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Te Tautiaki i nga tini a Tangaroa

New Zealand billfish and gamefish tagging, 2002-03

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EXECUTIVE SUMMARY

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The gamefish tagging programme has been an integral part of the New Zealand marine sports fishery since the mid 1970s. The species that form the focus of the programme are striped marlin (*Tetrapturus audax*), mako shark (*Isurus oxyrinchus*), blue shark (*Prionace glauca*), yellowfin tuna (*Thunnus albacares*), and yellowtail kingfish (*Seriola lalandi*). Worldwide there has been a growing trend toward the catch and release of large pelagic species hooked by recreational fishers. The collection of movement and, on occasion, growth information through cooperative tagging programmes with recreational fishers is a cost-effective way of collecting information on large pelagic species that are difficult to study by other means. However, in cooperative programmes, tagging may be spread over a long period and it is difficult to control the tagging event and quality of reporting.

Release and recapture data for the 2002–03 season are summarised in this report and compared with those from previous seasons. Particular recaptures that provide growth or movement information of significance or interest over the last season are described.

This season 1737 fish were reported tagged and released and 72 late reports were added to those of previous seasons. Generally this was a poor gamefish season with the number of striped marlin tagged down and the number of mako and blue sharks tagged the lowest for many years. Numbers of yellowfin tuna tagged were higher in 2002–03 than in previous years, but not yet at a level likely to ensure meaningful numbers of recaptures. The proportion of the total catch tagged to fish landed has remained similar to other seasons, so as soon as the availability of the migratory pelagic species improves the numbers tagged should increase.

A total of 41 recaptures were reported in the 2002–03 fishing season, including 27 yellowtail kingfish, 9 mako sharks, 1 striped marlin, and 2 blue marlin. The number of recaptures is down on previous years.

A possible cause of tag shedding has been observed. One of New Zealand's most experienced gamefish charter skippers (Bruce Smith of Striker) described seeing a remora (probably *Remora brachyptera*) swim out from under the boat and attach adjacent to a freshly placed tag in a striped marlin immediately after release. Tags that are not well anchored could be removed by remora.

Release weights for large fish are all estimated while the fish is in the water. A comparison of estimated weight with actual weight on recapture for striped marlin showed that fish under 100 kg were estimated to within 15 kg of their actual weight and that striped marlin estimated to be 110 kg or greater on release tended to be over-estimated. Overall the average bias was just 3 kg.

Sixty percent of kingfish have been measured on release. Recapture data indicate that size at release affects the likelihood that a kingfish will move out of an area (excluding fish tagged at White Island in the Bay of Plenty – about half of all releases, with 96% recaptured in the same area). Half of the fish under 85 cm were recaptured within 5 nautical miles of their release points and 31% moved more than 15 nautical miles. In contrast, larger kingfish (over 105 cm) move less; 77% moved less than 5 nautical miles and just 13% moved more than 15 nautical miles.

1. INTRODUCTION

1.1 Overview

The New Zealand Cooperative Gamefish Tagging Programme was initiated by the Ministry of Agriculture and Fisheries in 1975 following requests from gamefish clubs. This followed the establishment of a similar programme by New South Wales Fisheries in 1973 and the original cooperative gamefish tagging programme initiated in the USA by Woods Hole Oceanographic Institute in 1954. The first aim of the New Zealand programme was to introduce the concept of tag and release to anglers. Although the tags supplied were intended for billfish, it was accepted that a variety of gamefish species would also be tagged (Saul & Holdsworth 1992).

Generally the aims of cooperative tagging programmes are to provide basic information on: movement and migration patterns; age, growth, and longevity; and stock structure for defining management units (Ortiz et al. 2003). These programmes have gained widespread support from recreational anglers and provide the only logistically and economically feasible way to tag large numbers of billfish (Pepperell 1990).

The New Zealand Big Game Fishing Council (NZBGFC) has supported the programme since its inception and has purchased and distributed tags to gamefish clubs since 1992. In 1996, the Ministry of Fisheries was formed and administration for the gamefish tagging programme was contracted out to the National Institute of Water and Atmospheric Research (NIWA) and was put out to competitive tender in 2000.

1.2 Description of the fishery

The seasonal fishery for large pelagic species that arrive with warm oceanic currents in summer and autumn is an important component of the recreational fishery and local tourist industry in northern New Zealand. Striped marlin (*Tetrapturus audax*) is the mainstay of the gamefishery on the Northland east coast (Figure 1), with blue marlin (*Makaira nigricans*) increasing in importance, and small numbers of black marlin (*Makaira indica*), shortbill spearfish (*Tetrapturus angustirostris*), and swordfish (*Xiphias gladius*) also caught. Yellowfin tuna (*Thunnus albacares*) and mako sharks (*Isurus oxyrinchus*) are largely an incidental bycatch of the billfish fishery in Northland. In the Bay of Plenty (Figure 1), yellowfin tuna and large yellowtail kingfish (*Seriola lalandi*) are the main gamefish sought, though at times striped marlin and blue marlin are targeted. On the North Island east coast fishing clubs are established from Gisborne to Wairarapa (Figure 1). Shark species become increasingly important with distance south. Gamefishing has developed on the west coast of the North Island over the last 12 years with, at times, very good marlin and tuna fishing accessed from the west coast harbours as far south as Taranaki (Figure 1). In the South Island, gamefishing has been largely out of Canterbury, Otago and Fiordland (Figure 1), with blue shark (*Prionace glauca*) abundant and therefore the primary target species.

Where billfish and tuna are targeted by recreational anglers, surface trolling with artificial lures or baits is the predominant method of fishing, with most gamefish being caught on artificial lures trolled at speeds ranging from 4 to 10 knots. Since 1997 there has been a slight trend back towards the use of live baits for billfish, but most marlin are still caught on lures, as are many mako sharks. Some mako sharks and most other shark species are caught on drifted baits, either targeted or as an incidental catch during broadbill swordfish fishing.

Marlin species are also a bycatch of the commercial surface longline fishery that targets bigeye and southern bluefin tuna (*T. obesus* and *T. maccoyii*). Within the New Zealand Exclusive Economic Zone (EEZ), commercial fishers are obliged by regulation to release all billfish, except swordfish, alive or dead. This

regulation includes a provision that live billfish should be tagged if possible and previously tagged marlin recaptured by commercial fishers are permitted to be boated and brought to port for study.

1.3 Background

Between 1975 and 1984, Floy FH-69 billfish tags supplied by the US National Marine Fisheries Service (NMFS) were issued (H series). During 1985, 1000 modified Floy tags (model FH-69A, first of the G series) were issued. These tags were modified by enclosing the polyvinyl sleeve in a plastic sheath, but still relied on a brass crimp to hold the message sleeve on. Since 1986, the Hallprint billfish tag has been issued (G series continued). All three tag types have stainless steel tag heads capable of being implanted with the same slotted stainless steel applicator. During 1995 and 1996 a number of striped marlin were recaptured with the tag head and a short section of the Hallprint plastic streamer, but no readable information. These tags could be identified as G series but had broken below the tag number. A modified Hallprint tag with stainless wire extending the full length of the tag was issued from December 1996 onward. The new tag type started with serial number G 53501.

Data management and reporting for the Gamefish Tagging Programme is funded by the New Zealand Ministry of Fisheries, and the New Zealand Big Game Fishing Council purchases and distributes tags to fishing clubs and anglers at cost. Tags are supplied free of charge to commercial fishers who express an interest in tagging gamefish. Collection of tag report cards has been greatly assisted by the fishing clubs, most of which keep accurate records of captures and insist that tag report cards are handed in at the completion of successful trips.

For the last 11 years striped marlin, mako shark, blue shark, and yellowtail kingfish have been the focus of the programme. These species were selected during a review of the programme in 1992 on the basis that either there was potential to tag substantial numbers of fish and make sufficient recaptures to provide useful data, and/or they were species of national or international significance or concern. These criteria are still valid.

In October 2000 fishers and stakeholder groups were consulted on the scope and objectives of the programme and the resulting Gamefish Tagging Policy (Holdsworth & Saul 2003) was circulated to clubs and organisations. It was recommended that tagging of striped marlin, mako shark, blue shark, and kingfish continue, and that a trial to test angler willingness to tag and release yellowfin tuna be instigated. Objectives included increasing knowledge of the nature and range of migration of striped marlin and mako and blue sharks tagged in the southwest Pacific, and improving knowledge of kingfish growth and movement.

2. METHODS

Four thousand tags were purchased by the NZBGFC for the 2002–03 season. The process of tagging gamefish has been described by Saul & Holdsworth (1992). Numbered tag report cards are issued with each tag. They collect vital information on the species, date, location, and size of the fish tagged. More recent tag cards have included a space for latitude and longitude of release, the skipper's phone number, and tick boxes for capture method and whether or not the hook was removed before release.

The individually numbered tags are printed with the address of the Ministry of Fisheries Auckland office and the words "Please measure or weigh – Reward". Tag cards and recapture letters are passed on to the contractor for entry into the database. Upon recapture of a tagged fish, letters are sent back with a printed polo shirt as a reward to the person reporting a tag recapture. A copy of that letter is also sent to the skipper and angler who tagged the fish.

Data presented in this report are variously summarised by species and season, month, and area. The gamefish season refers to the period starting on 1 July and ending on 30 June. This is the standard fishing season for all New Zealand gamefishing clubs.

Large fish are not removed from the water during tag and release. Therefore, for most release records, weights are estimated by skipper or crew. Estimated weights have been summarised by 10 kg weight class rounded down as in previous NIWA gamefish tagging reports (Hartill & Davies 1999, 2000, 2001). For example, the 10 kg weight class includes fish from 10 to 19 kg.

More than half of the kingfish tagged are measured (fork length) by anglers before release. These data are more accurate records of the size of fish than estimated weights. The kingfish size distribution has been summarised by 5 cm size classes; lengths are rounded down. For kingfish records where the length was not measured, the estimated weight was converted to length using the following formula derived from the length weight relationship in Walsh et al. (2003) where length is in centimetres and weight is in grams:

$$\text{Length} = 3.3154\text{Weight}^{0.3621}$$

Distances moved are expressed as minimum possible travel distances in nautical miles. Where straight lines between release and recapture positions cross landmasses, the shortest distance by sea was calculated.

Kingfish recaptures (excluding White Island) were separated into size categories (<55, 55–64, 65–84, 85–104, and 105–150 cm) and distance categories (<5, 5–14, 15–49, 50–1500 nautical miles). These categories were selected to have a roughly equal number of recaptures in each. The proportion of fish that moved in each distance category was plotted by size class. Days at liberty may influence distance moved, so all recaptures within 30 days of release were removed and the displacement rate (nautical miles per day) of fish in each size category was plotted.

3. RESULTS

3.1 Striped marlin

The number of striped marlin reported as tagged and released in the 2002–03 season was 636, which is somewhat less than in 2001–02 (751) and 35% down on the average of the previous 10 years (976) (Table 1). A further 432 striped marlin were reported as landed in gamefish club records (Roz Nelson, N.Z. Big Game Fishing Council, pers. comm.) It is estimated that 60% of recreationally caught striped marlin were tagged and released in 2002–03, down slightly from the previous season (64%). The number of striped marlin landed by fishers and not recorded in 2002–03 is not known. An estimate of billfish not recorded in club records of 7% was calculated as part of a survey on the economic contribution of the New Zealand recreational billfish fishery in the 2000–01 season (Boyd et al. 2002). This estimate was derived from interviews with fishers returning to main fishing ports and may be an underestimate of the proportion of billfish not recorded in New Zealand that year.

The monthly totals of striped marlin tagged over the last three seasons are shown in Figure 2a, indicating that this is more a summer and autumn fishery which peaked in February in 2001 and March in 2002, but showed an even spread of catches from February through April in 2003. This season the first reported striped marlin caught by a recreational boat in New Zealand waters was from the vessel *Isobar* off Cape Brett on 22 December 2002 (Jill Going, Whangarei Deep Sea Anglers' Club, pers. comm.).

A summary of marlin tagged within Ministry of Fisheries statistical areas (Figure 2b) shows most striped marlin were tagged in areas 002 and 003 off East Northland and areas 047 and 048 near the Three Kings

Islands. This season, 92% of all striped marlin tagged were released in these four areas. This is a higher proportion than the average of 84% over the preceding five years. The Bay of Plenty from Coromandel Peninsula to Cape Runaway accounted for 4% of striped marlin, with most of the remaining tag reports coming from the west coast of the North Island, between Manukau and Taranaki.

Striped marlin release weights by 10 kg weight class for the last three seasons show a similar proportion of fish tagged across a range of size classes (80 to 120 kg) in 2002–03 (Figure 3). In the two preceding seasons the 80 kg and 90 kg sizes have been more pronounced (Figure 3). NZBGFC affiliated clubs have applied a voluntary minimum size of 90 kg for marlin since 1988. Landed fish under this weight are recorded but not recognised by clubs for contests or trophies. The proportion of striped marlin tagged and released that were estimated as 90 kg or larger was 74% in 2001–02 and 68% in 2002–03.

Striped marlin weights are estimated while the fish is alongside the boat before release. The ability of skippers to estimate size correctly will vary with experience and most round off their estimates in 5 or 10 kg steps. For recaptures to date, 16 tagged striped marlin have been weighed on recapture, 15 had been at liberty between 2 and 175 days and 1 was recaptured after 375 days. The difference between estimated release weights and recapture weights is plotted in Figure 4. Most release estimates are within 15 kg of the actual recapture weight and the mean difference is 9.5 kg (s.d. 6.84 kg), without the recapture after a year. There appears to be tendency to overestimate the release weights of larger marlin

There was one recapture of a striped marlin for this programme in 2003. This fish was tagged on 19 January 2003 off Doubtless Bay by John Angus, fishing from the vessel *Primetime*. It was caught on a lure, the fight time was 20 minutes, and it was estimated at 95 kg. It was recaptured on 2 March 2003 by Warwick Glenny 15 miles off the Manukau bar. It was estimated to be 115 kg and was retagged and released in good condition. It had been at liberty for 42 days and travelled from the east coast of Northland to the west coast off Auckland, a minimum distance of 230 nautical miles from its release point.

There is one other record of a tagged marlin moving between coasts within the same season. That fish travelled from west to east. It was tagged on 8 February 1998 off Glinks Gully, Dargaville, by Thomas Ingram and estimated at 110 kg on release. It was recaptured 21 days later at Penguin Rise, Bay of Plenty, a minimum travel distance of 440 nautical miles. The fish was landed and weighed 87.4 kg.

About a quarter of striped marlin recaptures have been made within 20 nautical miles of their release points up to 10 weeks after release (see Figure 2d). There is also a cluster of eight recaptures with displacement of around 1000 nautical miles between 5 and 10 weeks after release. Some fish have travelled further (up to 3250 nautical miles) and two fish have been recaptured back in New Zealand waters after a year (see Figure 2d). Overall the recapture rate is 0.5 % (Table 2) and most striped marlin (83%) have been recaptured within 5 months of release. There is a wide spread of recapture locations across the southwest Pacific and Tasman Sea (Figure 2c) that is not seen to the same extent in other striped marlin tagging programmes elsewhere in the Pacific (Ortiz et al. 2003).

Over the last three years the New Zealand gamefish tagging data, particularly the striped marlin release and recapture files, have been requested by a number of researchers from other agencies.

Dr Michael Hinton of IATTC, La Jolla, used striped marlin release and recapture data, plus various catch rate, biological and genetic data for a report on the stock structure of marlins in the Pacific.

Dr Donald Bromhead from the Bureau of Rural Sciences, Canberra, is using New Zealand striped marlin tagging data in a major report on that species.

Dr Eric Prince and Mauricio Ortiz from NMFS in Miami, Florida, with other authors, published a global overview of the major constituent-based billfish tagging programmes in the world's oceans in the proceedings of the Third International Billfish Symposium. (Ortiz et al. 2003)

3.2 Mako shark

The number of mako sharks tagged during the 2002–03 season was 155, down significantly (-78%) from the average number of makos tagged for the 10 previous seasons and down from 329 tagged in 2001–02. According to NZBGFC records, the proportion of mako sharks caught that were tagged by gamefish club members in 2002–03 was 72%, similar to last year. The number of makos released without being tagged is unknown.

Generally, makos are not a target species in northern New Zealand but are caught as a bycatch in areas fished for billfish or tuna. Most makos tagged in 2002–03 were caught in waters off the North Island from New Plymouth on the west coast around to Whakatane on the east coast (Figure 5). Of the 155 mako sharks tagged and released, 53% were tagged off east Northland and the Three Kings area, 10% off Coromandel/Bay of Plenty, and 28% off the west coast of the North Island (Figure 5).

Most makos were tagged between January and July in 2000–01 and 2001–02 with a seasonal mode in February (Figure 6a). There were generally fewer fish in all months in 2002–03, but releases follow a similar seasonal pattern except for June and July. There were no fish tagged in these months in 2003, unlike previous seasons (Figure 6a).

The size distribution of makos tagged in 2001–02 shows a broad distribution of estimated sizes from 20 kg to 100 kg with a mode at 40 kg (Figure 6b). This is a similar distribution to the previous season. Notably, there are marked spikes at 150 kg and 200 kg indicating that anglers have rounded off their estimates of larger fish to these weights.

The distribution of mako shark recaptures plotted as distance travelled against days at liberty shows clusters of recaptures close to the release points in the first few months, then again after about one year, and again after two years (Figure 6d). There is also a band of recaptures between 800 and 1250 nautical miles for fish at liberty from 36 days to 5 years or more. Not all these movements are to the tropics as both tropical Fiji, New Caledonia, Tonga, and temperate Australian waters are within this range (and recaptures have been recorded at all these locales).

There were 9 tagged mako recaptures reported in 2002–03, down on previous seasons (Table 2). Time at liberty for these fish ranged from 83 to 2372 days and 6 were recaptured outside the New Zealand economic zone.

Three tagged makos were reported from Fijian waters (Figure 6c). These ranged between 70 and 100 kg and were recaptured on tuna longline vessels in July, August, and October 2002. The first had been at liberty for 550 days and had been tagged off the Poor Knights Islands, the second was at liberty for 217 days after being tagged off Cape Brett, and the third was out for 182 days, having been tagged at Ranfurly Bank.

Two makos were recaptured in September 2002. The first was at Middleton Reef, on the Lord Howe Rise in the Tasman Sea. This fish had been at liberty for 6.5 years (2372 days) and is estimated to have grown from 25 kg on release to 60 kg on recapture. The second was caught east of New Caledonia after 253 days at liberty from its release point off Tutukaka, Northland.

In October 2002, a tagged mako was recaptured on a longline west of the Ha'Apai Group in the Kingdom of Tonga. This fish was 198 cm long (equivalent to about 70 kg) and had been at liberty for 1325 days (3.6 years) after being tagged in the eastern Bay of Plenty.

Also of interest was a small mako, estimated at 10 kg on release, that was recaptured 534 days later and estimated to be 150 cm and 25–30 kg. This fish was tagged off Cape Karikari, Northland, and caught by a longliner 90 nautical miles north in October 2002. Finally a mako of about 55 kg was tagged off the Manukau Harbour on the west coast in March 2003 and recaptured 83 days later 34 nautical miles east of East Cape. Overall the recapture rate for mako sharks is 2.8% in this programme (Table 2).

3.3 Blue shark

There were fewer blue sharks tagged during the 2002–03 season (78) than during the 2001–02 season (163). The average for the previous 10 years for this species is 259 per season. In 2002–03 most blue sharks tagged were between 30 and 50 kg (Figure 8b), and 73% (57) were tagged off Otago Heads predominantly in February (Figures 7 and 8a). This is a similar distribution to that in previous seasons (Holdsworth & Saul 2003)

The distribution of tagged blue shark recaptures plotted as distance travelled against days at liberty shows that of 53 recaptures with data there has been a group of 12 recaptures close to their release points in the first month after release, then another group of 5 recaptures close to the release points after about one year (Figure 8d). There is also a band of recaptures between 1200 and 1800 nautical miles for fish at liberty from 3 months to 3 years. One-third of blue shark recaptures have been recorded from outside New Zealand waters. In some aspects, the recapture locations are similar to those reported for striped marlin and mako sharks – Australia, New Caledonia, Fiji, Tonga, French Polynesia (Figure 8c) – but there have also been two more extensive movements. One shark travelled to the Indian Ocean (40° 21' S 109° 20' E) from Tutukaka, east Northland in 206 days and the other travelled 4630 nautical miles east, almost to Chile (31°16' S 85°10' W) in 624 days.

In the 2002–03 fishing season only one report of a blue shark recapture was reported and the recapture date was from a previous season. This fish was tagged off Otago Heads on 17 February 2001 and was recaptured 113 days later by a tuna longliner off Hawke Bay. Overall the recapture rate for blue sharks is 1.6% in this programme (Table 2).

3.4 Kingfish

The number of kingfish tagged and released in 2002–03 was 644, 10% lower than the mean number tagged in the previous 10 years, which was 715 (see Table 1). This season, kingfish were tagged mainly in the waters off east Northland (41%); Coromandel/Bay of Plenty (24%), and the east coast between Cape Runaway and Gisborne (31%) (Figure 9b).

Most kingfish are tagged over summer and autumn. In 2002–03 tagging numbers were low over winter, built up in spring to a seasonal mode in February, then fell away in the autumn of 2003 (Figure 9a).

Sixty percent of kingfish were measured on release in 2002–03, the same percentage as last season. Kingfish size distribution is therefore presented as length frequency. Where length at release was not supplied by anglers, it was calculated from the estimated weight as described in the methods section.

Kingfish tagged in the 2000–01 season had a size mode of 100 cm (size class 100 cm to 104.9 cm) with 51% of tagged kingfish 100 cm or over (Figure 9c). Most of the smaller kingfish were tagged off east Northland or

east coast (statistical areas 002 and 003 or 012), while most kingfish larger than 95 cm were tagged at White Island, Ranfurly Bank, or the Three Kings area (statistical areas 10, 11, 47, and 48) (Figure 9b).

In the 2002–03 season 27 kingfish recaptures were reported (Table 2). Time at liberty ranged from 6 to 2294 days with a mean of 392 days (13 months). A 9 kg kingfish tagged off Tolaga Bay in April 2002 was recaptured on 30 December (252 days) near Ngawi, South Wairarapa coast, 253 nautical miles south. The first ever kingfish recapture from mainland South Island came from Cable Bay, northeast of Nelson, 23 March 2003. This fish, which weighed 11.7 kg on recapture, had been tagged in February 2002 at the Ranfurly Bank, East Cape, so had been at liberty for 13 months and had travelled 410 nautical miles southwest (Figure 9d).

A 20 kg kingfish released at the Three Kings Islands in May 2002 was caught at the southern end of Great Barrier Island, Hauraki Gulf, in February 2003. This is the first record of movement of a kingfish from the Three Kings to coastal New Zealand. In 297 days at liberty it had travelled 214 miles southeast. The recapture was made by a spearfisher who reported seeing another tagged fish in the same school. Last season a kingfish tagged at Three Kings Islands was recaptured in the same area after 1870 days (5 years). This fish was estimated to be 15 kg on release and on recapture measured 128 cm, estimated at 27 kg, and was re-released with the same tag in place.

A kingfish of 7 kg and 83 cm (using a measuring board) tagged at Ranfurly Bank was recaptured in the same area after 3 years (1132 days). It was remeasured on the same vessel at 113 cm and estimated at 19 kg before being released with the tag intact. Therefore this fish appears to have grown 10 cm and 4 kg per year, quite a remarkable growth rate. Kingfish are known to sometimes try and rub tags off against hard substrate. Unfortunately, some tags that have obviously been in fish for a long time are unreadable when they are removed from recaptured fish. Such a case was a 42 kg tagged kingfish which was recaptured on the Ranfurly Bank with no readable number left on the tag. This fish was retagged and released.

The great majority of kingfish recaptures tend to be close to the release point. In the programme so far, 93% of recaptures have been within 50 nautical miles of the release point. However, a significant number of all kingfish tagged have been released close to White Island and most of these are recaptured in that area. The plot of distance against days at liberty for White Island recaptures shows that very few fish (4%) have moved away from the area (Figure 10). This degree of site fidelity is not as apparent for kingfish released in other areas. A separate plot of distance against days at liberty for fish tagged in all areas excluding White Island shows more dispersal and a greater number of fish moving more than 10 nautical miles (31%) than the White Island fish (Figure 10).

It appears that location may influence the amount of movement recorded for tagged kingfish. The size of fish may be another factor. The proportion of kingfish (excluding those tagged at White Island) was broken down by size class and distance moved. Half of the kingfish less than 85 cm were recaptured within 5 nautical miles of their release points (Figure 11). Fish between 85 cm and 105 cm at release tended to move less, with 64% being recaptured within 5 nautical miles and a further 19% between 5 and 50 nautical miles of their release point. The largest size class (105–150) moved least with 77% within 5 nautical miles and a further 16% between 5 and 50 nautical miles.

However, distance travelled may be influenced by time at liberty. To reduce this effect we have plotted the displacement rate (nautical miles per day) for fish that were at liberty for more than 30 days. The pattern is similar to that described above, with a large proportion of fish showing little movement and with a tendency for that proportion to increase for the larger size classes (Figure 11). Between 53% and 60% of the size classes under 85 cm showed little movement (less than 0.04 nautical miles per day). The proportion showing little movement increased to 83% for fish over 105 cm (Figure 11). Overall, the recapture rate for kingfish is 8.7% in this programme (Table 2).

3.5 Yellowfin tuna

Seventy six yellowfin tuna were tagged in the 2002–03 season. Most were estimated to be 15–20 kg. Although this is an improvement over recent years, it is still well short of the number required to ensure usable results in the form of regular tag returns. However, the availability of yellowfin to recreational and commercial fishers varies widely from year to year, and in the three seasons since tagging of this species was reintroduced, catches have been lower than historic levels, particularly in the Bay of Plenty. Gamefish clubs reported landing 180 yellowfin in 2002–03 and 76 tagged (Roz Nelson, NZBGFC, pers. comm.) giving a 30% tagging rate. Some yellowfin were probably taken by non-club members or not recorded.

3.6 Other billfish

Blue marlin have been tagged in greater numbers over the last three seasons, mainly by anglers in the Kingdom of Tonga (see Table 1). Of the 60 blue marlin tagged in the 2002–03 season, 6 were tagged in New Zealand at North Cape, Three Kings, and Cape Runaway (Figure 12 b) and 54 in Tongan waters, many off the Vava'u Group. Most blue marlin were tagged during February and March, though numbers have declined over the last three seasons in New Zealand (Figure 12a). In Tongan waters, the number tagged tends to peak in September with more of an overlap with the New Zealand season in 2003 (Figure 12a). The fish tagged in Tonga were generally estimated at 110 kg or less, while in New Zealand they were larger (Figure 12c).

There have been two blue marlin recaptures in 2002–03. A 40 kg fish released off Vava'u, Kingdom of Tonga, in September 2002 was reported recaptured by a Fijian-based tuna longliner in January 2003 west of Vanuatu (19° 45' S). This fish was at liberty for 126 days and had travelled 1000 nautical miles west (Figure 12 d). The second recapture was made in June south of Fiji (21° 33' S) but no release card has been handed in as yet. The tag number has been traced to a charter boat working in Vava'u and was probably tagged this year. The skipper reported that he often gives the completed tag cards to the anglers to mail when they return to New Zealand. The overall recapture rate of blue marlin is now 1.0% for this programme (Table 2).

3.7 General

The number of tags issued and number used in each region in 2002–03 is given in Figure 13. The selection of regions is based on the commonly used gamefish areas. Overall, 3200 tags were issued to clubs and individuals and 1730 were used in 2002–03. In some regions it is obvious tags issued in previous seasons have been used.

4. DISCUSSION

The number of striped marlin tagged has declined over the last three seasons. Anglers have maintained a consistent tagging percentage, of almost two-thirds of all striped marlin caught each season for the last seven seasons. Therefore this decline appears to reflect a decline in overall catch that may be a result of a decrease in the availability of striped marlin and/or a decline in fishing effort.

At present, most fishing clubs have a voluntary 90 kg size limit for marlin to encourage tag and release. This figure was chosen as it represented the long-term average weight of striped marlin caught by

gamefish anglers in New Zealand. A large proportion (71%) of striped marlin tagged over the last two seasons has been estimated at 90 kg or larger, indicating that many anglers are tagging irrespective of size.

The accuracy of striped marlin weight estimates will vary with the experience of the skipper and crew. According to the 16 records of fish that have been weighed after recapture, fish under 100 kg were being estimated to within 15 kg of their actual weight. Fish that were estimated at 110 kg or greater on release tended to be overestimated. Nevertheless, the average error was 9.5 kg with some overestimates and underestimates. A striped marlin recaptured after 375 days weighed 14.6 kg more than its estimated release weight. It is likely that this fish grew over this time and the release estimate could have been reasonably accurate.

The recapture of a striped marlin tagged east of Northland and caught and retagged by a recreational angler west of Auckland 42 days later gives an insight into the mobility of these fish. In 1998 a striped marlin tagged off Kaipara on the west coast was recaptured in the Bay of Plenty, 437 nautical miles away by sea after 21 days at liberty. Movements from one coast to the other are generally not expected and some fishers claim that west coast fish 'look different' from those caught on the east coast (although this is not supported in any way by genetic studies).

The recapture of two blue marlin tagged in Tongan waters (from just 53 releases this season) brings the total number of recaptures for the species in this programme to five. Four of these recaptures have been made by longliners in Fijian waters and the fifth was from a vessel fishing in Vanuatu. Overall the recapture rate for blue marlin is now 1.0%, twice that of striped marlin. Tag retention may contribute to this difference between the species. Two blue marlin recaptures in this programme came from fish at liberty for more than three years. However, almost all striped marlin, in all tagging programmes, have been recaptured within one year at large (Ortiz et al. 2003).

There are many possible causes of tag shedding. Bruce Smith, skipper of *Striker* described seeing a remora (probably *Remora brachyptera*) attach adjacent to a freshly placed tag on a striped marlin immediately after release, in February 2003 at North Cape. Remora would be capable of removing a newly placed tag, unless very firmly anchored. It is thought that remora get some of their food by removing parasites from the body of the host (Ayling & Cox 1987).

The number of sharks tagged and released has declined over the last 5 years. The number of makos tagged has ranged between 300 and 700 per season, but the 155 tagged in 2002–03 is the lowest for 18 years. This reflects an overall decline in the number of sharks caught by recreational anglers as most sharks caught are taken as a bycatch of marlin or tuna fishing and tagged and released (Roz Nelson, NZBGFC, pers. comm.).

The proportion of mako tag returns from commercial vessels has increased since the development of the domestic tuna longline fisheries in New Zealand and in other South Pacific island states (Holdsworth & Saul 1998). In 2002–03 the number of mako shark recaptures reported (9) was the lowest in 10 years, but still provided evidence that some makos spend winter and spring (July to October) in tropical waters (Australia, New Caledonia, Fiji, and Tonga). There was also an in-season movement (March to June) of a mako from the west coast of the North Island to East Cape. In many ways the distribution of mako sharks and striped marlin tagged in New Zealand appears similar, or at least reflects that they are susceptible to the same fisheries.

There were no blue shark recaptures in 2002–03, the first time since 1989–90. Like striped marlin and makos, blue shark recaptures outside New Zealand waters are generally made off Australia and the tropical islands of the southwest Pacific. However, two long-distance recaptures; one in the Indian Ocean and one in the southeast Pacific, have not been observed for the other species.

It has been recognised for some time that kingfish tagged at White Island and associated reefs tend to be recaptured in that area (Saul & Holdsworth 1992). More movement is observed for fish not tagged at White Island. Even with this subset of fish, 55% of all recaptures are made within 5 nautical miles of the release location. To some extent this may be affected by the distribution of targeted fishing at specific locations and short-term recaptures. Some fish do move large distances, but, overall, kingfish 105 cm or over are less likely to move out of the area where they were tagged than smaller fish. Removing recaptures for fish under 30 days at liberty and plotting the movement rate per day for different sized kingfish still showed the same pattern. Fish in the three size classes under 85 cm tend to move in about the same proportions as each other, kingfish over 105 cm move less and the 85 cm to 105 cm size class is somewhere in between. The onset of sexual maturity may be a factor in movement as the size that kingfish reach 50% sexual maturity at 81 cm in males and 94 cm in females (Poortenaar et al. 2001) (although recent unpublished analysis of the same data estimated size at maturity to be 83 cm for males and 97 cm for females, (Watson & McKenzie 2003).

A study of 1376 kingfish recaptured in the New South Wales Fisheries gamefish tagging programme suggested that small fish (under 62 cm fork length) showed less movement than larger fish (Gillanders et al. 2001). However, most of the kingfish tagged were between 35 and 62 cm fork length, and few fish over 100 cm were tagged. If the size range of fish tagged is limited, then extrapolating to the entire size range may be misleading (Gillanders et al 2001). A broad size range of kingfish has been tagged in the New Zealand programme and it seems clear that the largest size classes of fish are more likely to be recaptured close to their release points. Whether there are small areas of particular habitat that attract and hold large kingfish, or whether there are areas with greater effort specifically targeting large fish will need to be investigated in a future study.

5. ACKNOWLEDGMENTS

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Table 1: Number of fish tagged and released by species, and season, and the mean number of releases for the ten seasons previous to 2002-03.

Season	BEM	BKM	BWS	KIN	MAK	SHA	SAI	SSF	STM	SWO	YFN	OSP	Total
1974-75			1		9								10
1975-76			-	1	17	2			3		1		24
1976-77			1	1	34	-			2				38
1977-78			-	15	58	-			7				80
1978-79	2		1	107	152	1			18			5	286
1979-80			26	22	129	3			17			-	197
1980-81		1	7	7	116	2			2			7	142
1981-82			99	30	185	3			11			17	345
1982-83			18	55	151	4			6		2	11	247
1983-84			15	54	220	7			9		6	9	320
1984-85			10	143	98	4			-		25	2	282
1985-86			23	318	211	1			2		8	6	569
1986-87			12	365	177	31			2		7	22	616
1987-88	1	1	91	689	505	47			97	6	13	82	1 532
1988-89	1	-	122	371	370	32			371	4	63	116	1 450
1989-90	7	4	87	427	424	26		3	365	4	140	100	1 587
1990-91	-	2	90	528	417	32	4	7	229	5	24	51	1 389
1991-92	5	2	128	389	353	40	-	1	241	20	39	38	1 256
1992-93	11	1	64	693	352	24	5	9	386	36	13	80	1 674
1993-94	20	2	162	1 100	667	19	5	17	929	3	104	41	3 069
1994-95	29	4	175	1 444	1 531	23	9	29	1 206	10	215	28	4 703
1995-96	46	6	163	643	1 158	30	4	15	1 104	3	110	12	3 294
1996-97	26	5	343	416	920	36	4	5	1 302	4	33	9	3 103
1997-98	24	5	724	364	518	54	6	1	898	-	3	4	2 601
1998-99	43	2	276	311	754	40	2	6	1 541	2	19	8	3 004
1999-00	64	3	314	818	398	56	11	3	791	2	27	40	2 527
2000-01	71	1	203	606	277	72	8	1	851	6	17	4	2 117
2001-02	68	3	163	751	329	66	11	13	751	3	7	3	2 168
2002-03	60	1	78	644	155	53	14	16	636	3	76	1	1 737
Total	478	43	3 396	11 312	10 685	708	83	126	11 777	111	952	696	40 367
10 year Mean	40	3	259	715	690	42	7	10	976	8	55	23	2 826

BEM blue marlin
 BKM black marlin
 BWS blue shark
 KIN kingfish
 MAK mako shark
 SHA other shark species

SAI sailfish
 SSF shortbill spearfish
 STM striped marlin
 SWO broadbill swordfish
 YFN yellowfin tuna
 OSP all other species

Table 2: Number of fish recaptured by species and season. Total and recapture rate by species.

Season	BEM	BKM	BWS	KIN	MAK	SHA	SCH	STM	SWO	YFN	OSP	Total
1976-77				1	2							3
1977-78					3							3
1978-79				7	6							13
1979-80				3	3						1	7
1980-81				2	3							5
1981-82				2	8							10
1982-83			1	11	5							17
1983-84				9	1							10
1984-85				10	7							17
1985-86				56	10							66
1986-87				92	9	1	3					105
1987-88				77	8	-	1				3	89
1988-89			2	91	13	-	1	1			3	111
1989-90			-	45	10	2	4	2			-	63
1990-91			3	37	7	-	3	1		1	1	53
1991-92			3	31	12	1	-	-		-	3	50
1992-93			2	43	3	-	2	3		-	-	53
1993-94			1	54	10	1	4	4		1	-	75
1994-95			2	86	16	-	-	6		-	1	111
1995-96		1	1	71	32	-	1	6		3	1	116
1996-97		-	4	52	35	-	2	5		1	1	100
1997-98	1	-	9	26	17	-	2	12		1	1	69
1998-99	-	-	10	20	15	2	2	14		-	-	63
1999-00	1	-	11	57	23	1	4	5		-	2	104
2000-01	1	-	4	29	15	3	-	2		1	1	56
2001-02	-	-	3	48	16	1	-	2	1	-	-	71
2002-03	2	-	-	27	9	1	1	1	-	-	1	42
Total	5	1	56	987	298	13	30	64	1	8	19	1 482
Releases	478	43	3 396	11 312	10 685	708	109	11 777	111	952	696	696
Recapture rate (%)	1.0	2.3	1.6	8.7	2.8	1.8	27.5	0.5	0.9	0.8	2.7	

BEM	blue marlin	SCH	school shark
BKM	black marlin	STM	striped marlin
BWS	blue shark	SWO	broadbill swordfish
KIN	kingfish	YFN	yellowfin tuna
MAK	mako shark	OSP	all other species
SHA	other shark species		

Species included in SHA

bronze whaler
porbeagle shark
sevengill shark
thresher shark

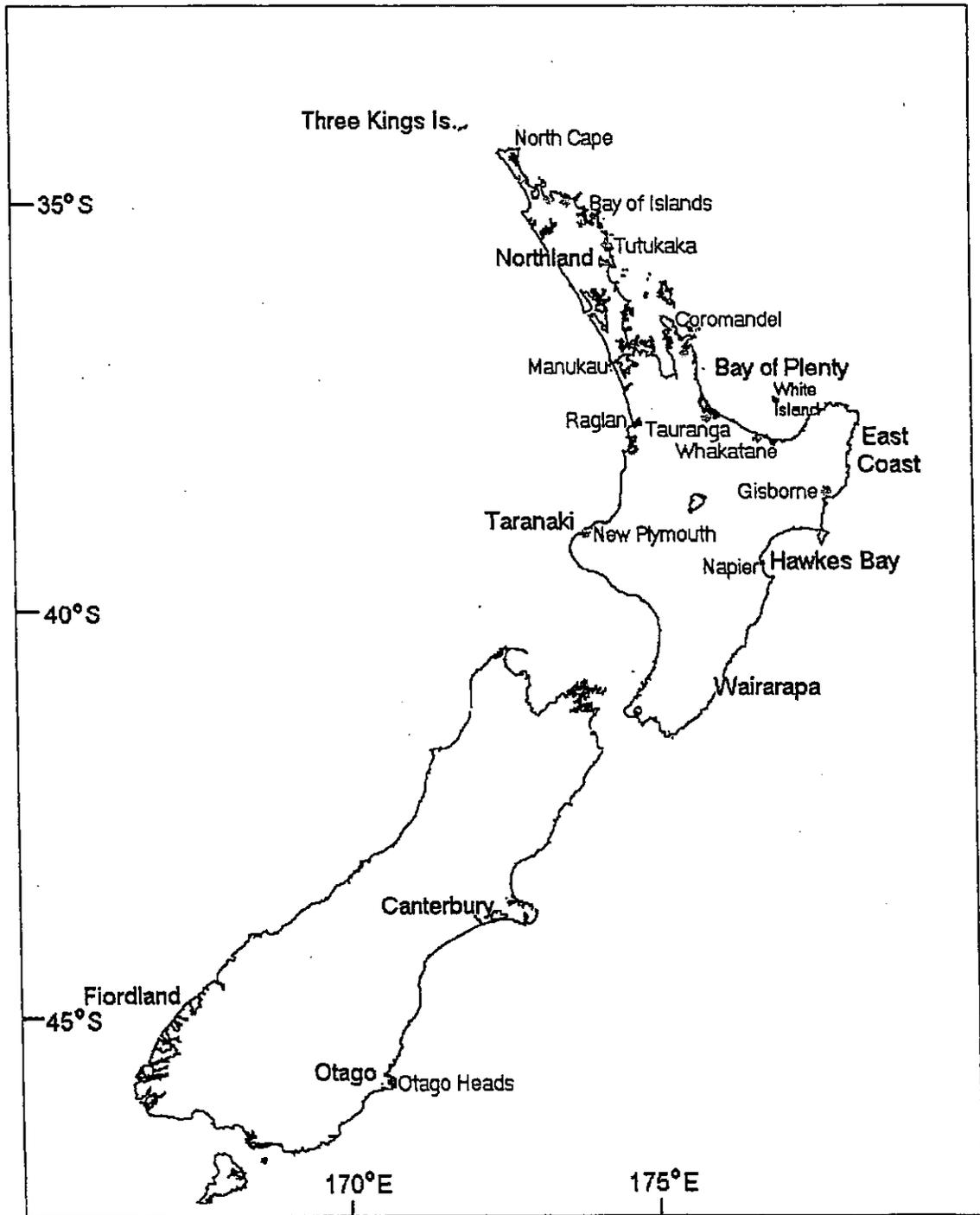


Figure 1: Location of the main areas of gamefish tagging in New Zealand.

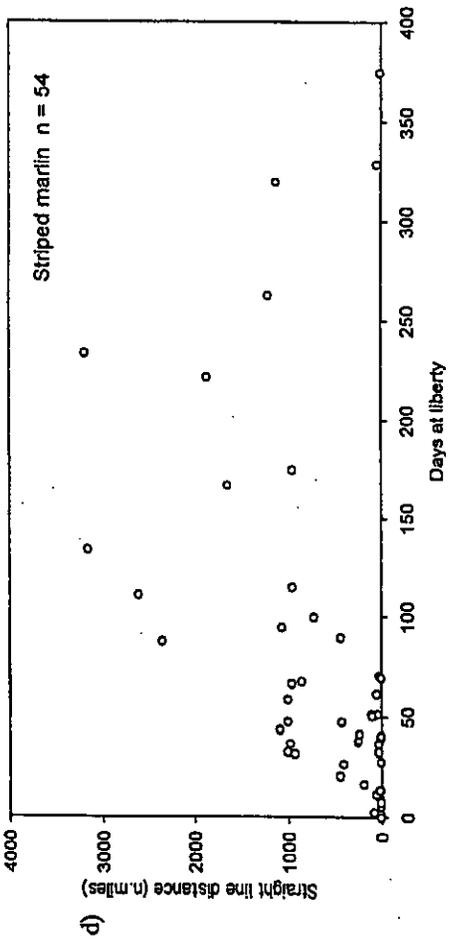
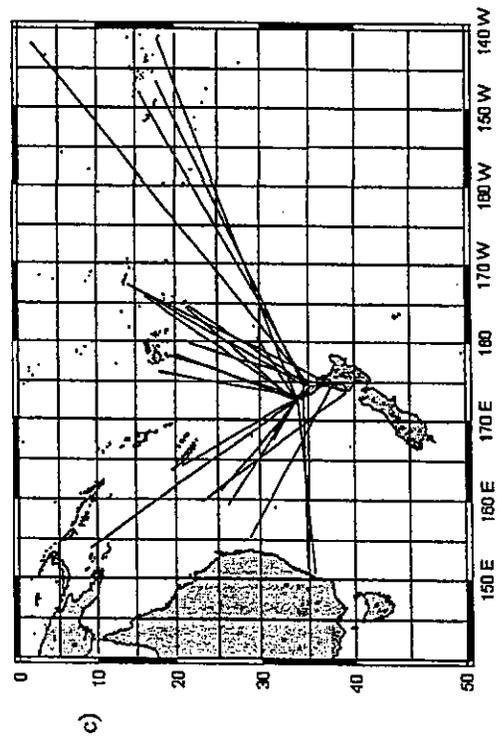
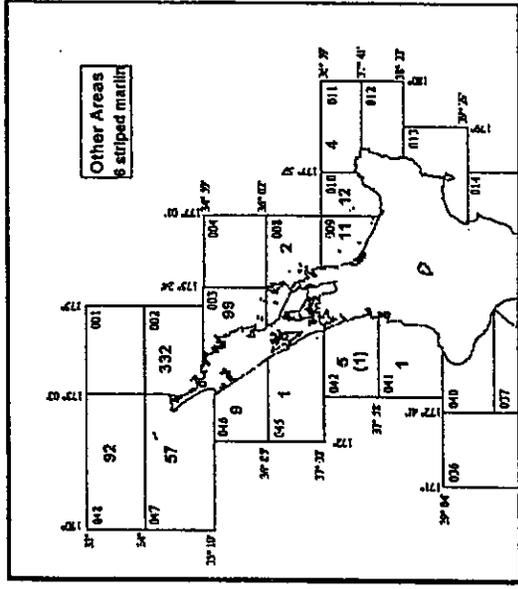
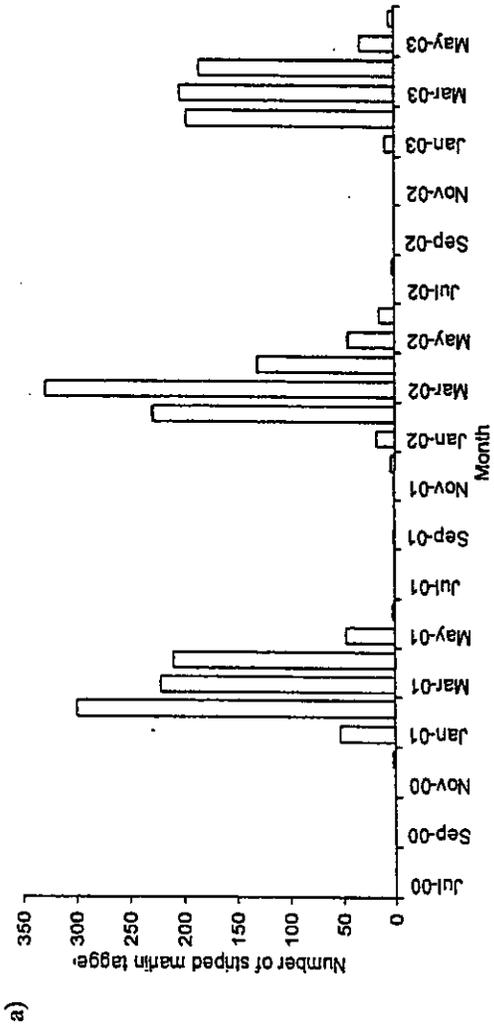


Figure 2: (a) Number of striped marlin released by month during 2000-03; (b) Numbers of striped marlin released by statistical reporting area in 2002-03; (c) Long distance movements of tagged striped marlin; (d) Striped marlin days at liberty and straight line distance travelled.

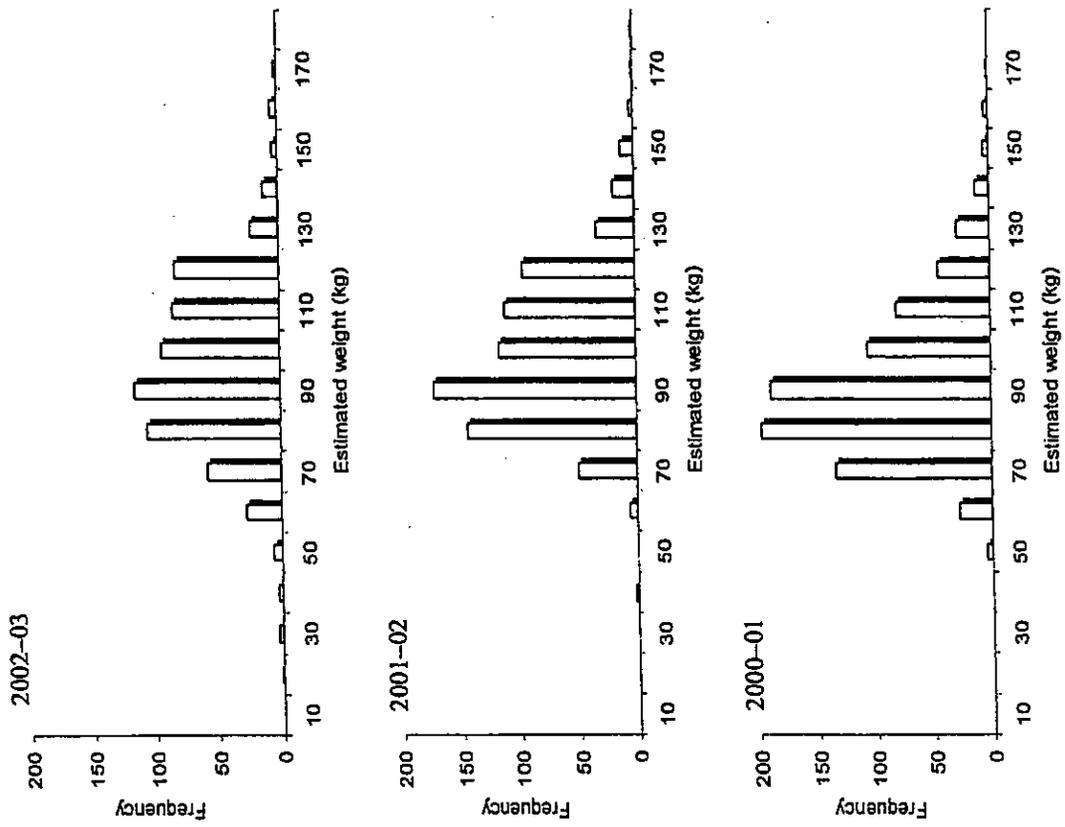


Figure 3: Striped marlin estimated release weight frequency by season.

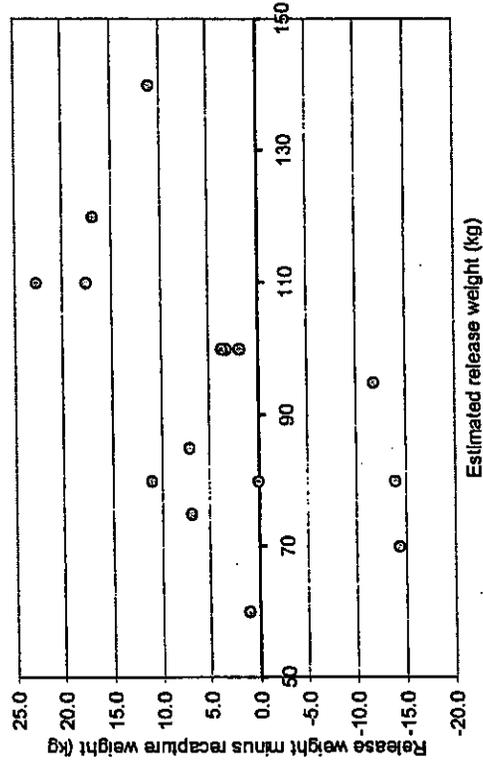


Figure 4: Residuals for striped marlin estimated release weight minus actual weight on recapture.

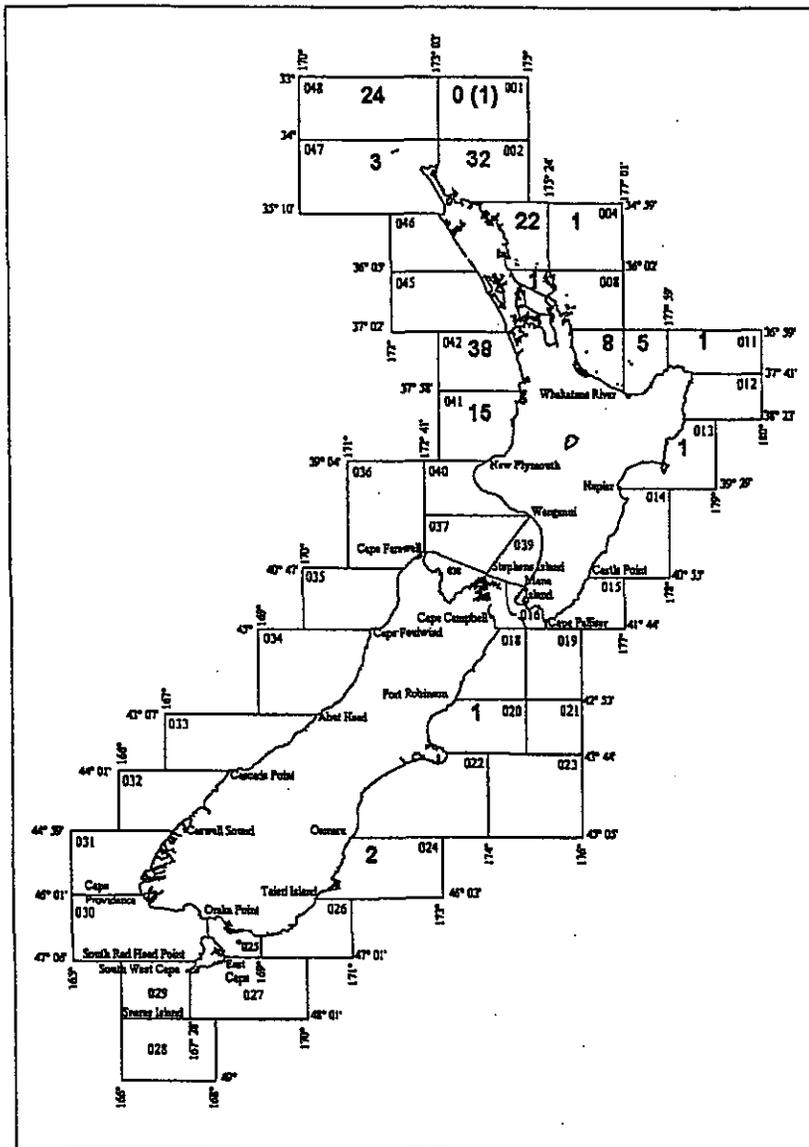


Figure 5: Mako sharks tagged and released by statistical reporting area in 2002-03.

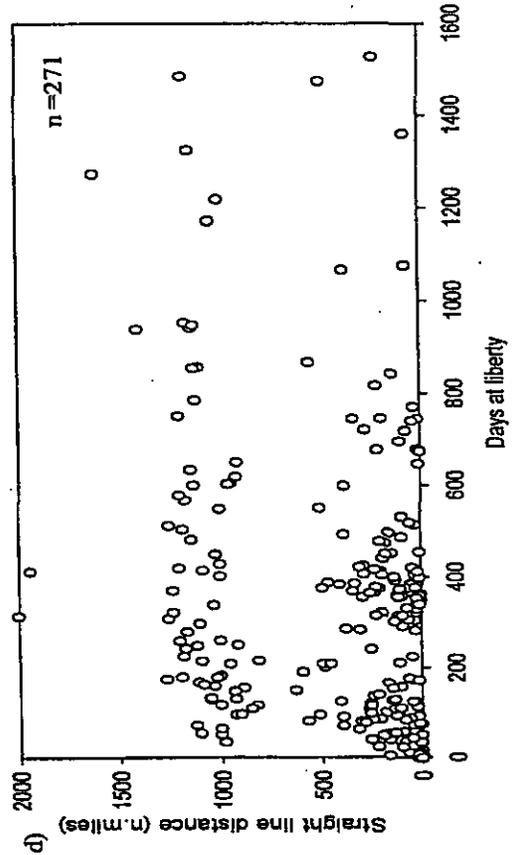
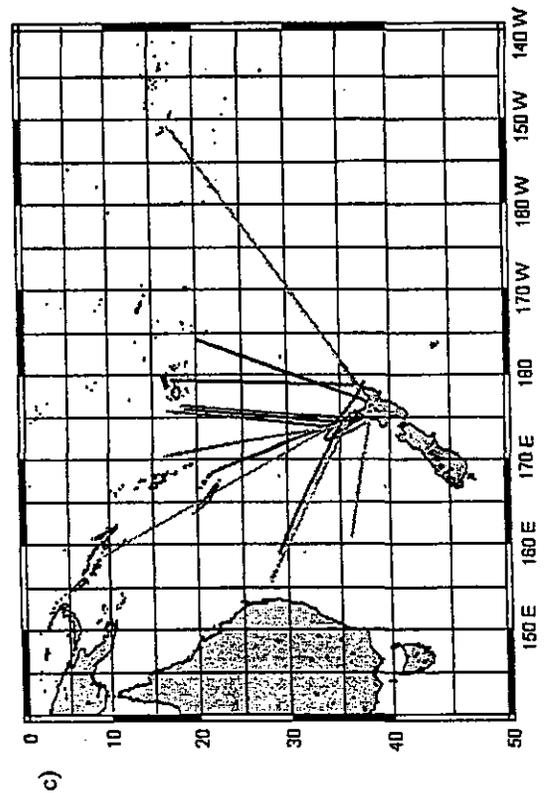
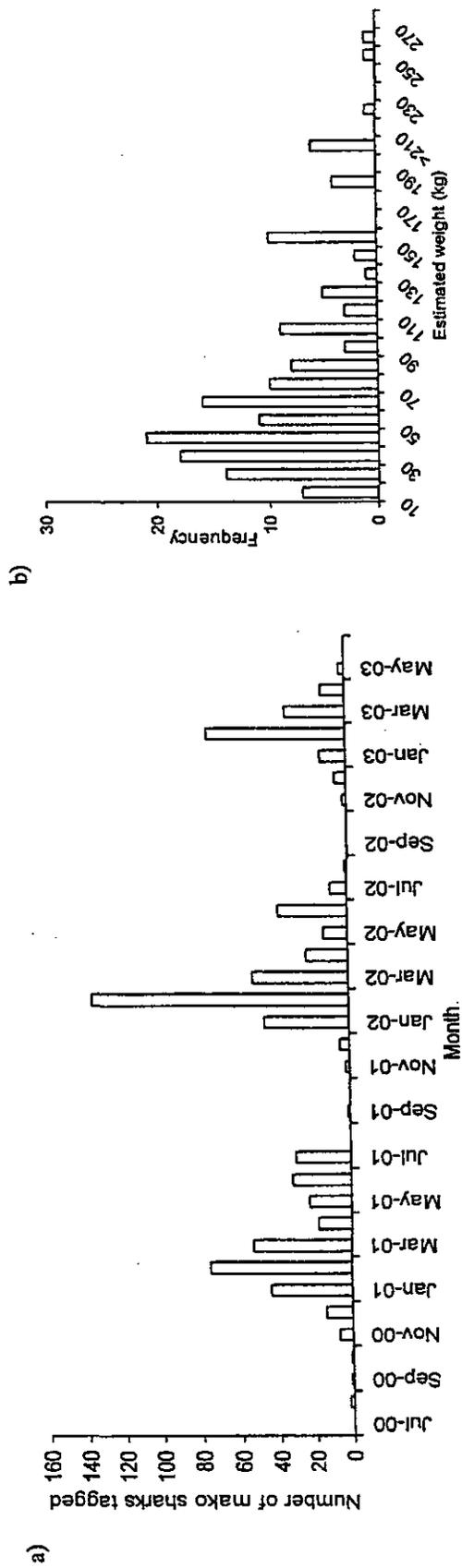


Figure 6: (a) Number of tagged mako sharks released by month, 2000-03; (b) Mako shark estimated release weight frequency, 2002-03; (c) Long distance movements of tagged mako sharks for 2001-02 (grey) and 2002-03 (black); (d) Mako shark days at liberty and distance travelled (one long-term recapture of 4118 days and 190 nautical miles not plotted; one long distance recapture of 3000 nautical miles and 190 days not plotted).

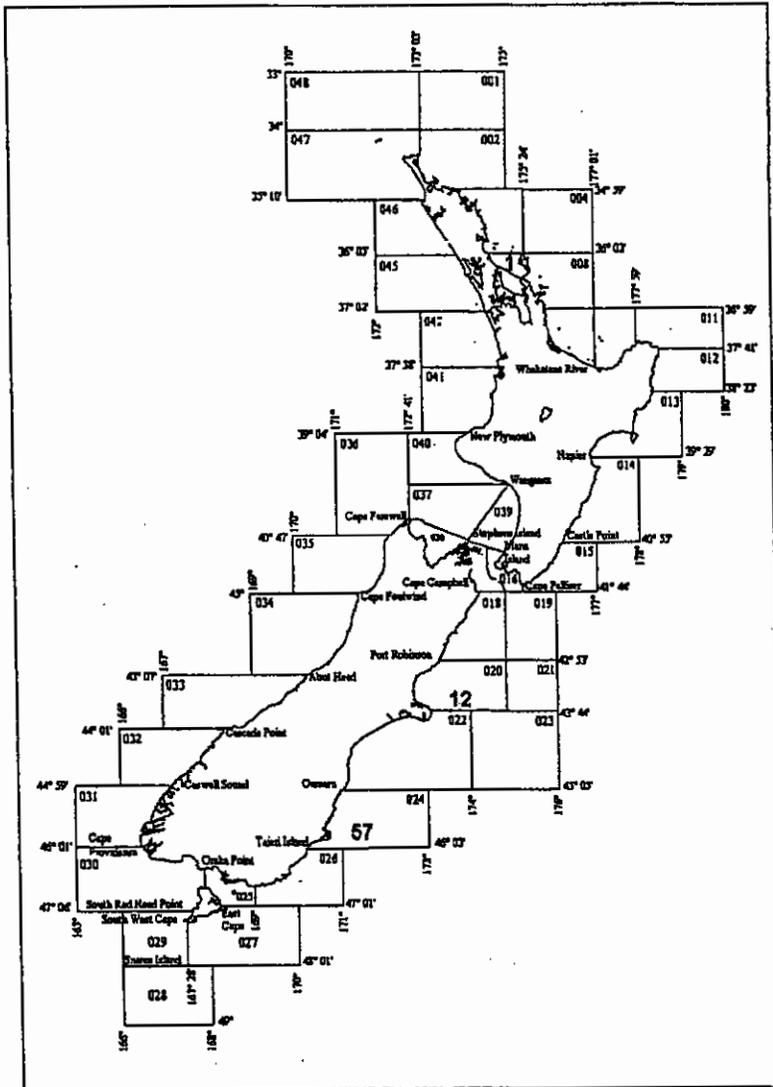


Figure 7: Blue sharks tagged and released by statistical reporting area in 2002-03.

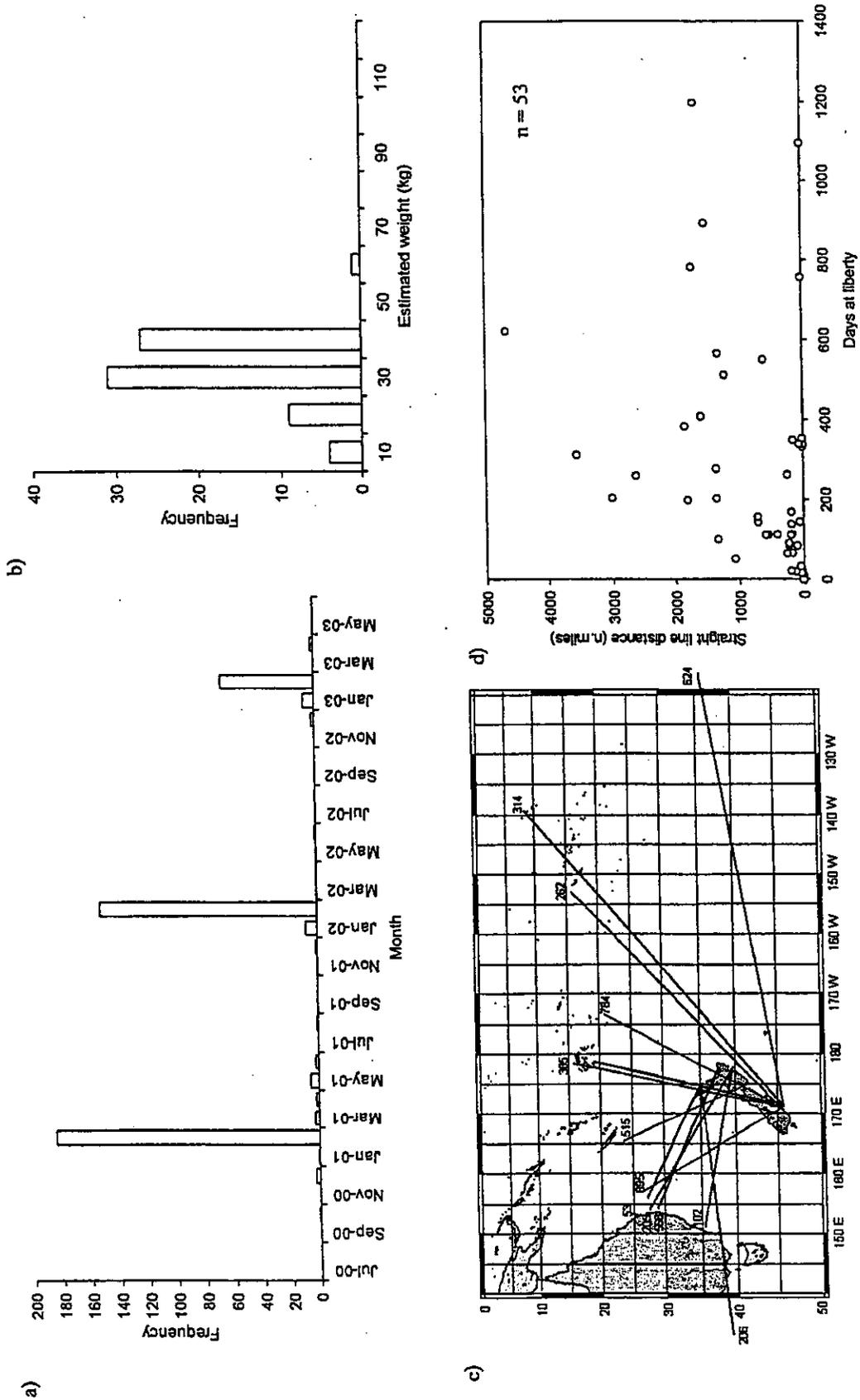


Figure 8: (a) Number of tagged blue sharks released by month 2000–03; (b) Blue shark estimated release weight frequency 2002–03; (c) Long distance movements of tagged blue sharks all seasons (days at recapture point); (d) Blue shark days at liberty and straight line distance travelled.

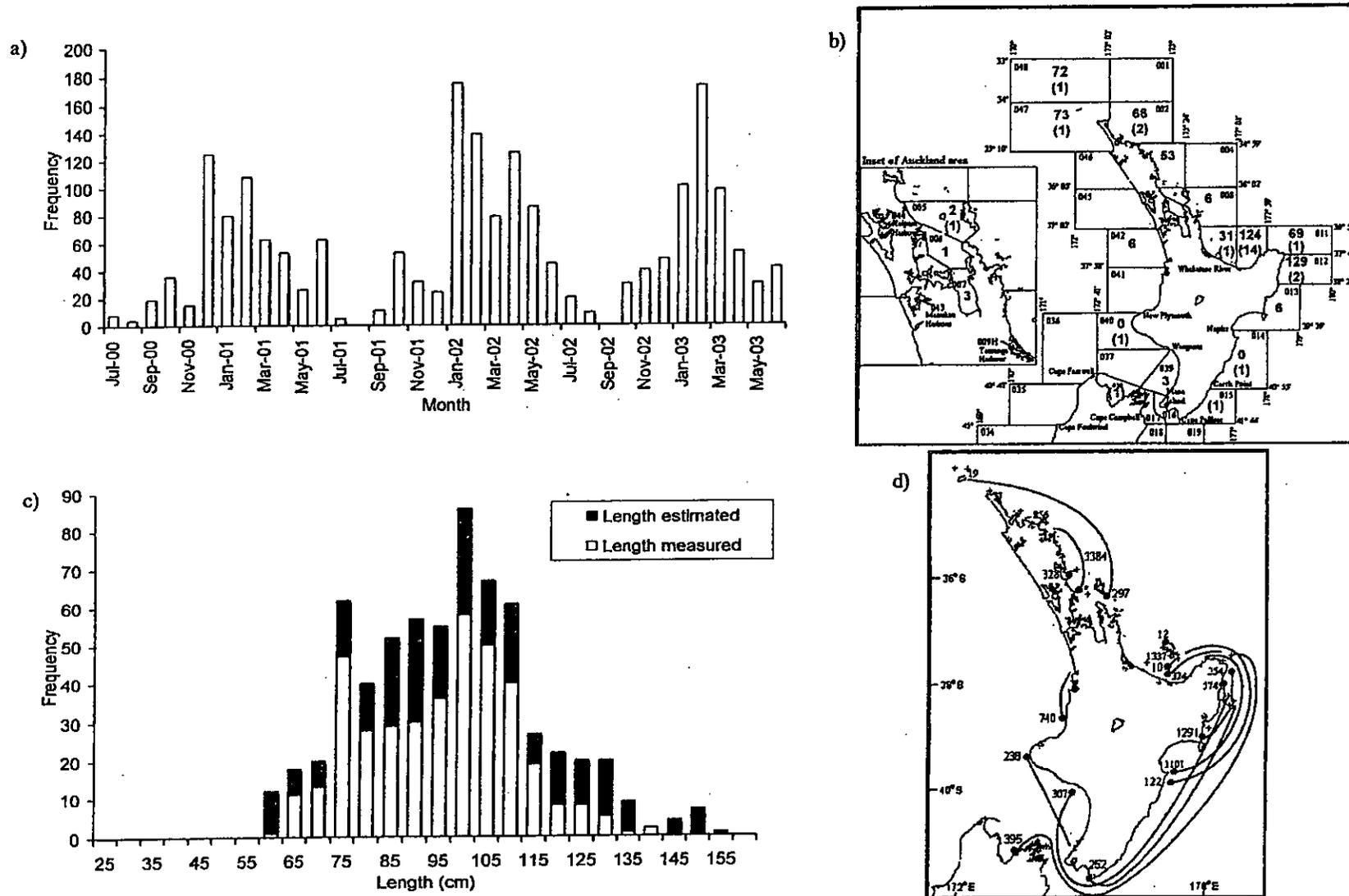


Figure 9: (a) Number of tagged kingfish released by month 2000-03; (b) Numbers of kingfish released, and numbers recaptured (in parentheses), by statistical reporting area for the 2002-03 season; (c) Kingfish release length frequency in the 2002-03 season; (d) Kingfish movement indicated by recaptures 2000-03 with days at liberty near recapture point, crosses indicate recaptures in the same location.

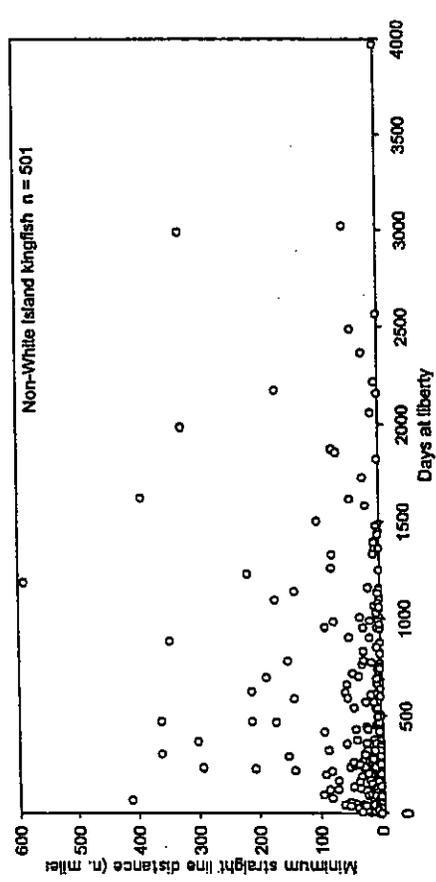
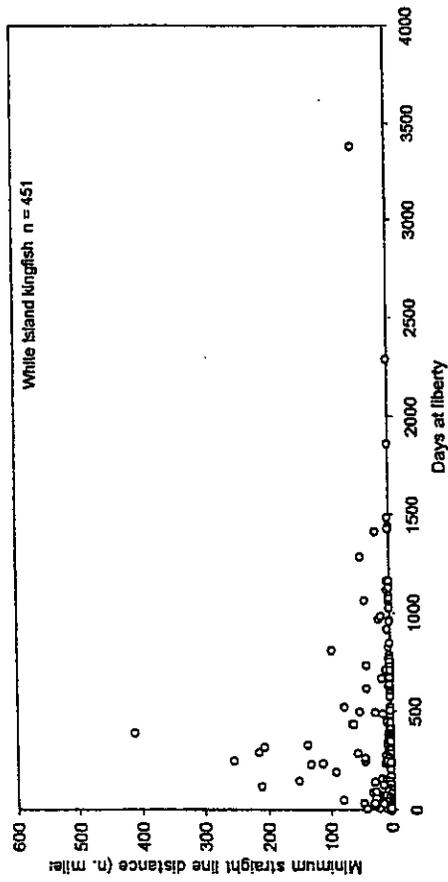


Figure 10: Kingfish days at liberty and straight line distance travelled for White Island (top) and non White Island (bottom) released fish.

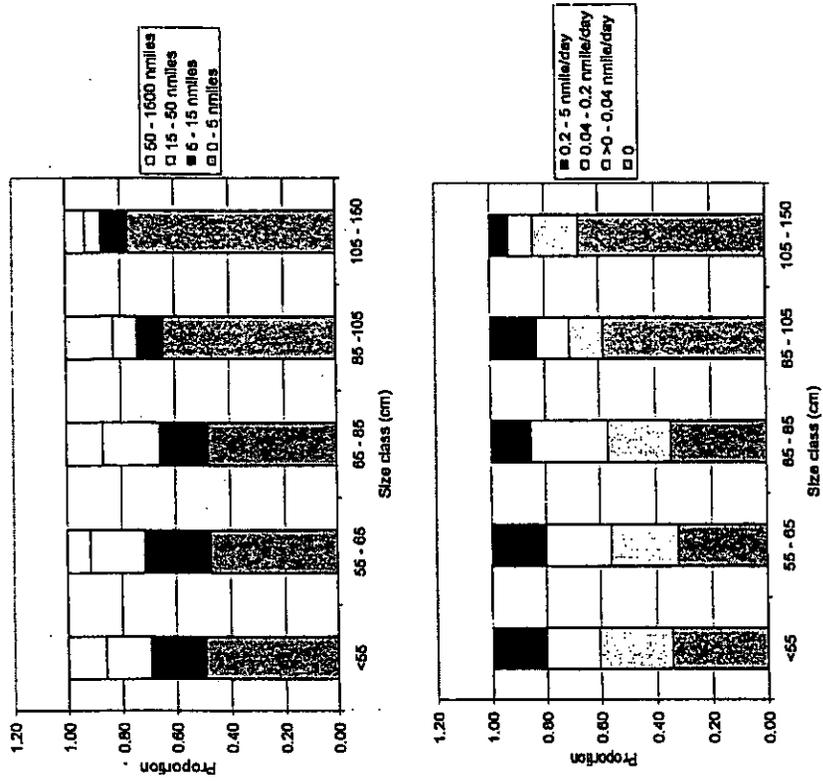


Figure 11: Proportion of kingfish displacement by distance category and size class for fish not released at White Island (top) and the rate of kingfish displacement (nautical miles per day) by size class.

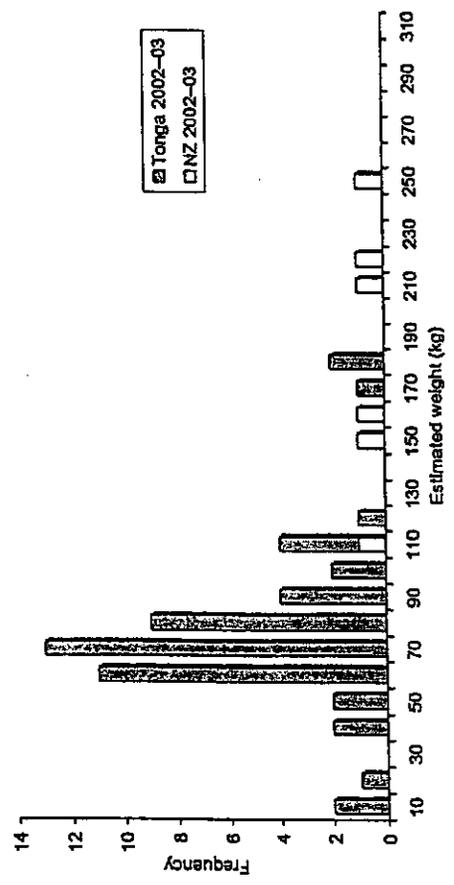
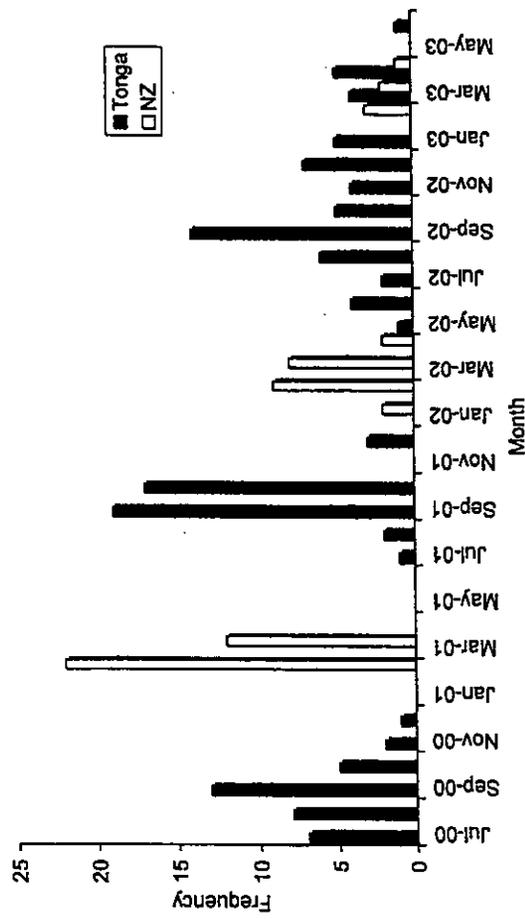
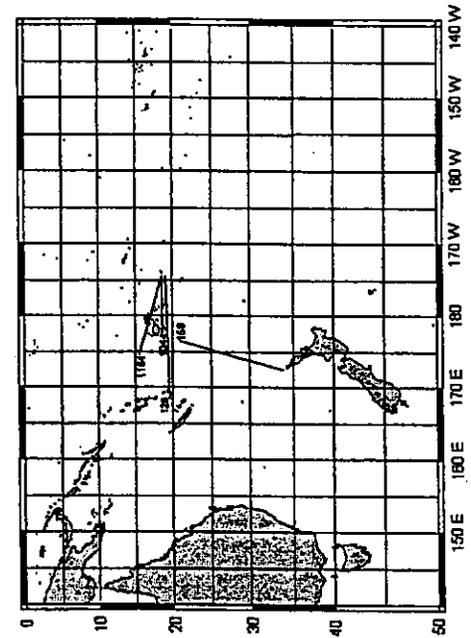
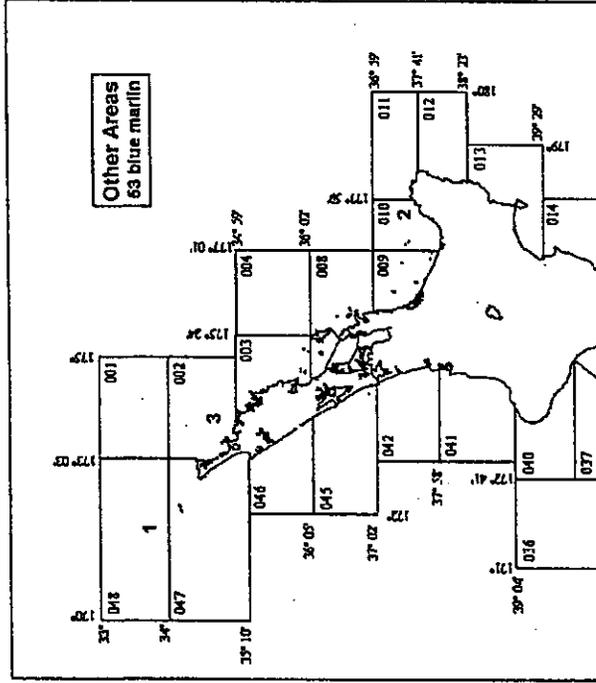


Figure 12: (a) Number of blue marlin tagged and released by month in Tongan waters (solid bars) and New Zealand waters (open bars) 2000-03; (b) Number of blue marlin tagged by statistical area for the 2002-03 season; (c) Blue marlin release weight frequency in the 2002-03 season; (d) Blue marlin movement as indicated by recaptures for all seasons (days at liberty at recapture point).

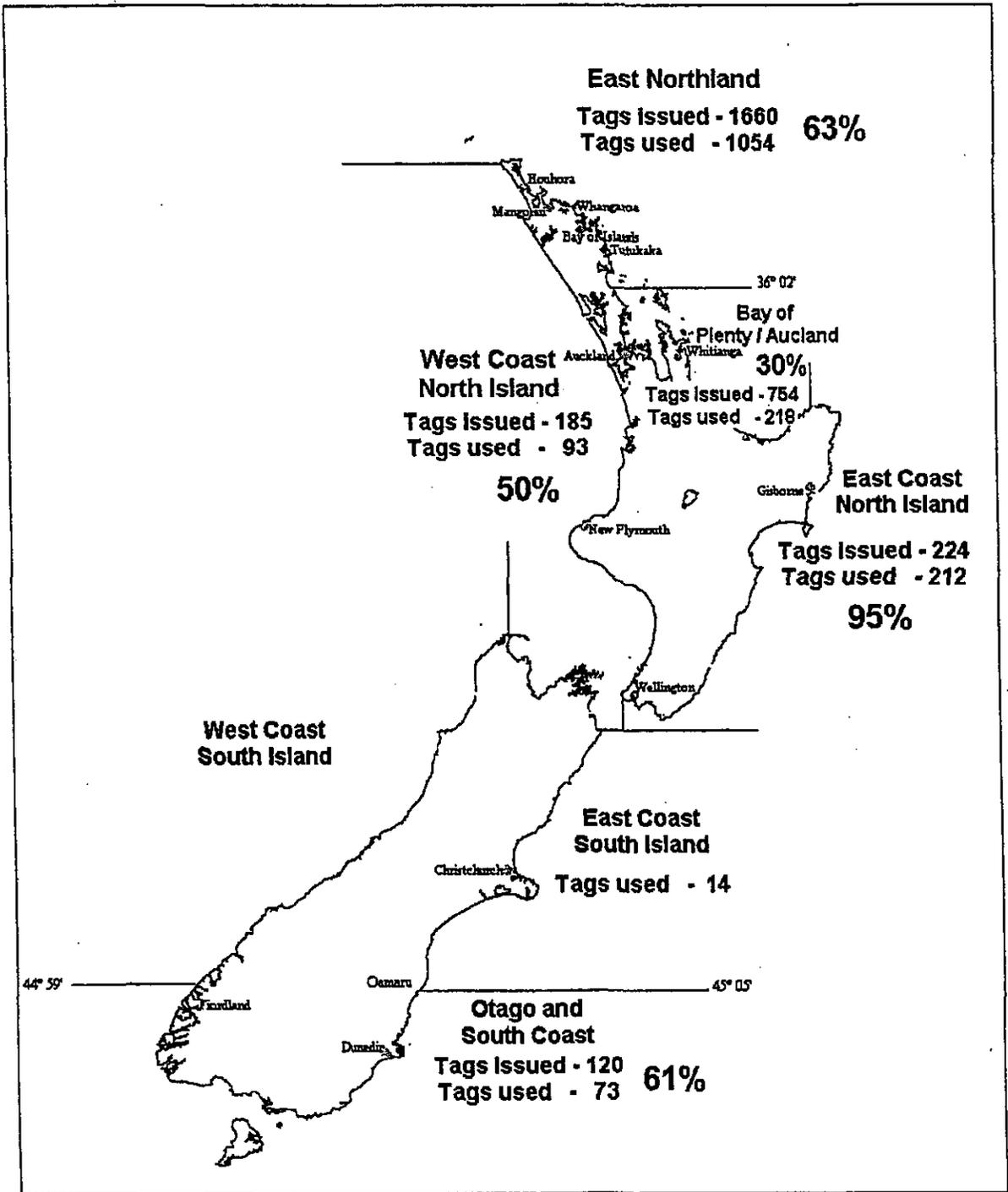


Figure 13: The number of tags issued to clubs and individuals and the number reported used by region for the 2002–03 season. The percentage of tags used can be influenced by the number of tags issued in previous seasons.