

poverished. Only 132 terrestrial invertebrates have so far been recorded from these islands. Many of these show a strong South American affinity, and the insects are believed to have been derived predominantly from that continent by airborne immigration in the prevailing westerly winds (M. W. Holdgate). Occasionally South American Lepidoptera and land birds appear as stragglers in the islands. The Tristan group also shows slight faunistic affinity with St. Paul and Amsterdam, but none with the colder and more southerly oceanic islands. These do, however, share something of a truly circumpolar fauna with relations to South America and New Zealand. Most of these islands are believed to be young, and their faunas likewise. In the Tristan-Gough group this hypothesis is supported by botanical evidence (N. M. Wace).

Within the littoral marine fauna, it is possible to recognize a distinct southern circumpolar element paralleled in the algal flora (G. A. Knox). Many of the species are dominants and give a characteristic aspect to southern temperate shores. A schematic classification of these zonation types can be derived, although distinct species groups are peculiar to each southern continent. Africa, despite an upwelling of cold Sub-Antarctic water off the south-west coast, has little truly southern cold-temperate faunistic relationship (T. A. Stephenson), a fact paralleled in its terrestrial invertebrate fauna (P. Brinck) and its flora (R. S. Adamson). In planktonic organisms, also, the southern waters have circumpolar, clearly zoned forms which show abrupt specific limitations near the convergences (N. A. Mackintosh). The Antarctic penguins also show somewhat of a circumpolar distribution with a radiation to distinct and geographically limited species farther north. In contrast, the shelf fauna of the Antarctic itself has a very high (70-80 per cent) incidence of endemism, and while many of its component species spread all around the continent they show no clear relationship with the animals of the other southern land masses (N. A. Mackintosh).

Oceanic birds are of profound ecological significance in the south, since they breed in vast numbers on many islands. One major vegetation type—tussock

grassland—may be in part a biotically induced formation (N. M. Wace). Yet despite their abundance, these birds have so far been imperfectly studied and the validity of their taxonomic definition is still questionable in many cases (R. C. Murphy). Many species make great migrations, and may act as dispersal agents for seeds and invertebrates: this role may be filled especially by juvenile petrels, which often fly while still bearing down contaminated from the nest burrow (R. A. Falla).

There is no doubt that the Southern Cold Temperate Zone possesses many features as a whole. Despite wide separation, there are many floristic and faunistic similarities between southern America and New Zealand and Australasia, and this applies also to the structural features of almost all the southern cold-temperate vegetation types. There is geological evidence which accords with that of present distribution in suggesting a common origin for such groups in a temperate Antarctic during the Tertiary. In contrast, no terrestrial vertebrates have a distribution of the true southern cold-temperate type (P. J. Darlington), and indeed, except for birds, land vertebrates seem to be largely absent from the region. Those that do occur appear to be recent immigrants from the north. Ecological rather than distributional factors may underlie this anomaly. It is evident that many features of this zone reflect the exacting requirements of the high-oceanic climate. The species-poverty of the southern islands and of south-west Chile no doubt depends in part on dispersal difficulties and upon recent ice-retreat, but it may well also derive from the narrow and specialized range of habitat conditions. The Southern Cold Temperate Zone indeed emerges as an area with a highly characteristic biology, and with a climate more profoundly influenced by the temperature and circulation of the sea than any other major world zone (C. F. A. Pantin). It is apparent, however, that much more work remains to be done there. Native faunas and floras are fast vanishing before the onset of northern hemisphere species introduced by man; yet there is virtually no southern island or mainland area which can be said to have received adequate study in all respects.

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AN INTERNATIONAL TAGGING TEST WITH SALMON (*SALMO SALAR* L.) SMOLTS

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FOR many years various experiments have been carried out in Great Britain and other European countries to investigate the migratory habits of the Atlantic salmon (*Salmo salar* L.). Much of the work has been undertaken to obtain further information about the movements of salmon in the sea, the proportion of smolts returning as adult fish and the percentage of spent fish surviving to spawn in following years, and in recent years thousands of salmon smolts have been tagged in Britain and Scandinavia.

Nearly all these experiments have involved the marking or tagging of the fish in some way. Numerous methods of tagging have been tried both with internal tags and external ones attached to various parts of the fish's body. The tagging of salmon smolts presents special difficulties because of the difference in the size of the fish between tagging and recapture. The lengths of most of the smolts tagged lie within the range 12-18 cm.; but when the fish are recaptured after spending one, two or more years at sea, the lengths will be between 50 and 100 cm.

or even longer. It follows that a tag which is attached to such a small fish must not restrict its freedom of movement unduly, but at the same time the tag must be such as to remain on the fish for a number of years. Also, in most instances, the tag must be clearly visible when the adult fish is caught. Although the type of tag has varied considerably, most of the workers have attached it near the base of the main dorsal fin of the fish.

In Great Britain, the number of tagged smolts being recaptured as adult fish has rarely exceeded 2 per cent. Norwegian returns have been somewhat lower, whereas in Sweden, the average figure has been between 5 and 10 per cent, with even higher figures for some of the larger smolts tagged. These high returns have been obtained both with Baltic salmon, where the fish are caught commercially on the feeding grounds, and with west-coast salmon, where they are caught along the coast near the mouths of the rivers.

The efficiency of different tagging methods was discussed at a symposium held by the Salmon and Trout Committee at the meeting of the Conseil International pour l'Exploration de la Mer, in October 1958. It was proposed that there should be an interchange of tagging methods. As a result, during April and May 1959, a number of Scottish smolts were tagged by Scottish, English and Swedish workers, using their own tags and techniques. Later on in May we visited Norway and Sweden in order to apply our English methods to the tagging of Scandinavian smolts.

All the smolts tagged in Norway and Sweden during this experiment were hatchery-reared and were two years old. We used two types of tag, one of which was a small silver plate, the other a small square of 'Ivory' (celluloid)¹. These tags were serially numbered, and for both types a short length of fine silver wire was used as a means of attachment. The Swedish tag (Carlin tag)¹ consisted of a small piece of cardboard coated with celluloid, with a message printed on one side of the cardboard. A serial number appeared on the other side. The tag is attached by means of a moveable hinge to a short length of soft stainless-steel wire which in turn is hinged to another stainless-steel wire, both ends of which are separately inserted into the body of the fish and twisted together on the other side. The tag used by the Norwegians is called the Lea hydrostatic tag¹ and is used in Britain for tagging adult fish. It consists of a small sealed plastic cylinder containing a printed message. It was attached to the fish by means of a bridle of soft stainless-steel wire. In all cases, hypodermic needles were used to facilitate the passage of the wires through the fish. A single needle was employed in the English and Norwegian techniques, a double needle in the Swedish method. The English and Norwegian workers attached the tag to the base of the anterior end of the main dorsal fin, so that the tag is carried on a loop above the back of the fish. The Swedish workers attached the tag to the body of the fish immediately below the dorsal fin. Thus, with the English and Norwegian methods, a small loop of wire extends over the back of the fish, whereas with the Swedish method there is no such loop. The Norwegian and Swedish workers anaesthetize the smolts with a 2 per cent solution of urethane for the tagging operation. The English workers do not normally use anaesthetics, but the fish are tagged in running water using a special holding block.

In Norway, more than two thousand smolts were tagged by the three different methods at the Lunda-

moen Hatchery near Trondheim. The fish were all released into the Gaula River. In Sweden, the production of electricity is based almost exclusively on the utilization of water-power, and a series of dams is being built on the main salmon rivers flowing into the Baltic Sea. The effect of these installations would be to destroy large areas of natural spawning grounds for salmon. The seriousness of such a situation would appear even more acute when it is realized that the particular value of the Baltic salmon fishery lies in its complementary relationship to the very important herring fishery in these waters. It has been decided, therefore, to substitute for the natural spawning grounds a system of hatcheries and rearing stations whereby the run of salmon can be maintained artificially by the annual release of a sufficient number of hatchery-reared smolts. In order to discover whether this system could be worked economically the Swedish authorities have tagged large numbers of artificially reared smolts during recent years.

A comparison of Swedish and English tagging methods was carried out at three stations on the east coast. The first batch of smolts was tagged at Galtström just south of Sundsvall. Fish reared at this particular station have normally produced a very high percentage of recaptures. The smolts were larger than normal, averaging 16–18 cm. in length and in excellent condition. More than four thousand smolts were tagged at Galström and all the fish were released into the nearby River Ljungan.

Another collection of smolts was tagged at Bergeforsen, near the mouth of the Indalsälven, one of the large rivers flowing into the Gulf of Bothnia north of Sundsvall. Here is situated one of the largest Atlantic salmon hatchery and rearing stations in the world. By means of a device consisting of batteries of plastic trays, more than two and a half million salmon eggs can be brought to the 'eyed' stage in quite a small room. The rearing station is constructed for the production of about four hundred thousand smolts of salmon and sea trout reared for two or three years. About 1,200 smolts were tagged at Bergeforsen and the fish were released into an artificial channel from which they could migrate into the main river at any time.

The third batch of smolts were tagged at Lulavan, situated on the Lule älv near the port of Luleå in Northern Sweden. The installation at Lulavan was merely a tagging station; but the history of the rearing of these smolts was most interesting. Although the salmon ova were from the north, the fish had been reared at Munka-Ljungby on the west coast of southern Sweden, where growth was more rapid. At the smolt stage, the fish had been transported back to the north by road tanker, a distance of 1,600 km. More than six hundred smolts were tagged at Lulavan and the fish were released into the main river.

In the spring of 1960, it is expected that Scottish, Swedish and Norwegian workers will tag smolts in an English river. Here, the fish will not be hatchery-reared but will be tagged during their natural migration out to sea.

It is hoped that some tagged fish will return in 1960; but it is clear that a statistical comparison of the methods of tagging employed in 1959 will not be possible until the end of the 1961 season, for only then will the major part of the 1959 smolt crop have been harvested.

¹ *J. Cons. Intern. Explor. Mer*, 9, No. 2 (1953).