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Tagging of Marine Fishes in New Zealand

by
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Fisheries Research Division
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Introduction

Tagging is a valuable technique in fisheries research. It can provide information not only on the biology and population dynamics of fish species, but also on the fisheries for them.

The most frequent use of tagging is in studying fish movements. Sometimes tagging experiments are carried out to test hypotheses based on changes in abundance and location of fish on fishing grounds. At other times there is no previous knowledge or theory, and tagging is the only way to determine factors such as distances travelled, directions of migrations, and the degree of mixing of populations of the same species from different areas. This information may have important consequences for fisheries management. For example, if a species is shown to be wide ranging in its movements, any management plan for it will need to be applied over a much larger area than for a sedentary species, whose populations in different places are largely independent of each other.

Tagging can also be used to study growth if fish are measured at tagging and at recapture. This application is most useful for species which cannot be aged by the usual methods of counting annual rings on scales or otoliths (ear bones). It also provides data on the growth of individuals which are not obtainable from population studies. However, it has the disadvantage that tagged fish may grow more slowly than untagged fish.

Population size and fishing rate can be estimated from tagging experiments, but to provide reliable results, careful experimental design and tagging procedures are needed. Measurements of the effects of tag loss and other factors on return rates are also required. The mark-recapture method for population estimation is simple in concept. A known number of fish (N) is tagged and released; some time later a sample (c) of the population is taken and the number of marked fish in it (n) is recorded. The population size (C) can then be estimated by proportion: $n/N = c/C$, thus, $C = Nc/n$. The recapture sample, c, is sometimes collected by research staff, but usually it is the landed catch in a certain time period (converted to numbers of fish) and n is the number of tags returned by fishermen over the same period. The usefulness of tagging for population size estimates therefore also depends on the accuracy of fishery statistics.

Tagging can provide information on the relative proportions of a stock taken by different fishing methods, including the share taken by recreational fishermen.

In New Zealand the first significant tagging programmes on marine fish were started during the 1950s. Most effort was concentrated on the important commercial species snapper (*Chrysophrys auratus*), tarakihi (*Nemadactylus macropterus*), and flatfishes of the family Pleuronectidae. These early experiments generally produced low return rates, which were due mainly to the poor condition of fish when tagged and sometimes to unsatisfactory tags. Most of this work was not published, except for brief accounts by McKenzie (1961) and Allen (1963). Subsequently, Paul (1967) evaluated the results of snapper tagging carried out between 1952 and 1963 and found that of nearly 8000 fish tagged only 43 (0.5%) were recaptured.

From 1964 to 1966 an extensive and successful tagging programme on sand flounder (*Rhombosolea plebeia*) was conducted in Canterbury by A. R. Mundy. The results of this were published by Colman (1978).

In the 1970s work on tagging was greatly increased. Major programmes were carried out on snapper (Crossland 1976a, 1980, 1982, Tong 1978) and trevally (*Caranx georgianus*) (James 1979, 1980); tagging was also carried out on flounders (Colman 1974) and tarakihi. Improvements in catching and tagging techniques made during these years, plus better tags, resulted in much higher return rates than those of earlier programmes; from about 13 000 snapper tagged in the Hauraki Gulf between 1974 and 1977 there were 707 (5.3%) returns. Increased fishing pressure has also contributed to higher return rates.

In 1979 the first large-scale tagging in New Zealand of a highly migratory species took place when almost 12 000 skipjack tuna (*Katsuwonus pelamis*) were tagged as part of the South Pacific Commission's Pacific-wide tagging programme (Kearney and Hallier 1979).

The results of these tagging experiments have made an important contribution to knowledge of fish and fisheries in New Zealand. Other tagging programmes have provided useful results, but much of the information is contained in unpublished reports of the former Marine Department (MD) or Fisheries Management Division (FMD) and Fisheries Research Division (FRD) of the Ministry of Agriculture and Fisheries, and it is not widely available.

This publication summarises and reviews data from both published and unpublished sources, briefly describes current tagging programmes, and considers future research in which tagging would be useful. Emphasis is placed on commercial species.

Methods

Catching

The ability to catch fish in good condition is the most important requirement for any successful tagging programme.

In New Zealand many capture methods have been used, of which trawling has been the most widely employed. However, trawling with unmodified gear is not usually suitable, as fish are frequently damaged while in the net or when landed on deck. Much early tagging of snapper and tarakihi was of limited success because of this, but trawling has been satisfactory with robust species such as trevally (James 1980) and flounders (Tunbridge 1966, Colman 1974, 1978), when tows have been kept short and only undamaged fish tagged. An improvement to this method was the development of the canvas cod-end technique. This was first tried on the 42-m *James Cook* for tagging tarakihi, but it was more effective when used for tagging snapper, on the smaller, 19-m *Ikatere* (Crossland 1976a). The canvas cod-end (Fig. 1) was attached to the vessel's normal bottom trawl by a zip line. On hauling, the zip line was undone and the canvas cod-end raised by the boat's gear. The water-filled bag was too heavy to be lifted clear of the sea; so fish were brailed out with dip nets (Fig. 2). The new 28-m research vessel *Kaharoa* will be able to lift the canvas cod-end directly on to the deck, which will further improve this technique.

Apart from trawling, lining (particularly hand-lining) has been the method most used for catching fish for tagging. Large numbers of snapper (Paul 1967) and blue cod (*Parapercis colias*) (Rapson 1956) and some tarakihi have been caught by hand-lining. Long-lines have also been used for snapper (Mace 1980) and drop-lines for groper (*Polyprion oxy-neios*) (Johnston 1979). Roberts (1974) tagged l-caught albacore tuna (*Thunnus alalunga*). S jack tagged by the South Pacific Commission in New Zealand waters were caught by pole-and-line with a lure attached to a barbless hook. A game-fish tagging programme marked a variety of species (mainly mako shark (*Isurus oxyrinchus*) and yellowtail kingfish (*Seriola lalandi*)) caught on commercial long-lines and by recreational anglers (FMD unpublished data).

All line-fishing methods yield fish in good condition for tagging, but, except for the pole-and-line method, they do not usually catch them in large numbers.

Beach seining has been used for flounders (Colman 1978) and snapper (Paul 1967), but its use is limited by the areas and seasons in which it is effective. James (1979) successfully tagged trevally caught by a commercial purse-seine vessel; this method is promising for tagging pelagic species, because large numbers of fish can be caught and, with careful handling, can be maintained in good condition.

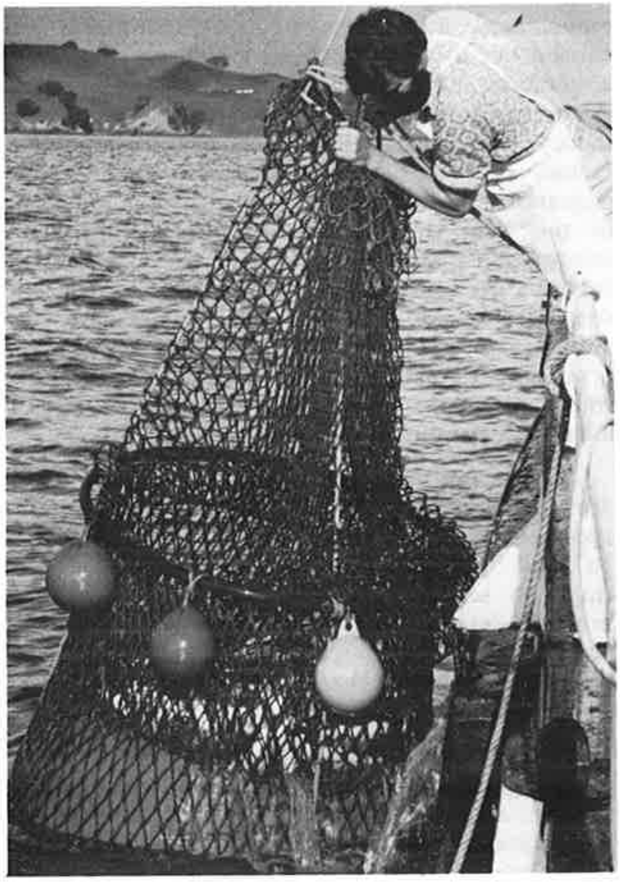


Fig. 1: Canvas cod-end.

Fig. 2: Brailing snapper out of canvas cod-end into tagging tank.

Of any of the methods tried, portable fish traps catch fish in the best condition for tagging, but catch rates are too low for use of the traps to be practical (Crossland 1976b).

The use of teichi (box) nets, which catch and keep fish alive until required, may have some value, but they have not been tried as a method of capture for tagging in New Zealand.

Tagging techniques

Speed in handling fish during tagging is important. Jakobsson (1970, page 487), in his review of fish tagging, stated "Handling time is . . . of great importance and should always be kept to a minimum." This factor, which depends on both the catching method and the type of tag used, is most critical for large, fast-swimming species such as tunas.

Skipjack caught by pole-and-line were landed individually into a hammock-shaped cradle, where they were measured and tagged in a few seconds (Kearney 1977). Large game fish have been tagged without removing them from the water, the tag being applied with a special pole fitted with an applicator tip. Other fish caught by lines, for example, snapper, were measured and tagged on deck immediately. This procedure usually took less than a minute. Fast handling and a reduction in injury can be achieved by using a barbless hook (Paul 1967).

Trawl-caught fish need to be held during tagging because of the large numbers involved. They have usually been kept on deck in tanks through which sea water continually circulates (Colman 1978, Crossland 1976a, 1980, James 1980, Tunbridge 1966). Colman (1974) found plastic fish boxes filled with sea water satisfactory for holding up to about 50 flounders at a time.

Most fish held in tanks can be tagged without difficulty provided they are handled carefully and not grasped near the tail. However, James (1980) found it necessary to anaesthetise trevally with benzocaine. This made tag insertion easier and reduced damage to the fish. Anaesthetised trevally were placed in a separate tank to recover before release. All other trawl-caught fish were released immediately after tagging. During snapper tagging fish were occasionally held for up to 1 hour before the last was tagged. Provided the fish were in good condition when caught, there was no significant difference in return rates between fish held a short time and those held for longer (my unpublished data).

Tong (1978) used scuba divers to tag trawl-caught snapper. A detachable cod-end (Fig. 3) was released from the trawl by divers at about 15 m below the surface and the divers, working in pairs, tagged fish through slits which could be unzipped in the cod-end. Results from this programme were encouraging and the technique could probably be improved with further experience. However, it is slower than tagging on deck and requires more people.

Tagging fish under water avoids the problem of rapid inflation of the swim bladder which occurs in some species when they are hauled to the surface and which may prevent them swimming down again after tagging. Pricking distended fish with a hollow needle to release trapped gases has been used successfully to overcome this problem with snapper (Crossland 1976a, FRD unpublished data) and with groper (Johnston 1979).

Trawl-caught snapper (Crossland 1976a, 1980) and flounders (Colman 1974, 1978, Tunbridge 1966) were measured before release. Measurement is essential for growth studies; it can also be useful in determining whether different size groups show different movement patterns and should be done whenever practical.

Tag types

The ideal fish tag should be quick to apply, conspicuous, and not harmful to the fish. It should not increase catchability of the fish, nor be easily shed. To combine all these qualities in a single tag is difficult because all tags are to some extent harmful to the fish. However, modern tags are far superior to those used in early experiments. The principal types of tags in recent use in New Zealand are shown in Fig. 4. Tags used on flounder, including some of the earlier types, are shown in Fig. 5.

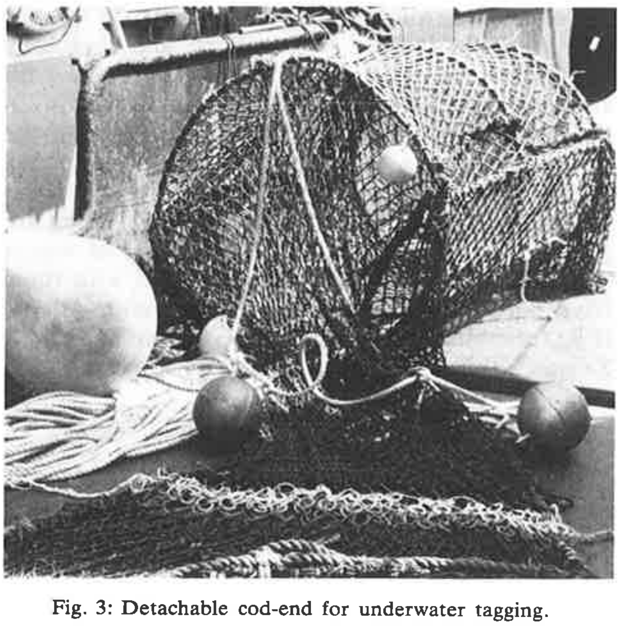


Fig. 3: Detachable cod-end for underwater tagging.

Operculum tags

Small metal tags wired to the gill cover were used by Rapson (1956) for tagging blue cod and were moderately successful. Similar tags, but clipped instead of wired, were used in early snapper tagging experiments (Paul 1967), but were not effective. These tags had the disadvantages of being easily shed, inconspicuous, and visible on only 1 side of the fish.

Petersen tags

These tags were used extensively in early experiments on snapper (Paul 1967), tarakihi (Allen 1963), and flounders (Tunbridge 1966, Colman 1978, MD unpublished data). They were attached through the back of the fish below the middle of the dorsal fin. Two plastic discs (yellow or white) were used on snapper and were fastened either with an elastic toggle (which was ineffective) or nylon thread. Discs used on flounders were attached with stainless steel staples; some fish were tagged with only 1 disc. The advantages of these tags are that they are conspicuous (though single discs are visible from only 1 side of the fish), they are not easily shed, and they do little harm to the fish. An important disadvantage is that they are slow to apply, and mainly for this reason they have not been used since 1966.

Tied spaghetti tags

These tags, made of yellow plastic tubing, have been used extensively since 1964 on many species of fish, including flounders (Colman 1974, 1978), tarakihi (FRD unpublished data), snapper (Tong 1978, FRD unpublished data), trevally (James 1980), and groper (Johnston 1979). Spaghetti tags are attached through the back of the fish in front of the dorsal fin (except in flounders) and should be tied with a figure of 8 knot. They are inserted far enough forward to prevent chafing the dorsal fin. In flounders they are placed below the middle of the dorsal fin. These tags are quicker to apply than Petersen tags, but are slow compared with lock-on spaghetti tags and dart tags (see below). They are conspicuous and there is little shedding of tags if they are properly tied. Tarakihi tagged with them have been recaptured up to 7 years after release (FRD unpublished data). Of the tags tried in New Zealand, this is probably the best type for long-term studies.

Clipped spaghetti tags

A different method of fastening spaghetti tags was used during some experiments on sand flounders. The 2 ends of the tag were crimped together with a copper ring (Colman 1978). Return rates of flounders tagged by this technique were significantly better than those tagged with tied spaghetti tags, but this was probably because the tied tags were fastened with an overhand knot rather than a figure of 8. Crimping was much slower than tying and it has not been used since.

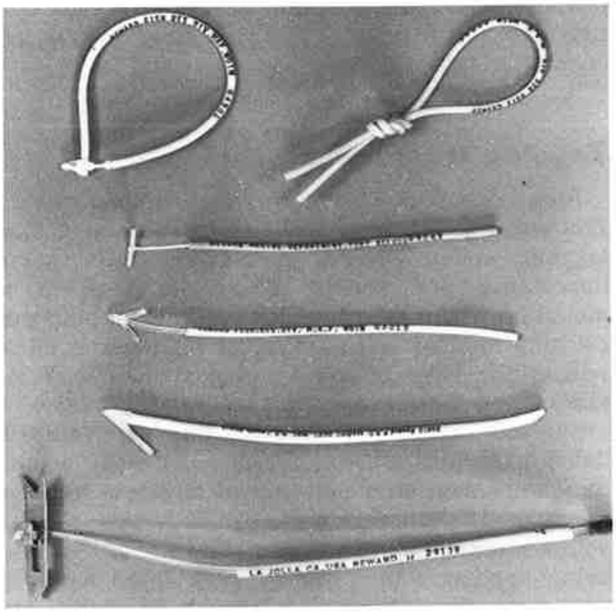


Fig. 4: Tag types, from top: lock-on spaghetti tag (left), tied spaghetti tag (right), anchor tag, small dart tag, large dart tag, H-tag.

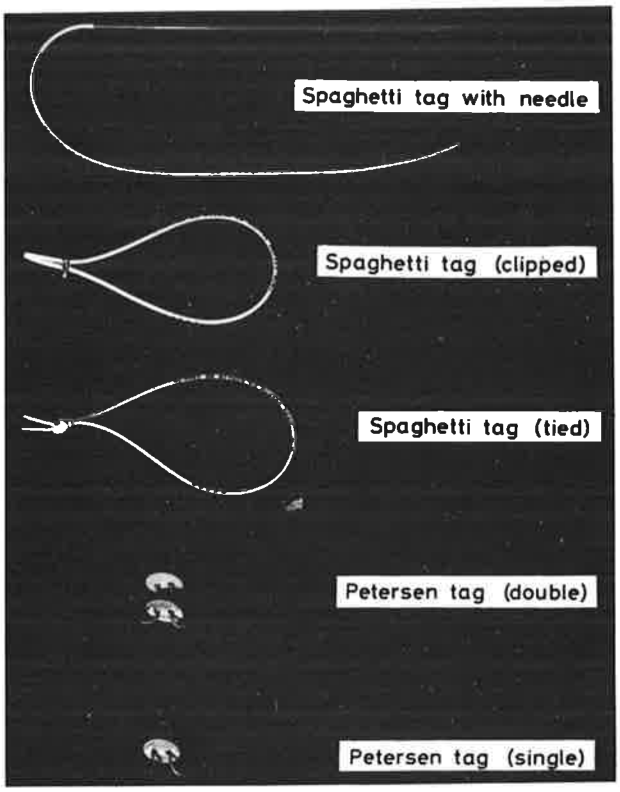


Fig. 5: Tags used in flounder tagging.

Lock-on spaghetti tags

These tags have been used since 1974 to tag large numbers of snapper (Crossland 1976a, 1980, 1982) and also purse-seined trevally (G. D. James pers. comm.). They are made of yellow plastic tubing and are inserted in the same place as tied spaghetti tags, but the ends are locked together with a toggle. They are conspicuous and are much quicker to apply than other types of tag (except dart and anchor tags). Snapper tagged with them have been recaptured up to 2½ years later, but the loss rate is greater than for tied tags. This is thought to result from deterioration of the glue holding the locking device into the tubing.

Dart tags

Large, single-barbed, yellow dart tags were used to tag albacore (Roberts 1974) and snapper (Crossland 1976a). The same type of tag, but from a different manufacturer, was used for skipjack (Kearney and Hallier 1979). Dart tags are inserted into the dorsal musculature below the dorsal fin and placed so that the barb locks behind the bones supporting the fin. They can be inserted in a few seconds and are the quickest of all to apply. They are the only type so far to be suitable for large, fast-swimming pelagic species. Dart tags are suitable for both round and deep-bodied fish, whereas spaghetti tags are not well suited for round fish. Dart tags are conspicuous, but may be visible from only 1 side of the fish, which is a disadvantage if recoveries are to be expected from bulk catching methods. If properly applied, large dart tags are not easily shed; snapper tagged with them have been recaptured up to 2¾ years later. However, a few fish were recovered with only the barbed head of the tag remaining, the rest of the tag having fallen off because of chemical breakdown of the tubing where it entered the fish (Crossland 1976a). This is a problem of materials, not tag type, and if dart tags are made from good quality plastic with a single hard nylon barb they are probably the best type for most tagging programmes.

Small, double-barbed dart tags were also used on snapper (Crossland 1976a), but no returns were received later than 5 months after tagging and it is thought that this type is easily shed.

Anchor tags

These small tags are applied with a tagging gun which holds a clip of 25 tags. The technique is very rapid and convenient, but it is difficult to ensure that the tags are properly inserted and locked between the dorsal fin supports, and because of this they are easily shed. Anchor tags (white or red) have been tried on snapper (Crossland 1976a), but there were no returns. Better results were obtained with blue cod (FMD unpublished data).

H-tags

These tags, which are used on game fish, are a type of anchor tag. They consist of a yellow vinyl streamer and an H-shaped, stainless steel anchoring device. They are fitted on to the applicator point of a tagging pole and are inserted into the upper back area near the front of the fish, with care being taken to avoid the head. Tagged fish have been recaptured up to 1½ years after release (FMD unpublished data).

Return of tags

An important part of any tagging programme is encouraging the return of all recaptured tags. This must be carefully considered during planning of the programme and requires regular promotion throughout the period when recoveries are expected.

In the early work reported by Allen (1963) publicity in the press and on radio was used to encourage returns, but no tag reward was offered. More recently, publicity has increased with the use of posters, articles in *Catch*, and direct contact with local fisheries officers and the fishing industry. In 1962 a reward of 40c was introduced for each tag returned accompanied by recapture information. In the early 1970s the reward was increased to $1, at which value it has remained*. However, in 1976 a further step to stimulate returns was taken with the introduction of a tagging lottery. Four lotteries are run each year. All tags recovered over a 3-month period are eligible for one $100 and two $50 prizes.

The return of tags from the South Pacific Commission's skipjack programme has been promoted by wide publicity, a lottery scheme, and the innovative reward of a printed T-shirt for each tag returned.

Tagging mortality

Tagging mortality is of 2 types. Immediate post-tagging mortality (initial mortality) may result from the shock of capture, handling, and tag insertion. Fish which have survived tagging often show a subsequent mortality rate higher than that of untagged fish. This is thought to be due to effects such as mechanical abrasion by the tag, infection of the tag wound, and increased vulnerability to predation.

Initial tagging mortality has been studied in several species. Samples of trawl-caught tarakihi

*Increased to $5 in 1982.

tagged and kept in cages on the sea bottom showed high mortality rates of 40%–70% in the first 12 hours after tagging (FRD unpublished data). Better results have been obtained with snapper caught by the canvas cod-end technique. From 78 tagged fish kept in a holding net, only 1 died within 12 hours and no others in the next week (Crossland 1976a). Trawl-caught trevally kept under similar conditions also showed a low initial mortality; 3 out of 90 died in the first 3 days after tagging, but these were caught in the corners of the net and may have survived in the open sea (James 1980). These results show that with appropriate techniques and careful handling, initial mortality can be reduced to negligible proportions.

Subsequent tagging mortality is much harder to measure and cannot be distinguished from tag loss without separate experiments, such as double tagging, or laboratory studies. Its effect has been shown by the rapidly declining tag return rate of tagged snapper (Crossland 1976a) and trevally (James 1980). Although some of this was due to fishing mortality and shedding of tags, fish tagged with tied spaghetti tags, which are considered to have a very low loss rate, also showed a similar decline (Fig. 6).

Fouling of tags, which occurs frequently, probably increases the detrimental effect of the tag and contributes considerably to tag induced mortality. Tags have been recovered with profuse growths of hydroids, tube worms, mussels, barnacles, and other marine organisms (Fig. 7). The development of a tag made from a material with anti-fouling properties, but which is non-toxic to fish, would be a major advance in fish tagging technology.

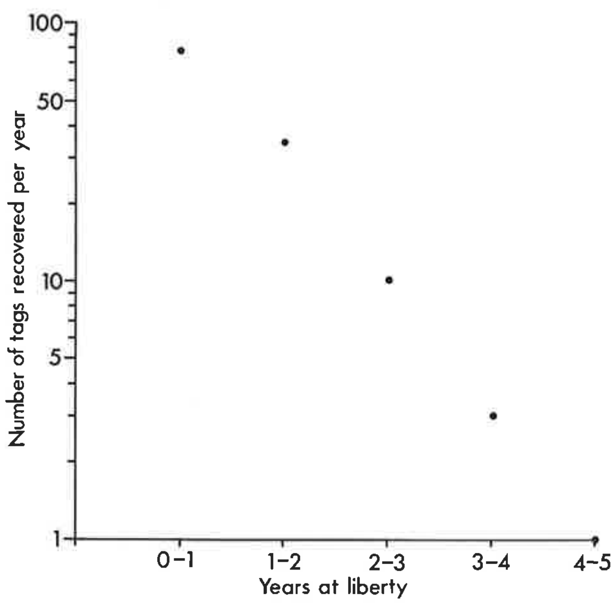
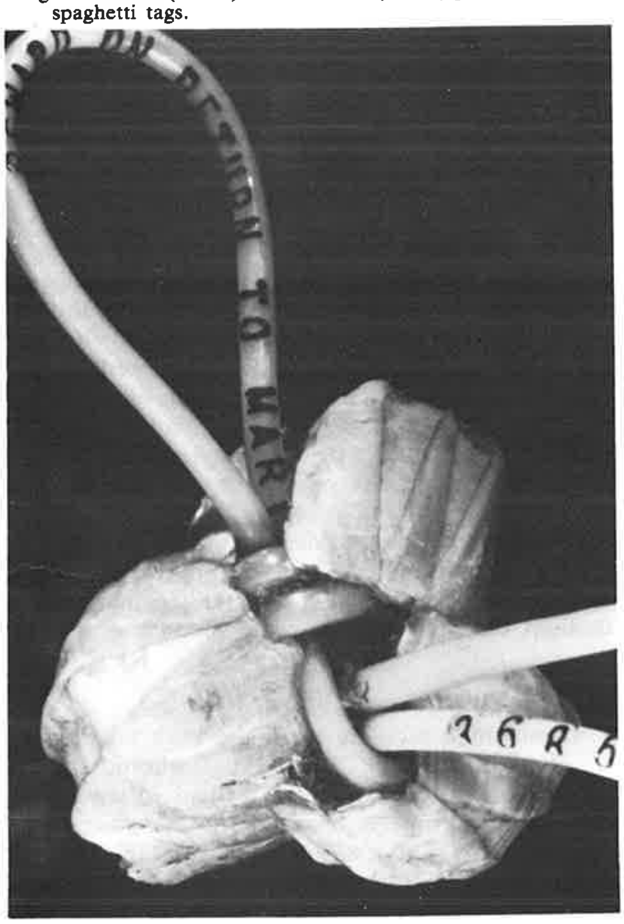


Fig. 6: Return rate of tagged trevally over time.

Fig. 7: Mussels (above) and barnacles (below) growing on tied spaghetti tags.



Species Tagged

Albacore tuna (*Thunnus alalunga*)

Four hundred and twenty-eight albacore were tagged in 1972 with yellow dart tags (Roberts 1974). Each fish was double tagged. There were no recoveries, which Roberts attributed to the low level of fishing at that time.

Blue cod (*Parapercis colias*)

Tagging was carried out in the 1940s by Rapson (1956) during a study on the biology of blue cod. Fish were caught on hand-lines and tagged with oxidised silver strips fixed by wire to the operculum. Totals of 3380 were tagged in the French Pass area, 1491 in the Marlborough Sounds, and 133 at Port Gore. The aims of the study were to investigate movements and growth.

Two hundred and eleven tags were returned. Return rates were variable; 5.0% (French Pass), 2.5% (Marlborough Sounds), and 0.8% (Port Gore)*. About 75% of all tags returned were returned within 6 months of tagging. Most fish were recaptured close to the tagging site, but 18 had moved more than 1 nautical mile (n mile) and 6 had moved more than 10 n miles. The maximum travel recorded was 30 n miles. Growth determined from recaptured tagged fish is shown in Table 1.

Further tagging experiments were carried out during 1973–75 when 2430 fish were tagged with anchor tags to study growth and movements (FMD unpublished data). These were tagged at various locations in Queen Charlotte Sound, Pelorus Sound, and on the eastern side of D'Urville Island. Eighty-three were recaptured.

During the 30 years between the 2 tagging studies there was a large increase in fishing pressure on blue cod in the Marlborough Sounds area, mainly by recreational fishermen. The return rate of 3.4% recorded in the 1973–75 study was lower than the overall return rate of 4.2% from Rapson's programme. This was probably because the anchor tags used in the later study were easily shed.

Flounders (*Rhombosolea* spp.)

There are 4 species of *Rhombosolea* in New Zealand: the sand flounder (*R. plebeia*), the yellow-belly flounder (*R. leporina*), the black flounder (*R. retiaria*), and the green-back flounder (*R. tapirina*). Tagging has been carried out on all species except the green-back, which is comparatively rare. The black flounder lives mainly in brackish or fresh water, but it also occurs in the sea (Graham 1956).

Flounders were among the first fish to be tagged in New Zealand and more of them have been marked than any other kind of marine fish except snapper. The main reasons for this are that they are found in shallow water and are easily caught, and they are robust and withstand handling and tagging well.

During 1959, 1500 flounders were tagged in Lake Ellesmere, a shallow, brackish lake separated from the sea by a narrow shingle spit through which a channel is opened from time to time. About equal numbers of sand, yellow-belly, and black flounders were tagged with Petersen tags attached by steel staples (Fig. 8). Up to July 1960, 24% of the tagged black flounders, 12% of the sand flounders, and 5% of the yellow-belly flounders were recaptured. Most fish were recaptured in the lake, but there were 6 recoveries at sea (3 sand, 1 yellow-belly, 2 black). One fish had not moved far, but the other 5 were recaptured well to the south of the lake outlet. The 2 furthest travelled were both black flounders; 1 was recovered at Shag River, 144 n miles away, and the other had moved 200 n miles to a position off Nugget Point. The other 3 recoveries were made between the Rangitata and Waitaki Rivers.

TABLE 1: Growth of tagged blue cod in the Marlborough Sounds (data from Rapson (1956))

No. in sample	Size on marking (cm)	Growth per year (cm)
8	25–29.9	4.6
27	30–34.9	3.5
16	35–39.9	3.3
6	>40	2.9

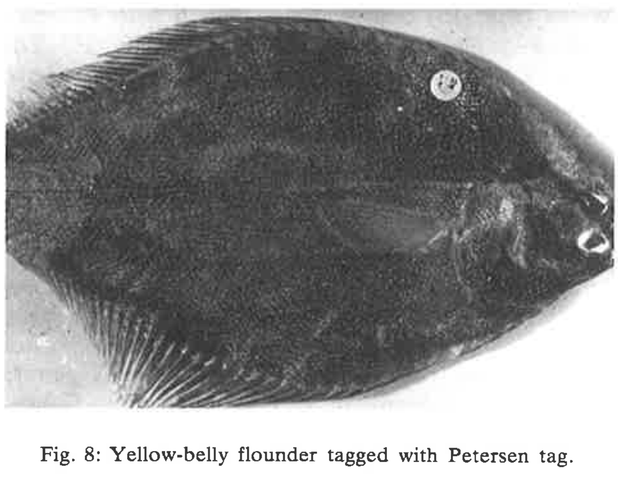


Fig. 8: Yellow-belly flounder tagged with Petersen tag.

*There is a slight discrepancy between the number of returns recorded by Rapson and the figure calculated from his return percentages.

In 1960, 6500 flatfish (mostly yellow-belly and sand flounders) were tagged with Petersen tags at various locations along the Canterbury coast between the Ashley River and Timaru (MD unpublished data). Most recaptures were close to the tagging site, but some fish moved large distances, generally along the coast to the south-west. Sand flounders moved more than yellow-belly flounders (Fig. 9).

Several thousand flatfish were tagged around the Otago Peninsula during the late 1950s and early 1960s (MD unpublished data). Most of these were sand flounders. An overall recapture rate of 19% was recorded from these experiments. Fish movements showed a similar pattern to those in Canterbury waters. The most distant recoveries were made at Te Waewae Bay, 200 n miles to the south of the release point.

In 1961 tagging of flatfish was carried out in Tasman Bay (Tunbridge 1966) to study their movements and growth rates and for comparison with the results obtained in Canterbury and Otago. Fish were caught by trawling and were held in a tank of sea water before being tagged with Petersen tags. Five hundred and seven sand flounders and 339 yellow-belly flounders were tagged. There were 26 (7.6%) recaptures of yellow-belly and 8 (1.5%) of sand flounders. No returns were recorded later than 7 months after tagging, which suggests a loss of tags, significant tagging mortality, or both. Results showed that there was a definite inshore movement and a rapid growth rate in early summer.

A large sand flounder tagging programme was carried out around Banks Peninsula during 1964–66 (Colman 1978). Fifteen thousand fish were tagged in the Heathcote-Avon Estuary, Lyttelton Harbour, and Akaroa Harbour. Tagged fish varied in length from 15 to 45 cm, but most (84%) were below the then legal size limit of 23 cm (9 in). They were caught by trawl (Lyttelton and Akaroa) and beach seine (Estuary) and held in a tank of circulating sea water (Fig. 10) before being tagged with Petersen tags or spaghetti tags (tied or clipped) (Fig. 11). The aims of the programme were to study movements, mortality, and growth.

Three thousand one hundred and forty-nine tags (21%) were returned and similar return rates were obtained from each area. Nearly all (98.5%) of the returns were made within 2 years of tagging and no tags were returned later than 4 years after tagging.

Recoveries of tagged fish showed that most moved away from inshore areas within a year of being tagged, this movement occurring in late winter-spring when fish reached 2 years old. A general southward movement was also noted. Colman considered the mixing of fish from the 3 tagging areas was sufficient to maintain a single stock.

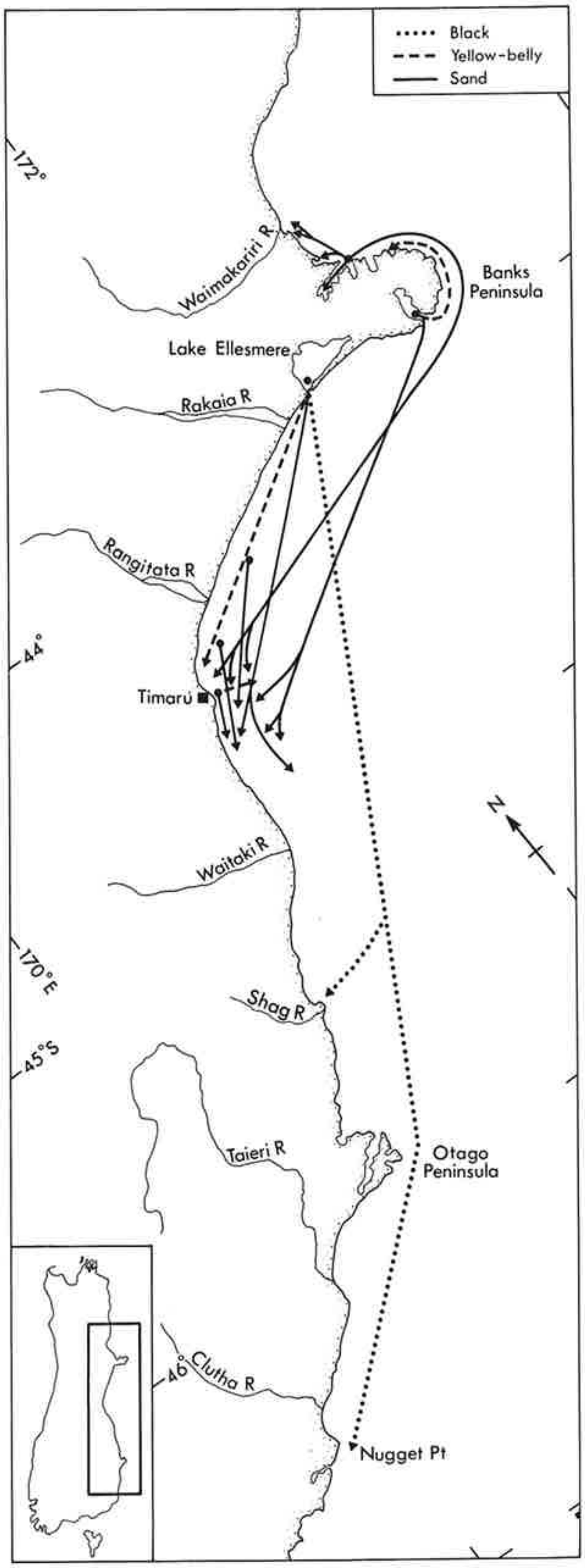


Fig. 9: Movements of tagged flounders from experiments in Canterbury, 1959–60.

Fig. 10: Flounder tagging in Akaroa Harbour.

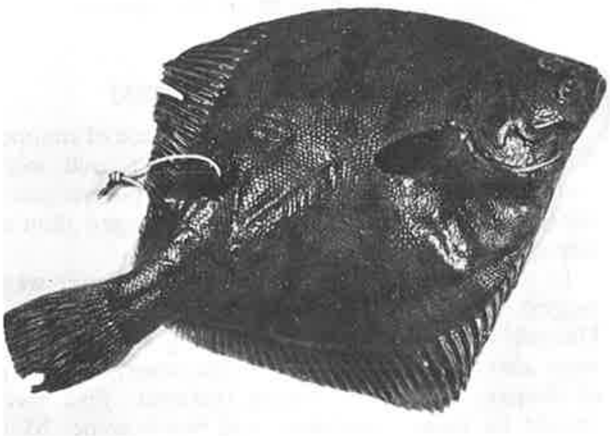


Fig. 11: Sand flounder tagged with tied spaghetti tag.

The annual mortality rate, from natural causes and fishing, was estimated to be from 75% to 88%. These values were thought to be overestimates because of the probable (but undetermined) effect of tagging mortality. Fishing mortality was lowest in Akaroa Harbour and highest in Lyttelton Harbour. It also varied with the size of the fish; it increased from 18%–24% in the 15–19-cm length range to as much as 67% for fish over 30 cm long.

Growth measured from tagging data was similar to the results of age-length studies based on otolith reading and showed that sand flounders are fast growing, with a fairly short life span and a high mortality rate.

Flounder tagging carried out in the Firth of Thames, Hauraki Gulf combined tagging results, data from trawl surveys, and fishery statistics to study movements (Colman 1974). Three hundred and thirty-nine trawl-caught sand flounders and 324 yellow-belly flounders were tagged with tied spaghetti tags. Thirty-six (11%) sand and 87 (27%) yellow-belly flounders were recaptured.

Sand flounders dispersed into deeper water during their second year. Spawning occurred at the end of the second year in the northern part of the Firth of Thames. Only 1 sand flounder was recaptured outside the Firth. The movements of yellow-belly flounders were similar, but dispersal into deeper water took place later in the year. Colman concluded that both species moved offshore to spawn in winter and spring and moved inshore after spawning; thus flounders were found in shallow water during summer.

Similar results were obtained from the tagging experiments in the Firth of Thames in 1976 and 1977. In these experiments 374 yellow-belly and 523 sand flounders were tagged in 1976, and 477 yellow-belly and 456 sand flounders in 1977 (FRD unpublished data). Of those tagged in 1976, 129 (37%) yellow-belly and 28 (6%) sand flounders were recovered, and from the 1977 taggings 132 (30%) yellow-belly and 26 (6%) sand flounders were recovered. The pattern of recoveries confirmed that fish moved into shallow water during summer, the yellow-belly flounder in particular penetrating several kilometres up the Waihou River. The recovery rate also showed that fishing mortality of this species was substantial in the Firth of Thames.

The large amount of tagging which has been done on flounders* has made a major contribution to the understanding of their life history and has provided much information on growth, populations, and the fisheries for the species. There appear to be 2 types of flounder population: those which live in large bays (for example, Hauraki Gulf and Tasman Bay) and spend their whole life cycle there, and those which live along open shores (for example, the east coast of the South Island) and frequently move considerable distances, so forming a continuously mixing population over long stretches of coastline.

Further tagging of flounders for biological data is probably not required, but could be useful for estimating population sizes for these heavily fished species.

Game fish

Since 1976 game-fish tagging has been conducted in New Zealand as part of the Pacific Cooperative Game Fish Tagging Program (Brun 1976). Tagging is done by members of game-fishing clubs and commercial fishermen and is co-ordinated by FMD for the United States National Marine Fisheries Service. The main aim is to study movements.

*Studies have also been carried out in Kaipara Harbour and Wellington Harbour, but the data were not available to the author.