range of different species from those of the other waters. Thus in the Cook Strait area there are potentialities for a dynamic interplay. Water properties will vary as mixing proceeds, and the plankton populations will be in a state of flux as specimens from one water are introduced into conditions foreign to them, and from which some will be eliminated as a result of lack of adaptability.

Information about Cook Strait at present available does little more than outline the essentials of the situation. There is a small amount of evidence from zooplankton, chiefly from the distribution of copepods, amphipods and euphausiids, which indicates that there is some interplay between water masses, and that the zooplankton of the Straits is in fact dependent on the waters influencing the area at a particular time.

It is concluded that Cook Strait and its environs offer possibilities for fundamental studies. These would concern, firstly, the relationships of species and water masses, and the species' reactions when introduced into a water foreign to them; and secondly, whether species which are distinctive of each of several waters may not in fact demonstrate the locale and extent of mixing between the waters, and, through the proportions of the original populations surviving, the time which has elapsed since mixing began.

Sharks and Rays of Cook Strait

J. A. F. Garrick

From the ecologist's point of view, Cook Strait is a region of considerable value for the study of any marine group, because of the variety of physiographic and hydrographic features that are encompassed within a relatively small area. For an ecologist wishing to study the sharks and rays, Cook Strait is an even better proposition because at least 90% of the known New Zealand species occur in the area. This richness of the Cook Strait fauna as exemplified by the sharks and rays, is no doubt due in part to the variety of habitat, plus the fact that most sharks and rays are fairly tolerant of a wide range of habitat anyway.

However, before any ecological study can proceed far it is necessary that the animals concerned be known from a systematic point of view, and in the case of an ecological study of a whole group, that something more than the majority of them be known adequately in this respect.

The position with regard to the sharks and rays of Cook Strait (which for the purpose of this talk I am regarding as extending from about Castlepoint to Kaikoura on the eastern side) is that there is as yet insufficient knowledge of them for an ecological study to make very much progress. Too many species are known from an inadequate number of specimens — for example 10% are known from one specimen of each while a further 10% are known from four specimens or less. When we consider that the total number of New Zealand sharks and rays is only 45 this number of poorly known species is significant.

Moreover, the species on which we have so little information are not all deep-water species—at least four of them, *Heterodontus portus-jacksoni* (bull-head shark), *Triakis attenuata* (shovel-nosed smooth-hound), *Arrynchobatis asperrimus* (long-tailed skate) and *Dasyatis thetidis* (long-tailed stingray) have been taken in 100 fathoms or less, while several others have been caught no deeper than 200 fathoms.

If we now turn our attention to the common species, the identity of even some of these is not firm. An example in this category is the shallow water spiny dogfish from the western side of the Strait, *Squalus griffini*, which is regarded as an endemic, though critical comparison with overseas specimens may still prove it to be identical with the Atlantic *Squalus fernandinus*. Similarly the systematic status of our well-known big-game shark, the mako, awaits

final determination as to whether it is actually a distinct Pacific species, *Isurus glaucus*, or whether it is the same as the Atlantic *Isurus oxyrinchus*. So far the examination of five specimens of mako points very significantly towards the latter species.

Such systematic deficiencies as those just mentioned might perhaps be regarded as pin-pricking, rather than as relevant objections to the furtherance of an ecological study of the animals concerned. I do not think this is really the case, for until the species are known with confidence, their affinities cannot be established, and most of us would agree, I think, that a knowledge of the affinities of a group can be of considerable aid in extending or modifying our ideas on the ecological status of that group. If this is so, then in the case of a relatively small group such as the sharks and rays, it does not require very many changes in our views on the specific identities of its members to cause quite large changes in our ideas as to the affinities of the group as a whole and hence to their ecological significance, the factors controlling their distribution, and so on.

As an illustration of how a revision of the species present can cause large changes in our views on the affinities of the N.Z. sharks and rays, we can compare the figures for the affinities based on the specific identifications recognised a few years ago, with those based on what I now believe to be their identifications.

	Previous figures.	Present figures.
Cosmopolitan species	11%	36%
Australasian species	36%	30%
Endemic species	47%	27%
S. Hemisphere & Pacific species	6%	7%

The previous figures show that only about 10% of the fauna is cosmopolitan, while more than 80% is either endemic or shared with Australia. Such a picture does not fit in with what is known of the mobility and tolerance to habitat of the group in other regions, particularly when one thinks of it in terms of the larger pelagic sharks, and the deeper water sharks. After all, in the Atlantic the larger pelagic sharks extend from the North Temperate zone down through the tropics to the South Temperate zone, almost without change, so it is not unreasonable to expect our equivalents of these sharks to be shared at least with the remainder of the Pacific, if not with the Atlantic as well. The same argument applies to our deeper-water sharks, though our previous apparently high degree of endemism with regard to them, compared with other regions such as Australia, is, I think, mainly because we have been fortunate in collecting them, while many other regions have not yet done so. Such good fortune is due more to our proximity to deep water than to special merit on our part.

The present figures for the affinities of the fauna, which suggest that a little more than one-third of it is cosmopolitan, while something more than a half is Australian, seems to me to be a much better approximation, though I would not say that they will not themselves change with further investigations. It may be a long time before we really reach a true picture.

It should however be noted that not all the percentage changes just mentioned are due to re-identifications. Many of them are due to the discovery of species not previously known. Such additions to the fauna can similarly cause large changes in our views on the affinities of the group as a whole, particularly if the additions are from an ecological environment not adequately explored before, and likely to be a continuum of similar environments in other regions. In this case, the ecological environment concerned is our deeper-water areas, from 200-1200 fathoms. We have by no means exhausted this environment, and are far from the stage when we might predict with any accuracy just what sharks and rays will be found in it in any particular place, depth or time. In fact, new problems are arising as fast as we gain information which helps to solve old problems. As an example of the former, we have caught several specimens of a deep-sea dogfish, *Scymnodon foliaceus*, in 200 fathoms, previously known only from Japan and the Philippines in much deeper water. But our specimens, like the Japanese and Philippine ones, are all juveniles, and we have not caught any adults in either deeper or shallower water even though we have been looking for them there. As an example of this deep-water exploration solving previous problems, we can quote another deep-sea dog-fish, *Scymnodon plunketi*, which was

previously known only from a few specimens off New Zealand, and considered rare. We know now that it is common in 300-500 fathoms, at least in certain areas off Kaikoura during the summer months.

The main trend in the changes of affinities that have occurred with the discovery of new species in our deeper water has been towards an increase in the number of species with North Hemisphere and North Atlantic affinities. In fact, we could now name several apparently bipolar species (though I doubt very much if this bipolarity is real—it is more likely due to lack of exploration of the deep water between the present localities).

Examples of these northern species are: *Scymnodon crepidater,* now known from two specimens from 480 fathoms off Kaikoura, but previously known only from Denmark, Iceland and the Faroes; *Scymnodon foliaceus,* mentioned previously as known only from Japan and the Philippines but not uncommon in 200 fathoms off Kaikoura; and two species of *Etmopterus,* a cosmopolitan genus including some phosphorescent species of which we now have one.

If we return now to a consideration of what is known of the New Zealand sharks and rays from a more strictly ecological viewpoint, there are three aspects I would like to mention briefly. These are:

(1) Restriction of habitats (other than depth restrictions).

Only one species, *Squalus griffini,* appears to be restricted in its distribution in Cook Strait. So far it is known in this area only on the western side. However, it occurs commonly towards the northern part of New Zealand and also at the Chatham Islands. Its distribution seems referable to the temperature of the water masses in these areas. A few other species, notably the mako and some other large pelagic sharks which are not common in Cook Strait, may be near the southern limit of their range, as their centres of abundance are quite clearly in the warmer waters further north (The apparent prevalence of the White Shark or Maneater in Cook Strait—of which several specimens have been taken in recent years—is probably due to the Tory Channel Whaling Station acting as a focus rather than to the suitability of the Cook Strait environment for them.)

(2) The depth distribution of most species is known in very general terms, and so far there do not seem to be any sharp demarcations in depth for any species. The depth tolerance of species varies considerably—stingrays are rarely encountered deeper than 50 fathoms, while the blind electric rays (*Typhlonarke* species) range from 40-200 fathoms and may go deeper.

(3) The seasonal movements and social behaviour (gregariousness, etc.) of our sharks and rays are not at all well known, though there is no doubt that such movements do occur in some species at least. It may be observed even in such small samples as the annual collection of shallow-water dogfish specimens for student dissections. It is not, however, restricted to shallow water species, for one set of a long-line in 480 fathoms off Kaikoura brought up 14 specimens of *Scymnodon plunketi,* all males, and all varying in size only from 43in. to 47in. long.

Briefly summing up the position with regard to an ecological study of sharks and rays in Cook Strait, we can say, that although data which will later have significance from an ecological point of view are becoming available and are being added to continually, there is still much preliminary work to be done by the systematist before any real ecological contribution can result. In the meantime, the group is showing promise of providing useful information to the students of animal distribution; and in doing so will also provide data of a broader nature for the ecologist.