R. J. CAMERON

Forest Research Institute, Rotorua

HISTORY OF EXPLOITATION

A thousand or so years ago the indigenous forests covered most of the land surface of New Zealand, the main unforested areas being those where climates were too extreme to allow forest to develop, or where volcanic eruptions, floods, or earthquakes had created seral conditions (Holloway 1954).

The Moa Hunters are believed to have been responsible for removing, or hastening the removal of large areas of climatically unstable forest from the more arid eastern plains and hills of both islands and may also have burnt forest in many other localities, probably retarding the regeneration of forests over the volcanic plateau of the central districts of the North Island (Holloway 1954).

The Maori of the Fleet, arriving in New Zealand some six hundred years ago, brought with them a number of tropical food plants which they were able to grow in warmer districts, clearing areas of forest to provide planting sites (Taylor 1958). As the native population increased in size so did their impact on the forests, particularly in northern districts where the greater part of post-fleet population was domiciled (Buck 1950). Towards the end of the eighteenth century a number of European vegetables were introduced, of these the potato being of particular importance, providing the Maori, for the first time, with a staple food that could be grown in all districts with a certainty of good yields — and which could be bartered with trading ships, missionaries, and settlers for muskets, axes, and other goods. This resulted in a great increase in the rate of forest destruction in all inhabited districts (Cameron *in press*).

Thus, by the time organised European settlement commenced, the indigenous forests had been reduced to some 28 million acres, perhaps half their primeval area. Most of this depletion can be called forest destruction, rather than forest exploitation, as only a very small proportion of the timber was used to any purpose, most of it disappearing in smoke during wild-fires. Maori utilisation of the forest was more for birds than for timber. The few trees needed by a tribe to build canoes, dwellings, or fortifications, to make tools or for fuel, could have been obtained from the forest with little visible effect.

The European settlers set about the destruction of the forests of lowland and hill country much more purposefully. Within a hundred years the area of indigenous forest had been reduced to less than 15 million acres, most of this being non-merchantable forest on steep, mountainous terrain. For the settler it has often been said, "one blade of grass was worth two trees", and this cannot be denied. Only in east coast districts was there any shortage of timber for fencing or building houses. Elsewhere timber was, at first, only valuable where it was situated